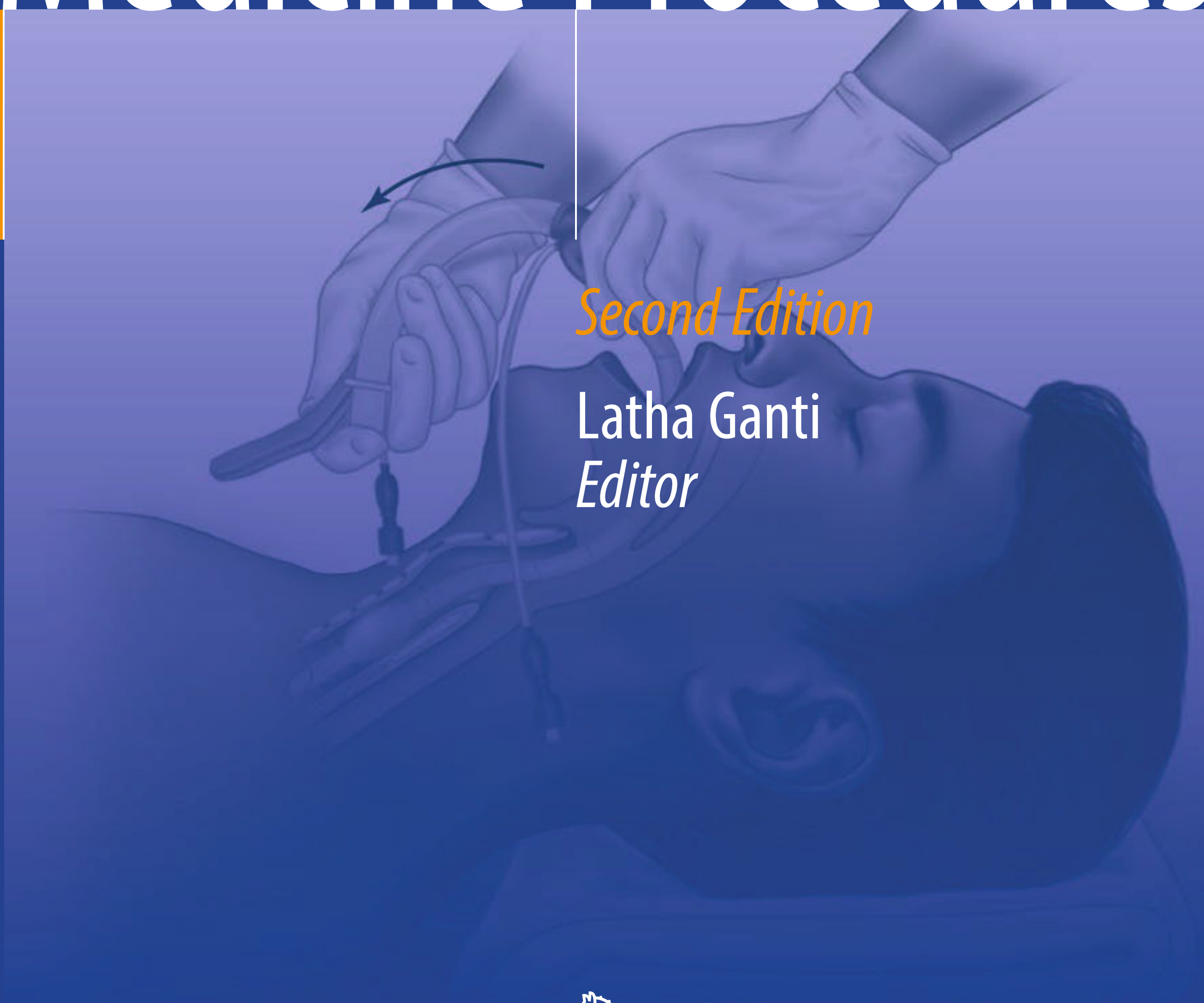
Atlas of Emergency Medicine Procedures



Second Edition

Latha Ganti
Editor

Springer

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To my father, my role model and career coach. – **Dr. Ganti L. Rao**
Dad, I wouldn't have had the career I do were it not for you. Your unconditional belief in me, your confidence in my success, your never-ending patience and generosity – you lead a life of great achievements with utmost humility. It is my privilege to be your daughter.

Preface

In this second edition of the *Atlas of Emergency Medicine Procedures*, we expand on the highly successful first edition with several additional chapters as suggested by our readers. These include percutaneous cricothyrotomy, pigtail catheter placement for small pneumothoraces, resuscitative endovascular balloon occlusion of the aorta (REBOA), ultrasound evaluation of pulmonary embolism and heart strain, ventriculoperitoneal shunt evaluation, occipital nerve block, sphenopalatine ganglion block, conducted energy weapon (e.g., TASER) probe removal, ring removal, rongeur for distal phalanx amputations, and many more. Overall, there is approximately 25% new content. We thank our readers for the helpful feedback and support.

As with the first edition, it is envisioned that this atlas can be used at the bedside, both by seasoned clinicians as a teaching aid, as well as novice practitioners. The most common procedures are grouped by organ systems for ease of reference. Each procedure follows a standardized format, beginning with key words, a definition if appropriate, indications, and contraindications. These are followed by materials and medications, often accompanied by a photograph of the specific equipment or setup. The procedure itself is numbered rather than bulleted, highlighting the sequence of the steps. Photographs are placed where the relevant information is encountered in the text rather than at the end. Every procedure also lists complications. Finally, there is a part on pearls and pitfalls, gleaned from the collective experience of the contributors in addition to traditional teachings.

Emergency medicine, by nature, is a field that is best suited to a text that is visually appealing and brief in words, but able to deliver the information required. Thus, the emphasis in this second edition continues to be on high-quality images that tell the story. All images are either actual photographs taken of the procedure steps or specially commissioned drawings by Springer's professional illustration team.

Orlando, FL, USA — Latha Ganti

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Part I

Vascular Procedures

Check for updates

1 Arterial Cannulation (Radial and Femoral)

Jeffrey Kile, Katrina John, and Amish Aghera

Indications

- Continuous monitoring of blood pressure in acute illness or major surgery
- Serial sampling of arterial blood during resuscitation
- Inability to use noninvasive blood pressure monitoring (e.g., burns, morbid obesity)
- Continuous infusion of vasoactive inotropes (e.g., phentolamine for reversal of local anesthesia)
- Angiography
- Embolization
- Resuscitative endovascular balloon occlusion of the aorta (REBOA)
- Extracorporeal membrane oxygenation (ECMO)

Contraindications

- Absolute
  - Circulatory compromise in the extremity
  - Third-degree burns of the extremity
  - Raynaud's syndrome
  - Thromboangiitis obliterans (Buerger's disease)
- Relative
  - Recent surgery in the extremity
  - Local skin infection
  - Abnormal coagulation
  - Insufficient collateral circulation
  - First- or second-degree burns of the extremity
  - Arteriosclerosis

Materials and Medications

- Radial artery over-the-needle cannulation (Fig. 1.1):
  - Antimicrobial solution and swabs
  - Sterile gloves
  - Local anesthetic (1–2% lidocaine without epinephrine)
  - Blunt needle
  - 25- or 27-gauge needle
  - Two 5-mL syringes
  - 4″ × 4″ gauze sponges
  - Standard over-the-needle catheter assembly
- Additional materials required for radial artery cannulation with integrated guide wire:
  - Over-the-needle catheter assembly with integrated guide wire
- Additional materials required for femoral artery cannulation (Seldinger technique):
  - Introducer needle
  - Guide wire
  - Scalpel
  - Dilator
  - Arterial catheter

Procedures

Procedure: Radial Artery Cannulation—Standard Over-the-Needle Catheter Technique

1. Use the Allen test (see details below) to ensure adequate collateral flow in the selected extremity.
2. Immobilize the extremity by dorsiflexing the wrist to approximately 45° over a small towel roll and taping the

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Fig. 1.1 Materials and medications

base of the fingers to an arm board or other flat, fixed surface (Fig. 1.2).

- Rotation of the wrist may shift the artery from its normal anatomical position, complicating cannulation.

3. Locate vessel by palpation of arterial pulse using the second and third fingers of the gloved nondominant hand.
4. Sterilize overlying skin with antimicrobial solution.
5. Inject local anesthetic to raise a small (0.5 cm) wheal using 25- or 27-gauge needle, and direct the needle through the wheal to infiltrate the skin superficial to the artery with additional local anesthetic.
   - Infiltration of the subcutaneous tissue with local anesthetic may also reduce vessel spasm during arterial puncture.
   - Injection of local anesthetic into the vessel may precipitate arrhythmia, so draw back on the plunger prior to infiltration to ensure that the tip of the needle is not inside the vessel.
   - Injection of excessive anesthetic when raising a wheal may obscure palpation of the pulse.
6. Ensure proper function of the needle-cannula assembly by checking that the cannula advances smoothly over the needle.
7. Connect a 5-mL syringe with the plunger removed to the over-the-needle catheter assembly.
   - Attachment of a syringe improves control during cannulation.

8. Hold syringe connected to the needle-cannula assembly like a pen, with the needle bevel facing upward.
9. Directing the needle at a 30° angle to the skin, puncture the skin through the anesthetic wheal immediately overlying the palpated artery, and advance the needle slowly until the tip enters the arterial lumen, which is confirmed by visible arterial blood flow ("flashback") into the needle hub and syringe (Fig. 1.3).
   - Avoid self-puncture by maintaining adequate distance between needle tip and index finger.
10. Reduce the angle between the needle and skin (by lowering the needle), and advance an additional 2 mm to ensure that the catheter tip (which sits approximately 2 mm behind the needle tip) has entered the lumen.

Fig. 1.2 Correct position of the wrist prior to cannulation

Fig. 1.3 Puncture of radial artery with standard over-the-needle catheter assembly

   - Advancing the needle too far (or failing to reduce the angle between the needle and skin) once the initial flashback is visualized may result in piercing the back side (or "double puncture") of the artery wall; in this case, visible blood flow will cease. If this occurs, slowly withdraw the needle several millimeters until pulsatile blood flow reappears.
11. Stabilize the position of the introducer needle, and advance the catheter alone into the artery over the needle until the hub of the catheter is in contact with the skin; blood flow from the catheter hub at this point indicates successful cannulation of the artery.
   - If difficulty is encountered at this step, rotate the catheter hub slightly to facilitate advancement.
12. Remove the needle without dislodging the catheter from the artery.
13. Manually apply pressure to the proximal aspect of the artery to occlude blood flow from the catheter.
14. Attach desired extension tubing, injection cap, and stopcock to the catheter hub.
15. Secure the catheter hub to the skin using silk (2.0) or nylon (4.0) sutures as follows: Take a 0.5-cm bite of the skin under the catheter hub with the suture needle, tie several knots in the suture without pinching the skin, and then tie a second set of knots around the hub of the catheter firmly. If the catheter assembly contains an integrated suture wing for fixation, take a 0.5-cm bite of the skin under the suture wing with the suture needle, thread suture through the wing perforation, and secure the wing against the skin with several knots. If the suture wing has two perforations, repeat this process to secure the other half of the wing to the skin (Fig. 1.4).
16. Cover the catheter with an appropriate self-adhesive sterile dressing.
   - A small bead of antibiotic ointment applied to the puncture site prior to dressing reduces the likelihood of cutaneous wound infection.

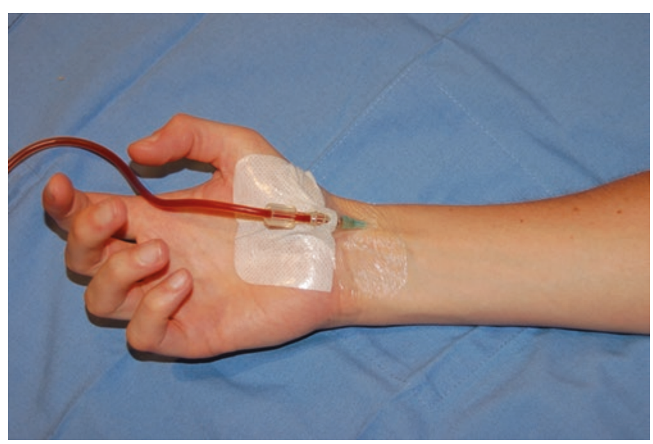

Fig. 1.4 Radial arterial catheter secured to the wrist

17. Secure the tubing connected to the catheter with gauze and adhesive tape or other sterile dressing.
18. Ensure that all connections extending from the catheter are tight and well secured, as accidental disconnection may result in rapid exsanguination.

Procedure: Radial Artery Cannulation—Over-the-Needle Catheter Technique with Integrated Guide Wire (Arrow and Other Brands)

Perform steps 1–6 from the “Radial Artery Cannulation: Standard Over-the-Needle Catheter Technique,” and then proceed with the steps below:

1. Remove protective cap from needle-cannula assembly, and ensure proper function by sliding the actuation lever along the extension tubing to advance and retract the guide wire through the needle.
2. Retract the guide wire as far back as possible (using the actuation lever) to maximize visibility of arterial blood flow (“flashback”) within the introducer hub.

Perform steps 8–10 from the “Radial Artery Cannulation: Standard Over-the-Needle Catheter Technique,” and then proceed with the steps below (Fig. 1.5):

3. Hold needle stationary, and slowly slide actuating lever forward to feed guide wire as far as possible into the artery.
   - If resistance is met while feeding the guide wire, discontinue sliding actuating lever, and withdraw entire unit from the artery to prevent damage to the guide wire or vessel wall.
4. Advance entire assembly 1–2 mm further into the vessel to ensure that the catheter tip (which sits approximately 2 mm behind the needle tip) has entered the lumen.
5. Stabilize clear introducer hub in position, and advance catheter forward into the artery over the guide wire until the hub of the catheter is in contact with the skin.
   - If difficulty is encountered at this step, rotate the catheter hub slightly to facilitate advancement.
6. Stabilize catheter in position, and withdraw introducer needle, guide wire, and feed tube as a single unit; blood flow from the catheter hub at this point indicates successful cannulation of the artery.

Fig. 1.5 Puncture of radial artery using an over-the-needle catheter assembly with integrated guide wire

Perform steps 13–18 from the “Radial Artery Cannulation: Standard Over-the-Needle Catheter Assembly”.

Procedure: Radial Artery Cannulation—The Allen Test

1. Occlude both radial and ulnar arteries of one extremity with digital pressure at the wrist.
2. Instruct the patient to repeatedly clench the fist tightly to exsanguinate the hand while occlusion of the arteries is maintained.
3. Without releasing digital pressure on arteries, instruct patient to extend fingers, and observe palmar surface to confirm blanching of the skin.
4. Release pressure on the ulnar artery only, and observe palmar surface for reperfusion (Fig. 1.6).

- If reperfusion of the hand does not occur within 5–10 seconds, ulnar arterial blood flow may be compromised, and radial artery cannulation should not be attempted. If reperfusion is brisk, repeat the test, releasing pressure on the radial artery only and observing palmar surface for reperfusion. If the return of rubor takes longer than 5–10 seconds, radial artery puncture should not be performed.

Procedure: Femoral Artery Cannulation—The Seldinger Technique

1. Place the patient in the supine position with mild external hip rotation.
2. Palpate the femoral pulse, located at midpoint between pubic symphysis and anterior superior iliac spine, using the second and third fingers of the gloved nondominant hand.

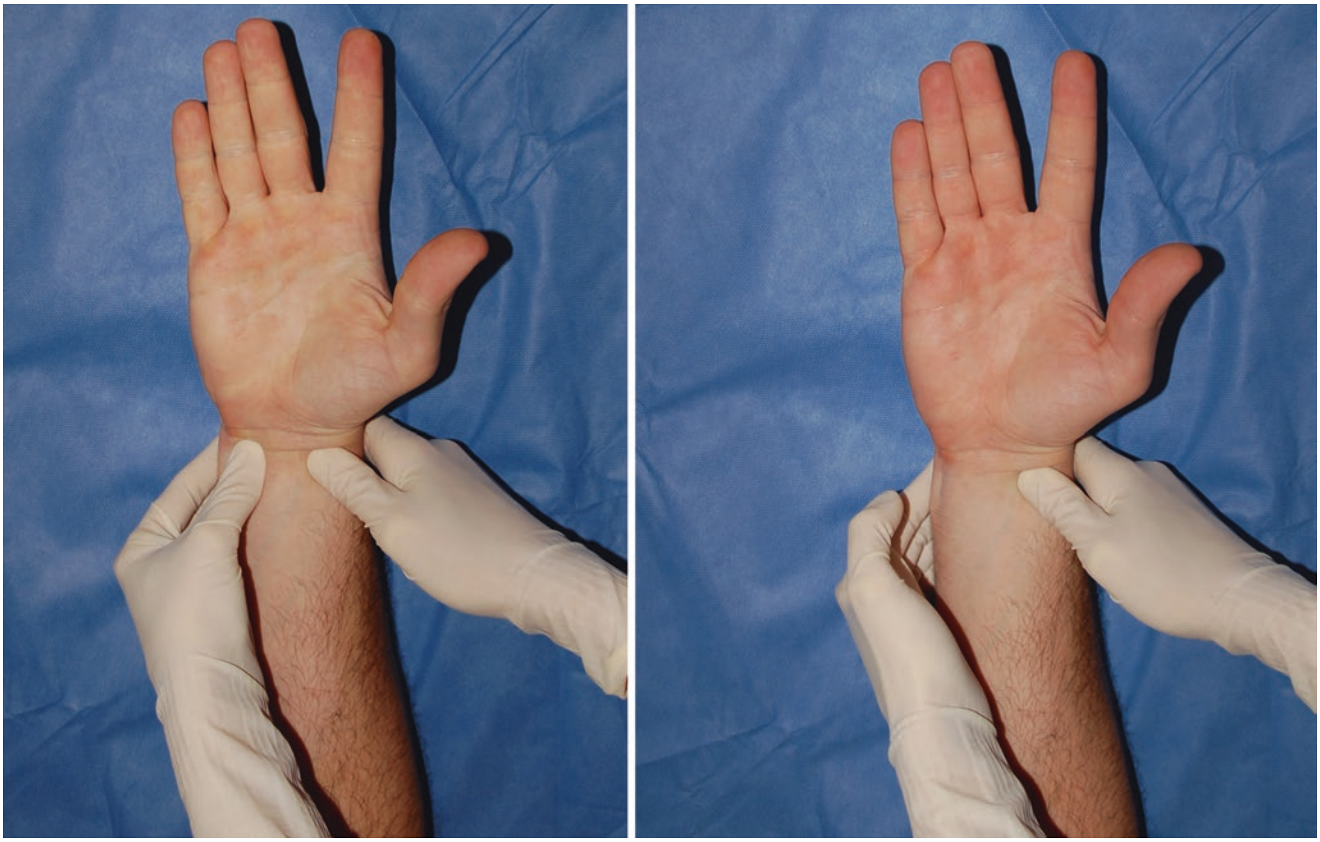

Fig. 1.6 The Allen test

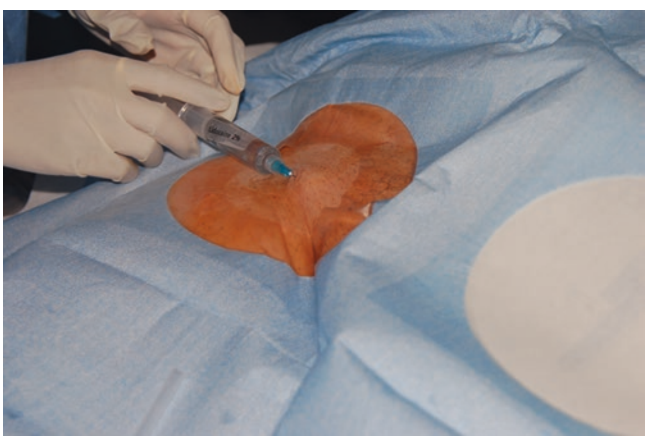

Fig. 1.7 Anesthetic injection over the femoral artery

3. Care must be taken to puncture below the inguinal ligament, to allow bleeding control and avoid bleeding into the pelvis.

Perform steps 4 and 5 from the "Radial Artery Cannulation: Standard Over-the-Needle Catheter Assembly" above (Fig. 1.7), and then proceed with the steps below:

4. Attach a 5-mL syringe to an introducing needle of bore sufficient to accommodate the guide wire.
5. Hold the syringe connected to the introducing needle with the needle bevel facing upward. Maintain a hand position on the syringe that allows for continued aspiration as the needle advances.
6. Directing the needle at a 45° angle to the skin in a cephalic direction, puncture the skin through the anesthetic wheal immediately overlying the palpated artery just distal to the inguinal ligament, and advance the needle slowly toward the palpated artery until the tip enters the arterial lumen, which is confirmed by visible arterial blood flow ("flashback") into the needle hub and syringe.
   - Avoid self-puncture by maintaining adequate distance between the needle tip and index finger.
   - Be careful to avoid trauma to the femoral nerve and vein bordering the femoral artery.
7. Hold the needle stationary, and remove the syringe, taking care not to displace the intraluminal position of the needle tip.
   - Advancing the needle too far after initial flashback is visualized may result in piercing the back side (or "double puncture") of the artery wall, in which case

visible blood flow will cease. If this occurs, slowly withdraw the needle several millimeters until pulsatile blood flow reappears.

8. Occlude the needle hub temporarily with a gloved finger to prevent unnecessary blood loss and air embolism.
9. Thread blunt end of flexible guide wire smoothly into the needle and gently into the artery until at least one quarter of the guide wire is intravascular (Fig. 1.8).
   - If resistance is met while threading the guide wire, remove wire from needle, reattach syringe, and aspirate blood to confirm continued intraluminal needle tip placement; if resistance is met while *removing* guide wire from needle, remove guide wire and needle from artery *as a single unit* to prevent shearing the guide wire off inside the vessel.
10. Holding the wire securely in place, remove the introducing needle.
11. Using a scalpel, make a small incision (approximately the width of the catheter to be used) through the dermis at the insertion site of the guide wire.
    - Face the sharp edge of the scalpel *away* from the guide wire, to avoid severing the wire.
12. While stabilizing the guide wire at its insertion site, thread the dilator over the free end of the guide wire until it is approximately 1 inch from the skin.
13. Grasp the free end of the guide wire protruding from the tail end of the dilator.
    - If it does not protrude from the tail end of the dilator, the guide wire must be removed sufficiently from the artery to be securely grasped; it must protrude visibly from the tail end of the dilator throughout the subsequent process of threading the dilator into the artery.
14. Holding the dilator firmly near its tip, thread the dilator over the wire into the skin with a back-and-forth twisting motion until it reaches the artery.

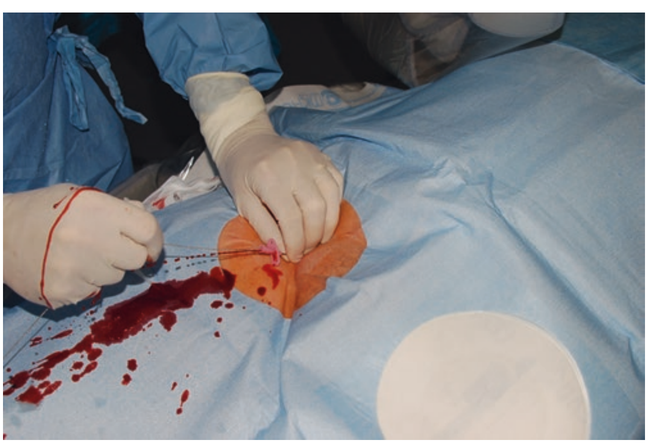

Fig. 1.8 Insertion of a guide wire into the femoral artery

    - Only the skin tract should be dilated; dilation of the artery may result in excessive arterial injury and/or hemorrhage.
15. Holding the wire securely in place, remove the dilator.
16. While stabilizing the guide wire at its insertion site, thread the catheter over the free end of the guide wire until it nears the skin.
17. Grasping the guide wire where it protrudes from the tail end of the catheter, thread the catheter into the skin to its appropriate insertion length.
18. While stabilizing the catheter at its insertion site, slowly remove the guide wire.
    - If resistance is met while removing guide wire, remove the guide wire and catheter from the artery as a single unit to prevent shearing the guide wire off inside the vessel.
19. Secure the catheter to the skin using silk (2.0) or nylon (4.0) sutures. Take a 0.5-cm bite of the skin with the suture needle. If the catheter assembly contains integrated "wings" for fixation, thread suture through the perforated wings, and secure the catheter against the skin with several knots. If no fixation device is included, tie several knots in the suture without pinching the skin, leaving both ends of the suture long. Using the loose ends of the suture, tie a second set of knots around the hub of the catheter, firmly but without constricting its lumen.

Complications

- Hemorrhage
- Hematoma (at puncture site)
- Infection (at insertion site or systemic)
- Thrombosis
- Arteriovenous fistula
- Pseudoaneurysm formation
- Exsanguination (secondary to dislodgement of catheter)
- Cerebrovascular accident (CVA), secondary to air embolism

Pearls and Pitfalls

- The shorter and stiffer the plastic tubing connected to the arterial cannula for blood pressure monitoring, the higher its frequency response and the more accurate its measurements.
- The use of an ultrasound probe can facilitate artery location and vessel cannulation.
- Puncture of the femoral artery proximal to the inguinal ligament, or distal to its bifurcation into the superficial femoral and deep femoral arteries, may cause massive

hemorrhage due to poor vessel compressibility in these regions. The artery should therefore be cannulated just distal to the inguinal ligament, where it is easily compressible against the femoral head if necessary.

- If difficulty is encountered when advancing an over-the-needle catheter into the artery, attach a 10-mL syringe containing 5 mL of sterile normal saline to the catheter hub, aspirate 1 or 2 mL of blood to confirm catheter tip placement within the vessel lumen, and then advance the catheter while gently injecting the saline-blood mixture; the jet of fluid momentarily dilates the lumen, aiding advancement of the catheter.
- An alternative approach to an over-the-needle catheter that will not fully advance is the use of a guide wire. After intraluminal placement of the cannula tip is confirmed by blood return, a guide wire is gently inserted through the catheter into the artery. The cannula is then passed along the guide wire until it is fully advanced. The guide wire employed must have a blunt, flexible tip to minimize the possibility of vessel wall trauma.
- The most common complication of arterial cannulation is hemorrhage, but another potential consequence is vessel obstruction secondary to intravascular thrombosis. Choice of puncture site is therefore essential. The radial and femoral arteries are the two most commonly cannulated arteries, owing in part to their generous collateral blood flow and ease of compressibility.
- Repeated puncture following unsuccessful cannulation increases the risk of arterial obstruction secondary to vessel wall damage and thrombosis.
- Double puncture of the cannulated artery by inadvertent overinsertion of the needle has not been shown to increase complications despite the additional trauma to the vessel walls.
- Never pull the catheter back over the needle, as this can shear the catheter and can lead to embolization of the catheter.
- For any redirection of the needle, first withdraw to the level of the dermis, and then advance.

Selected Reading

Anderson JS. Arterial cannulation: how to do it. Br J Hosp Med. 1997;57:497–9.

Gilchrist IC. Reducing collateral damage of the radial artery from catheterization. Catheter Cardiovasc Interv. 2010;76:677–8.

Lemaster CH, Agrawal AT, Hou P, Schuur JD. Systematic review of emergency department central venous and arterial catheter infection. Int J Emerg Med. 2010;3:409–23.

Mitchell JD, Welsby IJ. Techniques of arterial access. Surgery. 2004;22:3–4.

Wilson SR, Grunstein I, Hirvela ER, Price DD. Ultrasound-guided radial artery catheterization and the modified Allen's test. J Emerg Med. 2010;38:354–8.

2 Ultrasound-Guided Peripheral Intravenous Access

Javier Rosario

Indications

- Failure of peripheral IV line placement by traditional methods (anatomy, palpation)
- Multiple failed attempts
- Atypical anatomy
- Anticipation of difficulty based on chronic illness (renal failure, chemotherapy, sickle cell disease, etc.)

Contraindications

- Thrombus of selected location visualized on ultrasound
- Known history of site lymphedema
- Limb ischemia
- Injury to proximal IV insertion site
- Signs or symptoms of compartment syndrome

Materials

- Ultrasound machine
- High-frequency (13–16 MHz) linear probe or similar (Fig. 2.1)
- Needle of minimum 1 inch length (1.5+ inch preferred)
- Single-use ultrasound gel (or single-use lube) packets
- Probe cover or similar protective barrier (ideally with <30 nm pore size)
- IV setup kit

Fig. 2.1 High-frequency (13–6 MHZ) linear probe with probe marker highlighted (*green circle*)

Procedure

1. *Selection:* Scan the selected area(s) to identify a good target vessel for PIV cannulation.
   - The basilic vein (Fig. 2.2), which runs on the medial side of the upper arm, and the cephalic vein, which

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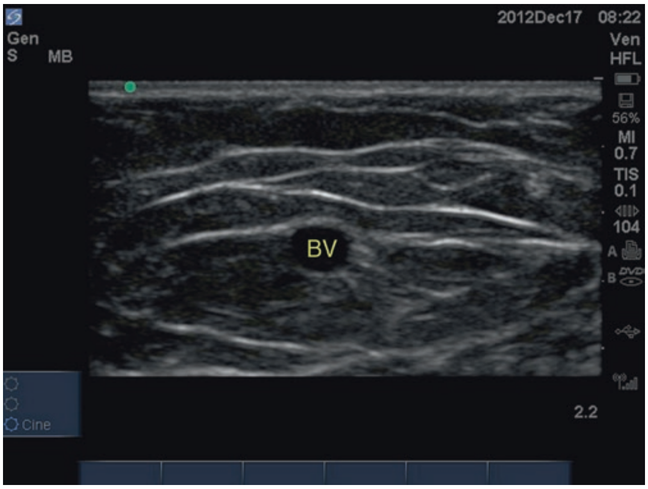

Fig. 2.2 Basilic vein (BV) located medially when scanning proximally from the antecubital fossa

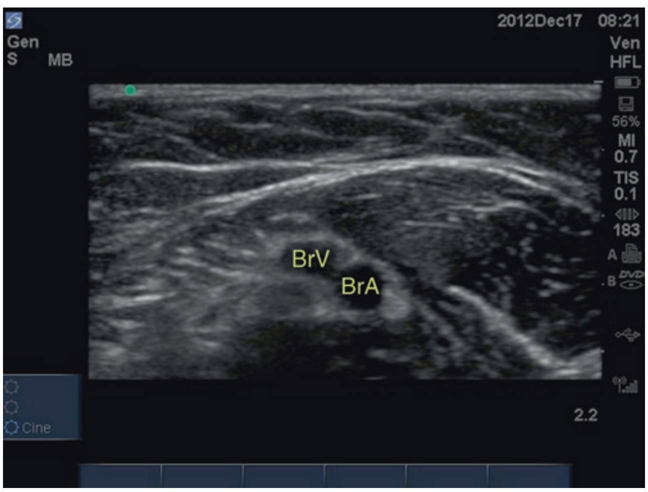

Fig. 2.3 Brachial artery (BrA) and vein (BrV). The less round, slightly compressed, anechoic structure on the left is the vein. The very circular, not compressed, anechoic structure to the right is the artery

runs on the lateral side of the upper arm, are good superficial veins that are generally not seen without ultrasound.

- The brachial vein is also an option, but extra caution is required, as it runs with the brachial artery and is usually adjacent to a nerve, so there is greater risk of discomfort and possible complications (Fig. 2.3).
- The median vein of the forearm and the median cubital vein are additional alternatives when the basilic or brachial veins cannot be accessed (Fig. 2.4).

2. *Preparation:* The selected site for IV insertion should be cleaned, preferably with chlorhexidine or a povidone-iodine applicator. An appropriate gauge long needle should be selected, and IV setup should be conveniently

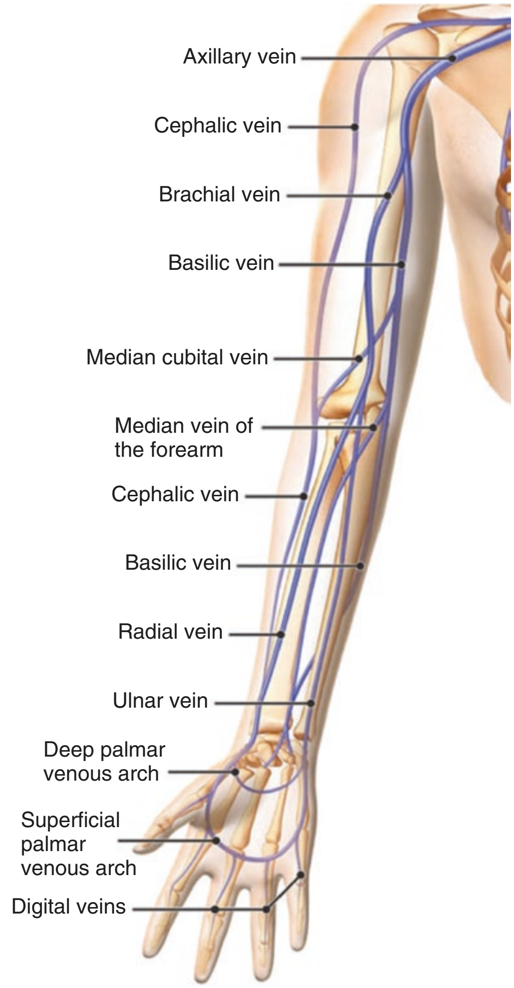

Fig. 2.4 Typical anatomical representation of upper extremity peripheral vessels. (*From* Moureau [1], *with permission*)

located for use when access is obtained. Needles that are too short will not reach deeper vessels.

3. *Scanning:* The ultrasound probe should be placed in the transverse plane (Fig. 2.5) to best visualize surrounding structures and the vein. Alternatively, the probe can be placed longitudinally (Fig. 2.6) for better visualization of needle depth and slope.
   - It is important to note that in the longitudinal approach, considerable stability is necessary to maintain the desired plane of approach.
   - Arteries travel close to the veins and can easily be mistaken without proper training.
4. *Technique:* The recommendation for all procedures is to place the probe marker to the left of the person performing the procedure, in order to align the image on the screen to the anatomical appearance on the patient. Probe and needle management are thus simplified: To move the needle to the left, you go left, and vice versa.

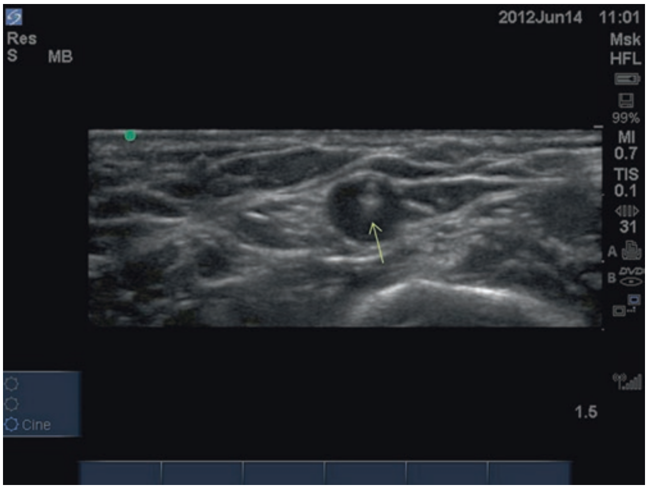

Fig. 2.5 Needle tip in the vein (*arrow*) seen in a transverse orientation

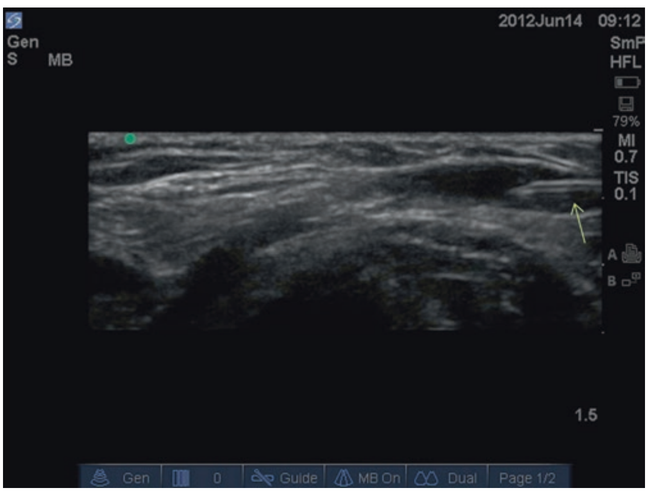

Fig. 2.6 Needle tip in the vein (*arrow*) seen in a longitudinal orientation

- The needle tip should always be observed while scanning. The concept of the Pythagorean theorem is used for accuracy: The needle should be inserted at a 45° angle to the skin, with the distance back from the probe approximately equal to the vertical depth of the vessel. The depth is given on the screen in centimeters, usually at the right side.
- As soon as the needle has penetrated the skin, the needle tip should be located by fanning the probe toward the needle until it is identified. The needle should then be advanced slowly, always keeping the needle tip in view. Once directly on top of the vein, it should tent with pressure, and then the needle should be inserted into the vein.
- It is recommended then to drop from the initial angle to a more shallow one while keeping a view of the needle tip in the center of the vein. To make sure that the catheter is securely in the vein and does not infiltrate, the needle is advanced several centimeters while keeping the tip of the needle in the center of the vein.

Complications and Tips

- Inadvertent puncture of an artery: Veins should be thin-walled and compressible and have no pulsations.
- Inability to pass catheter: Many times this is due to a premature attempt. Ideally, the needle should be advanced slowly into the vein before attempting to thread the catheter.
- The medial side of the arm usually contains the best venous targets for ultrasound guidance. The basilic vein is a globally preferred site.
- Ideally, the ultrasound probe should maintain the same axis as the vein selected. This is achieved by keeping the vein in the middle of the screen as you move proximally or distally in the arm.

Pearls and Pitfalls

- The midshaft of the needle can be mistaken for the needle tip. If this occurs, the needle tip is actually deeper than expected. The ultrasound machine will plot a hyperechoic "dot" on the screen for the needle tip, as long as it crosses the ultrasound beam at any point. This same "dot" will appear whether the tip is directly centered under the beam or any segment of the needle shaft is intersecting the beam. This can be visually deceiving and makes this procedure difficult to grasp.
- Very slow movements of the needle and the probe are important for keeping the needle tip in view. Once the needle tip is identified, the probe should be fanned forward (away from the operator) just slightly and then the needle advanced until the needle tip comes into view again. This procedure is repeated until the needle is securely moved further into the vein.

Probe Cleaning and Disinfection

- Special care should be taken to protect the probe as much as possible from blood or similar contaminating environments. Ultrasound-guided peripheral IVs are not required to be sterile, but adequate protection should be used to prevent cross-contamination between patients.
- Low-level disinfection (soap and water, ammonia sprays, wipes) will destroy most bacteria, some viruses, and fungi.

- High-level disinfection will remove all organisms except bacterial spores. Examples include chemical sterilants or germicides (e.g., Cidex®) or physical sterilization (e.g., trophon®).
- A probe that comes in contact with bodily fluids such as blood or pus should be considered contaminated and high-level disinfection should be considered.
- Appropriate probe covers to prevent contamination should have pore sizes of <30 nm, such as the sterile probe covers used for central line access.
- Follow individual institutional policies for probe disinfection and infection control.

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Reference

1. Moureau NL. Ultrasound anatomy of peripheral veins and ultrasound-guided venipuncture. In: Sandrucci S, Mussa B, editors. Peripherally inserted central venous catheters. New York: Springer; 2014. p. 54.

Suggested Reading

American College of Emergency Physicians. ACEP policy statement. Guideline for ultrasound transducer cleaning and disinfection. 2018. https://www.acep.org/globalassets/new-pdfs/policy-statements/guideline-for-ultrasound-transducer-cleaning-and-disinfection.pdf.

American Institute of Ultrasound in Medicine. Guidelines for cleaning and preparing external- and internal-use ultrasound probes between patients, safe handling, and use of ultrasound coupling gel. 2018. https://www.aium.org/officialStatements/57.

Costantino TG, Parikh AK, Satz WA, Fojtik JP. Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. Ann Emerg Med. 2005;46:456–61.

Ma OJ, Mateer JR, Reardon RF, Joing SA. Ma and Mateer's emergency ultrasound. 3rd ed. New York: McGraw-Hill Education; 2014.

Saul T, Del Rios RM, Lewiss R. Ultrasound image quality. ACEP Now. 2011;4:24–5. https://www.acepnow.com/article/ultrasound-image-quality/.

Central Venous Line Placement: Internal Jugular Vein, Subclavian Vein, and Femoral Vein

3

Kevin D. Ergle, Zachary B. Kramer, Jason Jones, and Rohit Pravin Patel

Indications

- Volume replacement
- Emergent venous access
- Administration of caustic medications: vasopressors, calcium chloride, hypertonic saline, high dose of potassium
- Dialysis catheter placement (hemodialysis)
- Nutritional support (total parenteral nutrition)
- Long-term antibiotics
- Chemotherapy
- Plasmapheresis
- Frequent or persistent blood draws or intravenous therapy when unable to establish peripheral access because of edema or other reasons
- Jugular and subclavian: central venous pressure monitoring, transvenous pacing wire introduction, pulmonary artery catheterization

Contraindications

- Absolute
  - Infection at site of insertion
  - Distorted anatomy/landmarks (prior surgery, radiation, or history of thrombus in the specified vein)
  - Subclavian only: trauma to the ipsilateral clavicle, anterior proximal rib, subclavian or superior vena cava vessels
- Relative
  - Morbid obesity
  - COPD
  - Children less than 2 years of age (higher complication rates)

    Coagulopathy (although ultrasound-guided internal jugular can be done in this situation)
  - Agitated or moving patient
  - Jugular only: trauma to the ipsilateral clavicle, anterior proximal rib, subclavian or superior vena cava vessels
  - Jugular and subclavian: inability to tolerate potential pneumothorax of the ipsilateral thoracic cage

    Pneumothorax or hemothorax of the contralateral thorax

    Patients receiving ventilatory support with high-end expiratory pressures (temporarily reduce the pressures)
  - Femoral only: intra-abdominal (or retroperitoneal) hemorrhage

Materials and Medications

- Central venous catheter tray or bundle: single/double/triple/quadruple lumen, dialysis catheter, large bore introducer (for transvenous pacing or pulmonary artery catheter kit)
- Sterile gloves
- Sterile drapes or towels
- Sterile gown
- Hat/hair cap and mask with eye protection
- Antiseptic solution with skin swabs (e.g., chlorhexidine)
- Sterile saline flushes (one 30-mL syringe or three 10-mL syringes)
- Lidocaine 1%
- Sterile gauze
- No. 11 blade scalpel
- Dressing (sterile waterproof transparent dressing or sterile 4 × 4 gauze with tape)

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- Sterile biopatch
- Suture material with needle driver if needed
- Transducing line (optional)
- Sterile probe cover (if using ultrasound guidance)

Procedures

Internal Jugular Vein Access Procedure

1. Obtain informed consent if not emergently indicated procedure.
2. Obtain supplies, and prepare the room, ensuring that all supplies are within operator reach prior to placing gown and commencing the procedure. Include a sterile ultrasound sheath on the sterile field if ultrasound is being used.
3. Raise bed to a comfortable height for the operator.
4. Place patient with head facing away from side of central line site. (If using ultrasound, other positions may be preferred.) Place patient in 15–20° Trendelenburg position to help fill the upper central veins, and reduce the risk of air embolism.
5. Identify the anatomy. Palpate triangle made by the clavicle and sternal and clavicular heads of the sternocleidomastoid (SCM) muscle to identify the location of the internal jugular vein (Fig. 3.1). If using ultrasound guidance, identify optimal anatomical arrangement.
6. Wash your hands, and wear sterile attire using aseptic technique, including cap, mask, gown, and sterile gloves.
7. Prepare the site from the clavicle to the ear and across the trachea with antiseptic solution. Allow the antiseptic (chlorhexidine or iodine) to fully dry.
8. Drape the site and patient with sterile towels and drapes included in most central venous line (CVL) bundles. Make sure to cover the whole area and bed.
9. Cover the ultrasound probe with a sterile sheath. This can be done solo or by holding the sterile ultrasound sheath and having an unsterile assistant hold the probe so that the probe can be covered by the sheath.
10. Prepare the kit by checking the guide wire and flushing the tubing and lines with saline included in the kit.
11. With a 25-gauge needle, use 1% lidocaine to anesthetize the skin at the apex of the triangle made by the SCM and clavicle. Aspirate to make sure the operator is not in a vessel, and make a superficial wheal for the insertion site.
12. The preferred method is with ultrasound guidance (see steps 13–17 and Sect. 3.6 for description of ultrasound guidance). If performing without ultrasound, palpate the carotid artery, and insert the needle lateral to the artery at the apex of the triangle formed by the SCM, aiming toward the ipsilateral nipple at an angle 30–45° above the horizontal plane (Fig. 3.1). Once blood is returned, go to step 18.
13. Place sterile ultrasound gel over the insertion site. Use the ultrasound to identify vessel anatomy, including the internal jugular vein and carotid artery. Use the ultrasound probe to compress the vein, which is compressible, as opposed to the carotid artery, which is not compressible (Fig. 3.2).
14. Prepare the insertion needle and syringe (if long and short needles are available, a short needle may be used to reduce posterior vein perforation); prime the syringe by pulling back on the plunger prior to making the puncture.
15. Use the ultrasound probe to reidentify the patient's anatomy.
16. Ultrasound can be used in short-axis or long-axis view (Fig. 3.3). The short-axis view is easier for novice operators, owing to increased ability to see the artery and vein, but it has a higher risk of posterior perforation if the needle tip is not visualized well. Once a short-axis view of the vein is found, turning the probe 90° clockwise allows the operator to see the vein in long axis. The needle is better visualized in this technically more difficult view, with less chance of penetrating the posterior wall. In patients with short necks, it may be difficult to obtain a long-axis view and needle insertion in the limited space.
17. Insert the needle using the ultrasound guidance, with dynamic approach preferred (see section "Ultrasound-Guided Cannulation: Tips for Each Approach" for specifics). Make sure to aspirate while inserting the needle to identify when the venous access is obtained. The needle tip should be visualized through the whole process.
    - If using the static approach (see section "Ultrasound-Guided Cannulation: Tips for Each Approach"), insert the needle lateral to carotid pulsation, as this is where the vein anatomically is located. The standard

Fig. 3.1 Internal jugular blind approach; the same location would be used for probe placement with ultrasound guidance

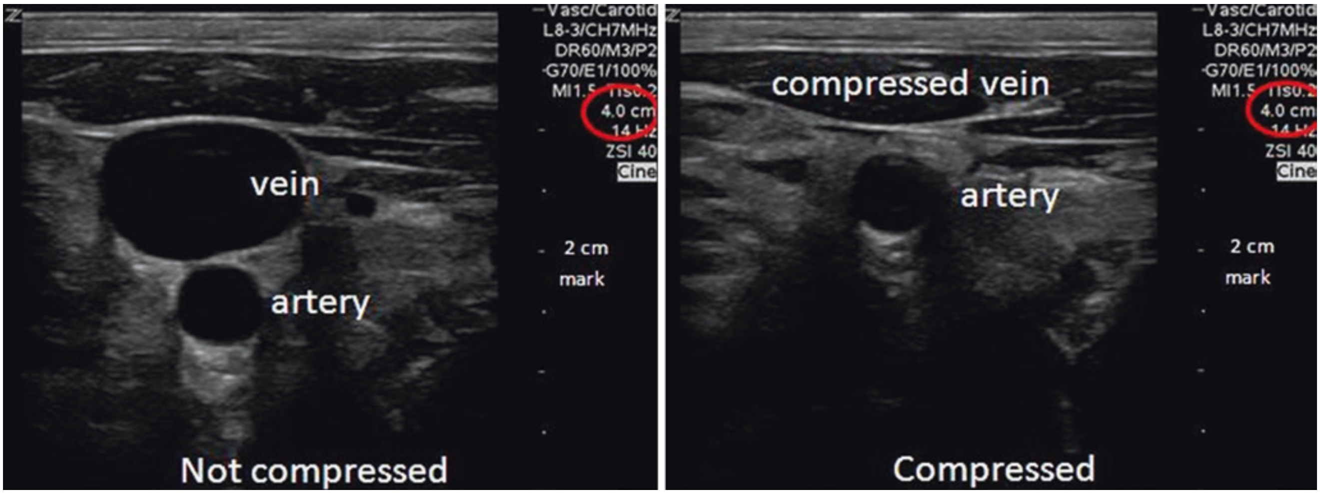

Fig. 3.2 Ultrasound showing internal jugular vein and artery with and without compression

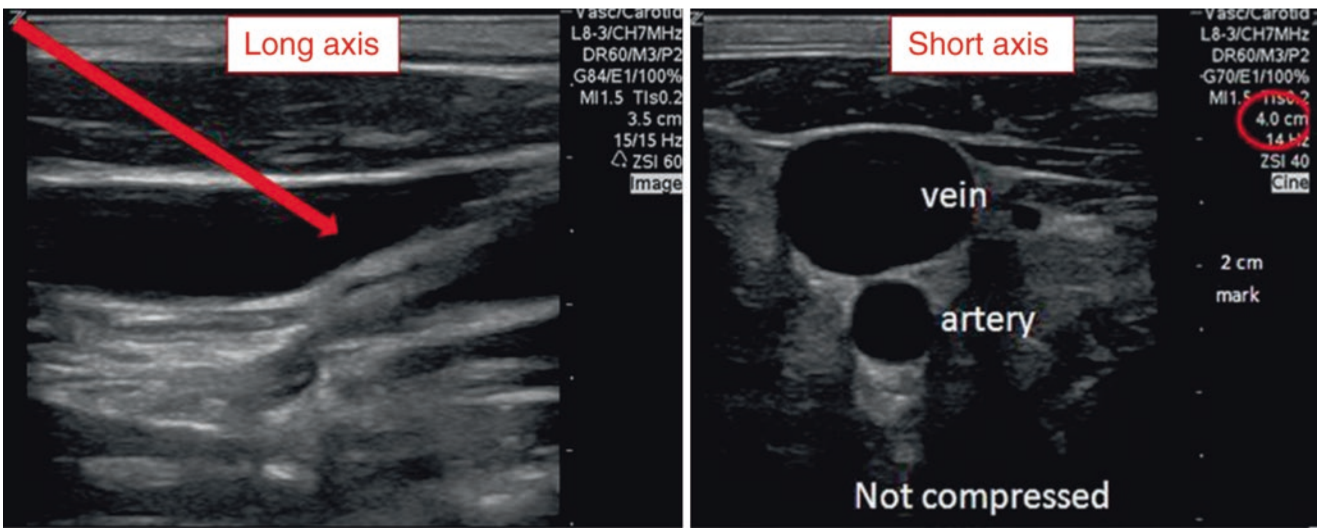

Fig. 3.3 Long-axis and short-axis views of the internal jugular vein (*arrow*)

method is to insert the needle as far back as the depth the vessel is visualized (e.g., if the vein is visualized 2 cm below the skin surface, the needle should be inserted 2 cm behind the probe at a 45° angle).

- If inserting the needle about 3 cm does not achieve access, gently withdraw the needle toward the surface of the skin while aspirating. Avoid withdrawing the needle completely from the skin. If needed, redirect the needle and advance until blood is aspirated. Cannulation of the vein often takes place while withdrawing the needle.

18. Hold the needle steady with your nondominant hand, and remove the syringe, taking care not to advance or withdraw the needle. You can place the base of your hand on the patient's chest to make your hand more stable during this part of the procedure. Occlude the hub of the needle to prevent air embolus.
19. You may verify that you are in the vein by transducing pressure with a fluid column. The fluid should flow easily into the vein.
    - If the aspirated blood is pulsatile and moves up the column, withdraw the needle completely, and apply pressure for 10–20 minutes, taking the patient out of Trendelenburg position (if nonemergent procedure).
20. Once it is verified that you are in the vein, insert the J-tip of the guide wire into the needle hub, and advance into the vein. The J-tip can be straightened with a pinching motion (Fig. 3.4). Always keep one hand on the guide wire until it is removed from the patient. Monitor for arrhythmias as the guide wire is advanced toward the right atrium.
    - If the guide wire does not flow easily, remove the guide wire, and reattach the syringe, checking for blood flow.

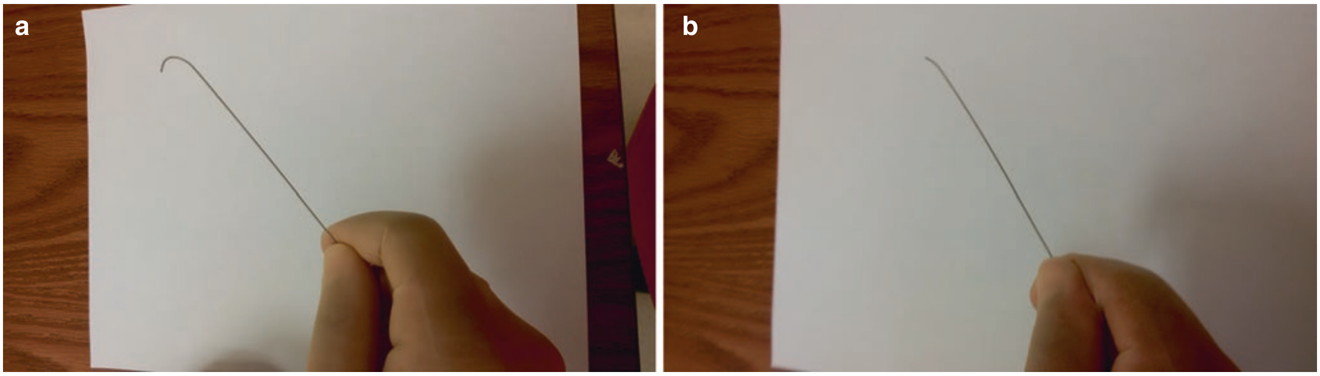

Fig. 3.4 (**a**, **b**) J-tip straightening using pinch/stretch method

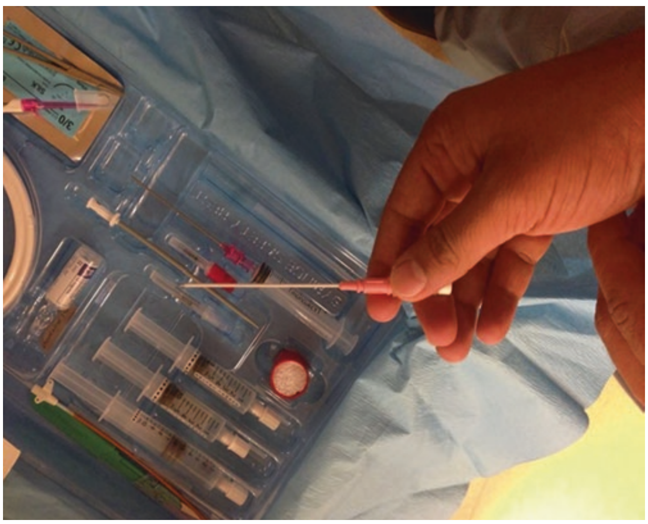

Fig. 3.5 Angiocath that can be used in patients who are difficult to cannulate/wire

- If arrhythmia occurs, slowly withdraw the guide wire until the patient's native rhythm returns.
- Alternatively, the catheter/syringe found in most kits can be used as a bridge to guide wire placement. Use the same steps above with the catheter (Fig. 3.5); and when you have return of blood, advance the angiocath into the vein, followed by insertion of the guide wire through the angiocath. This is especially useful in moving/agitated patients, patients who have collapsible veins due to hypovolemia, and patients who have abnormal anatomy and may have veins that take an abnormal angle shortly past the needle tip.

21. Remove the needle over the guide wire, making sure to always keep control of the guide wire.
22. Make an incision contiguous with the guide wire, using a straight (No. 11) blade with the scalpel blade facing upward (away from the wire).
23. Advance the dilator over the guide wire in a twisting motion, keeping control of the guide wire.

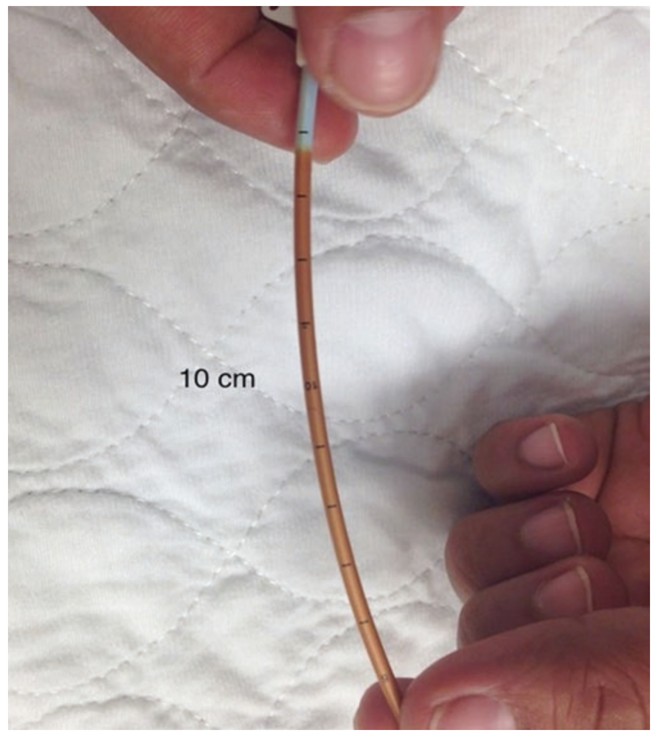

Fig. 3.6 Length: numbers marked on typical central venous catheters indicate the distance in centimeters from the distal tip

- The dilator only needs to go slightly beyond the anticipated depth of the patient's jugular vein. Do not advance the entire length of the dilator.

24. Withdraw the dilator and hold pressure over the wound site.
25. Advance the catheter over the guide wire while keeping control of the guide wire.
26. With the catheter inserted 10–12 cm from the skin insertion site, retract the guide wire until it comes out of the distal port. Maintain control of the guide wire and advance the catheter to the appropriate length. Usually catheters are inserted 15–16 cm from the right side and 18–20 cm from the left side (Fig. 3.6).

27. Flush each port of the catheter and check aspiration. If aspiration or flushing is difficult, concern is raised for catheter malposition. Change the depth slightly or twist the catheter and recheck.
28. At this time, an antibiotic ointment or biopatch may be applied to the skin around the intersection with the lumen of the catheter. (This step is based on local institutional guidelines.)
29. Suture the line in place.
30. Enclose the CVL site with a sterile, waterproof, transparent dressing.
31. Confirm placement using chest X-ray. The tip of the catheter should be in the lower third of the superior vena cava (SVC) at the insertion of the SVC into the right atrium.

Subclavian Vein Access Procedure

1. Obtain informed consent if not emergently indicated.
2. Raise bed to comfortable height for the operator.
3. Place patient in supine position and position so patient's head is at the top of the bed.
4. Place patient in 15–20° Trendelenburg position (if tolerated) to reduce risk of air embolism. Studies show this will also increase the size of the subclavian vein. Do *not* place a towel between the shoulder blades (arch shoulder back); this has been shown to decrease vein diameter and affect reliability of accessibility. Keep shoulders at anatomical location (forward).
5. Prep area chosen from the anterior neck, clavicle, and upper chest (above nipple line) with chlorhexidine prep or iodine.
6. Open kit and place close to operator's dominant hand to allow for easy access. Diameter of the catheter/kit used is based on the clinical situation:
   - Introducer or large bore if requiring large volumes of resuscitation
   - Triple-lumen catheters for vasopressors
   - Introducers if anticipating pulmonary artery catheter or venous pacer
7. Operator should prepare with all aseptic techniques (e.g., handwashing) and maximal barrier precautions (e.g., sterile gowns, sterile gloves, cap, mask covering both the mouth and nose, eye protection, and full-body patient drapes).
8. Once sterile and able to touch the inside of the CVL kit, the operator may want to retract the curved J-tip wire into the plastic loop sheath for easy directing into the introducer needle. The operator should also uncap all distal lumens and flush all ports with 3–5 mL from sterile normal saline syringes to ensure no defects in the lumen of the catheter. Close all ports except the distal tip port (usually marked with the words "distal tip") with the slide clamp.
9. Prep the area chosen (right or left side) from the anterior neck, clavicle, and upper chest (above nipple line) with sterile chlorhexidine prep (second cleaning).
10. Place full-body drape over the patient with an opening over the selected side where the needle will be inserted.
11. Needle insertion site options:
    - 1 cm inferior to the junction of the middle and medial third of the clavicle
    - Just lateral to the midclavicular line, with the needle perpendicular along the inferior lateral clavicle
    - One fingerbreadth lateral to the angle of the clavicle
12. Anesthetize the needle insertion site with 5–10 mL of 1% lidocaine superficially (pull back on needle syringe to ensure operator is not in the vein or artery).
    - Never place equipment on a patient.
13. Prepare the needle and syringe by placing the long needle on the syringe. Make sure to break the seal of the syringe by pulling back on the plunger of the syringe prior to making an incision with the needle.
14. Turn the patient's head to the side opposite of CVL placement, and retract the ipsilateral shoulder down to improve the clavicle-vein relationship. The retraction of the arm can be done a few steps earlier and can be held in position using a person or tape/restraints.
15. Direct the insertion needle toward the sternal notch in the coronal plane at an angle no greater than 10–15° while gently withdrawing the plunger of the syringe. Keep the bevel of the needle facing up and in line with the numbers on the syringe until the skin is entered, and then face the bevel caudally to facilitate smooth progression of the guide wire down the vein toward the right atrium.
16. It helps to place the nondominant hand (not holding the needle) on the sternal to feel where the sternal notch is and direct the needle in that direction (Fig. 3.7).
17. *Never* increase the angle of the needle greater than 15°, as pneumothorax may ensue.
18. Advance the needle under and along the inferior border of the clavicle, making sure the needle is virtually horizontal to the chest wall. Aim medially in the direction of the suprasternal notch, attempting to first aim for the clavicle and then "walk" the needle below the clavicle.
19. Once under the clavicle, continue to advance the needle in a plane almost parallel to the skin approximately 2–3 cm until venous blood is freely aspirated into the syringe.
20. When venous blood is freely aspirated, disconnect the syringe from the needle, immediately occlude the lumen to prevent air embolism, and insert the guide wire. If the vein is difficult to locate, remove the introducer needle, flush it clean of clots, and try again. Change insertion

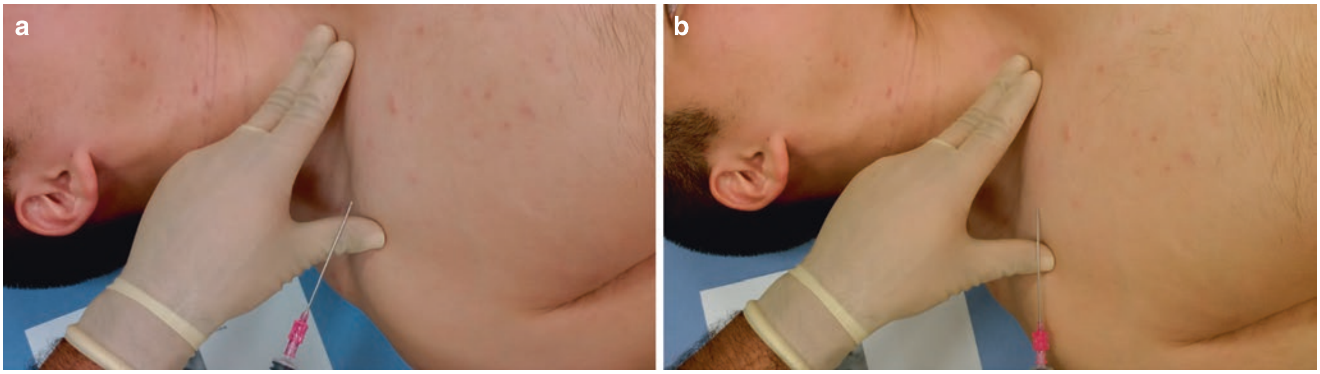

Fig. 3.7 Subclavian vein approach: wrong angle (**a**) and correct angle (**b**) for skin puncture

sites after three unsuccessful passes with the introducer needle.

21. At this point, the hand holding the needle should be "set in stone." Use the patient's chest wall as a base to keep the needle completely still, so as to not inadvertently advance or retract the needle out of the vein.
22. Insert the guide wire through the needle into the vein with the J-tip directed caudally to improve successful placement into the subclavian vein.
    - Beware a return of red, pulsatile blood. If this occurs, the wire is in an artery.
    - Beware of aspirating air bubbles through the probing introducer needle. This indicates a pneumothorax.
23. Advance the wire until it is mostly in the vein or until arrhythmia is seen on the cardiac monitor. Then retract the wire 3–4 cm.
24. If the wire does not pass easily, remove the wire, reattach the syringe, and confirm that the needle is still in the lumen of the vein before reattempting. The J-tip can be straightened with a pinching motion (*see* Fig. 3.4).
    - Alternatively, the catheter/syringe found in most kits (*see* Fig. 3.5) can be used as a bridge to guide wire placement. Use the same steps above with the catheter, and when you have return of blood, advance the angiocath into the vein followed by insertion of the guide wire through the angiocath. This is especially useful in moving/agitated patients, patients who have collapsible veins due to hypovolemia, and patients who have abnormal anatomy and may have veins that take an abnormal angle shortly past the needle tip.
25. Use the tip of the scalpel to make a small incision just against the needle to enlarge the catheter entry site for the dilator and catheter.
26. Holding the wire in place, withdraw the introducer needle and place it in a needle holder.
27. Thread the dilator over the wire and into the vein with a firm and gentle twisting motion while maintaining constant control of the wire. If a large bore introducer is placed, the dilator/introducer goes in one step; after the introducer is inserted, hold the wire in place and remove the dilator.
28. If it is difficult to thread the dilator, the skin incision made with the scalpel may have been too superficial or small. It may help to enlarge this incision to avoid having the dilator get caught on superficial skin or connective tissue.
29. It is helpful to have sterile gauze handy to apply pressure with the hand not holding the wire, as the vein will now bleed profusely from around the wire, secondary to dilation.
30. Thread the catheter until it is close to the skin insertion site. Then pull back on the guide wire until it shows outside of the distal port. Grasp the wire outside of the distal port, and thread the catheter while holding onto the guide wire. Catheters usually are inserted 15–16 cm from the right side and 18–20 cm from the left side.
31. Hold the catheter in place and remove the wire. After the wire is removed, occlude the open lumen.
32. Attach a sterile saline syringe to the hub and aspirate blood. Take needed samples and then flush the line with saline and recap. Repeat this step with all lumens.
33. Place a biopatch on the skin around the intersection with the lumen of the catheter.
34. Suture the line in place.
35. Enclose the CVL site with a sterile, waterproof, transparent dressing.
36. Confirm placement using chest X-ray. The tip of the catheter should be in the lower third of the SVC at the insertion of the SVC into the right atrium (tip at right bronchiotracheal angle or up to 2.5 cm below bronchiotracheal angle).
    - Alternatively, ultrasound can be used for subclavian line access, though studies confirming this technique to date are limited.

Subclavian Vein Pearls and Pitfalls

- Inadequate landmark identification: The operator should always palpate for landmarks and check anatomy prior to starting the procedure.
- Improper insertion position.
- Insertion of needle through periosteum.
  - Operator should *not* increase the angle of the needle to avoid the clavicle bone. (This can cause a pneumothorax.)
  - Operator should press on the needle with downward pressure on the chest wall to allow the needle to maneuver under the clavicle without changing the angle of insertion of the needle.
- Taking too shallow a trajectory with the needle.
- Aiming the needle too cephalad. (Aim for sternoclavicular junction.)
- Failure to keep needle in place for wire passage: The hand holding the needle should be planted on the patient's chest for stabilization.

Femoral Vein Access Procedure

1. Palpate the patient's femoral artery below the inguinal ligament. This is usually found halfway between the anterior superior iliac spine (ASIS) and the midline of the symphysis pubis.
2. Trim overlying hair as necessary.
3. If ultrasound-guided approach is desired, use the linear probe (as for internal jugular) to detect the femoral vein at this location. The femoral vein will be easily compressible; the femoral artery will be less compressible and pulsatile (*see* Fig. 3.2).
4. Wash hands, and use sterile technique to apply iodine or chlorhexidine solution (various forms available).
5. Open your femoral CVL kit and don cap, mask, sterile gown, and sterile gloves. Nonsterile assistants should wear a cap, mask, sterile gown, and sterile gloves. Flush all ports of your CVL kit with saline flushes, and check for leaks or malfunction of catheter.
6. Under sterile technique, apply the drape over the area of insertion, and have an assistant extend the drape the length of the bed. Reapply sterile iodine or chlorhexidine at the site.
7. Anesthetize the skin overlying the femoral vein with lidocaine.
8. If an ultrasound-guided approach is desired, have an assistant hold up the vascular ultrasound probe. Place your gloved hand through a sterile ultrasound sleeve, and grasp the top of the ultrasound probe. Without breaking sterile technique, pull and invert the sterile ultrasound sleeve over the probe and cable. See section "Ultrasound-Guided Cannulation: Tips for Each Approach" for detailed ultrasound-guided cannulation technique.
9. Insert the needle at a 45° angle, bevel down, directed superiorly, 1 cm medial to the palpable femoral artery pulse. Once the needle has broken the skin, aspirate by applying a small amount of continuous traction on the plunger of the attached syringe.
10. Advance smoothly and slowly until blood appears in the syringe. Stop once blood is aspirated. If the femoral vein is not cannulated, withdraw your needle until just beneath the skin and redirect.
11. Hold the hub of the needle with thumb and forefinger to immobilize in place. Remove the syringe carefully. If blood appears arterial or pulsatile, remove the needle, and hold pressure for 5–10 minutes.
    - Use the palm of your hand on the thigh to stabilize your hand. Not having your hand stable is a common mistake leading to needle movement out of the vein.
12. If the blood appears venous (dark color, emerges as a continuous trickle, or transduced), cannulate the needle with the guide wire. Maintain a two-finger grip on the guide wire at all times. Advance the guide wire until approximately 15 cm remains.
    - Must keep handle of guide wire at *all* times, which can be done through proper technique.
13. If the guide wire does not advance easily, remove the guide wire, and reposition the needle until blood aspirates easily. The J-tip can be straightened using a pinching motion if needed (*see* Fig. 3.4)
    - Alternatively, the catheter/syringe found in most kits (*see* Fig. 3.5) can be used as a bridge to guide wire placement. Use the same steps above with the catheter, and when you have return of blood, advance the angiocath into the vein, followed by insertion of the guide wire through the angiocath. This is especially useful in moving/agitated patients, patients who have collapsible veins due to hypovolemia, or patients who have abnormal anatomy and may have veins that take an abnormal angle shortly past the needle tip.
14. Using your scalpel, make a single ½-cm stab incision at the site of needle insertion to assist with dilator placement.
    - You can do the stab incision with or without the needle in place, but many novices have difficulty locating the correct stab location because a small amount of blood accumulates when the needle is taken out.
15. Remove the needle carefully, leaving the guide wire in place. Apply dilator over the guide wire, and advance into the body with gentle pressure and a twisting motion in the same plane that was used to direct the needle.
16. Holding pressure at the insertion site with sterile gauze 4 × 4 pads, remove the dilator from the guide wire, leav-

ing the guide wire in place. Insert the central venous catheter over the guide wire until it fits snugly against the skin. Use the markings on the catheter (*see* Fig. 3.6) to determine that the proper length is placed. (Usually with the femoral site, you can "hub" the catheter.)

17. Using a sterile saline flush, ensure that each lumen of the CVL draws blood easily and flushes easily. Carefully note any that do not, and consider repositioning as needed. You can attempt to move the catheter in or out a few centimeters or rotate the catheter and recheck. Apply caps to each open lumen of the CVL.
    - Remember to cover the introducer port if not used immediately. If you do not, it poses a risk to the patient of infection and air embolism.
18. Suture the line in place.
19. Place an antibiotic biopatch or similar antimicrobial dressing.
20. Enclose the CVL site with a sterile, waterproof, transparent dressing.

Femoral Vein Pearls and Pitfalls

- Femoral central venous lines cannot accurately transduce central venous pressures.
- Asking the patient to perform a Valsalva maneuver has been shown to increase the width of the femoral vein by one third.
- The mnemonic NAVEL (nerve, artery vein, empty space lymphatics) assists in remembering the order of femoral structures from lateral to medial.
- Traditionally, femoral venous lines were thought to have higher rates of infection than subclavian or internal jugular lines, but more recent analyses are challenging this belief.
- Obesity is a more important risk factor for infection in femoral sites.

Complications

Jugular and Subclavian Complications

- Pneumothorax/hemothorax:
  – Prevention: Remove patient from ventilator before advancing the needle, choose the right side rather than the left, and avoid multiple attempts when possible.
  – Management: Check postprocedure X-ray; if pneumothorax, arrange for thoracostomy depending on the size of the hemothorax/pneumothorax.
- Catheter embolization:
  – Prevention: Never withdraw a catheter past a needle bevel, which might shear off the catheter.
  – Management: X-ray the patient, and contact a specialist who can remove the embolized catheter.
- Arterial puncture: Hold compression if this occurs.
- Hematoma: Usually requires monitoring only.
- Thrombosis: This complication may lead to pulmonary embolism.
- Local or systemic infection: Using maximal sterile precautions has been shown to greatly decrease the rate of infection.
- Air embolism:
  – May be caused by negative intrathoracic pressure when inspiration by the patient draws air into an open line hub.
  – Prevention: Be sure the line hubs are always occluded. Placing the patient in the Trendelenburg position lowers the risk.
  – Management: The patient should be placed in Trendelenburg position with a left lateral decubitus tilt, which may prevent the movement of air into the right ventricle and onward into the left side of the heart. Administer 100% oxygen to speed the resorption of the air. If a catheter is located in the heart, aspiration of the air should be attempted.
- Dysrhythmias: Due to cardiac irritation by the wire or catheter tip. It usually can be terminated by simply withdrawing the line into the SVC. One should always place a central venous catheter with cardiac monitoring.
- Lost guide wire: If the operator is not careful about maintaining control of the guide wire, it may be lost into the vein. Retrieval by interventional radiology or surgery is required and is an emergency.
- Catheter tip too deep: Check the postprocedure chest X-ray, and pull the line back if the tip disappears into the cardiac silhouette.
- Catheter in the wrong vessel: Check the postprocedure chest X-ray for this complication; remove catheter and try again.
- Arterial puncture (subclavian only): The subclavian artery cannot be compressed, so the subclavian approach should be avoided in anticoagulated patients.

Femoral Complications

- Arterial puncture: The femoral artery site can be compressed, so if punctured, hold pressure.
- Hematoma: Usually requires monitoring only.
- Thrombosis: This complication may lead to pulmonary embolism.
- Catheter embolization:
  – Prevention: Never withdraw a catheter past a needle bevel, which might shear off the catheter.
  – Management: X-ray the patient and contact a specialist who can remove the embolized catheter.

- Lost guide wire: If the operator is not careful about maintaining control of the guide wire, it may be lost into the vein. Retrieval by interventional radiology or surgery is required and is an emergency.
- Local or systemic infection: Using maximal sterile precautions has been shown to greatly decrease the rate of infection.

Ultrasound-Guided Cannulation: Tips for Each Approach

- Venous anatomy is best visualized using a high-frequency (5–10 MHz) linear probe. Higher frequencies generate less penetration but better resolution.
- You can use the ultrasound to identify the location of the vessel prior to the procedure and utilize external landmarks during the procedure itself (*static technique*), or you can use the ultrasound to visualize cannulation of the vessel during the procedure (*dynamic technique*).
- An advantage of the static technique is that the ultrasound transducer is not needed during the sterile portion of the procedure, but it does not allow for direct visualization of cannulation and guidance during the procedure.
- The dynamic technique (preferred) allows for direct visualization during the procedure, but it requires more technical skill and entails the use of the transducer during the sterile portion of the procedure.
- The dynamic technique can be used with either a short-axis view (a cross-sectional view of the vessel and needle) or a long-axis view (a longitudinal view of the vessel and needle (*see* Fig. 3.3).
- The long-axis view allows for full visualization of the needle throughout the procedure and allows for better visualization and adjustment of needle depth. It is more difficult for lateral changes in positioning and tends to be more difficult technically.
  – Key in this view is that once a good section of vein is obtained, do not move the probe to visualize the needle; move the needle into the ultrasound view by slightly adjusting its trajectory.
- The short-axis view allows for lateral changes in position but is not as good at visualizing depth throughout the procedure, as visualization of the needle is in cross-sectional imaging. Perforation of the posterior wall is more common in this view.
- When using the short-axis view, remember to position the ultrasound probe so that the field of the ultrasound intersects the vessel (internal jugular, subclavian, or femoral) at the anticipated site of insertion of the needle into the vein. Remember that the needle is only visualized as it intersects the plane of the ultrasound.
- When using the long-axis view, make sure to visualize the vessel with the ultrasound in such a way that you can see the greatest diameter of the vessel along the entire length of the ultrasound probe. Keep the ultrasound steady during the procedure, and insert the needle at an angle at the lateral edge of the ultrasound probe. Using this technique, you can visualize the entire length of the needle.

Removing a Central Line

1. Place the patient in supine or Trendelenburg position (which can help decrease bleeding for femoral removal).
2. Remove suturing and dressing.
3. Jugular and subclavian: Have the patient exhale, and pull the line during the exhalation.
   - Exhalation increases intrathoracic pressure versus atmospheric pressure, thereby reducing the risk of air thromboembolism.
4. Hold pressure for approximately 1 minute to stop bleeding.
5. Dress with a sterile dressing.
6. If infection related to the central line is suspected, cut off the tip with sterile scissors and send it for culture.

Suggested Reading

Internal Jugular Vein Access

McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med. 2003;348:1123–33.

Mimoz O, Villeminey S, Ragot S, Dahyot-Fizelier C, Laksiri L, Petitpas F, Debaene B. Chlorhexidine-based antiseptic solution vs alcohol-based povidone-iodine for central venous catheter care. Arch Intern Med. 2007;167:2066–72.

Noble VE, Nelson B, Sutingco AN. Manual of emergency and critical care ultrasound. Cambridge: Cambridge University Press; 2007. p. 196–204.

Parry G. Trendelenburg position, head elevation and a midline position optimize right internal jugular vein diameter. Can J Anaesth. 2004;51:379–81.

Vesely TM. Central venous catheter tip position: a continuing controversy. J Vasc Interv Radiol. 2003;14:527–34.

Subclavian Vein Access

Elliott TS, Faroqui MH, Armstrong RF, Hanson GC. Guidelines for good practice in central venous catheterization. Hospital Infection Society and the Research Unit of the Royal College of Physicians. J Hosp Infect. 1994;28:163–76.

Fortune JB, Feustel P. Effect of patient position on size and location of the subclavian vein for percutaneous puncture. Arch Surg. 2003;138:996–1000; discussion 1001.

Fragou M, Gravvanis A, Dimitriou V, Papalois A, Kouraklis G, Karabinis A, et al. Real-time ultrasound-guided subclavian vein cannulation versus the landmark method in critical care patients: a prospective randomized study. Crit Care Med. 2011;39:1607–12.

Kilbourne MJ, Bochicchio GV, Scalea T, Xiao Y. Avoiding common technical errors in subclavian central venous catheter placement. J Am Coll Surg. 2009;208:104–9.

McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med. 2003;348:1123–33.

Femoral Vein Access

Dailey RH. Femoral vein cannulation: a review. J Emerg Med. 1985;2:367–72.

Lim T, Ryu HG, Jung CW, Jeon Y, Bahk JH. Effect of the bevel direction of puncture needle on success rate and complications during internal jugular vein catheterization. Crit Care Med. 2012;40:491–4.

McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med. 2003;348:1123–33.

Marik PE, Flemmer M, Harrison W. The risk of catheter-related bloodstream infection with femoral venous catheters as compared to subclavian and internal jugular venous catheters: a systemic review of the literature and meta-analysis. Crit Care Med. 2012;40:2479–85.

Swanson RS, Uhlig PN, Gross PL, McCabe CJ. Emergency intravenous access through the femoral vein. Ann Emerg Med. 1984;13:244–7.

4 Pulmonary Artery Catheter Placement

Raza A. Kazmi and Bobby K. Desai

Uses

- Continuous cardiac output monitoring
- Central temperature monitoring
- Measurement of mixed venous saturations
- Measurement of pulmonary artery pressure
- Estimation of diastolic filling of left heart

Indications

- Pulmonary hypertension
- Right ventricular failure
- Cardiogenic shock
- Weaning failure of cardiac origin
- Mixed shock states
- Post-cardiac surgery
- Cardiac tamponade
- Mechanical complications of ST-elevation myocardial infarction (STEMI), such as right ventricular infarction, ventricular septal rupture, papillary muscle rupture
- Transplantation evaluation

Contraindications

- Absolute
  - Right-sided endocarditis
  - Right-sided masses (e.g., myxoma) or thrombi
- Relative
  - Severe coagulopathy
  - Severe thrombocytopenia
- Caution use (recommend using with fluoroscopy)
  - Tricuspid regurgitation (difficult catheter passage)
  - Left bundle branch block (catheter passage may induce complete heart block)

Materials and Medications

- Chlorhexidine or other surgical skin prep
- Sterile drape and towels
- Surgical cap
- Sterile gloves
- Surgical mask
- Sterile gown
- Gauze
- Sterile saline flushes
- 25-gauge needle with syringe
- 1% lidocaine
- 18-gauge needle with syringe (Fig. 4.1)
- Guidewire
- Scalpel with number 11 blade
- Introducer sheath with internal obturator
- Sutures
- Needle driver
- Scissors
- Adhesive dressing
- Ultrasound device and probe
- Sterile sleeve
- Sterile conduction jelly
- Pulmonary artery catheter (Swan-Ganz catheter), comprising several lumens (Figs. 4.2 and 4.3):
  - *Blue*: Right atrial lumen, proximal injectate port. Terminates 30 cm from the tip of the catheter and lies within the right atrium when the tip of the catheter is in the pulmonary artery. This port can monitor right atrial (RA) pressures (RAP/ CVP) and receive the injectate for cardiac output studies. Can also be used to give fluids and drugs.
  - *Red/white connector*: Thermistor, includes a temperature-sensitive wire that terminates 4 cm proxi-

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L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0_4

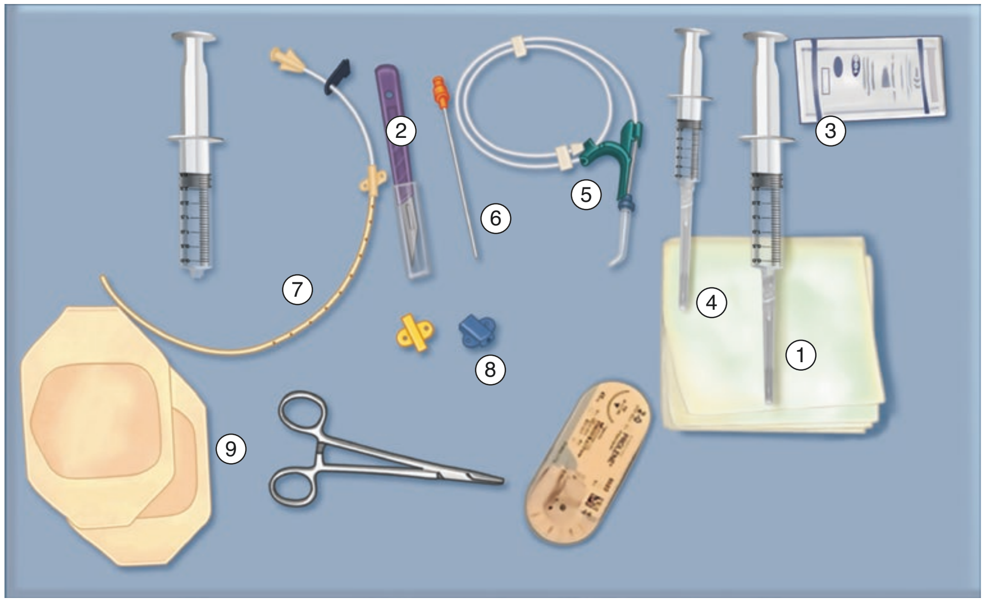

Fig. 4.1 Most of the equipment to be used for pulmonary catheter placement is the same as this central line kit, except of course the triple-lumen catheter! The numbers indicate the order of typical usage: 1. Syringe with local anesthetic. 2. Scalpel in case venous cutdown is needed. 3. Sterile gel for ultrasound guidance. 4. Introducer needle (here 18 Ga) on syringe with saline to detect backflow of blood upon vein penetration. 5. Guidewire. 6. Tissue dilator. 7. Indwelling catheter (here 16 Ga). 8. Additional fasteners and corresponding surgical thread. 9. Dressing

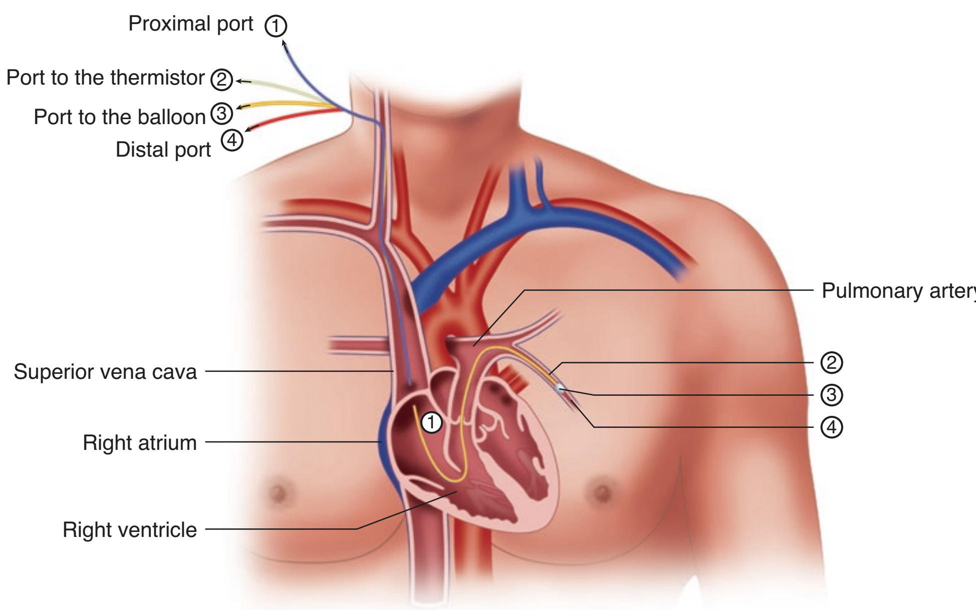

Fig. 4.2 Pulmonary artery catheter (Swan-Ganz catheter)

mal to the tip of the catheter. The terminal portion of the wire, termed the *thermistor bead*, lies in one of the main pulmonary arteries when the catheter tip is properly positioned. Connection of the thermistor port to a cardiac output (CO) monitor allows determination of CO using thermodilution.

– *White*: Proximal infusion port lumen terminates 31 cm from the tip of the catheter in the right atrium and is used for infusing fluids and drugs.
– *Yellow*: Pulmonary artery (PA) lumen, distal port allows measurement of PA pressures and measurement of mixed venous oxygen saturation (SO_2). Caustic or hyperosmotic solutions must not be infused through this lumen.
– *Red*: Balloon inflation/deflation.

- Plastic sleeve for catheter
- Appropriate tubing
- Electronic pressure monitor
- Resuscitation equipment (in case arrhythmias develop during placement)
- Pacemaker generator (in patients with left bundle branch blocks, as complete heart block may occur)
- Transvenous pacemaker (in case complete heart block occurs)

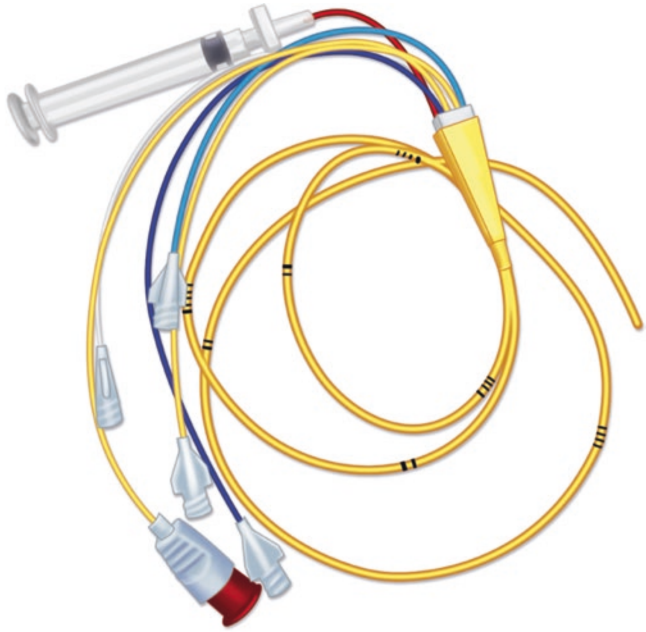

Fig. 4.3 Schematic drawing of pulmonary artery catheter

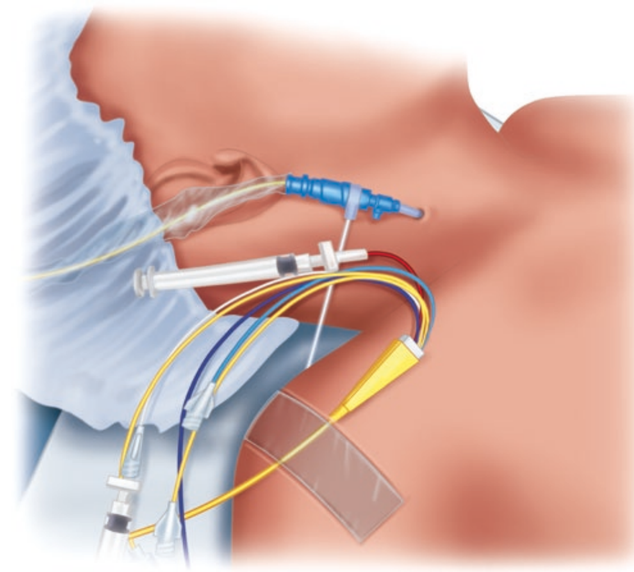

Fig. 4.4 Patient with pulmonary catheter in place

- Lead aprons (if using fluoroscopy)
- Lead thyroid guards (if using fluoroscopy)

Procedure

1. Informed consent may be required.
2. Place patient in supine position.
3. Using ultrasonography, locate the right internal jugular vein or left subclavian vein (Fig. 4.4). These are ideal sites for pulmonary vein catheterization because the curvature of the pulmonary artery catheter facilitates passage to the heart. Utilizing left internal jugular vein, right subclavian vein, or femoral vein can be more challenging and often will require fluoroscopic guidance.
4. Sterilize site with chlorhexidine or other surgical skin prep.
5. Put on sterile gown, gloves, cap, and mask after thoroughly washing hands to achieve sterile preparation.
6. Place sterile towels and drapes over the patient, ensuring proper sterile access to the site.
7. Cover the ultrasound probe with a sterile sleeve.
8. Flush ports on sheath and pulmonary artery catheter with sterile saline, ensuring proper functionality.
9. Inflate balloon at the tip of the catheter, ensuring that there is no air leak.
10. Slide plastic sleeve over catheter over the ports.
11. Use 25-gauge needle to infiltrate skin with lidocaine.
12. Approach vein using modified Seldinger technique.
    - Access vein with needle.
    - Pass guidewire through needle.
    - Introduce sheath over guidewire.
13. Advance 18-gauge needle toward the vein while applying negative pressure to the syringe. (If cannulating internal jugular vein or femoral vein, use ultrasound to guide the needle.)
14. Once dark red, nonpulsatile blood is aspirated, remove syringe from needle, and insert the guidewire.
15. Use scalpel to incise skin adjacent to the needle, and carefully remove the needle while leaving the guidewire in place.
16. While stabilizing the guidewire to ensure that it remains accessible and does not embolize, insert sheath and obturator over the guidewire until the hub of the sheath fills the incision.
17. You can now remove the guidewire and obturator, leaving behind only the sheath.
18. Using sterile flush, test port to see if there is adequate blood return/flow.
19. Have assistant connect pulmonary artery catheter to the pressure monitor.
20. While holding pulmonary artery catheter level with the patient's heart, instruct assistant to set pressure reading to zero.
21. Orient catheter so that its curvature follows the expected path of the vessel, and insert the catheter into the sheath.
22. Insert catheter roughly 15 cm so that its tip is outside its sheath; then inflate the balloon.
23. Continue to advance the catheter until a right atrial wave form is transduced (Fig. 4.5). Note a, c, x, v, and y components that make up the entirety of the waveform. Transcribe the right mean atrial pressure. Normal values are typically 0–6 mm Hg.

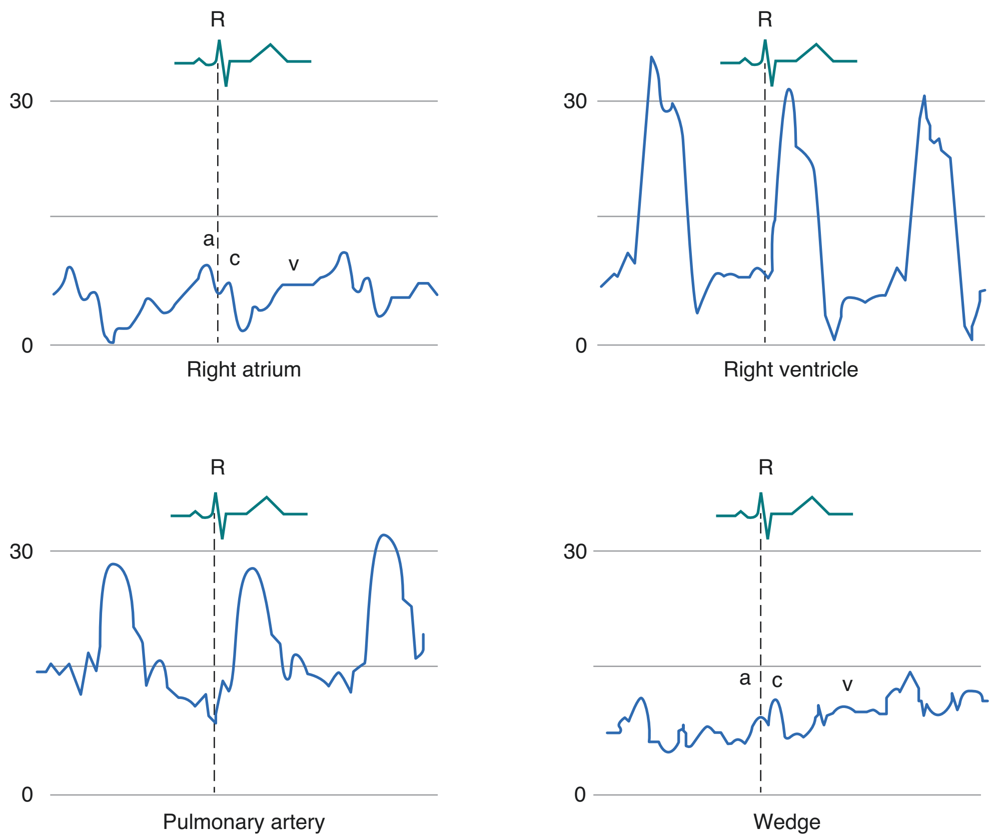

Fig. 4.5 Note the different waveforms at different sites of the pulmonary artery catheter. A few of the true marvels of human physiology!

24. Advance catheter an additional 5–10 cm until a right ventricular waveform (Fig. 4.5) is transduced. Note swift upstroke and downstroke, representing ventricular contraction and relaxation. Additionally, you will see a slower upstroke representing passive ventricular filling, followed by atrial contraction. Transcribe the right systolic and diastolic ventricular pressures. Normal values typically range from 15 to 30 for systolic pressures and 5 to 15 for diastolic pressures.
25. Advance the catheter an additional 5–10 cm until a pulmonary artery waveform (Fig. 4.5) is transduced. Note initial decline rather than incline of the waveform during the initial period of diastole. This helps to differentiate the pulmonary artery waveform from the right ventricular waveform. Next observe the overall increase in diastolic pressure as the waveform continues into its upstroke segment and blends into a dicrotic notch representing the closure of the pulmonic valve. Transcribe systolic, diastolic, and mean pulmonary artery pressures. Normal values are typically less than 25 for systolic pressures and less than 10 for diastolic pressures.
26. Continue to advance the catheter until a wedge pressure waveform (Fig. 4.5) is transduced. Note that this waveform is similar to the right atrial waveform except that greater variation may be noted with respiration. Transcribe the mean pressure at the end of expiration. Normal values may range from 2 to 12 mm Hg.
27. Now deflate the balloon, until the pulmonary artery waveform reappears.
28. Aspirate blood from the distal port to measure mixed venous oxygen saturation.
29. Measure cardiac output by connecting the thermistor to the computer and injecting a saline bolus into the right atrium. On a plot of temperature versus time, the area under the curve is inversely proportional to cardiac output.
30. Fasten a plastic sleeve to the sheath and secure the catheter. Suture sheath to the skin and apply adhesive dressing over the wound.
31. Obtain portable chest X-ray to ensure proper placement and rule out pneumothorax. The tip of the catheter should not extend more than 4–5 cm beyond the midline.
32. With the catheter in place, right atrial and pulmonary artery pressures may be monitored continuously. The balloon may be reinflated periodically to reassess pulmonary artery wedge pressure, but it must be deflated afterward.

Complications

- If a right ventricular waveform cannot be obtained, the catheter may be coiling in the right atrium or exiting through the vena cava.
- Tricuspid regurgitation may also be present and is suggested by large V waves on the atrial tracing, representing retrograde atrial filling.
- If a pulmonary artery waveform cannot be obtained, the catheter may be coiling in the right ventricle.
  - In each instance, the catheter balloon should be deflated and the catheter withdrawn a few centimeters. The balloon can then be reinflated and the catheter readvanced.
  - Fluoroscopy may help to prevent or overcome these complications.
- Ventricular arrhythmias.
- Right bundle branch block.
- Complete heart block.
- Guidewire embolism. (Consult vascular surgery).
- Infection.
- Bleeding.
- Catheter knotting, preventing withdrawal. (Consult vascular surgery.)
- Air embolism, often presenting with dyspnea, chest pain, tachycardia, hypotension, and acute increase in right heart pressures.
  - Treatment includes placing the patient in the Trendelenburg position and providing high-flow supplemental oxygen, which may reduce the nitrogen content of the blood and promote reabsorption of air.
  - In severe cases, hyperbaric oxygen must be provided.
- Pulmonary artery perforation. Risk is increased with an older patient, prolonged balloon inflation, pulmonary hypertension, and systemic anticoagulation. Typical presentation includes hemoptysis, hypoxemia, and shock.
  - Management includes balloon inflation, intubation with dual-lumen endotracheal tube.
  - Place patient in lateral decubitus position with affected side down.
  - Thoracic surgeon or interventional radiologist must be consulted immediately, as a perforation represents a true emergency.
- Late complications include thrombosis, catheter-related infection, and pulmonary infarction.

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Suggested Reading

Kelly CR, Rabbani LE. Pulmonary-artery catheterization. N Engl J Med. 2013;369:e35. https://www.nejm.org/doi/full/10.1056/NEJMvcm1212416

Nickson C. Pulmonary artery catheter. LITFL Critical Care Compendium 2019. https://lifeinthefastlane.com/ccc/pulmonary-artery-catheters/.

Roberts JR. Roberts and Hedges' clinical procedures in emergency medicine and acute care. 7th ed. Philadelphia: Elsevier; 2019.

Peripheral Venous Cutdown

5

Jeffrey Kile, Katrina John, and Amish Aghera

Indications

- Distorted anatomy of peripheral venous access sites
- Unavailability of cannulable veins (e.g., in hypovolemia, burn victim, traumatic anatomy, sclerosed veins, etc.)
- Emergency venous access for infusion/transfusion
- Unavailability of central venous access, intra-osseous access, or less-invasive means peripherally

Contraindications

- Absolute
  - Availability of less-invasive or less time-consuming means of vascular access
  - Overlying infection, traumatic tissue, burn, etc. at cutdown site
  - Traumatic injury proximal to cutdown site
- Relative
  - Coagulation disorders

Materials and Medications (Fig. 5.1)

- Sterile gloves
- Antimicrobial solution and swabs
- 4′′ × 4′′ gauze sponges
- Local anesthetic (1% lidocaine 5 mL)
- 5-mL syringe
- Blunt needle
- 25- or 27-gauge needle
- Scalpel
- Vein dilator/lifter
- Peripheral intravenous catheter
- Curved hemostat
- 0-0 silk sutures or 4.0 nylon sutures
- Iris scissors
- Intravenous infusion tubing
- Adhesive tape

Choice of Vessel for Cutdown

- *Greater saphenous vein:* This vessel is the longest vein in the body, is predominantly subcutaneous, and is exposed with minimal blunt dissection just anterior to the medial malleolus at the ankle.
- *Basilic vein:* This vessel is reliably located 1–2 cm lateral to the medial epicondyle on the anterior aspect of the humeral region. It is typically catheterized just superior to the antecubital fossa; its diameter permits relatively easy localization even in the hypotensive patient.
- *Cephalic vein:* This vessel runs anteromedially from the radial aspect of the wrist to the antecubital fossa. It is superficial and large in diameter and is most easily cannulated at the distal flexor crease in the antecubital fossa.

Procedure

Standard Venous Cutdown Technique

1. Apply antimicrobial solution liberally to the skin surrounding the incisional area.
2. Establish a sterile field by placing drapes around the incisional area.
3. Apply a tourniquet proximal to the planned cutdown site to maximize visualization of the vein to be cannulated.

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Fig. 5.1 Materials and medications

4. Inject local anesthetic to raise a small (0.5 cm) wheal using a 25- or 27-gauge needle; insert the tip of the needle through the wheal to infiltrate the skin superficial to the artery with approximately 4 mL of anesthetic.
   - Injection of local anesthetic into the vessel may precipitate arrhythmia, so draw back on the plunger prior to infiltration to ensure that the tip of the needle is not inside the vessel.
5. Incise the skin with a scalpel perpendicular to the course of the vein through all cutaneous layers until subcutaneous fat is visualized (Fig. 5.2).
   - Some practitioners prefer using a longitudinal incision to reduce the risk of transecting neurovascular structures, but this technique may not produce sufficient exposure of the vein.
6. Using a curved hemostat or gloved finger, bluntly dissect the subcutaneous tissue to isolate and mobilize approximately 2–3 cm of the vein (Fig. 5.3).

Fig. 5.2 Incision of the skin

   - A small, self-retaining retractor or tissue spreader can be used in this step to improve visualization of the vein, if desired.

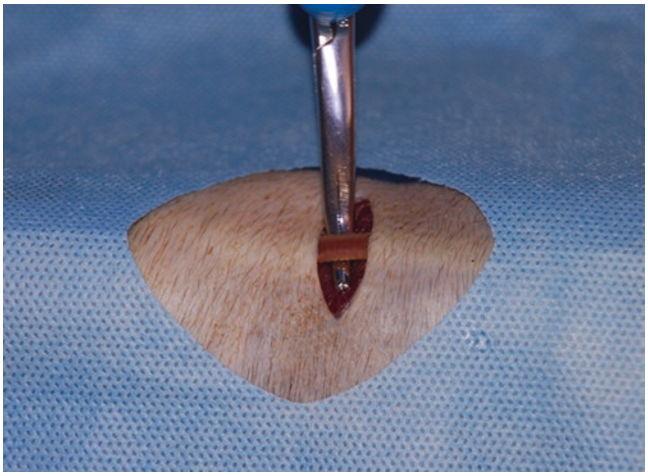

Fig. 5.3 Mobilization of the vein

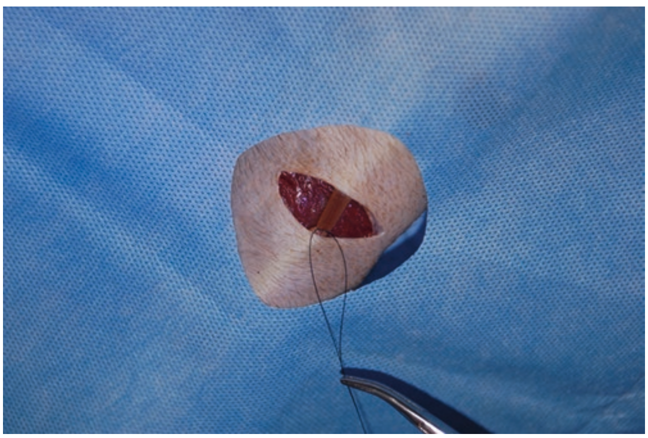

Fig. 5.4 Distal ligature tied around the vein

7. Pass suture under the vein distal to the planned venous puncture site using hemostat to stabilize the vein and tie the suture over the vein (Fig. 5.4).
8. Pass a second suture under the vein proximal to the planned venous puncture site, using the hemostat (Fig. 5.5).
   - This step enables increased visualization, vessel control, and hemostasis during incision.
   - Leave the ends of both sutures long to facilitate maneuvering the vein.
9. Incise one-third to one-half of the diameter of the vein using a scalpel or iris scissors held at a 45° angle to the vessel (Fig. 5.6).
10. Grasping the proximal edge of the incision with a hemostat to apply countertraction (in a distal direction), insert the tip of the catheter into the venous incision (Fig. 5.7).
    - Do not force the catheter if it does not easily advance.
    - The catheter can be introduced directly through the skin incision or via skin puncture adjacent to the skin incision.

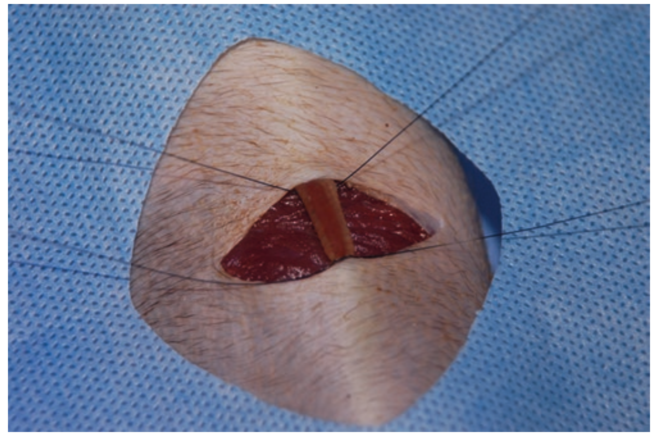

Fig. 5.5 Distal and proximal ligatures in place

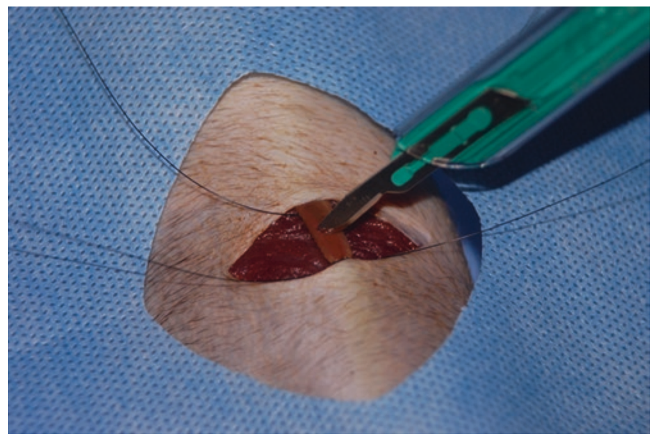

Fig. 5.6 Incision of the vein

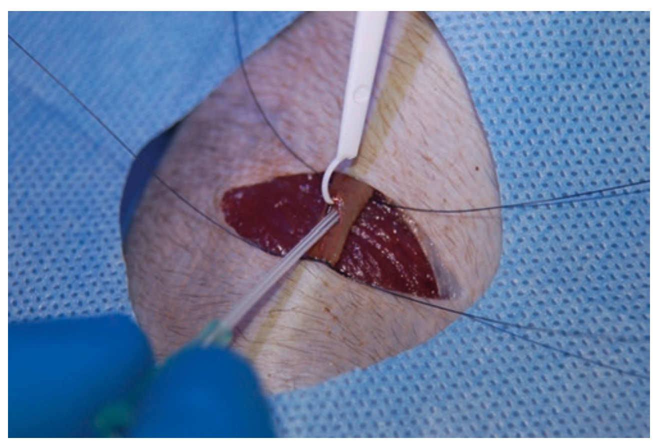

Fig. 5.7 Catheterization of the vein

    - If the catheter lacks a tapered tip, cut the distal end of the cannula at a 45° angle to fashion a beveled tip.
11. Thread catheter into the vein (Fig. 5.8).
12. Aspirate any air that may have entered the cannula during insertion.

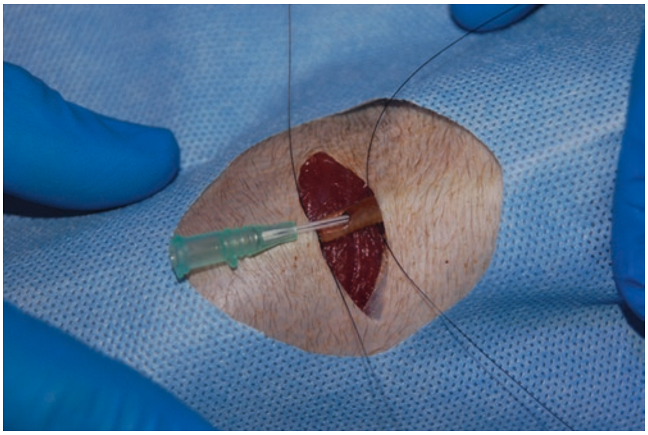

Fig. 5.8 Catheter threaded into the vein

13. Connect the hub of the catheter to intravenous tubing.
14. Tie the proximal suture around the vein just proximal to the venous incision, encircling both the vein and the intraluminal cannula with the suture.
15. Remove the tourniquet.
16. Secure the catheter hub to the skin using nylon (4.0) sutures as follows:
    - Take a 0.5-cm bite of the skin under the catheter hub with the suture needle.
    - Tie several knots in the suture without pinching the skin.
    - Then tie a second set of knots firmly around the hub of the catheter.
17. Close the incision using nylon (4.0) sutures.
18. Dress the wound with an appropriate self-adhesive sterile dressing or sterile gauze pads and adhesive tape.

"Mini-Cutdown" Technique

Perform steps 1–6 above; then proceed with the steps below:

1. Puncture the vein using a standard over-the-needle venous catheter.
    - The catheter can be introduced directly through the skin incision or via skin puncture adjacent to the skin incision.
2. Thread the catheter into the vein over the needle.
3. Remove and discard the needle.
4. Aspirate any air that may have entered the catheter during insertion.
5. Connect the catheter to intravenous tubing.

Continue with steps 15–18 above.

Modified/Guidewire Technique

Perform steps 1–6 from the "Standard Venous Cutdown Technique"; then proceed with the steps below:

1. Insert the blunt end of the guidewire into the incised vein.
2. While stabilizing the guidewire at its insertion site, thread the dilator and sheath assembly over the free end of the guidewire until it is approximately 1 inch from the skin.
3. Grasp the free end of the guidewire protruding from the tail end of the assembly.
    - If it does not protrude from the tail end of the assembly, the guidewire must be removed sufficiently from the vessel to be securely grasped. It must protrude visibly from the tail end of the dilator throughout the subsequent process of threading the dilator into the vein.
    - Never let go of the guidewire during this step, as insertion of the dilator and sheath assembly can otherwise push the guidewire completely into the vein.
4. Holding it firmly near its tip, thread the assembly over the wire into the vein with a gentle back-and-forth twisting motion.
5. Holding the sheath securely in the vein, remove and discard the dilator and guidewire.
6. Aspirate any air that may have entered the sheath during insertion.
7. Connect the sheath to intravenous tubing.
8. Remove the tourniquet.
9. Secure the sheath to the skin.
10. Close the incision using nylon (4.0) sutures.
11. Dress the wound with an appropriate self-adhesive sterile dressing or sterile gauze pads and adhesive tape.

Complications

- Hematoma
- Infection
- Sepsis
- Phlebitis
- Embolization
- Wound dehiscence

Pearls and Pitfalls

- Fluids are infused most quickly via short, large-bore catheters.
- If the line is inserted for slow infusion of intravenous drugs, catheter lumen size is relatively insignificant.
- In larger children and adults, intravenous plastic tubing, small-bore pediatric feeding tubes, and Silastic catheters may be used as infusion catheters.
- Threading a 10-gauge intravenous catheter or intravenous tubing directly into the incised vein achieves excellent flow rates.

- If difficulty is encountered while threading the catheter into the incised vein, ensure that the catheter is of an appropriate size; also ensure that the vessel lumen has been correctly identified and that no false passage has been created in the adventitia.
- The mini-cutdown technique is easier than the standard venous cutdown technique. It also preserves the vein, permitting repeated catheterization if necessary.
- Compared with the standard venous cutdown technique, the modified/guidewire technique reduces procedure time and increases the likelihood of vein salvage in the event of vessel transection.

Suggested Reading

Chappell S, Vilke GM, Chan TC, Harrigan RA, Ufberg JW. Peripheral venous cutdown. J Emerg Med. 2006;31:411–6.

Klofas E. A quicker saphenous vein cutdown and a better way to teach it. J Trauma. 1997;43:985–7.

McIntosh BB, Dulchavsky SA. Peripheral vascular cutdown. Crit Care Clin. 1992;8:807–18.

Nocito A, Wildi S, Rufibach K, Clavien PA, Weber M. Randomized clinical trial comparing venous cutdown with the Seldinger technique for placement of implantable venous access ports. Br J Surg. 2009;96:1129–34.

Shockley LW, Butzier DJ. A modified wire-guided technique for venous cutdown access. Ann Emerg Med. 1990;19:393–5.

Part II

Airway Procedures

Bag Valve Mask Ventilation

6

Braden Hexom and Tatiana Havryliuk

Indications

- Hypoxia
- Hypoventilation/apnea
- Rescue maneuver if failed intubation

Contraindications

- Absolute
  - Inability to ventilate due to the lack of seal (thick beard, deforming facial trauma)
  - Inability to ventilate secondary to complete upper airway obstruction
  - Active, adequate spontaneous ventilation
- Relative
  - Full stomach (aspiration risk).
  - After induction and paralysis during rapid sequence intubation (aspiration risk).
  - Presence of subcutaneous emphysema: Gases forced into the airway during BMV can expand the neck's soft tissues, compromising subsequent efforts to ventilate or intubate.

Materials (Fig. 6.1)

- Bag valve mask (BVM) with reservoir
- Oxygen connector tubing
- Nasal pharyngeal airway/oral pharyngeal airway
- Lubricant jelly

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Fig. 6.1 Bag valve mask (BVM) supplies: bag, mask, oral airways, nasopharyngeal airways, lubricant

Procedure

1. Position patient in "sniffing" position, with flexion of the neck on the body and extension of the head on the neck. This positioning can be aided by placing a roll beneath the patient's neck or occiput.
2. Open the airway with chin-lift/head-tilt or jaw thrust maneuvers.
3. Place airway adjuncts to maintain airway patency. Use an oral airway (Fig. 6.2) in unconscious patients. Use a nasal airway (Fig. 6.3) in semiresponsive patients.
4. Attach oxygen tubing to high-flow oxygen (15 L/min).
5. Place an appropriately sized mask on the patient's face, covering the nose and mouth.
   - For one-handed technique (Fig. 6.4), use nondominant hand to make a "C" with index finger and thumb on top of the mask and form an "E" with the rest of the fingers, using them to pull up on the mandible (E-C technique). Use the dominant hand to provide bag ventilations.

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Fig. 6.2 (**a**–**c**) Oral airway insertion

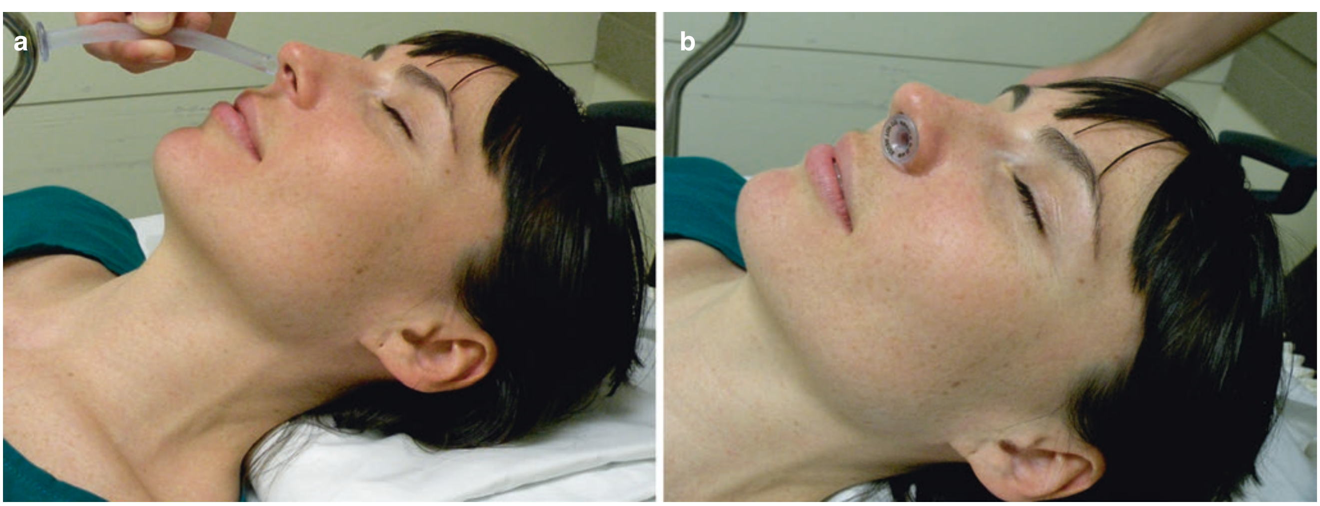

Fig. 6.3 (**a**, **b**) Nasal airway insertion

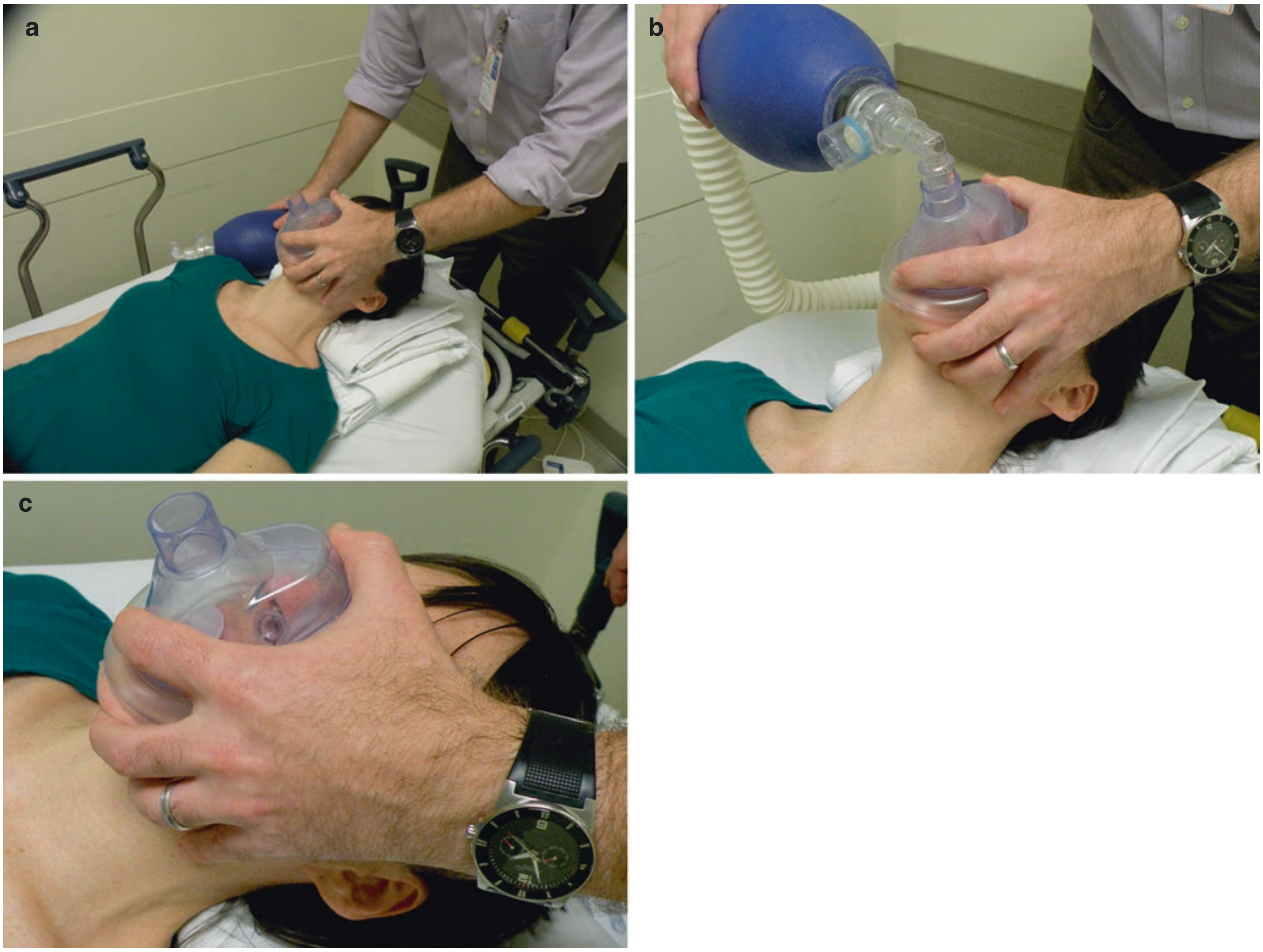

Fig. 6.4 (**a**–**c**) One-handed (E-C) seal technique

- For two-handed, two-person technique (preferred) (Fig. 6.5), make two semicircles with the index fingers and thumbs of both hands on top of the mask, and use the rest of the fingers to pull up on the mandible.

6. Consider the Sellick maneuver (cricoid pressure) to compress the esophagus against the cervical vertebrae, preventing gastric insufflation.
7. Ventilate the patient, providing reduced tidal volume breaths (500 mL) at a rate of 10–12 breaths per minute.
8. Give each breath gently over 1–1.5 seconds to avoid high peak pressures, avoiding gastric insufflation.
9. Prepare for definitive airway as dictated by the clinical scenario.

Complications

- Stomach inflation may lead to vomiting and aspiration.
- Increased positive thoracic pressure may cause decreased preload, worsening cardiac output, and/or hypotension.
- Hypoventilation (inadequate O_2 tidal volume, airway patency, or mask seal).

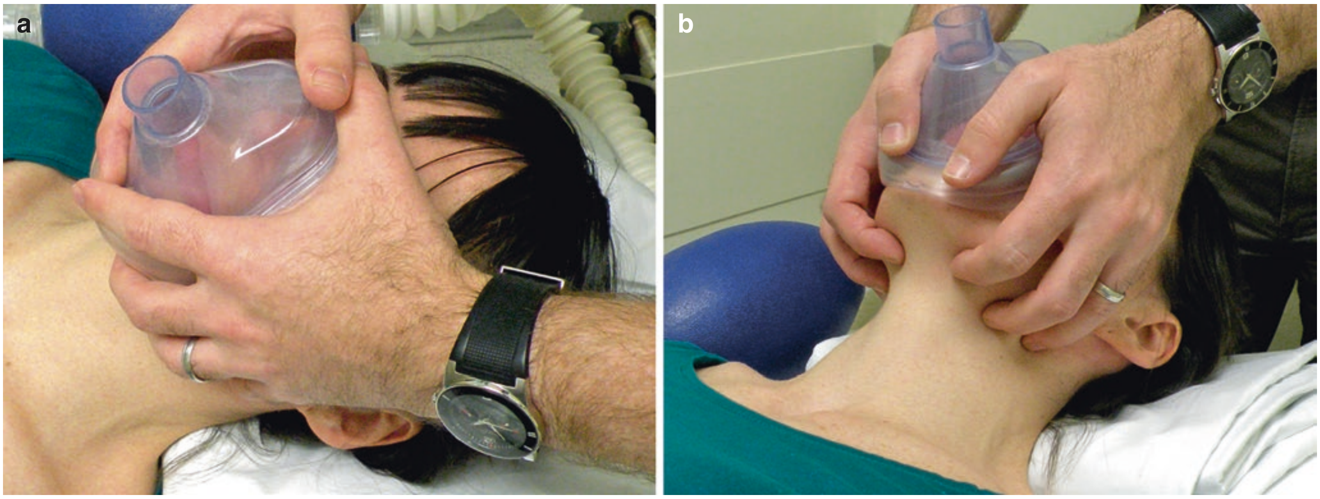

Fig. 6.5 Two-handed seal technique: two semicircles (**a**), alternative thumb method (**b**)

- Manipulation of the C-spine may worsen injuries in patients with neck trauma.

Pearls and Pitfalls

- Pearls
  - Use jaw thrust to open the mouth for patients with possible cervical spine injury.
  - Use airway adjuncts whenever available, especially if prolonged BVM ventilation is anticipated.
  - Use lubricant jelly to insert nasal airway; do not insert in patients with severe facial trauma.
  - Place the mask on the patient's face before attaching the bag.
  - Apply pressure only to the bony part of the mandible, to avoid soft tissue injury or compression of the airway.
  - Provide just enough tidal volume to see a chest rise, and deliver each breath gently over 1–1.5 seconds, to prevent gastric insufflation.
  - Ensure good seal:

    Select appropriate mask size.

    Choose two-handed technique over one-handed, if possible.

    Keep well-fitting dentures in place if present (and remove before intubation).

    Lift the mandible toward the mask (as opposed to pushing the mask onto the face).

    Rock the mask on the face until no leak is present.

    Apply K–Y jelly or Tegaderm film to beard to improve the seal.
- Pitfalls
  - Overcompression during the Sellick maneuver can compress the cricoid ring, preventing ventilation.
  - Cricoid pressure (Sellick maneuver) is not recommended during cardiac arrest resuscitation.
  - Do not press the mask down onto the face of a patient with potentially unstable facial fractures.
  - Difficult BVM ventilation: MOANS

    *M*ask seal

    *O*besity/obstruction

    *A*ge

    *N*o teeth

    *S*tiff

Suggested Reading

Berg RA, Hemphill R, Abella BS, Aufderheide TP, Cave DM, et al. Adult basic life support: American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2010;122:S685–705.

Haut ER, Kalish BT, Efron DT, Haider AH, Stevens KA, Kieninger AN, et al. Spine immobilization in penetrating trauma: more harm than good? J Trauma. 2010;68:115–20; discussion 120–1.

Joffe AM, Hetzel S, Liew EC. A two-handed jaw-thrust technique is superior to the one-handed "EC-clamp" technique for mask ventilation in the apneic unconscious person. Anesthesiology. 2010;113:873–9.

Krausz AA, El-Naaj IA, Barak M. Maxillofacial trauma patient: coping with the difficult airway. World J Emerg Surg. 2009;4:21.

Roberts JR, Hedges JR. Clinical procedures in emergency medicine. Philadelphia: Saunders Elsevier; 2010.

Walls RM, Murphy MF. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008.

7 Awake Intubation

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Indications

- Patient requires urgent but not emergent endotracheal intubation and has these characteristics:
  - Is awake
  - Is currently protecting the airway
  - Is not a candidate for a supraglottic airway (laryngeal mask airway (LMA))
  - Other qualifications:
    - Is predicted to have a difficult airway
    - Has structural abnormalities of the airway
    - Will not tolerate a period of apnea
    - May lose the airway (anaphylaxis, angioedema, traumatic airway)
- Patient requiring urgent but not emergent intubation in whom paralytics are contraindicated (allergies, myasthenic crisis)

Contraindications

- Absolute
  - Surgical airway indicated
  - Emergent crash airway needed
  - Obtunded patient
  - Allergies to necessary medications (lidocaine, glycopyrrolate)
- Relative
  - Inability to maintain airway or tolerate secretions

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Materials and Medications

- Suctioning equipment
- Intravenous access equipment, cardiac monitor, pulse oximetry, blood pressure cuff
- 4% lidocaine solution
- 2% viscous lidocaine jelly
- Nebulizer
- Mucosal atomization device
- 4″ × 4″ gauze
- Tongue depressor
- Glycopyrrolate or atropine
- Sedation: ketamine, propofol, midazolam, and/or fentanyl
- Intubation equipment
- Backup emergency airway adjuncts
- Bag valve mask
- Laryngoscope, fiber optics, oral airway, etc.

Procedure

1. Preparation:
   - Establish IV access.
   - Place the patient on a cardiac monitor with continuous pulse oximetry.
   - Keep backup rapid sequence intubation (RSI) emergency airway medication and equipment at the bedside.
   - Position patient: likely seated upright or slightly reclined, in position of comfort.
2. 15 minutes before the procedure, administer 0.2–0.4 mg of intravenous glycopyrrolate (or 0.5–1 mg of atropine) to decrease secretions.
3. Nebulize 2 mL of 4% lidocaine with oxygen at 5 L O2 per minute to anesthetize the posterior pharynx (Fig. 7.1).

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4. Use Yankauer suction (with the patient's assistance) to dry out the mouth as much as possible. Dabbing the tongue with gauze can assist in this step.
5. Continue preoxygenation.
6. Immediately after the nebulized solution is applied, give the patient a "lidocaine lollipop" (Fig. 7.2).
   - A 2-mL dollop of 2% viscous lidocaine is placed on the end of a tongue depressor and is given to the patient to place in his or her mouth (like a lollipop).
   - The patient should gargle and then swallow the viscous lidocaine.
7. Using a mucosal atomizer, spray 2 mL of 4% lidocaine in the posterior oropharynx and as far down toward the glottis as possible (Figs. 7.3, 7.4, and 7.5).
8. Sedation
   - It is feasible to proceed with the awake intubation in an unsedated, wide-awake but cooperative patient.
   - Sedation can be initiated using institutional preferences; some options include:
     – Midazolam, 2 mg IV
     – Ketamine, 1 mg/kg IV

Fig. 7.1 Nebulization of 4% lidocaine

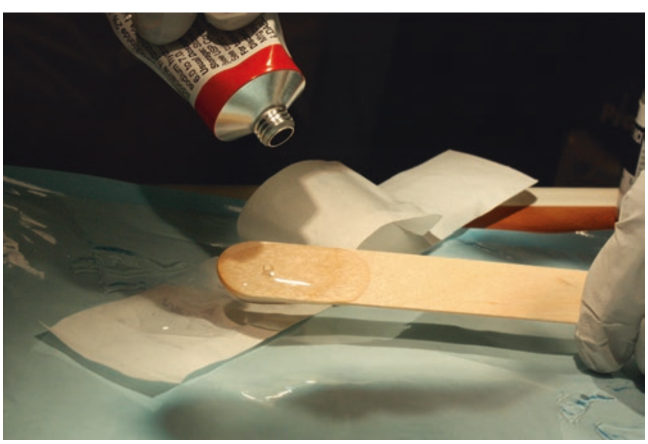

Fig. 7.2 Lidocaine lollipop

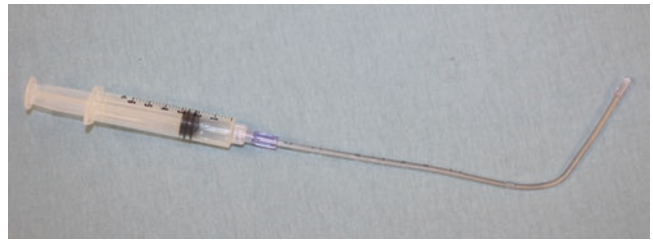

Fig. 7.3 Mucosal atomizer attached to syringe

Fig. 7.4 Pushing syringe plunger atomizes lidocaine

Fig. 7.5 Atomized lidocaine being administered to the posterior pharynx

     – Propofol, 1 mg/kg IV
     – Ketofol (ketamine and propofol, both at concentrations of 10 mg/mL and 5 mL of each mixed in a 10 cc syringe) titrated at 1–3 mL aliquots
   - More atomized lidocaine can be provided prior to passage of the endotracheal tube (ETT), but one must be aware of the upper lidocaine dose for your patient.
   - Adequate anesthesia is confirmed by the absence of a gag reflex upon direct palpation (Fig. 7.6).

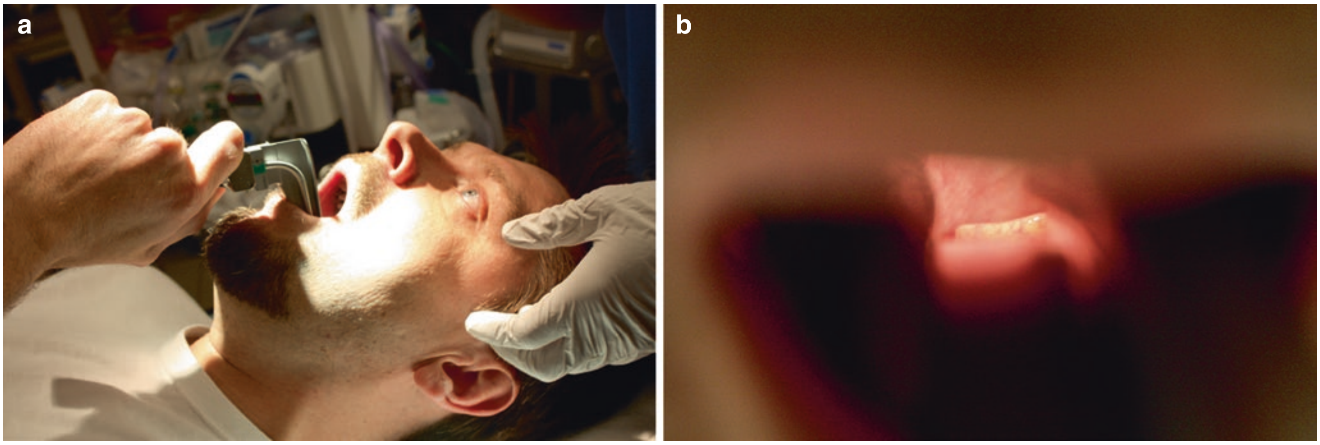

Fig. 7.6 Adequately anesthetized awake patient (**a**) with laryngoscopic view of the epiglottis (**b**)

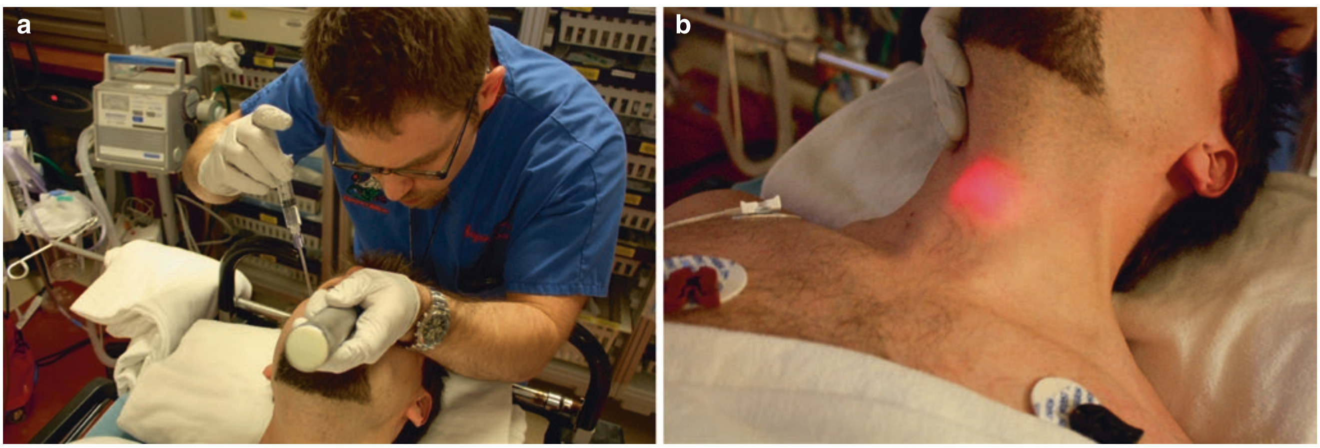

Fig. 7.7 (**a**) Final lidocaine atomization of deep structures and trachea. (**b**) Intubation using a lighted stylet

9. Intubation, induction, and gentle direct laryngoscopy can be performed at this point to place the ETT (Fig. 7.7). Thorough discussions on intubation techniques can be found in other chapters.
   - Induction (if no prior sedation) and paralytic agents should be available to administer immediately after ETT placement.

Pearls and Pitfalls

- Pearls
  – Steps 3–7 should be done successively and as quickly as possible to capitalize on the short half-life of lidocaine.
  – Simultaneous preoxygenation and anesthetization can be achieved by nebulizing the 4% lidocaine through a face mask.
  – If the patient has been sedated, soft restraints may help prevent the patient from inadvertently grabbing the tube or the intubating equipment.
  – A nasotracheal intubation can be performed by simply using lidocaine jelly and/or atomized lidocaine to anesthetize the nares through which the ETT will be placed. Use a smaller tube size (#6.5 or #7.0), and advance over a fiber-optic scope after cannulation of the trachea.
- Pitfalls
  – Failure to prepare all equipment beforehand may extend the procedure beyond the lidocaine half-life.
  – The toxic dose of lidocaine is 300 mg or 3–5 mg/kg. The dosages listed are intended for a 70-kg patient and yield a total dose of 270 mg (4 mg/kg). This dose may need to be decreased for smaller individuals.

Suggested Reading

Agrò F, Hung OR, Cataldo R, Carassiti M, Gherardi S. Lightwand intubation using the Trachlight™: a brief review of current knowledge. Can J Anaesth. 2001;48:592–9.

Rhee KY, Lee JR, Kim J, Park S, Kwon WK, Han S. A comparison of lighted stylet (Surch-Lite™) and direct laryngoscopic intubation in patients with high Mallampati scores. Anesth Analg. 2009;108:1215–9.

Walls RM, Murphy MF. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2007.

8 Rapid Sequence Intubation

Ram A. Parekh and Joshua Tsau

Indications

- Airway protection and patency
- Respiratory failure (hypercapneic or hypoxic), decreased work of breathing (WOB), and projected clinical course deterioration
- Minimize oxygen consumption and optimize oxygen delivery (e.g., sepsis)
- Unresponsive to pain, GCS >8 or rapidly decreasing GCS in trauma setting
- Temperature, seizure, pain control
- Safety during transport, pre-procedure, projected clinical course deterioration

Contraindications

- Absolute
  - Complete upper airway obstruction
  - Significant facial and airway trauma with loss of landmarks for orotracheal intubation
- Relative
  - Anticipated difficult intubation
    Not an absolute contraindication, but careful assessment and plan are required.
    Consider an "awake" intubation.
    Consider alternative airway adjuncts (e.g., extraglottic devices, video laryngoscopy, laryngeal mask airway [LMA]).
  - Induction or paralytic agent-specific contraindications given clinical circumstances
    Caution: induction agents that lower blood pressure in hypotensive patients
    Caution: succinylcholine in potentially hyperkalemic patients
  - Crash airway
    Apneic, arrest, and periarrest situation

Materials and Medications

- Laryngoscope with appropriate blade (choice based on proceduralist's preference and patient anatomy) (Fig. 8.1)
- Intubating stylet
- Endotracheal tubes (ETTs)
- Syringe, 10 mL (to inflate ETT cuff)
- Surgilube
- Suction catheter
- Oral and nasal airways (Fig. 8.2)
- Ambu bag and mask attached to oxygen source
- Induction, pretreatment, and paralytic agents
- Airway adjuncts and backups at bedside: bougie, supraglottic airway devices, video laryngoscopy device, surgical cricothyrotomy kit
- Endotracheal tube (ETT) confirmation devices: qualitative and quantitative carbon dioxide detection devices (*see* Fig. 8.7)

Procedure

1. Preparation
   - Thoroughly assess patient for difficulty of intubation, using "LEMON" mnemonic:
     - *L* = Look externally (facial trauma, beard or moustache, and large tongue)
     - *E* = Evaluate the 3–3-2 rule (inter-incisor distance <3 fingerbreadths, chin-hyoid distance <3 fingerbreadths, hyoid-thyroid distance <2 fingerbreadths)
     - *M* = Mallampati score ≥3 (Fig. 8.3)

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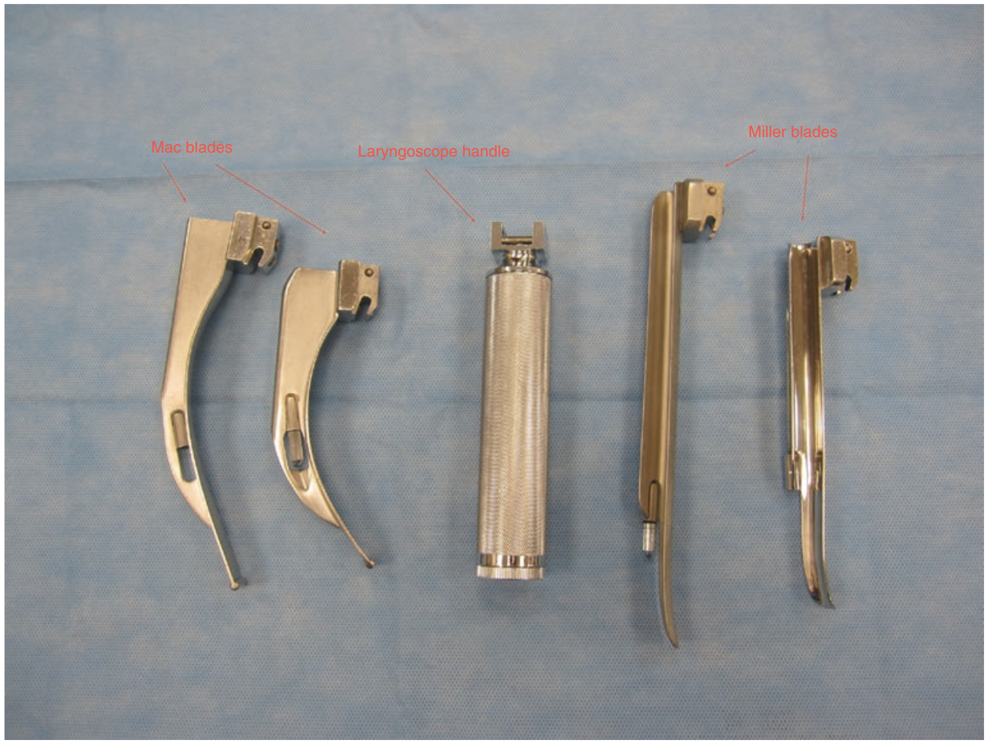


Fig. 8.1 Laryngoscope and blades

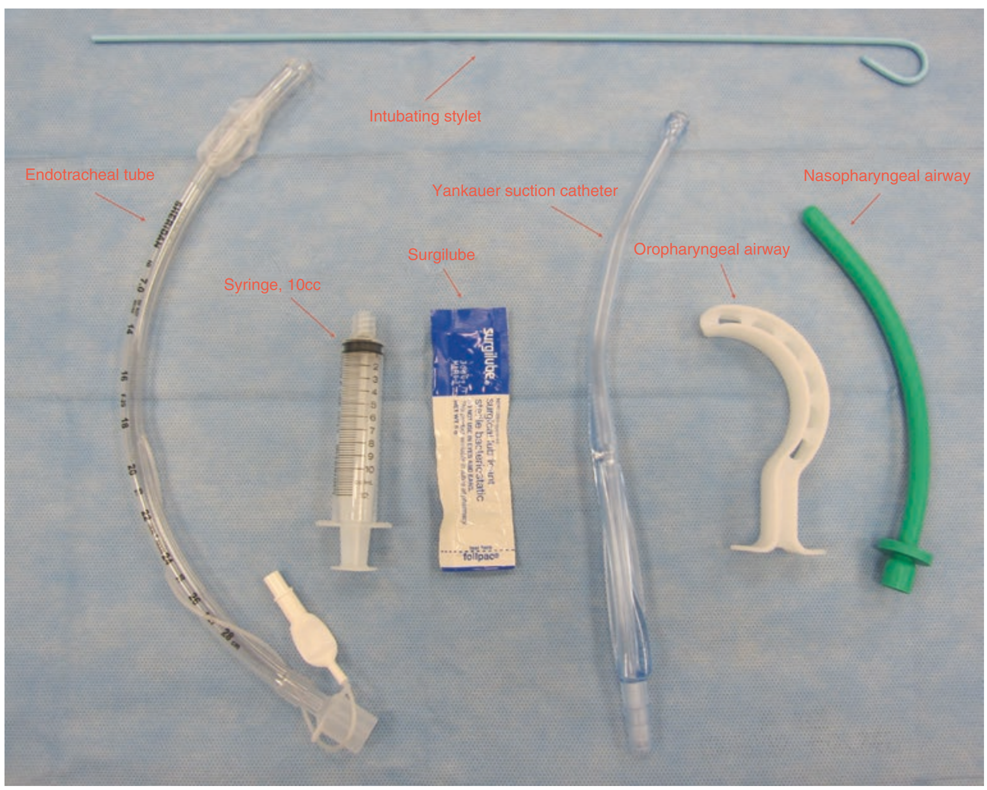


Fig. 8.2 Oral and nasal airways

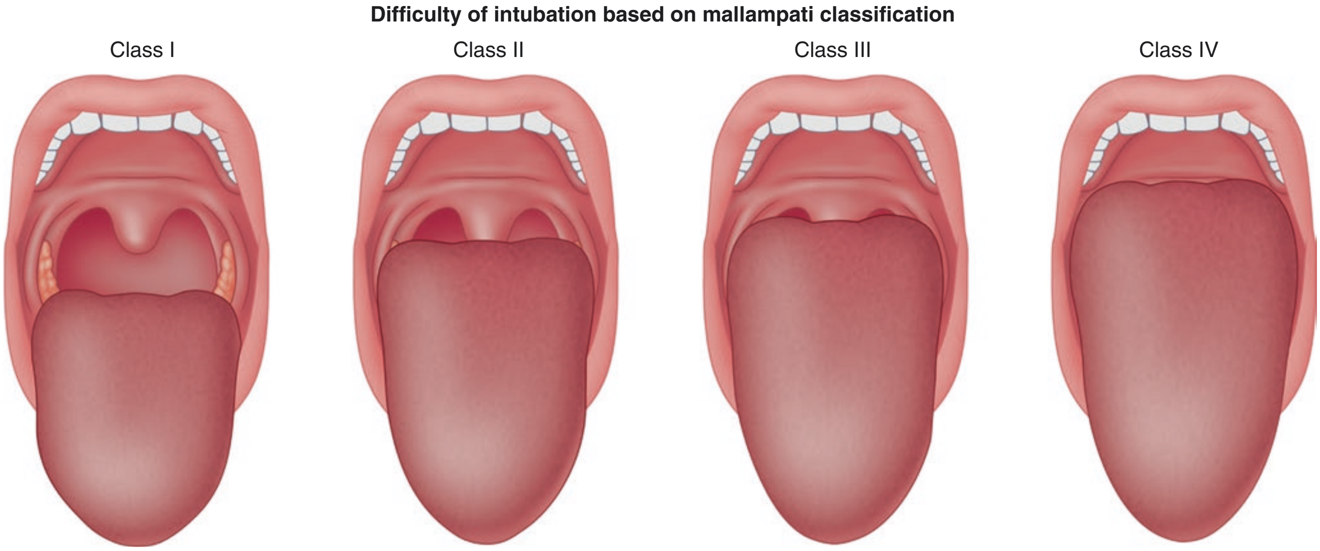


Fig. 8.3 Assess patient for difficulty of intubation, based on the Mallampati classification

 - = Obstruction (presence of any condition that could cause an obstructed airway)
 - *N* = Neck mobility limited
- Develop fallback plans for failed intubation attempt.
- Establish at least one (preferably two) secure intravenous (IV) lines.
- Place patient on cardiac monitor with pulse oximetry, blood pressure monitoring, and continuous capnography.
- Yankauer suction device is attached to suction, with suction on.
- Pharmacological agents are drawn and labeled.
- Laryngoscope and blades are tested to ensure proper functioning of light source.
  - Mac 3 or 4 for adults
- Desired ETT size, prepared for intubation:
  - 7.5 tube for most adults, 7.0 for smaller females, 8.0 for larger males.
  - Test cuff by filling with air using a 10 cc syringe; deflate, with syringe left attached.
  - Stylet in position (tip at eye of ETT)
  - ETT configured per proceduralist's preference (hockey stick: straight to cuff with 30-degree bend or curved).
- Have backup and rescue airway equipment at arm's reach.

2. Preoxygenation
   - Administer high-flow oxygen for 3–5 minutes (Fig. 8.4).
     - Nitrogen is exchanged for O_2 in the functional residual capacity of the lungs.
     - Establishes oxygen reservoir within lungs (primarily), as well as in blood and body tissue (also known as nitrogen "washout").
   - This can be done using a variety of devices (Fig. 8.5):
     - Non-rebreather mask (delivers 65–70% oxygen), if difficult intubation is not anticipated.
     - Well-fitting bag valve mask (without positive-pressure ventilation)—delivers greater than 80% oxygen.
     - Noninvasive positive-pressure ventilation (NIPPV)—delivers 100% oxygen. Consider NIPPV in high-risk patients with moderate to severe shunt physiology.
3. Pretreatment
   - Administer pharmacological agents to mitigate adverse physiological effects of intubation, induction, and paralysis, which may be undesirable in certain clinical circumstances (Table 8.1).
4. Induction and paralysis
   - Administer a rapidly acting induction agent to produce rapid loss of consciousness via IV push (Table 8.2).
   - Immediately follow induction agent with a neuromuscular blocking agent via IV push (Table 8.3).
5. Positioning
   - If no cervical spine injury is suspected, place the patient in the "sniff" position (Fig. 8.6):
     - Flex neck
     - Extend head
   - Ideally, the patient's pinna will be at the level of the sternum.
   - In setting of trauma with possible C-spine injury, remove C-collar, but have assistant maintain in-line

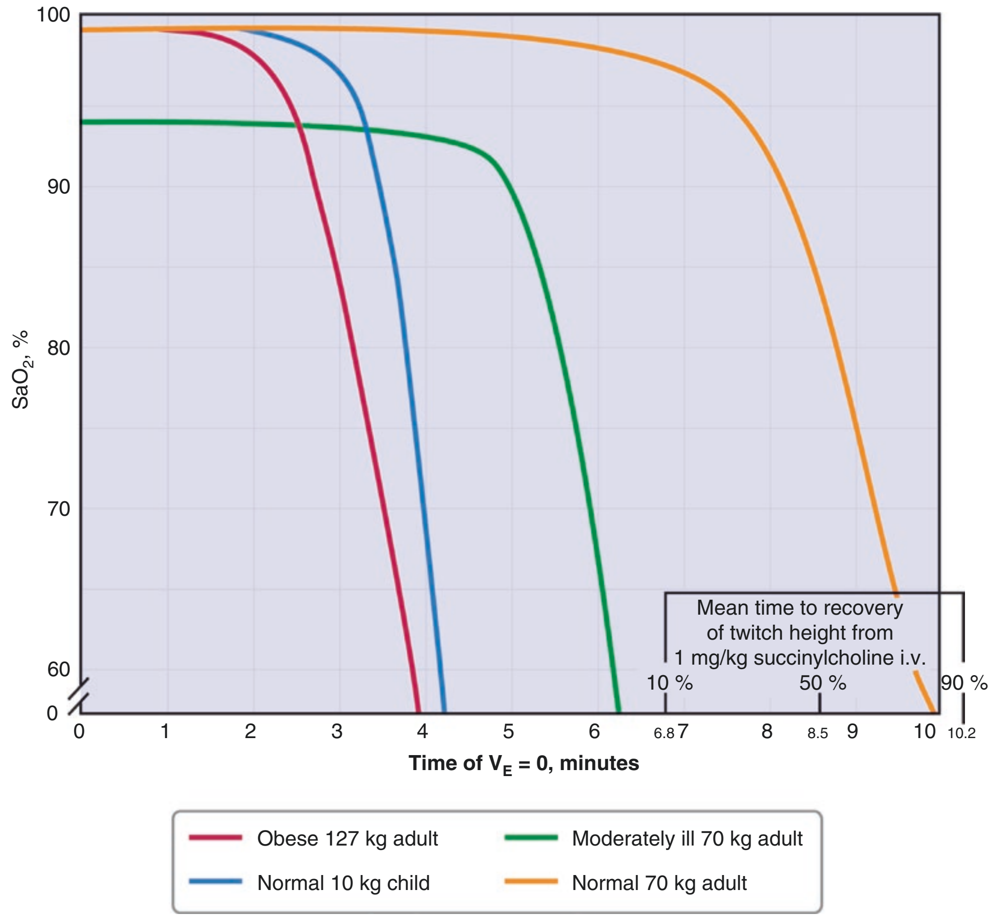


Fig. 8.4 F_AO_2, fractional concentration of alveolar oxygen; SaO_2, arterial oxygen saturation; V_E, expired volume per minute

Fig. 8.5 Preoxygenation materials. PEEP—positive end-expiratory pressure

Table 8.1 Pretreatment: pharmacological agents used to mitigate adverse physiological effects of intubation, induction, and paralysis

Agent	Dose (IV)	Indication
Lidocaine	1.5 mg/kg Rapid push	Use in tight brain to attenuate ICP increase from laryngoscopy/intubation; use in tight lungs to blunt bronchospastic response
Fentanyl	1–3 μg/kg Slow push	Use in the tight brain, tight heart, and tight vessels to blunt reflex sympathetic response to laryngoscopy

ICP intracranial pressure

Table 8.2 Induction: rapidly acting induction agents used to produce rapid loss of consciousness

Agent	Dose (IV), *mg/kg*	Onset, *seconds*	Duration, *minutes*
Midazolam	0.2–0.3	60–80	15–30
Etomidate	0.3	15–45	3–12
Thiopental	3	<30	5–10
Ketamine	1.5–2.0	45–60	10–20
Propofol	1.5	15–45	5–10

Table 8.3 Paralysis: neuromuscular blocking agents administered immediately after induction agent

Agent	Dose (IV)	Onset, *seconds*	Duration, *minutes*
Succinylcholine	1.5 mg/kg	45	6–10
Rocuronium	1.0 mg/kg	60–75	40–60
Vecuronium	0.01 to prime, then 0.15 mg/kg	75–80	60–75

immobilization during the procedure. Minimize manipulation of the head and neck, and replace the collar immediately after confirmation of tube placement.

6. Direct laryngoscopy (*see* Chap. 9)
7. Proof of placement
   - Visualize ETT passing vocal cords.
   - Confirm tube placement via end-tidal carbon dioxide concentration (Fig. 8.7).
   - Auscultation of breath sounds:
     – Lung fields bilaterally
     – Epigastric region (ensuring no breath sounds in the stomach)
8. Postintubation management
   - Secure ETT (Fig. 8.8).
   - Initiate mechanical ventilation.
   - Postintubation sedation and analgesia.
   - Postintubation chest X-ray.
   - Consider placement of Foley and/or orogastric tube in patients who will be immobilized for a prolonged period.

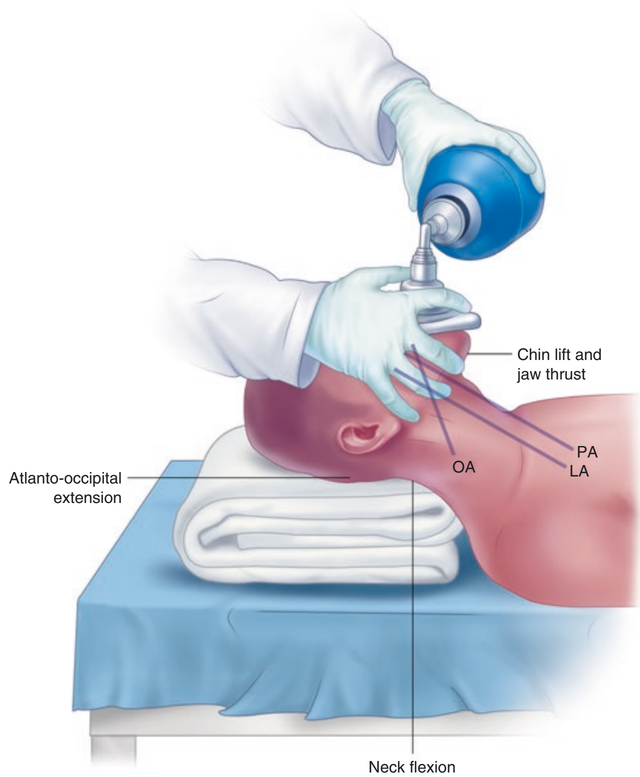


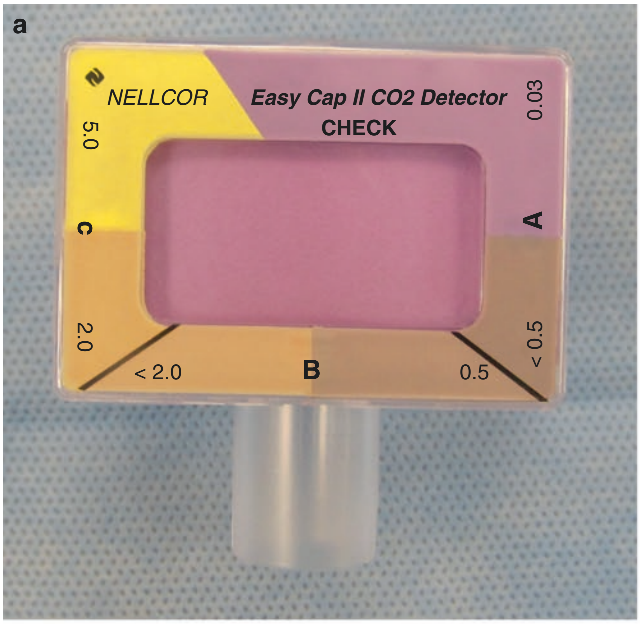
Fig. 8.6 Patient in the "sniff" position. LA, laryngeal axis; OA, oral axis; PA, pharyngeal axis

Complications

- Esophageal intubation
- Right mainstem intubation
- Pneumothorax from laryngeal trauma
- Aspiration
- Dental trauma
- Vocal cord injury
- Hypotension
  – Induction agent
  – Decreased venous return from positive pressure
  – Pneumothorax
- Hyperkalemia (succinylcholine used in mildly hyperkalemic patient)
- Iatrogenically obstructed airway
- Failure to intubate

Pearls and Pitfalls

- Consider mnemonics to help in preparation for procedure and to decrease cognitive load in a stressful and time-sensitive situation:



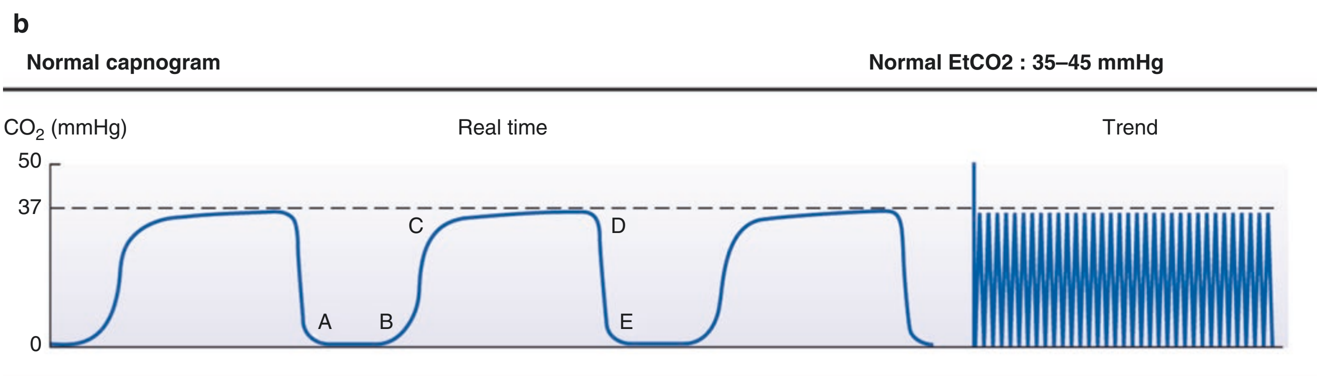
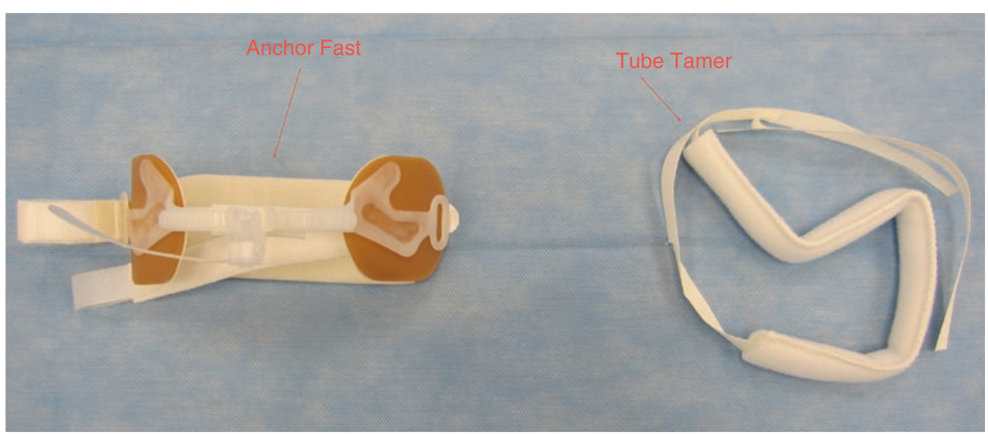


Fig. 8.7 End-tidal carbon dioxide ($EtCO_2$) concentration. (**a**) Qualitative detection device (Easy Cap II, Nellcor). (**b**) Quantitative continuous $EtCO_2$ waveform on monitor (preferred)

Fig. 8.8 Equipment used to secure endotracheal tube



  - LEMON and "3-3-2" rules for predicting difficult airways
  - SOAPME: Suction, oxygen, airway, pre-oxygenate, medications, equipment
- Utilization of oral and nasal airways will greatly increase the ease of preoxygenation and reoxygenation.
- Inadequate preoxygenation will cause premature desaturation, decreasing time for intubation.
- Suboptimal patient positioning can prevent vocal cord visualization during direct laryngoscopy. The use of a roll under the patient's head or neck may be helpful.
- Always have alternative airway devices ready at the bedside before intubation. Verbalize a difficult airway plan with your team.
- In patients who have difficult airway characteristics, first-attempt intubation success has been shown to be higher with the use of a bougie rather than ETT and stylet.
- Underdosing of induction or paralytic agents will yield inadequate time to perform the procedure or create patient discomfort.
- Inappropriately sized Macintosh laryngoscope blades create difficulty:
  - Too small: more difficulty in moving the tongue and epiglottis out of way for vocal cord visualization
  - Too large: easier to overshoot and go past vocal cords into the esophagus
- Excessive cricoid pressure (Sellick maneuver) may lead to disrupted laryngoscopic view and difficulty passing the ETT.
  - Disrupted view: Readjust larynx using the dominant hand to allow cord visualization.
  - Difficulty passing ETT: Ask for release of some cricoid pressure to allow for ETT passage.
- Postintubation sedation and analgesia can be inadequate, especially when long-acting paralytics are used.
- Acidic gastric contents can cause CO_2 qualitative capnometry to change to yellow, falsely indicating tracheal placement of the ETT.

Selected Reading

Driver B, Dodd K, Klein LR, Buckley R, Robinson A, McGill JW, et al. The bougie and first-pass success in the emergency department. Ann Emerg Med. 2017;70:473–8.

Stept WJ, Safar P. Rapid induction-intubation for prevention of gastric-content aspiration. Anesth Analg. 1970;49:633–6.

Walls RM, Murphy MF. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2007.

Weingart SD. Preoxygenation, reoxygenation, and delayed sequence intubation in the emergency department. J Emerg Med. 2011;40:661–7.

Direct Laryngoscopy

9

Bharath Chakravarthy and Weston Seipp

Indications

- Orotracheal intubation
  - Maintenance of oxygenation/ventilation
  - Airway protection
- Visualization of laryngeal anatomy
- Foreign body retrieval

Contraindications

- Absolute
  - None
- Relative
  - Presumed difficult airway

    Anatomical limitations
    - Small oral opening (less than three of the patient's fingers)
    - Small mandible (hyomental distance less than three fingers)
    - Small hyoid-thyroid distance (less than two fingers)

    Clinical limitations
    - Patient with unstable cervical spine
    - Patient with multiple facial or neck trauma
    - Patient with history of tracheal stenosis, irradiation, or history of tracheal mass or surgery

Materials and Medications (Fig. 9.1)

- Laryngoscope handle
- Laryngoscope blade with light
  - Macintosh blade ("Mac" or "curved blade")
  - Miller blade ("straight blade")
- Bag valve mask attached to 100% O_2 source
- Endotracheal tube (ETT)
- 10-mL syringe
- Yankauer suction
- End-tidal CO_2 ($EtCO_2$) monitor (colorimetric or quantitative)
- Magill forceps (for foreign body retrieval)
- Postintubation chest radiograph

Procedure

1. Check the laryngoscope handle and blades to ensure that the light is functioning.
2. Choose the appropriate blade based on patient size.
   - The Macintosh or Miller 3 size is appropriate for most adults, with a 4-size blade used for larger patients.
   - The Macintosh blade is generally preferred for adults, owing to increased space for ETT passage [1].
   - The Miller blade may be preferable for patients with limited mouth opening (smaller vertical height) or a particularly floppy airway (such as in infants and children) [1].
3. Position the patient (Fig. 9.2).
   - Raise the bed so that the patient's oral opening is at the level of the xiphoid process of the laryngoscopist.
   - The optimal laryngeal view is obtained in the neck flexion/head extension or "sniffing" position. To achieve this, place towels under the patient's occiput to raise it approximately 6–9 cm [2].
   - Confirm correct positioning with the ear to sternal notch alignment: A horizontal plane from the external auditory meatus passing through the sternal notch should be parallel to the ceiling
   - If the patient is in cervical spine precautions, then an assistant must hold the cervical spine in midline immobilization throughout the laryngoscopy; elevation of the occiput is contraindicated.

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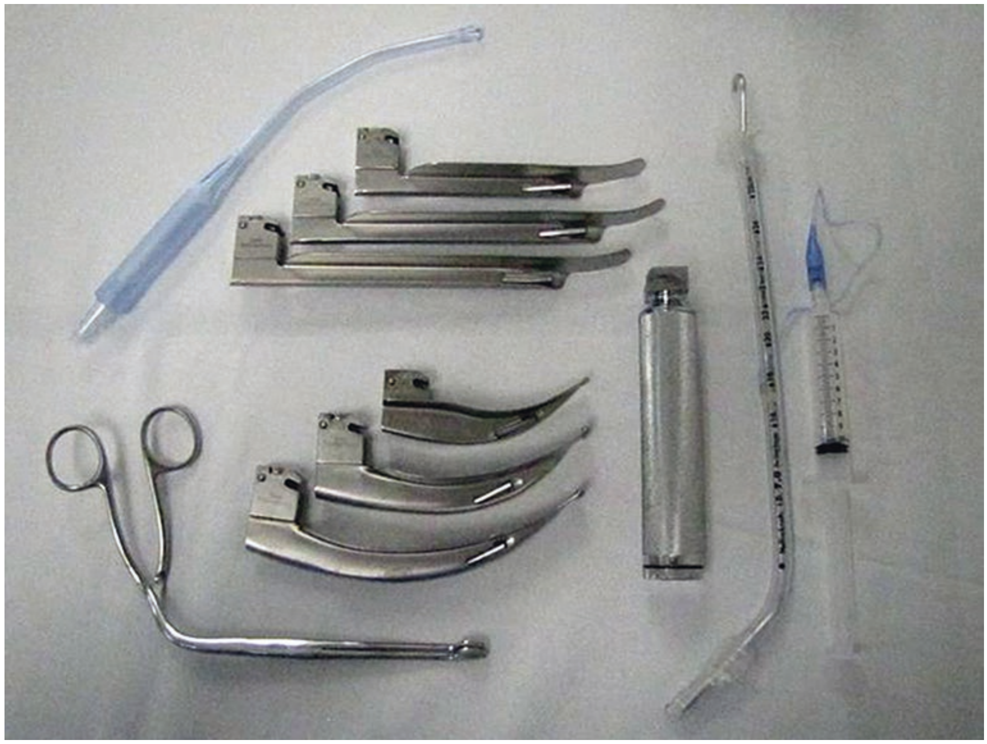

Fig. 9.1 Basic laryngoscopy supplies. *Clockwise from top left*: Yankauer suction, Miller blades, endotracheal tube, 10-mL syringe, laryngoscope handle, Macintosh blades, and Magill forceps

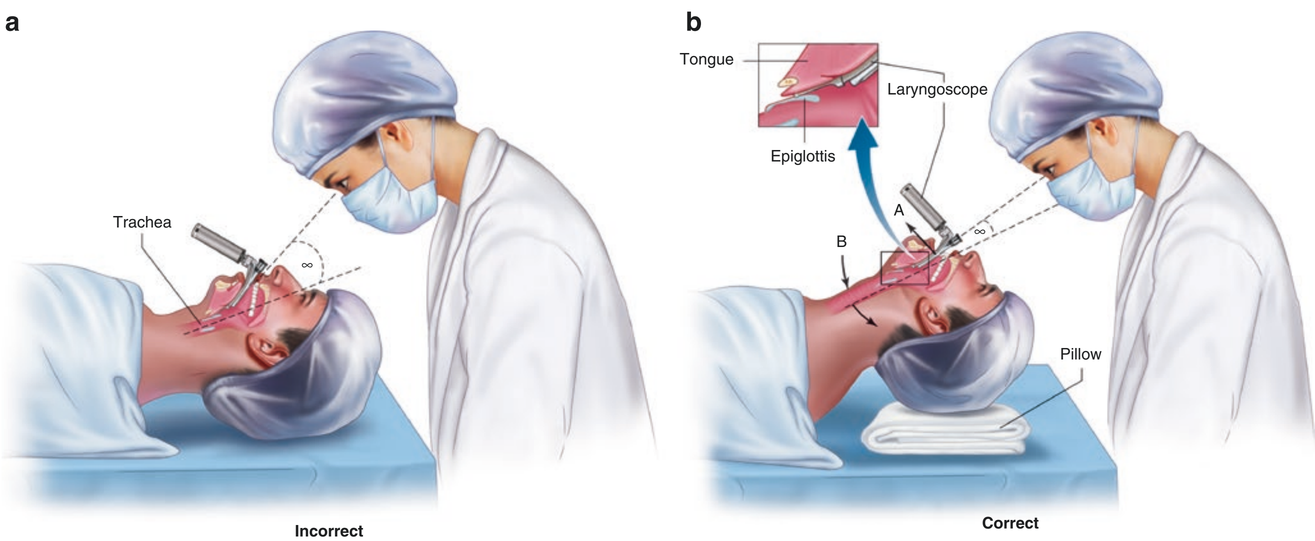

Fig. 9.2 Visualization axis and sniffing position. (**a**) The patient's occiput is not elevated and the neck is not in flexion, thereby creating a steep visual axis. (**b**) The occiput is correctly elevated 6–9 cm, placing the patient in sniffing position and allowing the visual axis to align with the airway axis

4. Provide 100% O_2 via face mask to preoxygenate the patient before laryngoscopy.
5. After ensuring adequate anesthesia and neuromuscular blockade (if performing laryngoscopy for intubation), perform the scissor technique using first and middle finger of your right hand to open the patient's mouth.
6. Macintosh blade insertion:
   - Insert the laryngoscope into the patient's mouth with your left hand, starting from the right side, and slowly advance into the oropharynx, using the blade's vertical flange to "sweep" the tongue to the left and away from the glottic opening.
   - Advance the blade along the tongue toward the tongue base, until the epiglottis and posterior arytenoids are viewed.
   - To expose the cords, insert the Macintosh blade into the vallecula, which is the potential space anterior to the epiglottis and posterior to the tongue base. This

will act as a fulcrum and raise the epiglottis, exposing the vocal cords.
- To further expose the cords and/or expose the vallecula, exert force outward at a 45° angle to the patient (Fig. 9.3). Do not "rock" the laryngoscope because this may cause injury to the teeth.

7. Miller blade insertion:
   - Insert the blade into the right side of the mouth, and slowly advance along the tongue toward the tongue base. (The Miller blade does not have a flange for isolating the tongue, so the Macintosh may be preferable in patients with large tongues.)
   - Advance the blade along the right side of the tongue until the epiglottis and posterior arytenoids are visible.
   - In contrast to the Macintosh blade, the Miller blade is used to directly isolate the epiglottis and expose the vocal cords. Using the tip of the Miller, move the epiglottis anteriorly to expose the vocal cords.
   - As with the Macintosh, exert force outward at a 45° angle to the patient to increase the view of vocal cords (Fig. 9.4). Do not "rock" the laryngoscope because this may cause injury to the teeth.
8. Assessing the glottic view:
   - With the epiglottis either directly or indirectly lifted from the glottic opening, assess the Cormack-Lehane laryngeal view grade (Fig. 9.5).
     – Grade I—view of entire laryngeal opening, including cords
     – Grade II—view of posterior laryngeal cartilages
     – Grade III—visualization of the epiglottis only
     – Grade IV—no structures visualized

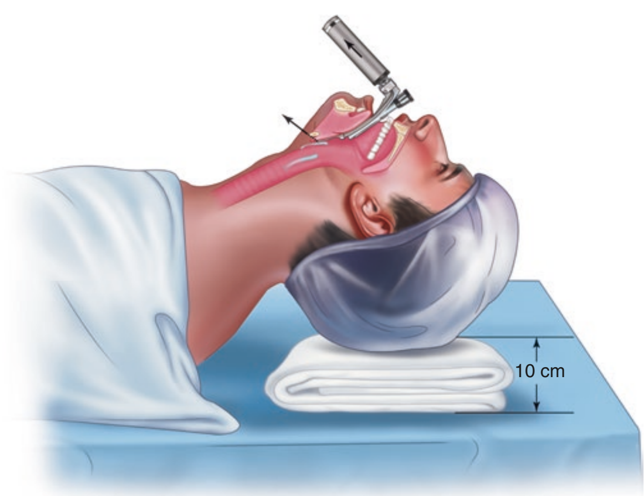

Fig. 9.3 Macintosh blade insertion. The blade is inserted into the vallecula, which raises the epiglottis and exposes the glottic opening

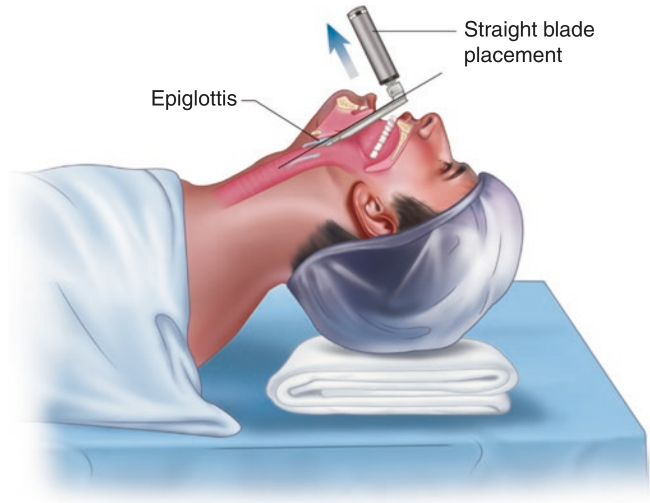

Fig. 9.4 Miller blade insertion. The blade is used to elevate the epiglottis directly, exposing the glottic opening

   - A view of a lower grade (better view) is predictive of intubation success [3].
   - If the view is of a higher grade, the operator may request airway adjuncts, such as a bougie.
9. Improving the glottic view [4–6]:
   - With the laryngoscope blade in your left hand and still visualizing the glottic structures, it is possible to improve your glottic view by using your right hand to manipulate the occiput: Often a subtle lift will further align the ear with the sternal notch.
   - With the laryngoscope still in the desired position, use your right hand to exert backward pressure on the thyroid cartilage (bimanual laryngoscopy); then have an assistant hold the thyroid cartilage in the optimal position for viewing (Fig. 9.6).
10. Passing the endotracheal tube (Fig. 9.7):
    - With the optimal view of the cords obtained, pass the ETT from the right corner of the mouth through the vocal cords to a depth where the cuff is just distal to the vocal cords (often 21 cm at the incisors in women and 23 cm in men).
    - Inflate the ETT cuff with approximately 5 cc of air until the pilot balloon is firm to the touch.
11. After completing intubation or after completion of laryngoscopy, slowly remove the blade from the mouth, taking care to avoid trauma to the teeth or lips.
12. Attach a capnography device to the ETT tube to ensure end-tidal CO_2 return (*see* Fig. 8.7).
    - Colorimetric devices will turn from purple to yellow in the presence of $EtCO_2$.
    - Quantitative devices will return a CO_2 waveform.

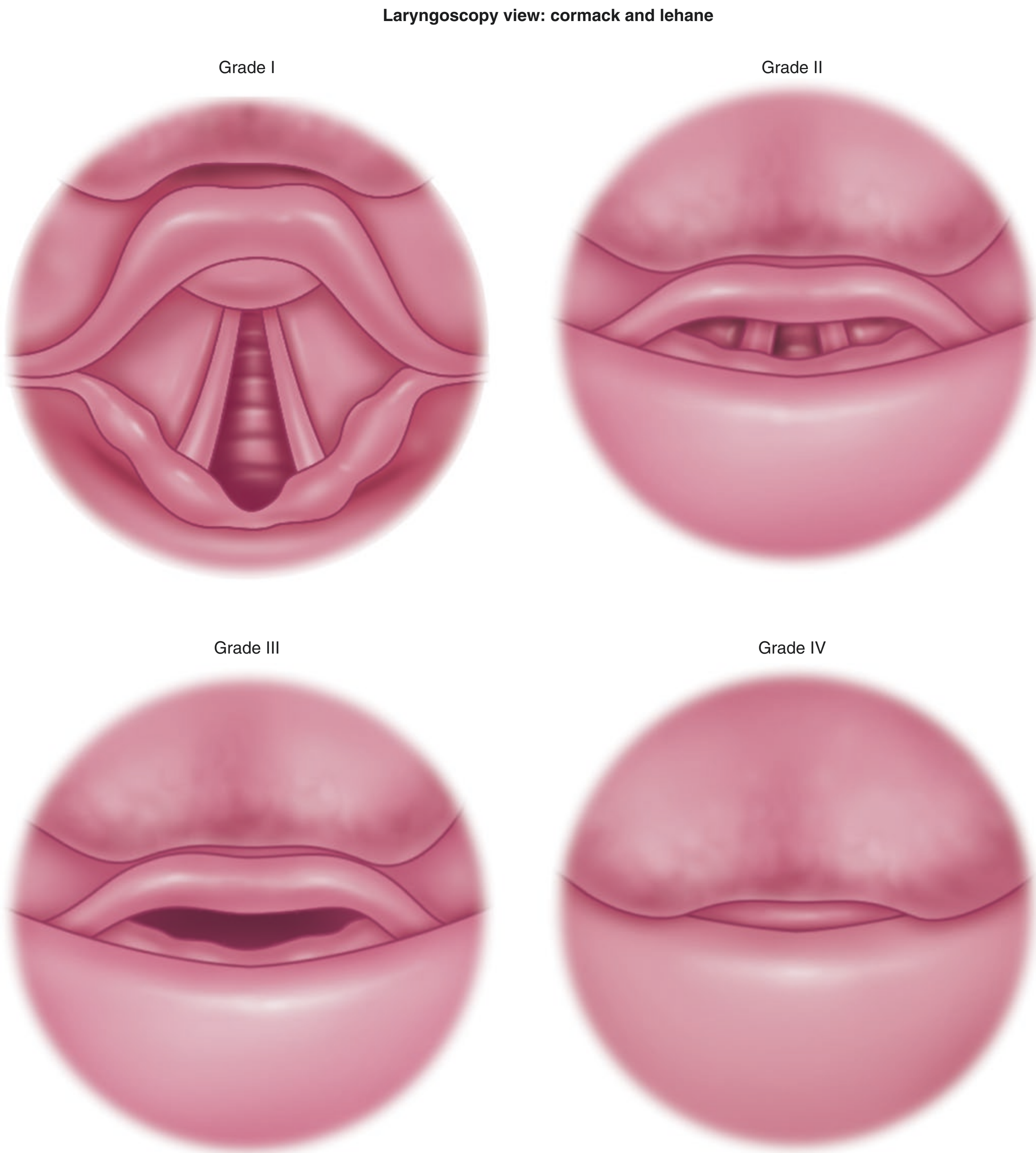

Fig. 9.5 Cormack and Lehane laryngeal view grades

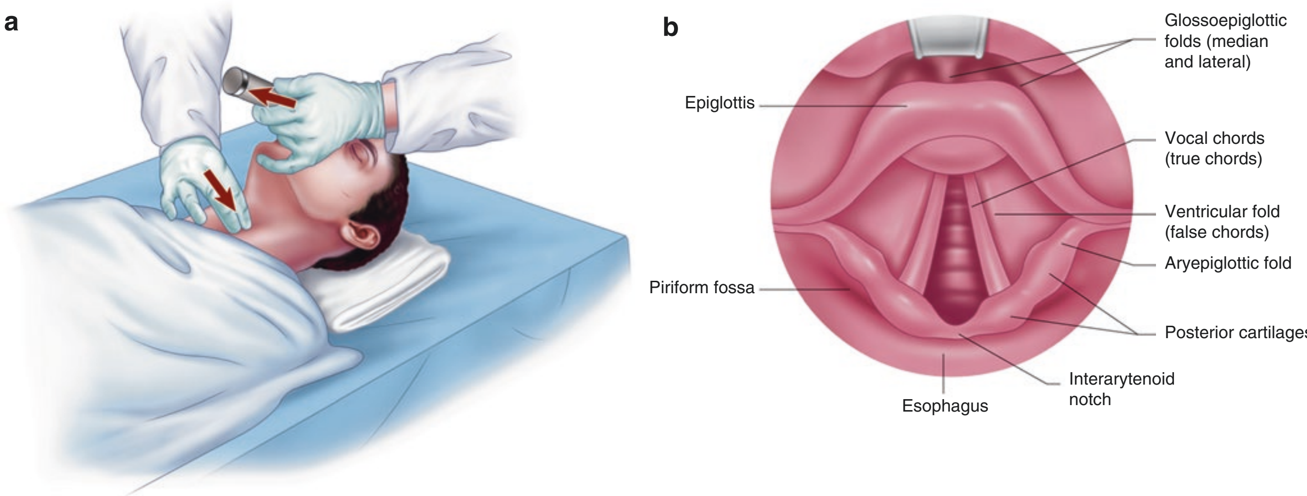

Fig. 9.6 (**a**) Bimanual laryngoscopy. The force on the neck is opposite the direction of lift by the laryngoscope. (**b**) Laryngoscopy view

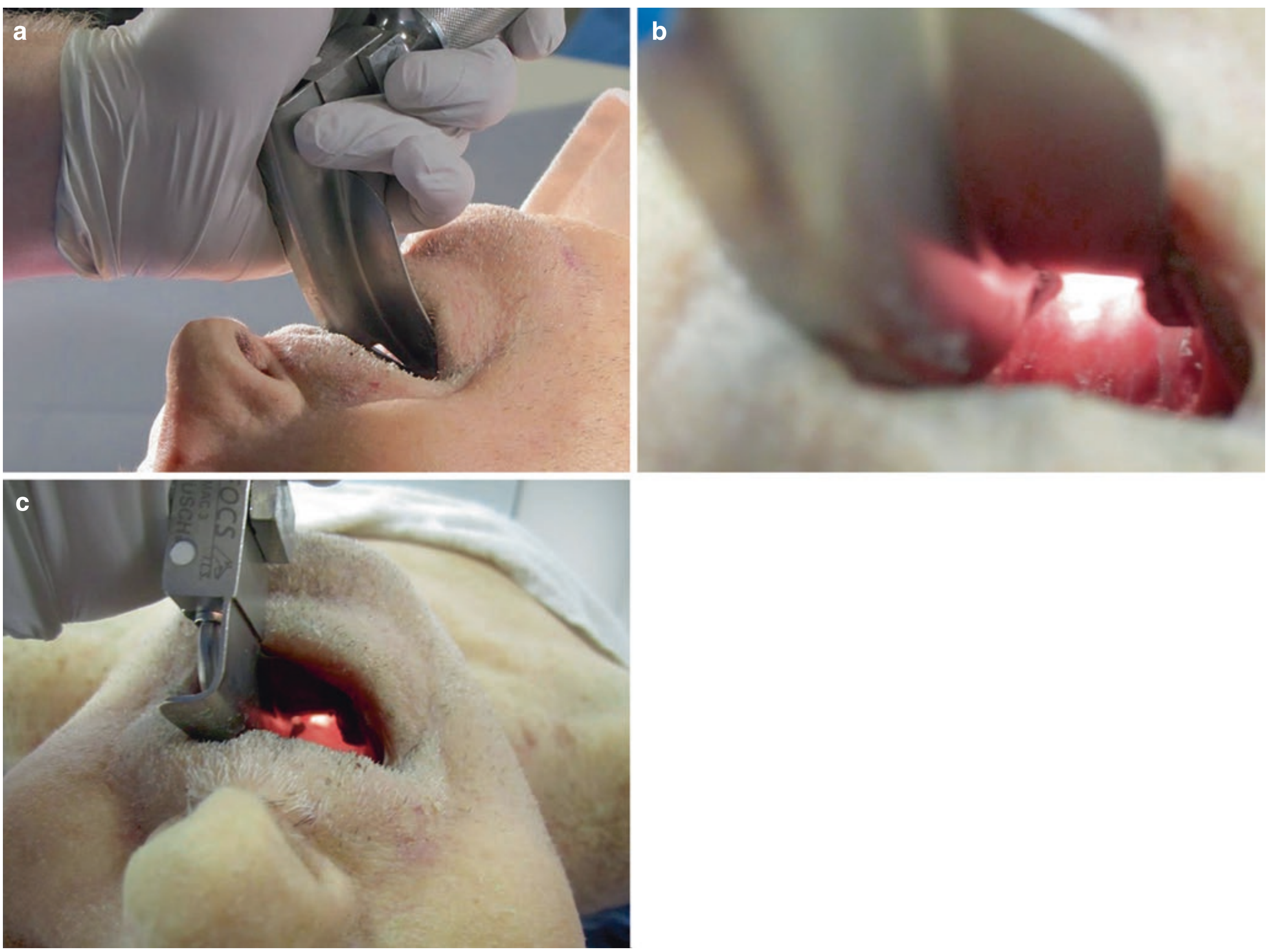

Fig. 9.7 Passing the endotracheal tube. (**a**) Insert the laryngoscope into the mouth. (**b**) Sweep the tongue to the left. (**c**) Advance the laryngoscope until the epiglottis is visible, and insert the blade into the vallecula to expose the cords. When using the Miller blade, insert the blade until the epiglottis is seen. Slide the blade under the epiglottis and lift to expose the cords

13. Attach the ETT to a ventilator or bag valve mask connected to an oxygen source.
14. Auscultate breath sounds in both lung fields, and ensure that breath sounds are absent over the epigastrium (where they could signify esophageal intubation).
15. Obtain a postintubation chest X-ray to ensure no right mainstem intubation or pneumothorax.

Complications [3, 7]

- Common (1–4%)
  – Esophageal intubation—*can be fatal if unrecognized*
  – Mainstem bronchus intubation
  – Tachycardia
  – Aspiration
  – Hypotension
- Uncommon (<1%)
  – Dental or oral trauma
  – Oropharyngeal edema or bleeding
  – Laryngospasm
  – Dysrhythmia
  – Pneumothorax
  – Cardiac arrest

Pearls and Pitfalls

- Pearls
  – Positioning is of key importance—all patients with a stable cervical spine should be placed in the "sniffing" position to maximize view.
  – Position yourself in an optimal position:
    Your eyes should be 12–18 inches from the head of the patient. Being too close will give you a narrow view of the surrounding environment; after achieving an adequate view, you should not have to take your eyes off the target to reach for suction or the ETT.
    Your left arm holding the laryngoscope should be roughly 90 degrees flexed and held close to your body. This position gives more control, as well as a mechanical advantage to lift the laryngoscope blade toward the ceiling. The laryngoscope handle should be gripped as low down as possible.
  – Consider the "ramping" position in obese patients with stable cervical spines. Elevation of the head and shoulders allows redundant tissue to fall and gives an improved glottic view.
  – Always have suction readily available to remove blood, vomitus, or edema.
  – Bend the ETT and stylet to shape: straight to cuff with 30-degree bend. Your line of sight is a straight line and your straight tube will follow this trajectory. The bend allows the tube to pass anterior to the interarytenoid notch; rotation of the tube will then allow fine vertical control of the tip [8].
  – If structures are not readily visible, withdraw the blade gradually; it is common to insert the blade too deep.
  – To prevent right mainstem intubation, stop advancing the ETT once you visualize the cuff passing the cords. Similarly, do not let go of the tube until it is firmly secured.
  – If you meet resistance while passing the tube through the cords, give the tube a clockwise (rightward) turn to lower its leading edge.
  – Always have airway adjuncts within arm's reach, including bougie, supraglottic airway devices, and surgical cricothyrotomy ("cric") kit. Consider a backup airway roll or kit.
- Pitfalls
  – "Rocking" the laryngoscope instead of lifting outward, causing dental trauma
  – Failure to recognize esophageal intubation
  – Failure to evaluate a postintubation chest X-ray

References

1. Hagberg CA. Benumof's airway management. Maryland Heights: Mosby; 2007. p. 363–5.
2. Park SH, Park HP, Jeon YT, Hwang JW, Kim JH, Bahk JH. A comparison of direct laryngoscopic views depending on pillow height. J Anesth. 2010;24:526–30.
3. Martin LD, Mhyre JM, Shanks AM, Tremper KK, Kheterpal S. 3,423 emergency tracheal intubations at a university hospital: airway outcomes and complications. Anesthesiology. 2011;114:42–8.
4. Levitan RM, Kinkle WC, Levin WJ, Everett WW. Laryngeal view during laryngoscopy: a randomized trial comparing cricoid pressure, backward-upward-rightward pressure, and bimanual laryngoscopy. Ann Emerg Med. 2006;47:548–55.
5. Levitan RM, Mechem CC, Ochroch EA, Shofer FS, Hollander JE. Head-elevated laryngoscopy position: improving laryngeal exposure during laryngoscopy by increasing head elevation. Ann Emerg Med. 2003;41:322–30.
6. Schmitt HJ, Mang H. Head and neck elevation beyond the sniffing position improves laryngeal view in cases of difficult direct laryngoscopy. J Clin Anesth. 2002;14:335–8.
7. Walls RM, Brown CA 3rd, Bair AE, Pallin DJ, NEAR II Investigators. Emergency airway management: a multi-center report of 8937 emergency department intubations. J Emerg Med. 2011;41:347–54.
8. Levitan RM, Pisaturo JT, Kinkle WC, Butler K, Everett WW. Stylet bend angles and tracheal tube passage using a straight-to-cuff shape. Acad Emerg Med. 2006;13:1255–8.

10 Laryngeal Mask Airway

Sohan Parekh

Indications

- Rescue device in a failed intubation
- Initial device in a predictably difficult airway
- Temporizing airway prior to definitive endotracheal intubation or surgical airway
- Rapid advanced airway in either a resource-limited or difficult setting (e.g., out of hospital, cardiac arrest with ongoing compressions)

Contraindications

- Absolute
  – Inadequate mouth opening
- Relative
  – Neck trauma/injury/radiation
  – High risk of aspiration

Materials and Medications

- Appropriately sized laryngeal mask airway (LMA) (Table 10.1) and corresponding syringe. Figure 10.1 illustrates various types:
  – LMA Unique™
  – LMA Classic Excel™
  – LMA Fastrach™
- Surgilube.
- Bag-valve mask
- Continuous end-tidal CO_2 ($EtCO_2$) or colorimetric $EtCO_2$ detector.
- 8-mm or smaller endotracheal tube (ETT) (for Fastrach intubating LMA only).

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Table 10.1 Laryngeal mask airway sizing

Size	Patient weight, *kg*	Maximum cuff inflation volume, *mL*	LMA product availability
1	<5	4	Unique
1½	5–10	7	Unique
2	10–20	10	Unique
2½	20–30	14	Unique
3	30–50	20	Unique, Classic Excel, Fastrach
4	50–70	30	Unique, Classic Excel, Fastrach
5	70–100	40	Unique, Classic Excel, Fastrach
6	>100	50	Unique

LMA laryngeal mask airway

Procedures

LMA Unique or Classic Excel

1. If using a reusable LMA Classic Excel, ensure that it is sterile, and inspect it for any damage or wear.
2. Tightly deflate the cuff using a syringe, so that it forms a spoon shape (Fig. 10.2).
3. Lubricate the posterior surface of the LMA with sterile lubricating jelly.
4. Stand behind the patient at the head of the bed, as for direct laryngoscopy.
5. Place the patient's head in the sniffing position and ensure proper induction and paralysis.
6. Hold the LMA with the index finger of the dominant hand positioned at the juncture of the tube and cuff (Fig. 10.3).
7. Widely open the mouth with the nondominant hand, and insert the LMA with the flattened tip flush with the palate.
   - Ensure that the tip of the device does not fold over during insertion.
8. Using the index finger, push the LMA along the curvature of the hard and soft palate (Fig. 10.4).

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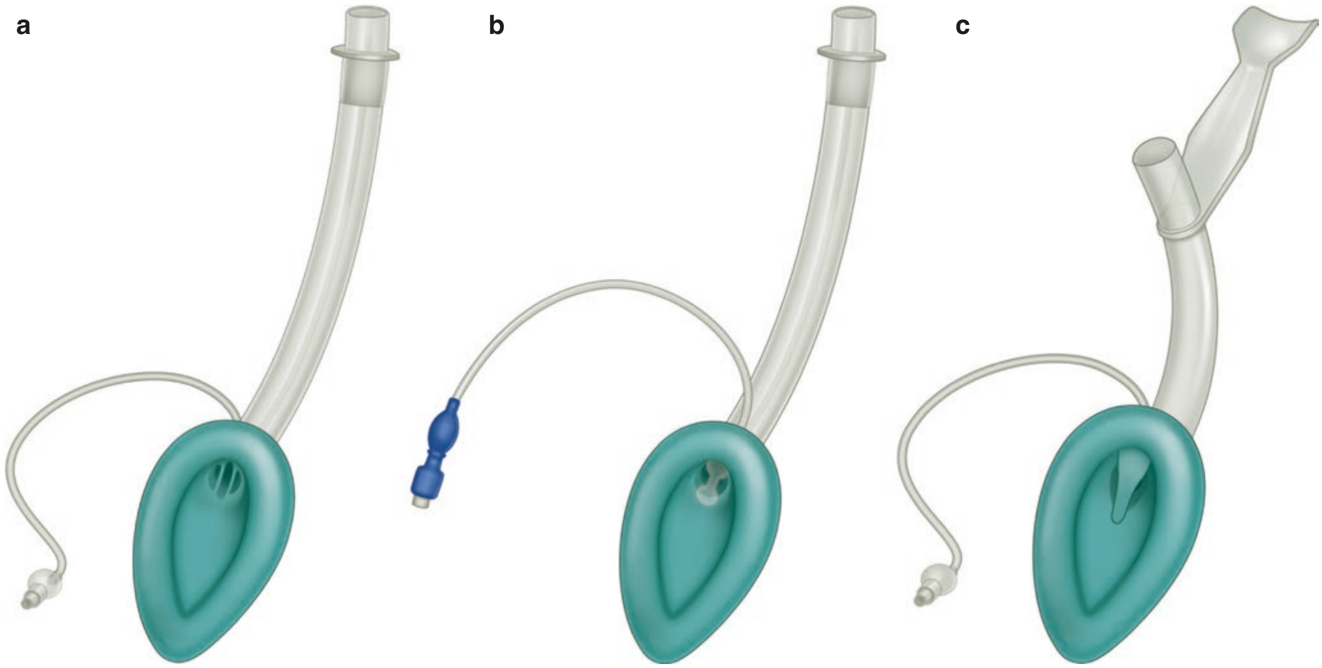
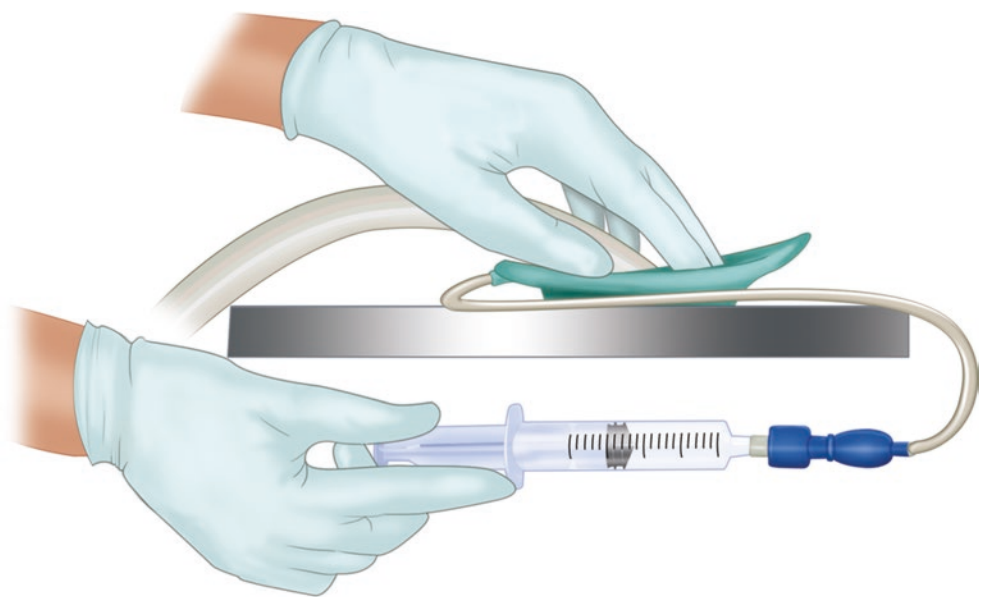


Fig. 10.1 Types of laryngeal mask airway (LMA): (**a**) LMA Unique™. (**b**) LMA Classic Excel™. (**c**) LMA Fastrach™

Fig. 10.2 Deflate the LMA cuff using a syringe



9. Continue to insert the LMA into the hypopharynx until resistance is felt. (At this point, the tip of the LMA is in the esophagus.)
10. Stabilize the tube with the nondominant hand, and remove the index finger of the dominant hand from the LMA.
11. Inflate the cuff of the LMA to at least half of the maximum value, using a syringe.
    - The LMA might move slightly outward during cuff inflation as the LMA positions itself in the hypopharynx.
12. Confirm placement and adequate gas exchange with continuous $EtCO_2$ capnography or colorimetry.

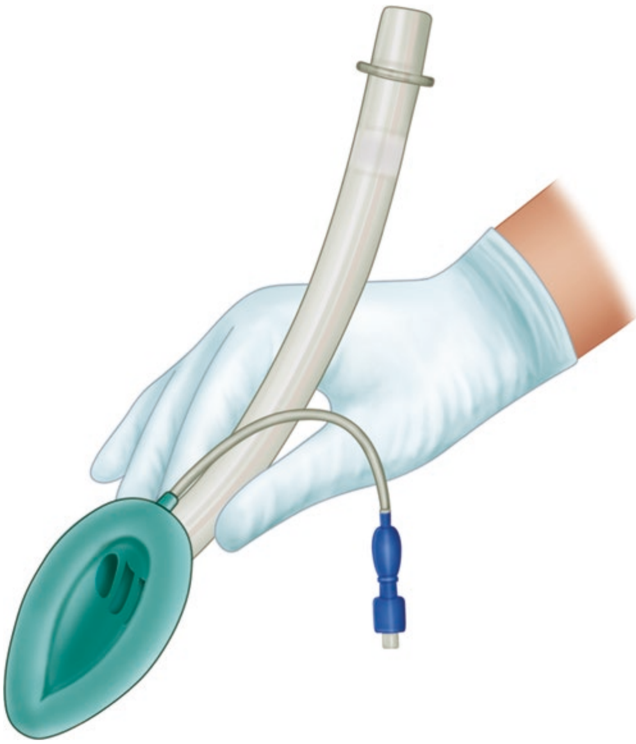


Fig. 10.3 Hold the LMA with the index finger positioned at the juncture of the tube and the cuff

LMA Fastrach

1. If using a reusable LMA Fastrach, ensure that it is sterile, and inspect it for any damage or wear.
2. Tightly deflate the cuff using a syringe, so that it forms a spoon shape.
3. Lubricate the posterior surface of the LMA with sterile lubricating jelly.
4. The LMA Fastrach may be inserted from any position with respect to the patient's head.
5. Position the patient's head in the neutral position. Do not extend the head.
6. Widely open the mouth with the nondominant hand.
7. Holding the handle of the LMA Fastrach, insert the device into the mouth, placing the deflated cuff flush with the superior palate.
   - Distribute the lubricant over the superior palate using a side-to-side motion to allow for easier insertion.
   - Ensure that the tip of the device does not fold over during insertion.
8. Using the handle, gently advance the LMA Fastrach directly into the oropharynx until the curved portion of tube comes into contact with the patient's chin (Fig. 10.5).
9. At this point, use the handle to rotationally advance the device further into the oropharynx following the natural curvature of the palate and posterior pharynx (Fig. 10.6).

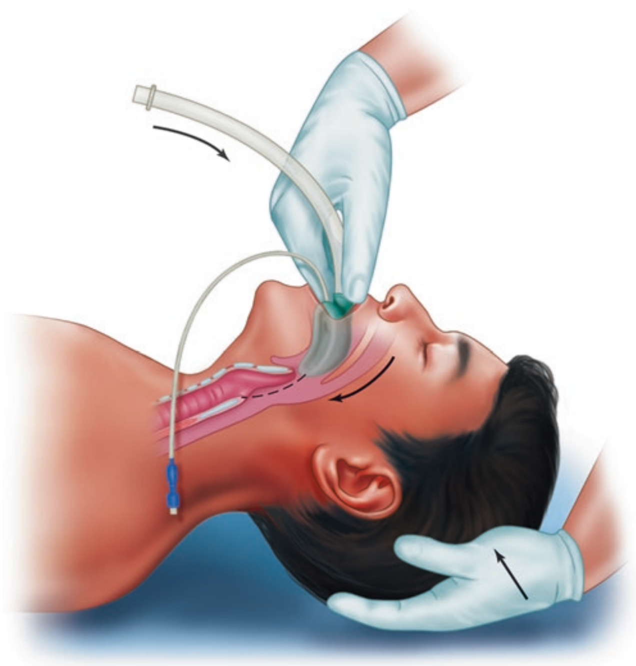


Fig. 10.4 Use the index finger to guide the LMA along the hard and soft palate

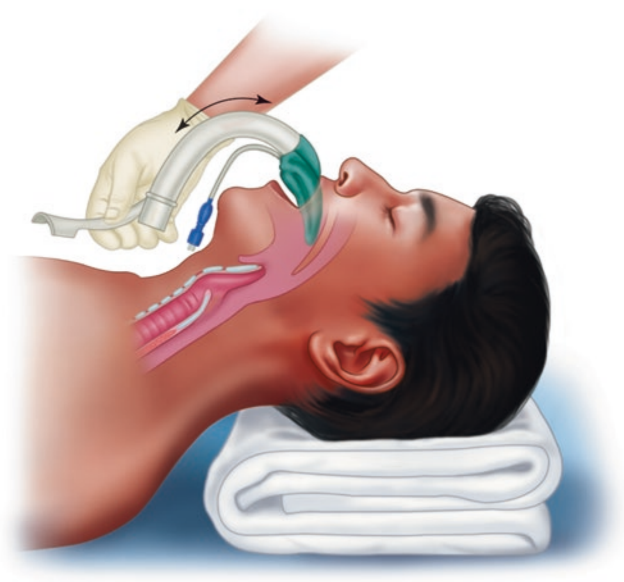


Fig. 10.5 Using the handle, insert the LMA Fastrach™ such that the posterior surface is in contact with the superior palate

Fig. 10.6 Once the tube is in contact with the chin, use the handle to rotationally advance the device further into the oropharynx

- Do not initiate any rotation until the tube is in contact with the patient's chin.

10. Once resistance is felt, inflate the cuff of the device to at least half of the maximum value, using a syringe.
    - Note that the tube is directed slightly caudally when properly inserted.
    - Confirm placement and adequate gas exchange with $EtCO_2$ capnography or colorimetry.

Endotracheal Intubation Through the LMA Fastrach

1. Ensure that the ETT will pass freely in the LMA.
2. Lubricate the cuff of the ETT.
3. Firmly hold the handle of the LMA Fastrach with the nondominant hand, and insert the ETT to a depth of 15 cm (Fig. 10.7), which places the ETT tip at the point of emerging from the LMA Fastrach.
    - Ensure that the tube does not pass beyond 15 cm at this point.
4. Using the handle of the LMA Fastrach, draw the device outward in order to displace the larynx slightly to accommodate insertion of the ETT (Fig. 10.8).
    - Use a lifting rather than a levering motion.
5. Carefully advance the ETT slightly further. If no resistance is felt, continue with insertion of the ETT (Fig. 10.9).

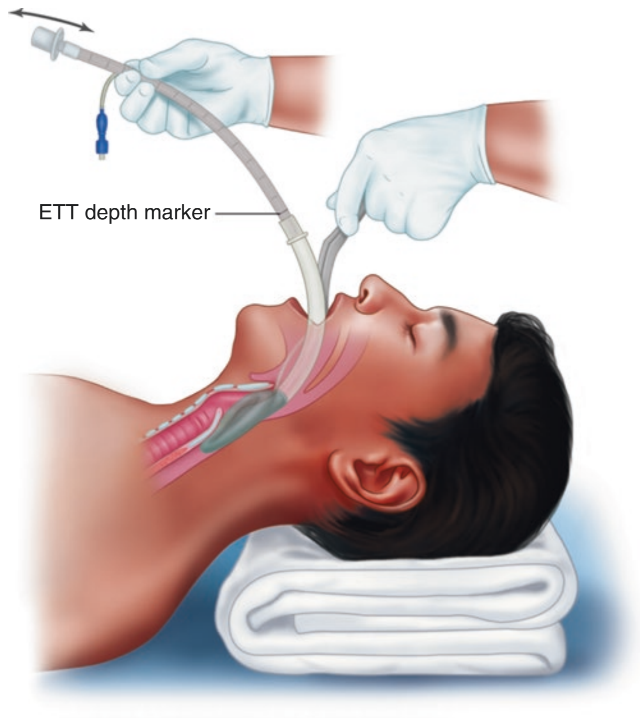


Fig. 10.7 While holding the handle of the LMA, insert the endotracheal tube (ETT) to the 15-cm mark

Fig. 10.8 Lift the handle outward to open the glottis for the ETT

Fig. 10.9 If no resistance is felt during further insertion of the ETT, the ETT may be fully advanced

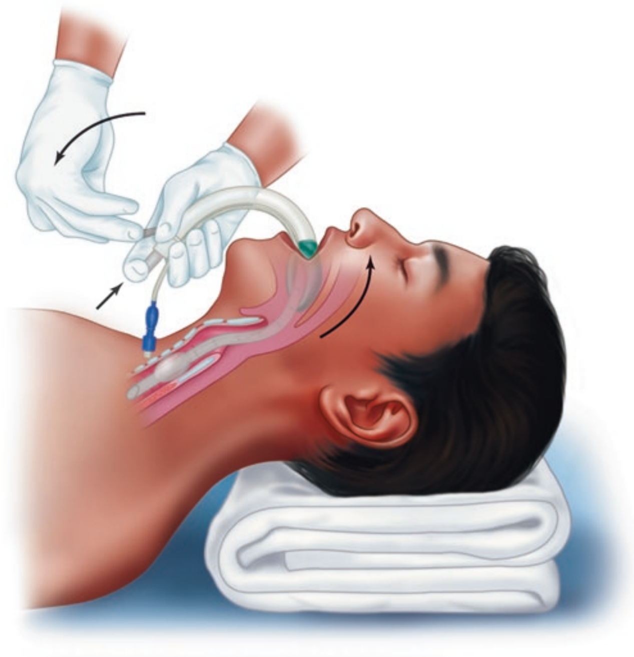


Fig. 10.10 Rotate the handle caudally to gently ease the LMA Fastrach out of the pharynx

6. Confirm placement and adequate gas exchange with $EtCO_2$ capnography or colorimetry.
7. Once successful confirmation of intubation is established, deflate the cuff pressure on the LMA Fastrach.

Removing the LMA Fastrach After Successful Intubation

1. The LMA Fastrach need not be removed immediately, but if removal is desired, first adequately oxygenate the patient, and then disconnect the patient from the circuit.
2. Remove the airway connector from the proximal end of the ETT.
3. Ensure that the cuff of the LMA Fastrach is entirely deflated.
4. Stabilize the ETT with the nondominant hand, and using the dominant hand, gently ease the LMA Fastrach out by rotating the handle caudally (Fig. 10.10).
5. Once the tube of the LMA Fastrach reaches the proximal end of the ETT, use the stabilizer rod to maintain the position of the ETT while continuing to remove the LMA Fastrach using the handle (Fig. 10.11).
6. After the cuff of the LMA Fastrach has been fully removed from the oral cavity, release the stabilizer rod,

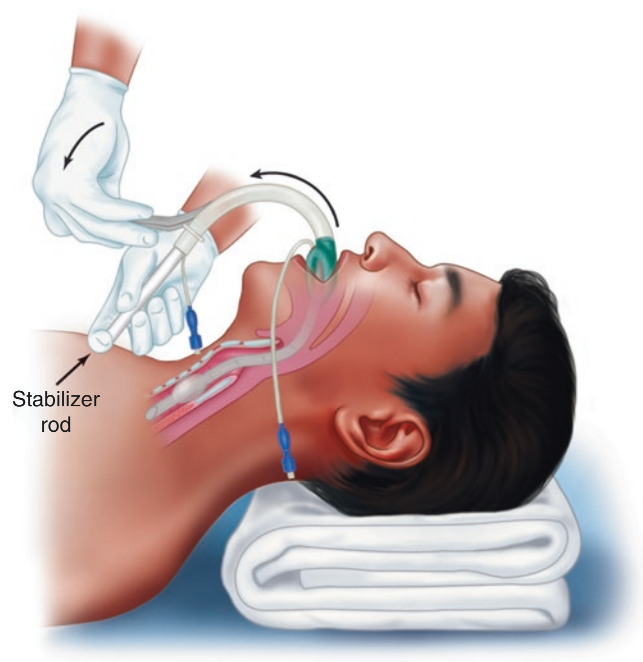


Fig. 10.11 Use the stabilizer rod to allow for further removal of the LMA Fastrach

Fig. 10.12 Once the cuff of the LMA Fastrach is out of the mouth, grasp the ETT distally, and remove the LMA entirely

Fig. 10.13 Carefully pass the pilot balloon and inflation line of the ETT cuff through the tube of the LMA Fastrach as it is removed

and ensure stability of the ETT by grasping it distally at the mouth with the nondominant hand (Fig. 10.12).

7. Continue to ease the LMA Fastrach out from around the ETT, ensuring that the pilot balloon and inflation line of the ETT cuff pass through the device (Fig. 10.13).
   - Take care not to rupture the pilot balloon or tear the inflation line of the ETT.
8. Replace the airway connector on the proximal end of the ETT, and reconnect the patient to the circuit.

Complications

- Regurgitation and aspiration with resulting pneumonitis
- Ineffective seal resulting in insufficient ventilation
- Malposition, dislodgement, laryngospasm, trauma to the upper airway
- Insufflation of the stomach
- Coughing, bucking, or breath holding
  – Ensure that the patient is adequately sedated.

Pearls and Pitfalls

- Cricoid pressure can push the tip of the LMA out of the esophagus and prevent optimal placement.
- LMAs provide rapid protection of the airway in the field and are technically easier to insert than an ETT. Consider a supraglottic airway as part of your initial advanced airway management plan during a cardiac arrest to limit interruptions to chest compressions, especially in a prehospital setting.
- Some models include a gastric port that allows for suctioning in hematemesis or regurgitation.

Suggested Reading

Barata I. The laryngeal mask airway: prehospital and emergency department use. Emerg Med Clin North Am. 2008;24:1069–83.

Benger JR, Kirby K, Black S, Brett SJ, Clout M, Lazaroo MJ, et al. Effect of a strategy of a supraglottic airway device vs tracheal intubation during out-of-hospital cardiac arrest on functional outcome: the AIRWAYS-2 randomized clinical trial. JAMA. 2018;320:779–91.

LMA Classic™ instructions for use. Research Triangle Park: Teleflex Medical; 2015. http://www.lmaco-ifu.com/sites/default/files/node/166/ifu/revision/4367/ifu-lma-classic-paa2100000buk.pdf.

LMA Fastrach™ Single Use instructions for use. Research Triangle Park: Teleflex Medical; 2015. http://lmacoifu.wpengine.com/sites/default/files/node/903/ifu/revision/3683/ifu-lma-fastrachettcombo-pms2100006aus.pdf.

Pollack CV. The laryngeal mask airway: a comprehensive review for the emergency physician. J Emerg Med. 2001;20:53–66.

Walls RW, Murphy MF, editors. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008.

Wang HE, Schmicker RH, Daya MR, Stephens SW, Idris AH, Carlson JN, et al. Effect of a strategy of initial laryngeal tube insertion vs endotracheal intubation on 72-hour survival in adults with out-of-hospital cardiac arrest: a randomized clinical trial. JAMA. 2018;320:769–78.

Combitube

11

Clint Masterson

Indications

- Need for ventilation and oxygenation in an unconscious, unresponsive, or paralyzed patient.
- Rescue airway needed after failed intubation.
- Any time it is not possible to visualize the cords.

Contraindications

- Absolute
  - Awake, responsive patient
  - Intact gag reflex
  - Known esophageal disease
  - Ingestion of caustic substances
  - Known esophageal disease (e.g., cancer, varices, scleroderma)
  - Patient less than 5 feet tall (unless the smaller *Combitube*® SA is used; it is suitable for patients 4 feet tall or taller)
  - Children under 16 years of **age**, unless at least 5 feet tall (or 4 feet tall if *Combitube*® SA)
- Relative
  - D50 or naloxone about to be given
  - Facial trauma

Materials

- Combitube sized based upon height (Fig. 11.1)
  - >5 feet—size 41 French (cuff inflation 15 and 100 mL)
  - >4 feet to <5.5 ft—size 37 French (cuff inflation 11 and 85 mL)

Procedure

1. Test both balloons and cuffs for leaks as one would an endotracheal tube (ETT).
2. Open up the airway:
   (a) Use a laryngoscope to move the tongue and open the oropharynx or
   (b) Use the left hand to elevate the chin, elevating the tongue and pharyngeal tissue.
3. Insert Combitube blindly into the oropharynx until the teeth lie between the two black bands on the proximal Combitube (Fig. 11.2).
4. Inflate the proximal blue cuff until the manufacturer's recommended pressure is reached:
   (a) 85 mL for 37 French Combitube
   (b) 100 mL for 41 French Combitube
5. Inflate the distal white cuff until the manufacturer's recommended pressure is reached:
   (a) 12 mL for 37F Combitube
   (b) 15 mL for 41F Combitube
6. Identify placement and attach to oxygen:
   (a) Ventilate through tube #1 (blue).
   (b) Auscultate the stomach and lungs:
      (i) If breath sounds are heard, the Combitube is in its more common esophageal location.
      (ii) Attach tube #1 to bag valve mask and O_2.
   (c) *Only if* gurgling is present over stomach when tube #1 is ventilated:
      (i) Ventilate through tube #2 (white).
      (ii) If breath sounds are heard, the Combitube is in the less common tracheal location.
      (iii) Attach tube #2 to bag valve mask and O_2.
7. If no breath sounds are heard in either location:
   (a) Consider obstruction—Combitube may be obstructing the glottis or collapsing the trachea owing to deep proximal cuff inflation:

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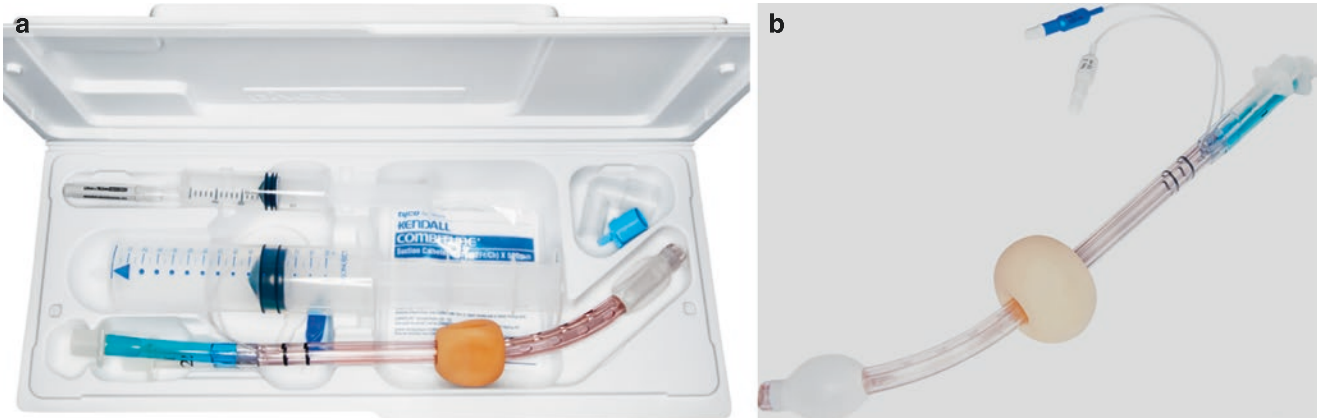

Fig. 11.1 Combitube equipment (**a**) Combitube in box (**b**) Inflated

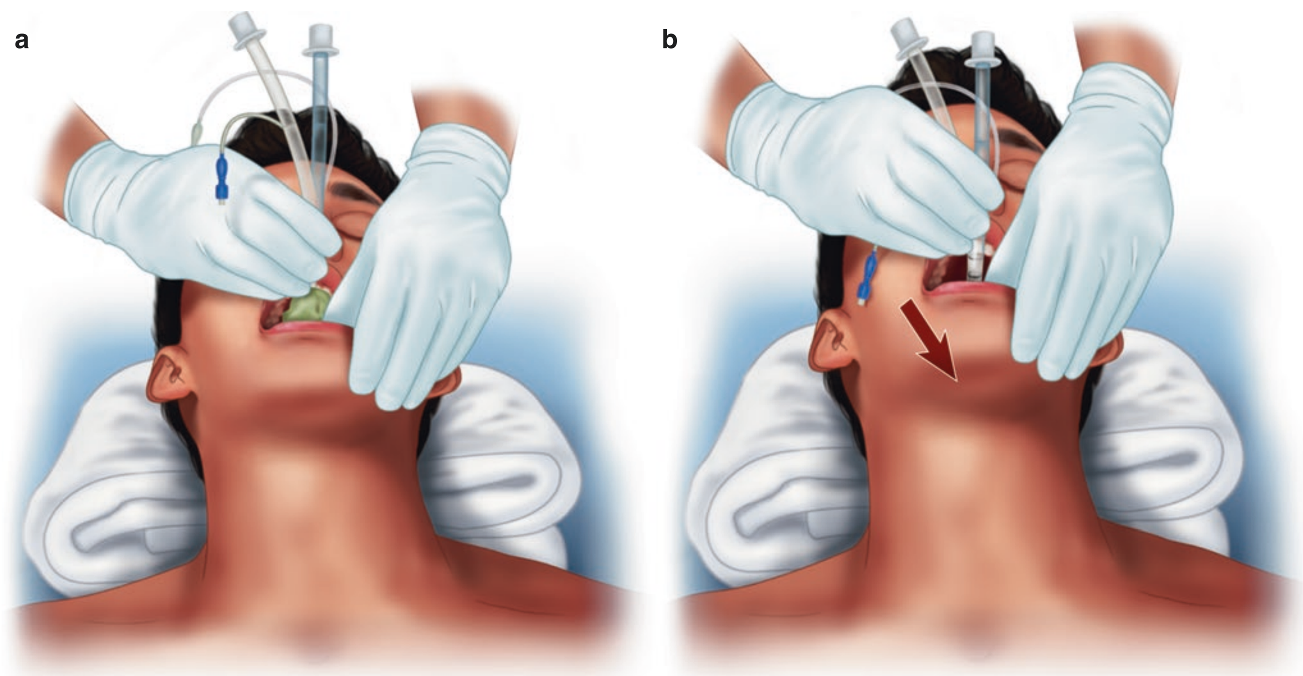

Fig. 11.2 (**a**) Insertion of Combitube. (**b**) Teeth should lie between the two black bands on the proximal Combitube

- (i) Deflate the cuffs.
- (ii) Withdraw 3 cm.
- (iii) Reinflate and start from step 4.

(b) Consider equipment failure:

- (i) Check that balloons are maintaining pressure and intact.

(c) Consider reinsertion.

8. Confirm placement with capnogram and pulse oximetry.
9. Secure the Combitube in position (Fig. 11.3).

Pearls and Pitfalls

- Pearls
  - In an esophageal intubation situation, a suction tube may be threaded down tube #1 to decompress the stomach.
  - The Combitube comes with an L-shaped piece that may also be attached to the end of tube #2 to deflect gastric contents away from practitioners.
- Pitfalls

Fig. 11.3 Secure the Combitube in position

- After Combitube placement, a definitive airway should be placed when possible:
  - Gastric contents may aspirate despite placement of the Combitube.
  - Combitube should be considered a bridging airway device.
- Combitubes are associated with a more pronounced hemodynamic stress response than ETTs or laryngeal mask airways (LMAs).
- Balloon overinflation can lead to esophageal rupture (albeit rare).
- Combitubes are associated with an increased incidence of sore throat, dysphagia, and upper airway hematomas than ETTs and LMAs.
- Piriform sinus perforation.

Suggested Reading

Agro F, Frass M, Beunmof JL, Krafft P. Current status of the Combitube: a review of the literature. J Clin Anesth. 2002;14:307–14.

Laurin E, Bair A. Devices for difficult airway management in adults. www.uptodate.com. Accessed 28 July 2019.

Liem EB. Combitube insertion. University of Florida Department of Anesthesiology, Center for Simulation, Advanced Learning and Technology, Virtual Anesthesia Machine Web site. 2006. http://vam.anest.ufl.edu/airwaydevice/combitube/index.html. Accessed 28 July 2019.

Walls R, Murphy M. Manual of emergency airway management. Philadelphia: Lippincott Williams & Wilkins; 2008.

Assessment of the Difficult Airway

12

Melinda W. Fernandez and Lars K. Beattie

Indications

- Should be performed on all patients that require airway management, conditions permitting
- Respiratory distress
- Airway protection

Materials and Medications

- None required for assessment

Procedure

1. Anticipating a difficult airway in emergency department patients is the first step to avoiding an unexpected surgical airway.
2. Two mnemonics can be applied quickly and easily to aid in airway assessment: MOANS and LEMON.

Predicting Bag Valve Mask Difficulty

1. Use the mnemonic *MOANS* to assess for possible bag valve mask (BVM) difficulty:
   - *M*—mask seal. Will you be able to get a good seal on the face? Predictors of difficulty include facial hair such as a beard or a patient with loss of muscle tone in the face due to being elderly or emaciated.
   - *O*—obesity. Body mass index (BMI) >30.
   - *A*—age (>55 years). Loss of facial muscle tone can make bagging difficult.
   - *N*—no teeth. Although being edentulous makes intubation easier, it makes bagging more difficult.
   - *S*—stiff lungs. Acute or chronic lung disease can make a person difficult to bag. In the setting of trauma, pulmonary contusions or other direct lung injuries may increase BVM difficulty.

Predicting Difficult Laryngoscopy

1. If at all possible, attempt to assess for a potentially difficult airway. This does not mean you cannot perform direct laryngoscopy if you are anticipating a difficult airway, but it does force you to consider all options and to have a solid backup plan in place, with backup equipment readily available in the room.
2. Use the mnemonic *LEMON* to predict difficult direct laryngoscopy:
   - *L*—look. A quick look at the patient will tell you a lot. Are there facial injuries, facial anomalies, obesity, a short thick neck, or a small mouth or mandible?
   - *E*—evaluate. Use the 3-3-2 rule to quickly assess for the strongest predictors of difficult laryngoscopy (Fig. 12.1):
     – *3*: When the patient's mouth is open, three vertically aligned fingers should fit between the incisors.
     – *3*: Three finger widths should fit along the length of the mandible from the mentum to the hyoid bone. Shorter or longer distances may make for a difficult intubation.
     – *2*: The thyromental distance should ideally be two fingers. Measure this from the hyoid to the thyroid.
   - *M*—Mallampati classification (Fig. 12.2). If the patient's condition and situation allow, have the patient

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Fig. 12.1 *The 3-3-2 rule:* 3-finger inter-incisor distance (**a**); 3-finger distance from the anterior tip of the mandible to the anterior neck (**b**); 2-finger distance from the floor of the mandible to the thyroid notch (**c**)

open the mouth wide, stick out the tongue, and say "Ahh." Evaluate for visible structures:
  - *Class I:* Tonsillar pillars and the entire uvula are visible.
  - *Class II:* More than the base of the uvula is visible but no pillars are visible.
  - *Class III:* Only the base of the uvula is visible.
  - *Class IV:* No uvula or soft palate is visible. Only the hard palate is visible.

  These classifications correlate with the Cormack-Lehane grading system for laryngoscopic views. A Mallampati class I will correlate with a grade 1 view about 99% of the time, whereas a Mallampati IV will always be a grade 3 or 4 view, and a rescue plan with backup equipment immediately available should always be in place [1, 2].
- *O*—obstruction. Observe for anything that can get in the way (e.g., the tongue, dentures, blood, vomit, foreign body, edema, redundant tissue).
- *N*—neck mobility. If the patient's condition and situation allow, have the patient flex and extend the neck to evaluate mobility. Many patients in the emergency department have limited neck mobility, such as a trauma patient who arrives in cervical collar immobilization or a patient with degenerative or rheumatoid arthritis.

3. The *6-D* method is another assessment tool that can be used to predict difficult laryngoscopy and intubation. This method can be remembered by the fact that the word "difficult" begins with the letter "D":
   - *Disproportion*
     - Increased tongue size in relation to pharyngeal size
     - Airway swelling or trauma
   - *Distortion*
     - Neck mass, hematoma, abscess, previous surgical airway, arthritic neck changes
   - *Decreased thyromental distance*
     - Anterior larynx and decreased mandibular space.
     - Look for a receding chin or greater than three fingerbreadths from the mentum to the hyoid bone.
   - *Decreased inter-incisor gap*
     - Reduced mouth opening.
     - Look for less than two to three fingerbreadths placed vertically in the patient's open mouth.

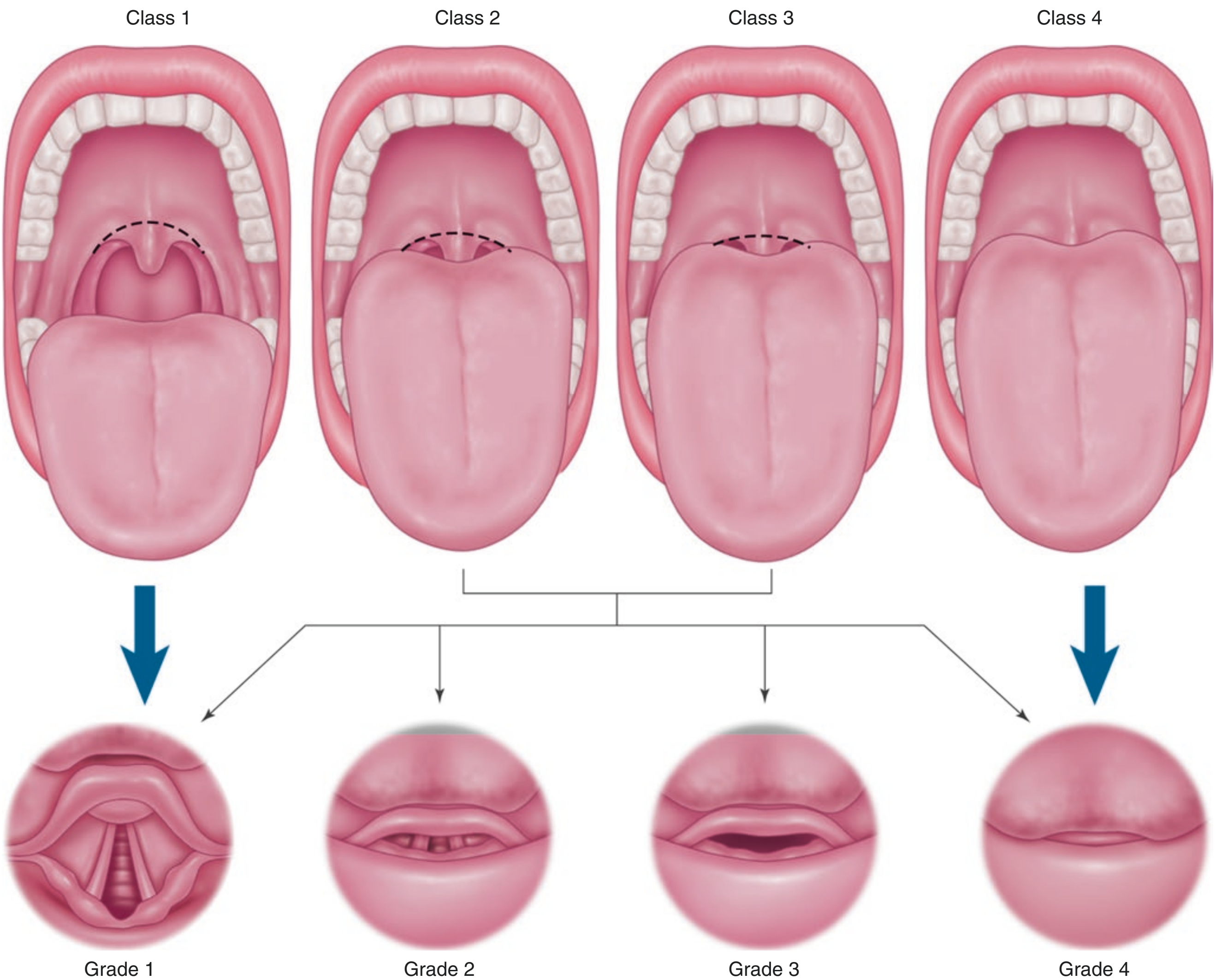

Fig. 12.2 Mallampati classification

- *Decreased range of motion in any joints of the airway*
  - Limited head extension
  - Previous neck radiation and/or surgery
  - Neck contractures
- *Dental overbite*
  - Oversized, angled teeth disrupt the alignment of airway axes.
  - Can decrease the inter-incisor gap.

Optimizing Laryngoscopy in the Obese Patient

- It is essential that emergency medicine physicians are able to successfully intubate the obese patient.
- Proper assessment and positioning will increase the success rate:
  - The goal is to ensure alignment of the oropharyngeal-pharyngeal-laryngeal (OA-PA-LA) airways by placing the patient in the head-elevated laryngoscopy position.
  - Align the external auditory meatus with the sternal notch along a horizontal line by positioning the patient on a "ramp."
  - The ramp can be created by stacking blankets or towels under the lower back, ramping up to the neck and head (Fig. 12.3).
- While the patient is in position on the ramp, the support is adjusted to minimize head flexion and allow for positioning in the sniffing position.
  - Because of the increased height, a step stool may be required to adequately visualize the airway from the head of the bed.

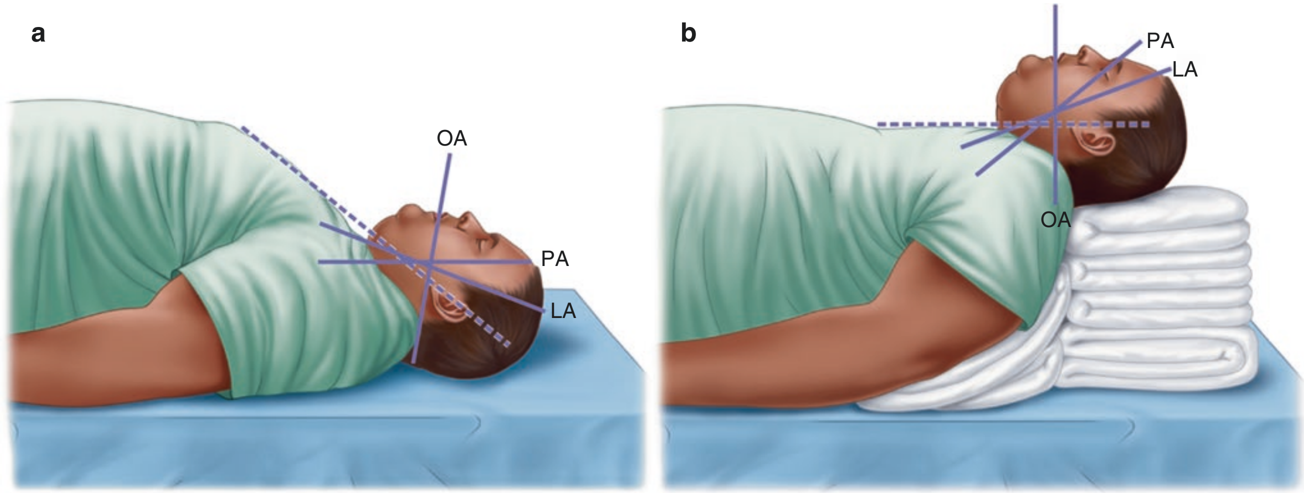

Fig. 12.3 (**a** and **b**) Ramping the obese patient will align the axes of the airway and allow easier direct laryngoscopy when viewed from the head of the bed. LA laryngeal airway, OA oropharyngeal airway, PA pharyngeal airway

Other Difficult Factors

- In addition to the patient's anatomy, other factors can make it difficult to establish a definitive airway:
  – When did the patient last eat? A full stomach will increase risk of regurgitation, vomiting, and aspiration.
  – In patients who have hematemesis, hemoptysis, or airway trauma, blood may impede visualization of the glottis.
  – The patient may have extremely short safe apnea times. Consider physiologic factors that make intubating unsafe or may lead to rapid deterioration:
    Hypotension: Medications used for preintubation or rapid sequence intubation (RSI) may potentially cause it.
    Oxygenation: Obese patients who have not had proper preoxygenation may have minimal O_2 reserve and desaturate rapidly.
    pH: Patients with diabetic ketoacidosis (DKA) and other profoundly acidotic patients may become bradycardic or arrest when their compensatory hyperventilation is removed.

Pearls and Pitfalls

- Owing to time-sensitive patient care situations, emergency physicians are often not able to perform a thorough airway evaluation on every patient.
- With every airway that you manage and before pushing any drugs, always ask yourself:
  – Will I be able to ventilate this patient?
  – Will I be able to intubate this patient?
  – What is my difficult airway plan if I encounter trouble?
  – Will I be able to perform a surgical airway, if necessary?
- Be sure you have a solid backup plan (A, B, and C) before pushing any drugs.
  – Have backup airway equipment at the bedside, in the resuscitation room, or within arm's reach.
  – These include—but are not limited to—alternative laryngoscope blades, video scopes, laryngeal mask airway (LMA) or other supraglottic devices, bougie, and surgical airway cricothyrotomy (cric) kit.
  – Verbally discuss your plan with your team.
- Call for assistance early. If you are uncomfortable as you anticipate a particularly difficult airway and time allows, have a more experienced proceduralist at the bedside, including a more senior provider, anesthesiology/ENT for fiber-optic intubation, or surgeon for cricothyrotomy.

References

1. Lee A, Fan LT, Gin T, Karmakar MK, Ngan Kee WD. A systematic review (meta-analysis) of the accuracy of the Mallampati tests to predict the difficult airway. Anesth Analg. 2006;102:1867–78.
2. Boschert S. Think L-E-M-O-N when assessing a difficult airway. ACEP News. Nov 2007.

Selected Reading

Henderson JJ, Popat MT, Latto IP, Pearce AC, Difficult Airway Society. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. Anaesthesia. 2004;59:675–94.

Murphy M. Bringing the larynx into view: a piece of the puzzle. Ann Emerg Med. 2003;41:338–41.

Rich JM. Recognition and management of the difficult airway with special emphasis on the intubating LMA-Fastrach/whistle technique: a brief review with case reports. Proc (Bayl Univ Med Cent). 2005;18:220–7.

Roberts J, Hedges J. Clinical procedures in emergency medicine. 5th ed. Philadelphia: WB Saunders; 2009. p. 60–2.

Weingart S. The HOP mnemonic and AirwayWorld.com next week. EMCrit Blog. 2012. https://emcrit.org/emcrit/hop-mnemonic/. Accessed 23 May 2019.

Wilson W. Difficult intubation. In: Atlee J, editor. Complications in anesthesia. Philadelphia: WB Saunders; 1999. p. 138–47.

13 GlideScope

Sohan Parekh

Indications

- Initial device in a predictably difficult airway
- Initial device in trauma patient with cervical spine immobilization
- Rescue device in a failed intubation

Contraindications

- Absolute
  - Inadequate mouth opening
- Relative
  - Blood, vomit, or other secretions that can coat and obstruct the camera lens

Materials and Medications

- GlideScope video monitor with video cable (GlideScope Video Laryngoscope [GVL] system) (Fig. 13.1) or appropriate size video baton (Cobalt system) (Fig. 13.2)
- Appropriate size reusable video laryngoscope (GVL) or single-use laryngoscope blade (GVL Stat) (Table 13.1)
- Endotracheal tube (ETT)
- Malleable stylet or GlideRite rigid stylet
- 10 mL syringe
- End-tidal CO_2 ($EtCO_2$) capnography or colorimetry

Fig. 13.1 GlideScope video laryngoscope (GVL) system. (*From* Noppens et al. [1]; with permission)

Procedure

1. Insert the video cable (GVL system) or the video baton (cobalt system) into the GlideScope video monitor (Fig. 13.3).
2. If using the GVL system, insert the distal end of the video cable into the port on the handle of the reusable video laryngoscope (GVL) (Fig. 13.4).

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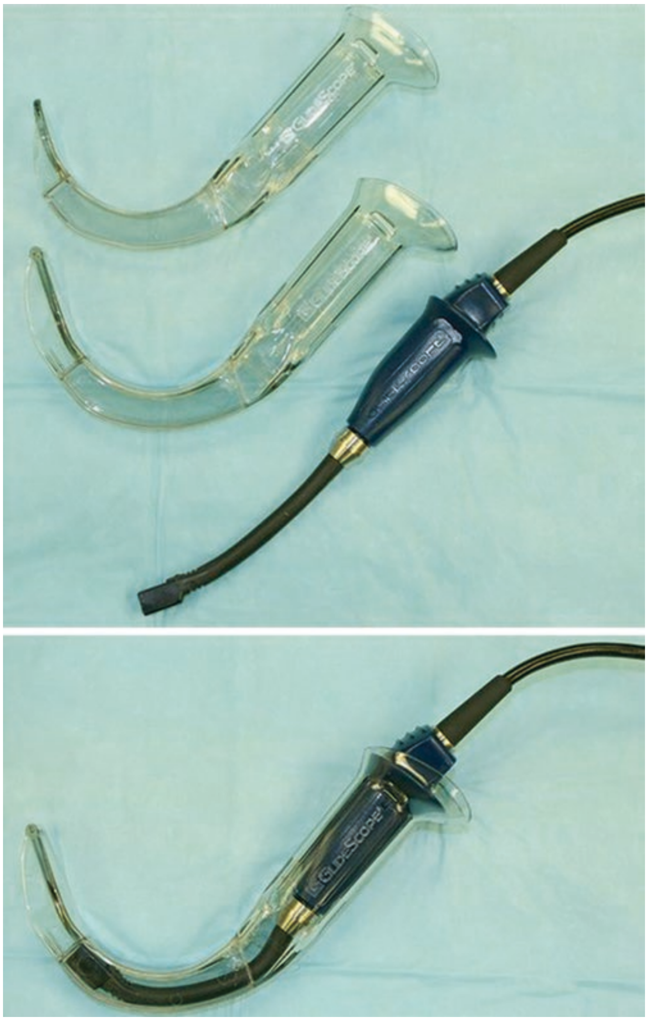

Fig. 13.2 GlideScope cobalt system. (*From* Jones et al. [2]; with permission)

3. If using the cobalt system, insert the video baton into the single-use laryngoscope blade (GVL stat) (Fig. 13.5).
   (a) Align the logo on the side of the video baton with the logo on the side of the GVL stat.
   (b) The video baton should slide smoothly and click into place.
4. Turn on the GlideScope for at least 30 to 120 seconds before use to fully activate the antifog mechanism.
5. Insert a stylet into the ETT. If using a malleable stylet, shape the curvature of the distal end of the tube to conform to the 60° curvature of the laryngoscope blade.
6. Firmly hold the laryngoscope handle in the left hand, and ensure that an image can be clearly seen on the video monitor.
7. After ensuring adequate sedation and paralysis, open the mouth wide, and insert the laryngoscope blade in the midline under the tongue (Fig. 13.6).
8. Looking at the video monitor, advance the laryngoscope blade further into the oropharynx in order to obtain a view of the epiglottis.
   - Do not look directly into the oropharynx.
   - Movements and adjustments should be guided by the image on the video monitor.
9. Place the laryngoscope blade in the vallecula (analogous to a Macintosh blade), and apply a gentle backward tilt to expose the glottis.
10. If a satisfactory glottic view cannot be obtained, the laryngoscope blade may be advanced and used like a Miller blade to lift the epiglottis out of the way.
11. Directing attention back toward the patient, insert the ETT into the mouth adjacent to the laryngoscope blade.
12. Guide the ETT toward the tip of the laryngoscope such that the end of the ETT emerges on the video monitor.

Table 13.1 GlideScope sizing and GVL stat sizes [3]

				Video baton 1–2			Video baton 3–4	
GVL 1	**GVL 2**	**GVL 3**	**GVL 4**	**Stat 0**	**Stat 1**	**Stat 2**	**Stat 3**	**Stat 4**
1.8–10 kg	10 kg—adult	40 kg—morbidly obese	40 kg—morbidly obese	<1.5 kg	1.5–3.6 kg	1.8–10 kg	10 kg—adult	40 kg—morbidly obese

GVL stat sizes		
Stat	**Video baton**	**Recommended patient weight/size**[a]
GVL 0	Video baton 1–2	<1.5 kg (3.3 lb)
GVL 1	Video baton 1–2	1.5–3.8 kg (3.3–8.4 lb)
GVL 2	Video baton 1–2	1.8–10 kg (4–22 lb)
GVL 2.5	Video baton 1–2	10–28 kg (22–61.7 lb)
GVL 3	Video baton 3–4	Between 10 kg/adult (22 lb–adult)
	Video baton 2.0 large (3–4)	
GVL 4	Video baton 3–4	Between 40 kg/large adult (88 lb/large adult)
	Video baton 2.0 large (3–4)	

[a]Weight ranges are approximate; a medical professional must evaluate on a patient-by-patient basis

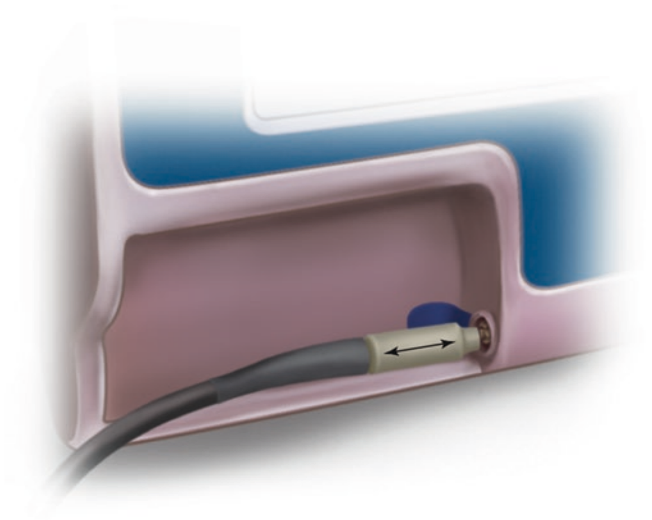

Fig. 13.3 Cable insertion into the video monitor

Fig. 13.4 Connect the distal end of the video cable into the port on the handle of the GlideScope video laryngoscope (GVL)

Fig. 13.5 Slide the video baton into the GVL stat (cobalt system)

Fig. 13.6 Insert the laryngoscope blade in the midline beneath the tongue. (*From* Osborn et al. [4]; *with permission*)

13. Looking at the video monitor, advance the ETT toward the glottis, and maneuver the tip of the tube between the vocal cords by rotating and altering the angle of the ETT.
    - If the ETT tip is posterior to the arytenoids:
      – Pull the ETT superiorly, rotate it over the left arytenoid, and gently twist the tube over the epiglottic aperture.
      – Apply external laryngeal manipulation.
      – Withdraw the blade to reduce tilting of the laryngeal axis and lessen the angle of introduction.
    - If the ETT abuts the false vocal cords, turn the ETT in the clockwise direction while withdrawing the stylet.
14. Using the thumb, partially withdraw the stylet a few centimeters from the ETT (Fig. 13.7).
    - The distal end of the tube should be free of the stylet.
    - An assistant can perform this task to allow for greater control and stability of the ETT.
15. Insert the ETT to the desired depth.
16. Fully remove the stylet, use a syringe to inflate the cuff of the ETT, and confirm placement with end-tidal carbon dioxide ($EtCO_2$) capnography or colorimetry.

Complications

- Dental injury
- Airway trauma

Fig. 13.7 Partially withdraw the stylet from the ETT to allow for passage through the vocal cords

Pearls and Pitfalls

- Unlike conventional laryngoscopy, there is no need to aggressively sweep the tongue to the left.
- Occasionally, the patient's chest may prevent insertion of the scope into the mouth through a midline approach. In this case, insert the scope at 90°, and then rotate back to midline prior to advancing the scope, similar to inserting an oropharyngeal airway (OPA).
- The greatest challenge when intubating with the GlideScope is maneuvering the ETT into the glottis aperture. There are alternatives to the conventional technique:
  - Make a 90° bend in the ETT just proximal to the cuff, and insert it in the horizontal direction, with the tip toward the right cheek. Once the tube is advanced past the flange of the laryngoscope, rotate it counterclockwise, at which point it should be pointed at the glottis. The tube can then be gently rotated into the glottis.
  - Consider inserting the laryngoscope slightly to the left of the midline upon initial insertion, to allow greater space for advancement and maneuvering of the ETT.
- To manipulate the ETT more anteriorly, use your thumb to remove the rigid stylet slightly (roughly 1 cm) out of the ETT, or have an assistant pull it. Doing this will change the angle at which the ETT is bent.
- If there is blood in the airway, consider advancing suction into the mouth prior to insertion of the videoscope, as blood on the video camera will completely obstruct your view.
- Do not overly lever the laryngoscope or use excessive lifting force after insertion into the vallecula. An adequate view of the glottis is generally easily obtained with minimal effort.
- Video laryngoscope blades are hyperangulated, so they conform to the airway better in a natural supine position. Consider using GlideScope in patients in whom cervical spine manipulation is a concern.
- Given the hyperangulated shape of the blade, be sure to form malleable blades and bougies in the same curvature, as the airway will now be more anterior and curved and in the usual sniffing position.
- Display settings can be adjusted using the menu button on the video monitor.

References

1. Noppens RR, Werner C, Piepho T. Indirekte laryngoskopie. Der Anaesthesist. 2010;59:149–61.
2. Jones PM, Turkstra TP, Armstrong KP, Armstrong PM, Harle CC. Comparison of a single-use GlideScope Cobalt videolaryngoscope with a conventional GlideScope for orotracheal intubation. Can J Anaesth. 2010;57:18–23.
3. GlideScope GVL and Cobalt user's manual & quick reference guide. Bothell, WA: Verathon Inc.; 2009–2011.
4. Osborn IP, Kleinberger AJ, Gurudutt VV. Airway emergencies and the difficult airway. In: Levine AI, Govindaraj S, DeMaria S, editors. Anesthesiology and otolaryngology. New York: Springer; 2013.

Suggested Reading

Cho JE, Kil HK. A maneuver to facilitate endotracheal intubation using the GlideScope. Can J Anaesth. 2008;55:56–7.

Kramer DC, Osborn IP. More maneuvers to facilitate tracheal intubation with the GlideScope. Can J Anaesth. 2006;53:737.

Lim HC. Utilization of a GlideScope videolaryngoscope for orotracheal intubations in different emergency airway management settings. Eur J Emerg Med. 2009;16:68–73.

Walls RM, Murphy MF. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2007.

14 Endotracheal Tube Introducer (Bougie)

Joseph Rabinovich

Indications

- During orotracheal intubation, when only epiglottic visualization or partial glottic view is obtained during laryngoscopy.
- Particularly useful when neck mobility is limited, leading to inadequate visualization of the glottis (as in the case with cervical spine immobilization).
- When the glottic opening is narrowed from pathological causes (burns, trauma, tumor) or other anatomical variations.
- When the direct view of the airway is very narrow, as with limited mouth opening or large tongue. In these scenarios, the endotracheal tube (ETT) can obstruct one's view of the cords during placement.

Contraindications

- When a failed airway occurs (three unsuccessful attempts at endotracheal intubation and inability to adequately oxygenate)
- When surgical airway is indicated (i.e., upper airway obstruction that prevents passage of the ETT via the orotracheal route)

Materials and Medications

- ETT introducer (bougie) (Fig. 14.1)
- Water-based lubricant
- Lubricated ETT 6 mm or larger without stylet (Pediatric bougies are available that accommodate smaller ETTs.)
- Standard orotracheal direct laryngoscopy (Miller or Macintosh blade) or video laryngoscopy setup
- Assistant

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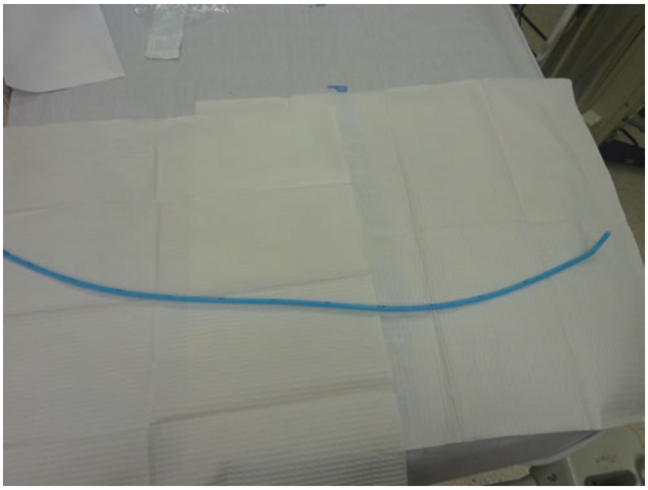

Fig. 14.1 Endotracheal tube introducer (bougie)

Procedure

1. The operator first optimizes airway visualization (Fig. 14.2). (Bougie use should not be a substitute for poor technique.)
2. Without losing sight of the airway, the operator asks the assistant to hand him or her the bougie with the coudé tip facing up.
3. The operator directs the bougie tip underneath the epiglottis (Fig. 14.3).
4. Confirmation of placement can be done visually or by tactile sensation:
   - A ratchet-like sensation may be felt as the bougie tip is advanced into the airway and slides over the tracheal rings.
   - As the bougie is further advanced, the operator may feel the bougie rotate as it enters the bronchus and/or will get a "hold up," the most reliable sign that the bougie is in the trachea [1]. (The "holdup" sign occurs when the bougie encounters a terminal bronchus, typically at about 35 cm, and stops advancing [2].)

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Fig. 14.2 (**a**) Assistat hands operator bougie with coudé tip directed upward, while operator remains focused on the target. (**b**) Bougie being placed, parallel with line of sight, underneath the epiglottis

Fig. 14.3 Bougie can be placed into the glottis using direct laryngoscopy or video assistance

5. Once placement is confirmed, the bougie should be partially withdrawn to about 25 cm at the lip line.
   - Some brands have a thick black indicator line.
   - A sufficient amount of the bougie needs to extend out beyond the proximal end of the ETT.
6. While the operator holds the bougie in place, the assistant threads the ETT over the bougie (Fig. 14.4).
7. The operator now grasps the ETT in her or his right hand and advances it over the bougie.
8. Simultaneously, the assistant holds and stabilizes the proximal end of the bougie.
9. The ETT should be advanced to approximately 23 cm in men and 21 cm in women. The assistant removes the bougie as the operator holds the ETT in place (Fig. 14.5).
10. As the operator holds the ETT firmly in position, the assistant inflates the ETT balloon and withdraws the bougie.
11. Confirmation of proper ETT placement is achieved through traditional means (end-tidal CO_2 detection, auscultation of breath sounds).

Complications

- Trauma to the esophagus, larynx, trachea, or bronchus, including perforation [3–5].
- In general, complications are rare.

Pearls and Pitfalls

- The line of sight should be as parallel as possible to the axis of the bougie as it is being passed, allowing better eye-hand coordination and resulting in more accurate placement of the bougie tip.
- Maintain the view of the airway as the assistant hands the operator the bougie.
- Keep the laryngoscope in place to support the soft tissues, as the endotracheal tube is slid over the bougie, to facilitate placement.
- If resistance is met during passage, withdraw the ETT slightly (about 2 cm), rotate the ETT counterclockwise one-quarter turn (90°), and reattempt passage.
  – This changes the position of the leading edge of the ETT, which may catch on the posterior laryngeal inlet [2].

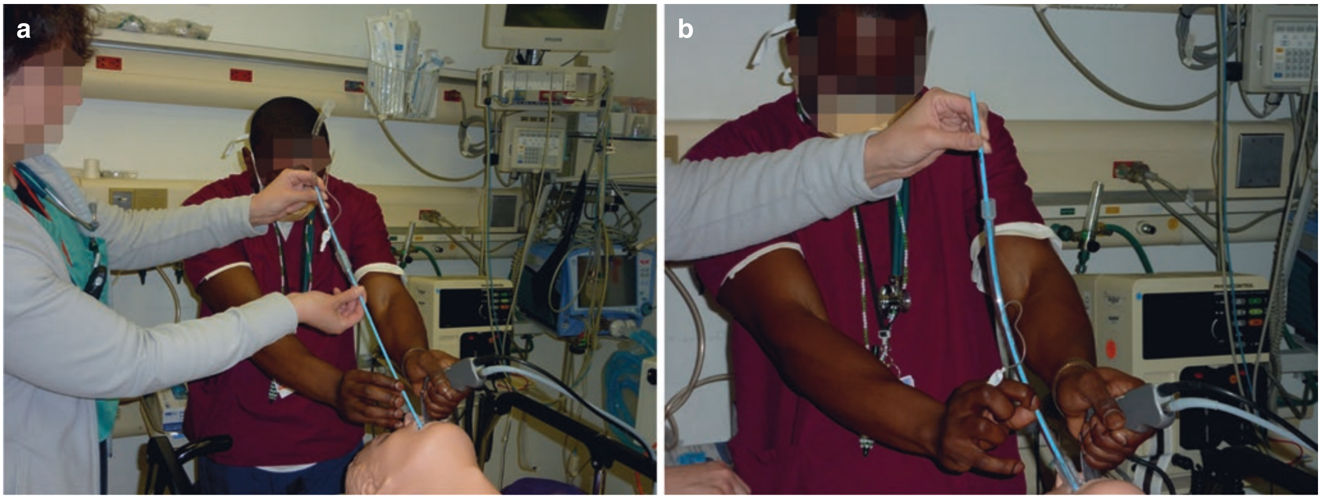

Fig. 14.4 (**a**) The assistant places the ETT over the bougie, and the operator withdraws the bougie until it protrudes out the top of the ETT. (**b**) Meanwhile, the assistant stabilizes the protruding portion of the bougie, and the operator railroads the ETT into the airway. The operator continues to support the soft tissues with the laryngoscope blade to facilitate placement

Fig. 14.5 The assistant removes the bougie while the operator stabilizes the endotracheal tube

  – By rotating the ETT, the leading edge now is anterior-facing and is less likely to catch on the arytenoid cartilage or other laryngeal inlet structures.
- If encountering resistance to ETT placement, consider releasing cricoid pressure (if used).
- Measurement markings on the bougie are aligned with the coudé tip. If not sure of orientation and the loose site of the tip, use the markings to properly orient the tip.
- If using a hyperangulated blade such as a GlideScope, form the bougie to the shape of the blade for a more anterior approach.
- Preload an ETT onto a bougie, curling the bougie and inserting the non-coudé tip into the eyelet of the ETT.
- The bougie may be passed into one of the main bronchi by rotating 90° in the preferred direction. This technique may be useful in massive hemoptysis to preferentially intubate and oxygenate only one lung.
- Always have a bougie and other airway adjuncts in the setting of a possibly difficult airway.

References

1. Kidd JF, Dyson A, Latto IP. Successful difficult intubation. Use of the gum elastic bougie. Anaesthesia. 1988;43:437–8.
2. Murphy MF, Hung OR, Law JA. Tracheal intubation: tricks of the trade. Emerg Med Clin North Am. 2008;26:1001–14.
3. Kadry M, Popat M. Pharyngeal wall perforation – an unusual complication of blind intubation with a gum-elastic bougie. Anaesthesia. 1999;54:404–5.
4. Smith BL. Haemopneumothorax following bougie-assisted tracheal intubation. Anaesthesia. 1994;49:91.
5. Driver BE, Prekker ME, Klein LR, Reardon RF, Miner JR, Fagerstrom ET, et al. Effect of use of a bougie vs endotracheal tube and stylet on first-attempt intubation success among patients with difficult airways undergoing emergency intubation: a randomized clinical trial. JAMA. 2018;319:2179–89.

15 Lighted Stylet Intubation

Benjamin M. Mahon and Lars K. Beattie

Indications

- Difficult/impossible direct laryngoscopy [1, 2]
  - Congenital abnormalities of airway
  - High Mallampati grade [3]
  - Dental appliances
- Failed direct laryngoscopy

Contraindications

- Absolute
  - Morbid obesity
  - Airway foreign body
  - Expanding neck mass
- Relative
  - Abnormal airway anatomy
  - Airway lesions (e.g., abscess, mass, epiglottitis) that change oropharyngeal anatomy
  - Acute care where concomitant resuscitation requires a well-lit room
  - Lack of familiarity or experience with procedure
  - "Can't oxygenate, can't ventilate" situation

Materials and Medications

- Intravenous (IV) access, O_2, monitor
- Ambu bag with supplemental oxygen
- Suction (Yankauer and tubing)
- Lighted stylet (LS)
- Endotracheal tube (ETT) 2.5-mm larger than LS with 10-cc syringe
- Surgilube
- Intubation medications (this procedure may be performed as an awake or a rapid sequence intubation)

Methods

1. Preoxygenate.
2. Positioning:
   (a) Sniffing position, pinna at the level of the sternal notch (Fig. 15.1).
   (b) Skip sniffing position if cervical spine injury is suspected.
3. LS-ETT unit preparation:
   (a) Insert the wire stylet into the device.
   (b) Check the LS light.
   (c) Lubricate the LS with K-Y Jelly.
   (d) Position the LS just distal to the Murphy eye.
   (e) Curve the LS to user preference at the line labeled "bend here."

Fig. 15.1 Sniffing position, pinna at the level of the sternal notch

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4. Administer intubation medications.
5. Have an assistant apply cricoid pressure.
6. Grasp and elevate the patient's jaw near the corner of the mouth with the operator's thumb, index, and middle fingers, elevating the tongue and epiglottis along with it.
7. Using the free hand, insert the LS-ETT unit into the oropharynx and advance (Fig. 15.2).
8. Use the midline glow in the neck to guide insertion of the LS-ETT (Fig. 15.3).
9. Bright light *below* the thyroid prominence indicates correct placement of the ETT tip.
10. Dim or blurred light or light at the thyroid prominence suggests incorrect positioning (Fig. 15.4).
11. If the transilluminated light is dim, off center, or not seen, esophageal positioning must be considered:
    (a) Withdraw the LS-ETT unit approximately 2–5 cm.
    (b) Reposition the patient's head and neck.
    (c) Reattempt according to steps 5–8.
12. Placement of the ETT (Fig. 15.5):
    (a) Hold the LS-ETT unit steady with one hand.
    (b) Check the depth of the ETT and adjust accordingly.
    (c) Release the LS latch that holds the ETT to the LS.
    (d) While holding the ETT in position, gently slide the LS out from the ETT.
    (e) Inflate the ETT balloon.

Fig. 15.2 Grasp and elevate the patient's jaw near the corner of the mouth with the operator's thumb, index, and middle fingers, elevating the tongue and epiglottis along with it. Using the free hand, insert the LS-ETT unit into the oropharynx and advance

13. Confirm ETT placement (continuous end-tidal CO_2 [$EtCO_2$], colorimetric capnometry).
14. Secure the ETT.

Pearls and Pitfalls

- Pearls
  - LS-ETT complex: Typically the classic "hockey-stick" shape with the 90° curve just proximal to the cuff is recommended [2].
  - Dimming the room lights will enhance transillumination.
  - Pulling the wire stylet out from the LS-ETT unit will make it more pliable and may facilitate its placement in the trachea and removal of the LS.
  - Some LS devices may start to blink after 30 seconds to prevent bulb overheating.
  - The LS may be used with nasotracheal intubation, intubation through a laryngeal mask airway (LMA), or conventional laryngoscopy to enhance success.
- Pitfalls
  - LS intubation should not be used as an emergency airway alternative by a proceduralist unfamiliar with the technique:
    - It is technically complicated and more challenging than many other airway adjuncts in the standard difficult airway algorithm.
    - One study compared the use of four rescue airway devices in the difficult airway algorithm. A success rate of only 20% was achieved with the Trachlight™ lighted stylet on the first attempt when in the hands of the novice physician when used as a rescue device in their difficult airway algorithm [4].
  - In very thin patients, transillumination may be visualized quite well even when the LS-ETT unit is in the esophagus:
    - When the unit is in the esophagus, typically the light will be more diffused.
    - When the unit is in the trachea, the transilluminated area will be well circumscribed.
  - In obese patients or patients with significant neck tissue, the transilluminated light from the LS-ETT unit may be dim despite correct positioning in the trachea.

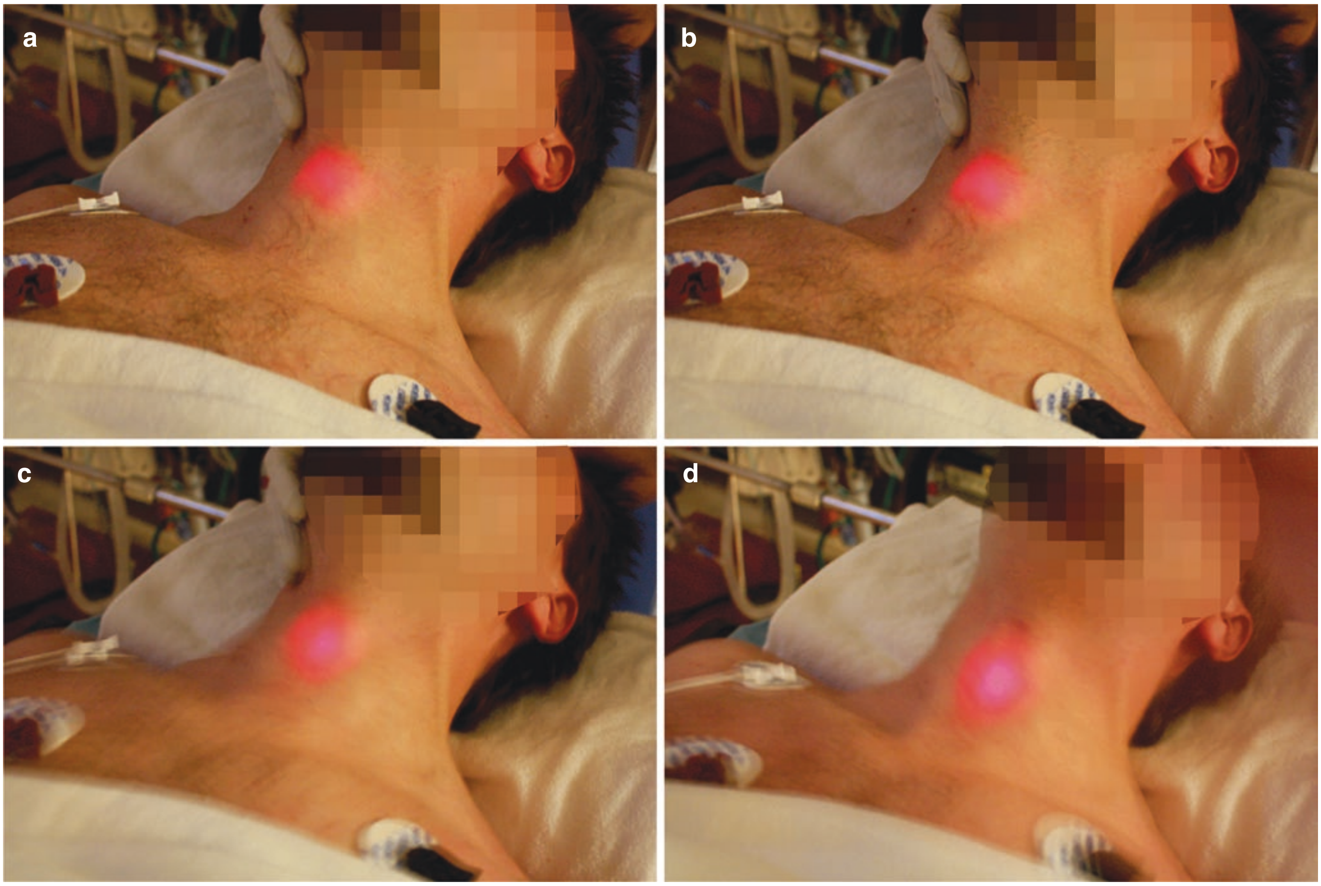

Fig. 15.3 (**a**–**c**) Use the midline glow in the neck to guide insertion of the LS-ETT. (**d**) Bright light *below* the thyroid prominence indicates correct placement of the ETT tip

Fig. 15.4 Dim or blurred light or light at the Laryngeal prominence suggests incorrect positioning

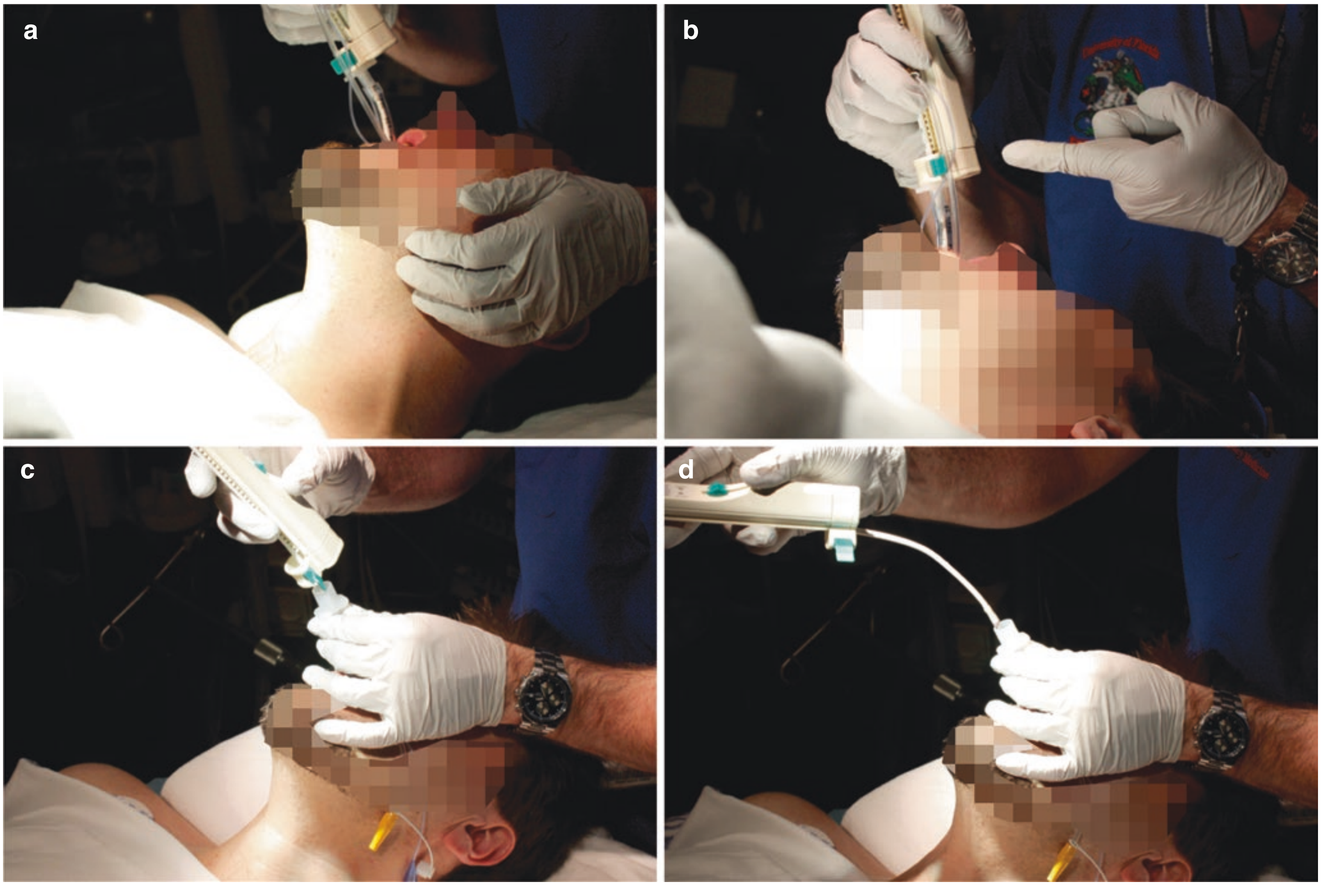

Fig. 15.5 (**a**) Hold the LS-ETT unit steady with one hand. (**b**) Check the depth of the ETT and adjust accordingly. (**c**) Release the LS latch that holds the ETT to the LS. (**d**) While holding the ETT in position, gently slide the LS out from the ETT

References

1. Agro F, Hung OR, Cataldo R, Carassiti M, Gherardi S. Lightwand intubation using the Trachlight: a brief review of current knowledge. Can J Anaesth. 2001;48:592–9.
2. Davis L, Cook-Sather SD, Schreiner MS. Lighted stylet tracheal intubation: a review. Anesth Analg. 2000;90:745–56.
3. Rhee KY, Lee JR, Kim J, Park S, Kwon WK, Han S. A comparison of lighted stylet (Surch-Lite) and direct laryngoscopic intubation in patients with high Mallampati scores. Anesth Analg. 2009;108:1215–9.2.
4. Aikins NL, Ganesh R, Springmann KE, Lunn JJ, Solis-Keus J. Difficult airway management and the novice physician. J Emerg Trauma Shock. 2010;3:9–12.

Suggested Reading

Langeron O, Birenbaum A, Amour J. Airway management in trauma. Minerva Anestesiol. 2009;75:307–11.

Walls RM, Murphy MF. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008: Chap. 11.

16 Fiber-Optic Stylet Intubation (Rigid and Semirigid)

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Indications

- For use in routine and predicted difficult oral intubations.
- Similar to a flexible fiber-optic scope with the specific advantages of:
  - Less setup time
  - Less time to perform the procedure
  - Appropriate for routine intubations (and easier to accumulate experience)
  - Rigid enough to lift up the epiglottis
  - Easier to navigate through tissue
  - Less susceptible to being obscured by blood and secretions
  - More durable, more portable, easier to clean, and less expensive
- Particularly useful when neck mobility or mouth opening is restricted.
- Advantageous in awake intubations because it can minimize tissue contact, resulting in less stimulation to the patient's airway and better tolerance.
- Certain stylets can be used to intubate through supraglottic airways such as laryngeal mask airways (LMAs).

Contraindications

- Complete upper airway obstruction where surgical airway is indicated
- Oral pharyngeal swelling requiring a nasotracheal or surgical approach
- Failed airway and unable to adequately maintain oxygenation

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Relative Contraindications

- Large amounts of blood and secretions may obscure visualization of the airway and cords.
- Very distorted airways. Compared with flexible endoscopy, this device is less maneuverable.

Materials and Medications

- Endotracheal tube (ETT) 5.5 mm or greater (Fig. 16.1). (Pediatric stylets are also available.)
- Water-soluble lubricant
- Defogging agent
- Optional: swivel adaptor and meconium aspirator

Procedure

1. Use standard preparation for rapid sequence intubation (RSI) or for awake intubation.
2. Place the ETT over the stylet.
   (a) The ETT should extend slightly beyond the stylet tip.
   (b) If using the malleable stylet:
      (i) Without a laryngoscope: bend tip to about 70° [1].
      (ii) With a laryngoscope: bend tip to 35° [1].
   (c) Lubricate the tip of the ETT.
3. Depending on specific scope capability, connect oxygen tubing to the port on the scope.
   (a) This keeps secretions away from the tip while providing an oxygen source.
   (b) Keep flow less than 6 L/min [2].
4. Lens fogging prevention:
   (a) Warm the tip of the scope with the hand or immerse the tip in warm saline.
   (b) Apply the defogging agent.
   (c) Alternatively, chlorhexidine is an effective defogger.

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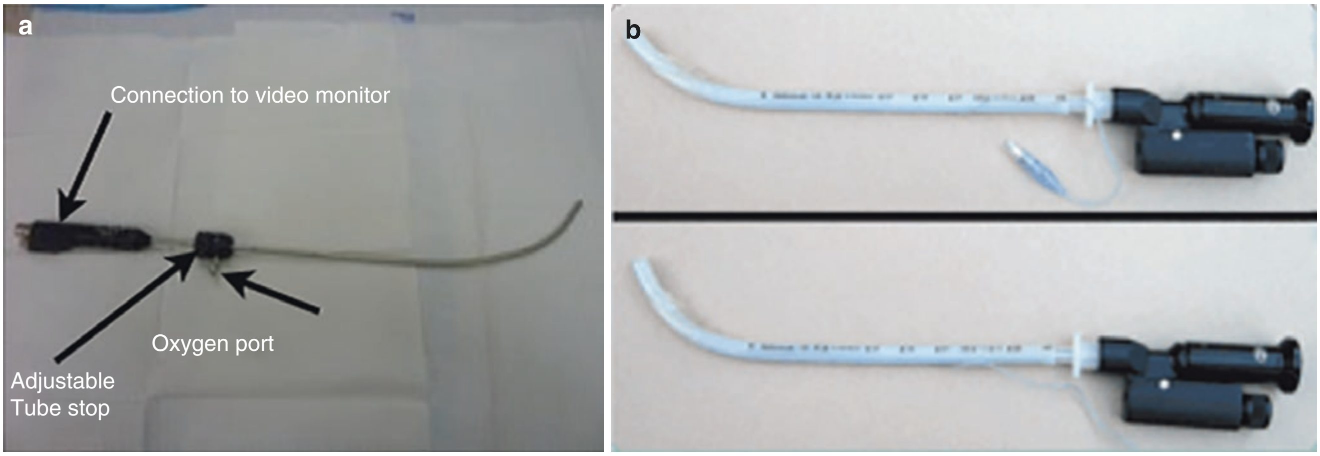

Fig. 16.1 (**a**) Bonfils rigid fiber-optic stylet, Karl Storz endoscopy, (**b**) Levitan FPS malleable fiber-optic stylet. (*Top*) Conformation when used in conjunction with laryngoscope. (*Bottom*) Conformation when used alone

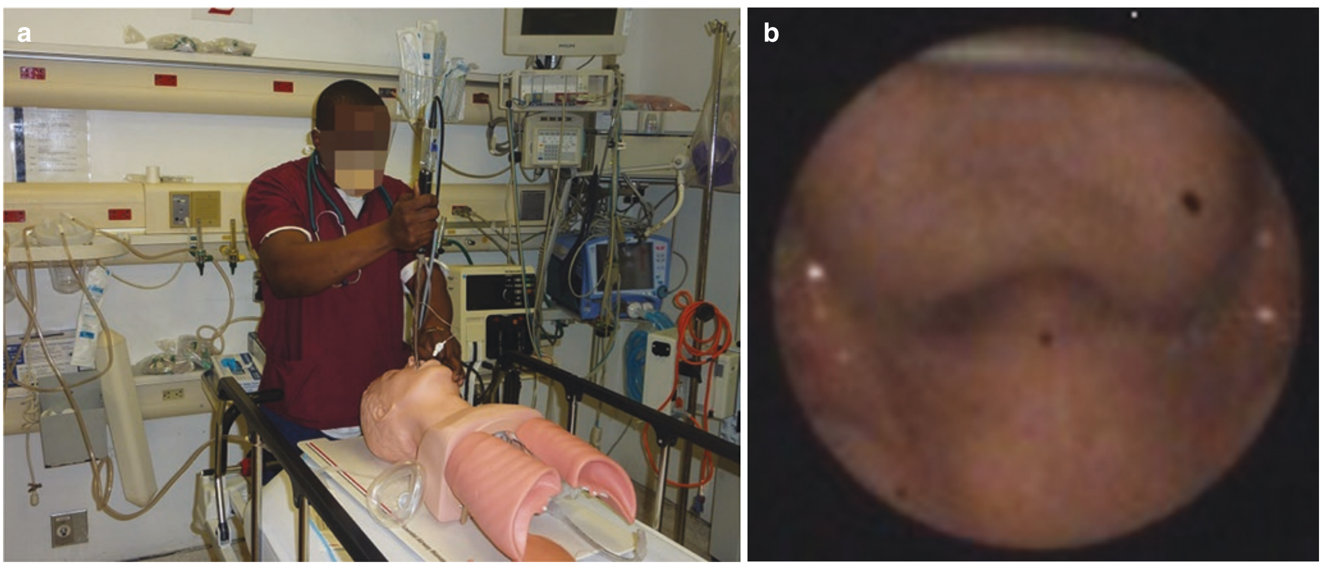

Fig. 16.2 (**a**) Initial placement of scope, under direct visualization. (**b**) Tip of scope in from of the uvula

5. Scope insertion:
   (a) Use the nondominant hand to pull the jaw forward while holding the tongue.
      (i) In an awake patient, have the patient protrude the tongue and the operator grasp it with 4 × 4 gauze. (Alternatively, a Macintosh laryngoscope blade can be used.)
      (ii) The goal is to move the base of the tongue off the posterior pharyngeal wall.
   (b) Initially position the scope horizontally and to the right of the patient's mouth.
   (c) Once the tip is in the oropharynx, reposition the scope vertically (Fig. 16.2a).
   (d) The scope tip should be in the midline or in the retro-molar position (per scope design).
   (e) Position the scope and the tip of the ETT in front of the uvula.
   (f) Refer to the eyepiece or video screen to see if there is a clear image of the uvula (Fig. 16.2b).
   (g) Advance the scope very slowly to maintain a view of landmarks, avoiding tissue contact (Fig. 16.3).
6. Once the epiglottis is visualized:
   (a) Continue to advance slowly.
   (b) To get underneath the epiglottis, the tip of the scope may need to be moved posteriorly (by tilting the operator's hand slightly forward) (Fig. 16.4).
7. Once underneath the epiglottis, tilt the scope back to advance into the more anterior directed airway.
   (a) Make sure the glottic opening is well centered on the screen to facilitate placement (Fig. 16.5).

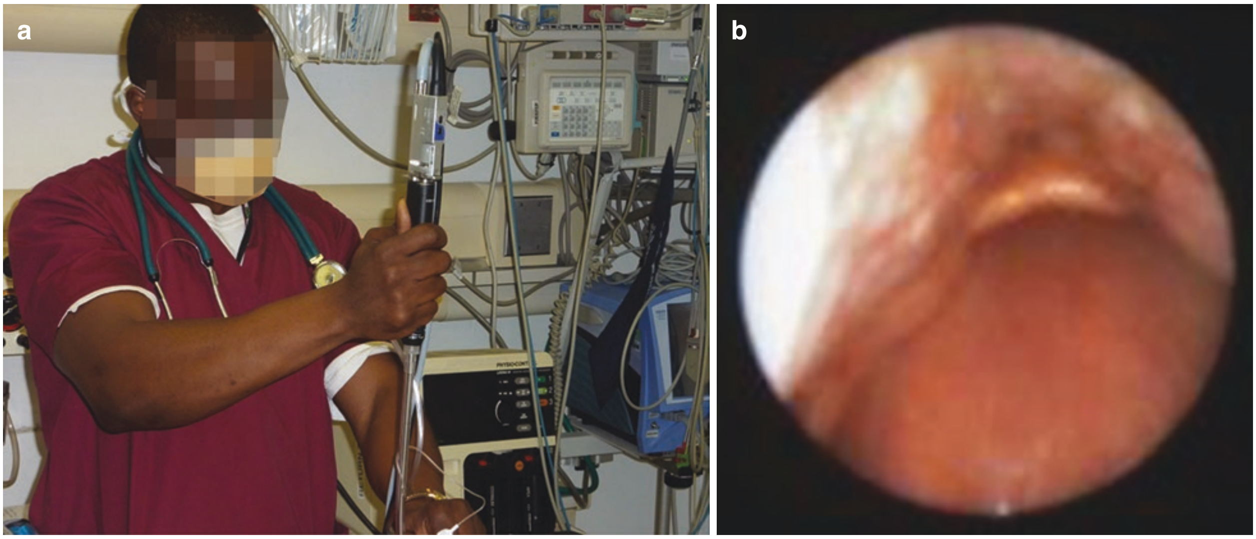

Fig. 16.3 (**a**) Using the video monitor or through an eye piece, operator advances to the next landmark, (**b**) the epiglottis

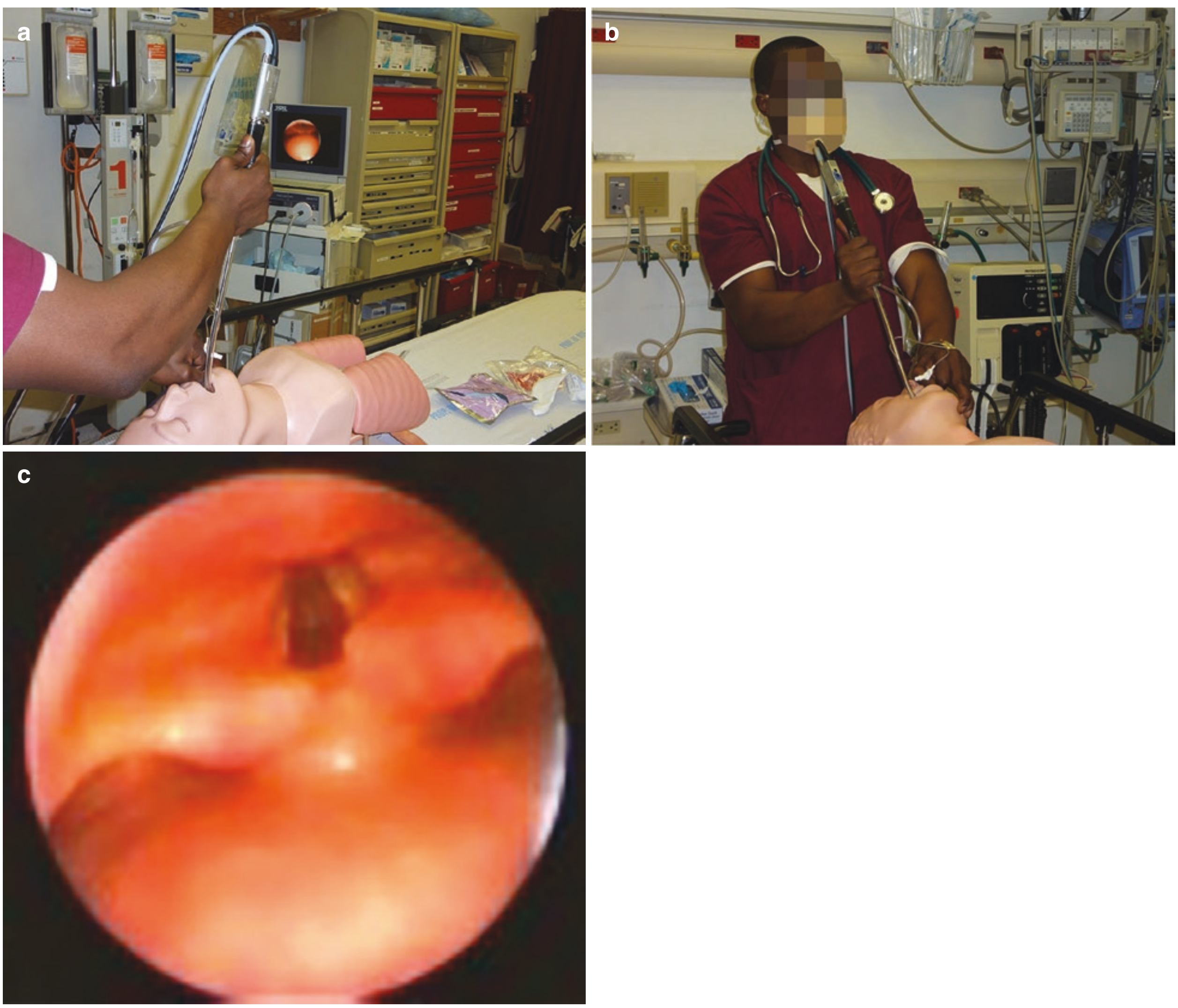

Fig. 16.4 (**a**) Operator tips scope forward to get underneath the epiglottis while advancing. (**b**) Once under the epiglottis, the scope may need to be tipped back to advance to the glottic opening. (**c**) Operator should try to keep the glottic opening in the center of the screen

Fig. 16.5 (**a**) Operator is advancing the scope (**b**) through the glottic opening keeping the image centered

Fig. 16.6 To remove scope, operator must pull it forward while stabilizing the endotracheal tube

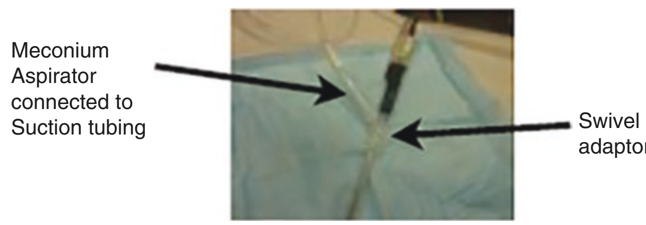

Fig. 16.7 By placing the stylet through the rubber valve of a swivel adaptor, which is then connected to suction via a neonatal meconium aspirator, the operator can now suction through the endotracheal tube

(b) If resistance is felt, operator may need to rotate the scope clockwise, or tip scope slightly forward, to prevent the ETT from abutting the anterior aspect of the trachea.
(c) The ETT may need to be advanced off the rigid stylet to allow further advancement.

8. To remove scope:
   (a) Twist the proximal end of the ETT clockwise.
   (b) Stabilize the tube with the nondominant hand.
   (c) Use the dominant hand to pull the scope forward, following the curvature of the stylet (Fig. 16.6).
   (d) An assistant may be of use during this step.

Pearls and Pitfalls

- Pearls
  – When the operator loses perspective or a clear view, withdraw the scope back to the point where identifiable structures are visualized and proceed.
  – The operator can suction through the scope by attaching a swivel adaptor and a meconium aspirator (Fig. 16.7) [3].
- Pitfalls
  – If the scope is advanced too quickly, orientation can be lost.
  – Structures that are too close to the scope will become blurred and unidentifiable.
  – If the scope tip abuts pharyngeal tissue, visualization can become blurred.
  – Flow greater than 6 L/min connected to the oxygen port may result in subcutaneous emphysema (single case report) [2].

References

1. Levitan RM. Design rationale and intended use of a short optical stylet for routine fiberoptic augmentation of emergency laryngoscopy. Am J Emerg Med. 2006;24:490–5.
2. Hemmerling TM, Bracco D. Subcutaneous cervical and facial emphysema with the use of the Bonfils fiberscope and high-flow oxygen insufflation. Anesth Analg. 2008;106:260–2.
3. Weingart SD, Bhagwan SD. A novel set-up to allow suctioning during direct endotracheal and fiberscope intubation. J Clin Anesth. 2011;23:518–9.

17 Storz Video Laryngoscope

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Indications

- Orotracheal intubation for both routine and predicted difficult airways.
- Teaching traditional direct laryngoscopy to novice intubators.
- Ideal for unanticipated difficult airway with the option of intubating indirectly if an adequate direct view is unobtainable.
- An excellent tool when cervical spine precautions need to be taken: Because the video view of the airway is generated by a camera at the tip of laryngoscope blade, less manipulation is required for optimal glottic views.

Contraindications

- Absolute
  - When orotracheal intubation is contraindicated, e.g., for massive facial trauma, complete upper airway obstruction precluding orotracheal access to the airway
  - In a failed airway (three unsuccessful attempts with inability to maintain adequate oxygenation)
- Relative
  - Blood or copious secretions may prevent indirect viewing of the airway but does not always preclude the use of this device.

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Materials and Medications (Fig. 17.1)

- Standard materials and medications for endotracheal intubation. Operator should have a backup laryngoscope in case of equipment failure.
- Endotracheal tube (ETT) with or without stylet.
- Water-based lubricant.
- Antifogging agent (not required for C-Mac).

Procedure

1. Standard preparation for orotracheal intubation. If there are no cervical spine precautions, then align the external auditory meatus with the sternal notch [1].
2. Apply antifogging drops to lens at tip of the blade, and/or hold the hand over the blade tip to warm it up to body temperature (older V-Mac model) (Fig. 17.2a).
3. Because blade geometry is the same as in standard laryngoscopes, the insertion technique is identical to that of standard laryngoscopy with a Macintosh blade (Fig. 17.2b).
4. Obtain the best direct view possible.
5. Consider the addition of the backward-upward-rightward pressure (BURP) maneuver [2].
6. Airway maneuvers may be performed by the operator or by the assistant using the video screen as a guide along with operator feedback (Fig. 17.3).
7. The operator has the option of intubating directly with adequate view or indirectly if visualization is improved.
8. Consider using an ETT introducer (bougie—see Chap. 15) if the view is inadequate.
9. Place the ETT, with or without a stylet, into the airway under direct or indirect visualization. If using a stylet, bend the distal end of the tube to approximately 35° as for a standard intubation (Fig. 17.4) [3].
10. Remove the stylet, inflate the cuff of the ETT using a syringe, and confirm placement with end-tidal CO_2, capnography, or colorimetry.

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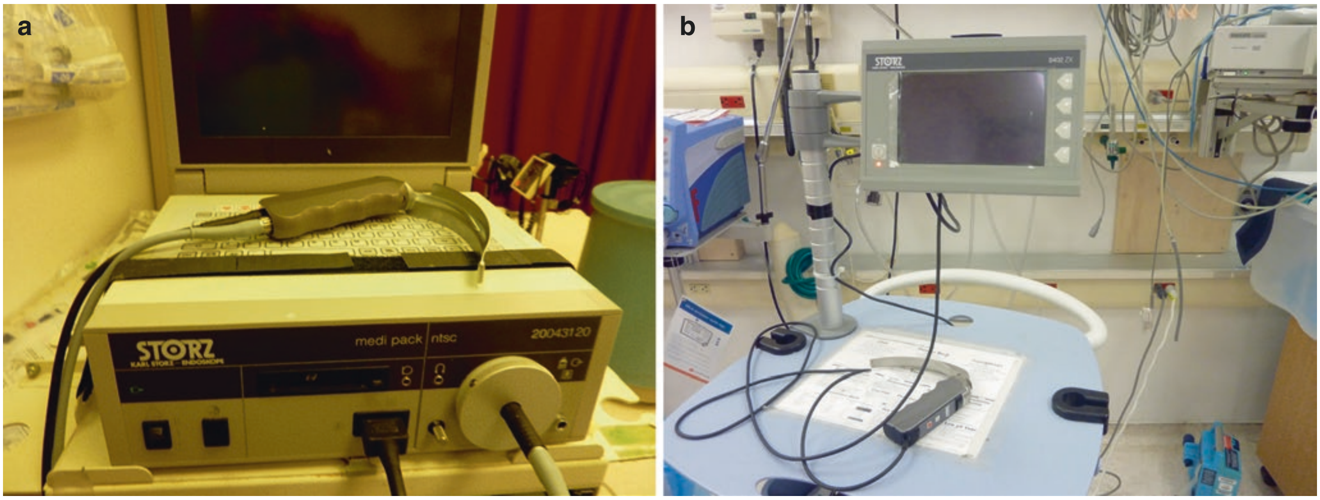

Fig. 17.1 (**a**) Storz video laryngoscope (older version), (**b**) Storz C-Mac (newer version)

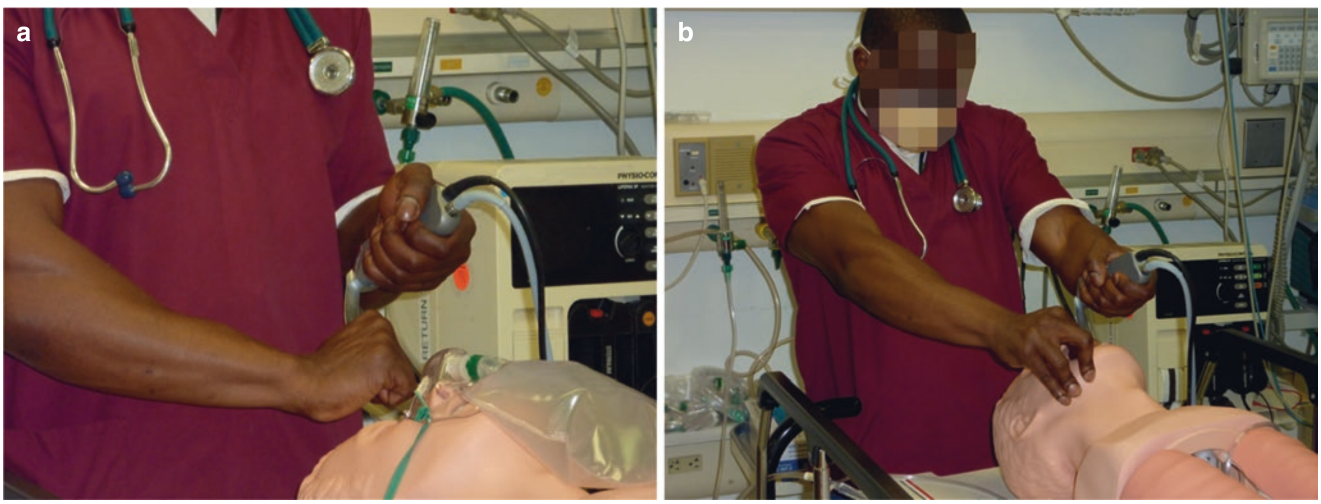

Fig. 17.2 (**a**) Operator warming the blade to prevent fogging, (**b**) laryngoscope blade insertion using the standard direct technique. Operator visually places the blade and optimizes the glottic view

Fig. 17.3 Operator has the choice of using direct visualization (preferred when a novice intubator is learning laryngoscopy) or the indirect video view of the glottis

Complications (as with Any Direct Laryngoscopy)

- Dental trauma
- Oropharyngeal trauma
- Vocal cord injury

Pearls and Pitfalls

- The initial placement of the laryngoscope blade and ETT should be done under direct visualization to avoid trauma to the oropharyngeal structures.
- As with direct laryngoscopy, the ETT should not be placed blindly, and the ETT must be seen to pass through the vocal cords to avoid placement in the esophagus.
- View can be obscured by secretions or fogging. If this occurs, the operator may need to remove the blade, wipe

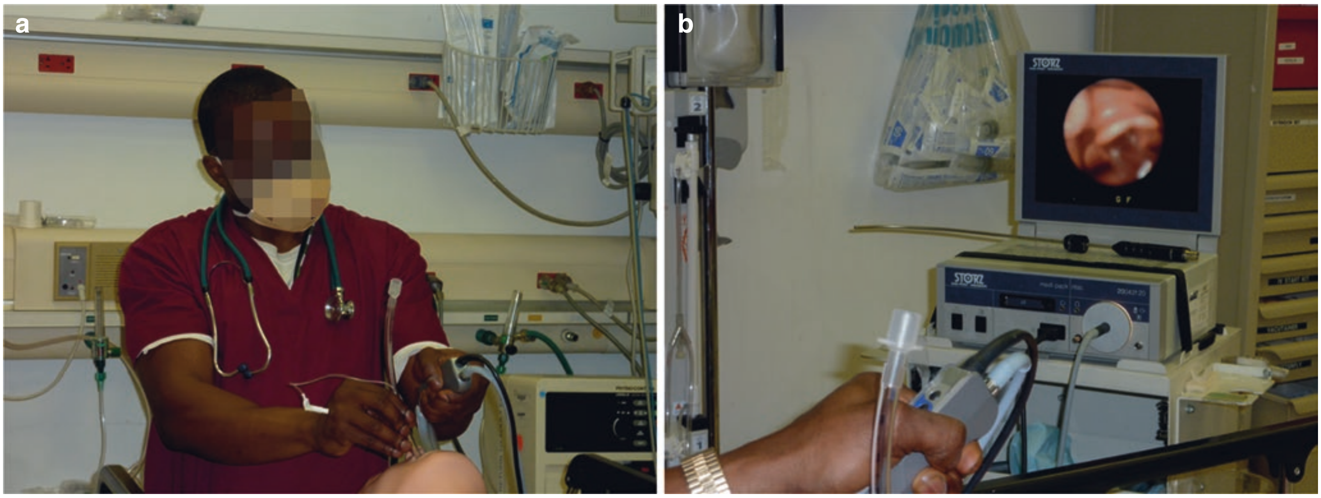

Fig. 17.4 (**a**) Operator initially places the endotracheal tube (ETT) into the oropharynx using direct visualization to avoid injury; (**b**) the tip of the ETT passing through the cords can be confirmed by direct visualization or by watching the video image

it down, and reinsert. The newer model, the C-Mac, is less likely to fog owing to design improvements. In a predicted contaminated airway either with blood or secretions, suction mouth, and advance ahead of laryngoscope view to prevent obscuring camera view.

- Observing the ETT pass through the vocal cords can sometimes be easier using the video image because the camera is angled to provide the most optimal view.
- Placement of the blade into the oropharynx can be awkward because the handle of laryngoscope is bulkier than a standard laryngoscope. Its handle is larger and has cables attached to its base. In patients with large anteroposterior diameter chests, the operator may need to rotate the laryngoscope handle toward the right corner of the mouth in order to introduce the blade into the oral cavity and then rotate it back to the proper position.
- These devices are ideal for teaching laryngoscopy to beginners while giving the instructor an unobstructed view of the procedure. With the same blade geometry, the technique is the same as with standard laryngoscopy. As the operator attempts intubation directly, the instructor can observe on the video screen and guide the student, changing position/cricoid pressure to give the student the best view. The instructor will also be able to visually confirm that the ETT is entering the trachea.
- Given the same blade shape as a standard Mac direct laryngoscope blade, this device also has the added benefit of being about to instantly convert to a direct approach when video fails. If the video stops working and becomes unplugged or camera is fogged/contaminated, look into the mouth for a direct view, and continue with the procedure.
- The use of a bougie is identical to direct laryngoscopy as well, not requiring a hyperangulated angle as with the GlideScope.

References

1. Greenland KB, Edwards MJ, Hutton NJ, Challis VJ, Irwin MG, Sleigh JW. Changes in airway configuration with different head and neck positions using magnetic resonance imaging of normal airways: a new concept with possible clinical applications. Br J Anaesth. 2010;105:683–90.
2. Knill RL. Difficult laryngoscopy made easy with a "BURP.". Can J Anaesth. 1993;40:798–9.
3. Levitan RM, Heitz JW, Sweeney M, Cooper RM. The complexities of tracheal intubation with direct laryngoscopy and alternative intubation devices. Ann Emerg Med. 2011;57:240–7.

Suggested Reading

Brown CA 3rd, Bair AE, Pallin DJ, et al. Improved glottic exposure with the video Macintosh laryngoscope in adult emergency department tracheal intubations. Ann Emerg Med. 2010;56:83–8.

Niforopoulou P, Pantazopoulos I, Demestiha T, Koudouna E, Xanthos T. Video-laryngoscopes in the adult airway management: a topical review of the literature. Acta Anaesthesiol Scand. 2010;54:1050–61.

Cricothyroidotomy

18

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Up to 7 intubation attempts in 1000 end up in a "can't intubate/can't ventilate" situation in the emergency department. These are considered failed airways that may require a surgical airway to maintain ventilation and oxygenation.

Indications

- Endotracheal tube (ETT) placement attempts unsuccessful
- Failed bag valve mask, laryngeal mask airway, or Combitube ventilation
- Severe facial trauma affecting the upper airway
- Severe oropharyngeal hemorrhage or profound emesis
- Obstruction (foreign body, mass, mass effect)

Contraindications

- Airway protection achievable using a less-invasive strategy
- Tracheal transaction
- Pediatric patients younger than 8 years

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Techniques

- Scalpel-bougie – minimalist
- Scalpel-Trousseau – standard

Scalpel-Bougie

Materials and Medications (Fig. 18.1)

- Betadine or chlorhexidine
- Scalpel #11 blade
- ETT (≥6 cm)
- Bougie
- Surgilube
- Bag valve mask

Procedure

1. Apply topical antiseptic.
2. Remove the 15-mm ETT ventilator connector from the ETT end.
3. Place copious Surgilube on the bougie and railroad over the end of the bougie.
4. Position yourself on your dominant hand side of the patient. With your nondominant hand, palpate the thyroid notch, cricothyroid membrane, and hyoid bone for orientation. This allows your dominant hand to be free for the procedure (Fig. 18.2a).
5. Stabilize the thyroid cartilage between the thumb and the middle finger of the nondominant hand.
6. Make a vertical skin incision (2–3 cm) over the cricothyroid membrane (Fig. 18.2b).
7. Use the index finger to palpate the cricothyroid membrane.
8. Turn the scalpel 90°, and make a 1.5-cm horizontal incision through the lower half of the cricothyroid membrane (Fig. 18.3a).

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Fig. 18.1 *Right to left*, *top to bottom*: ETT (≥6 cm), bag valve mask, trauma shears, scalpel #11 blade, bougie

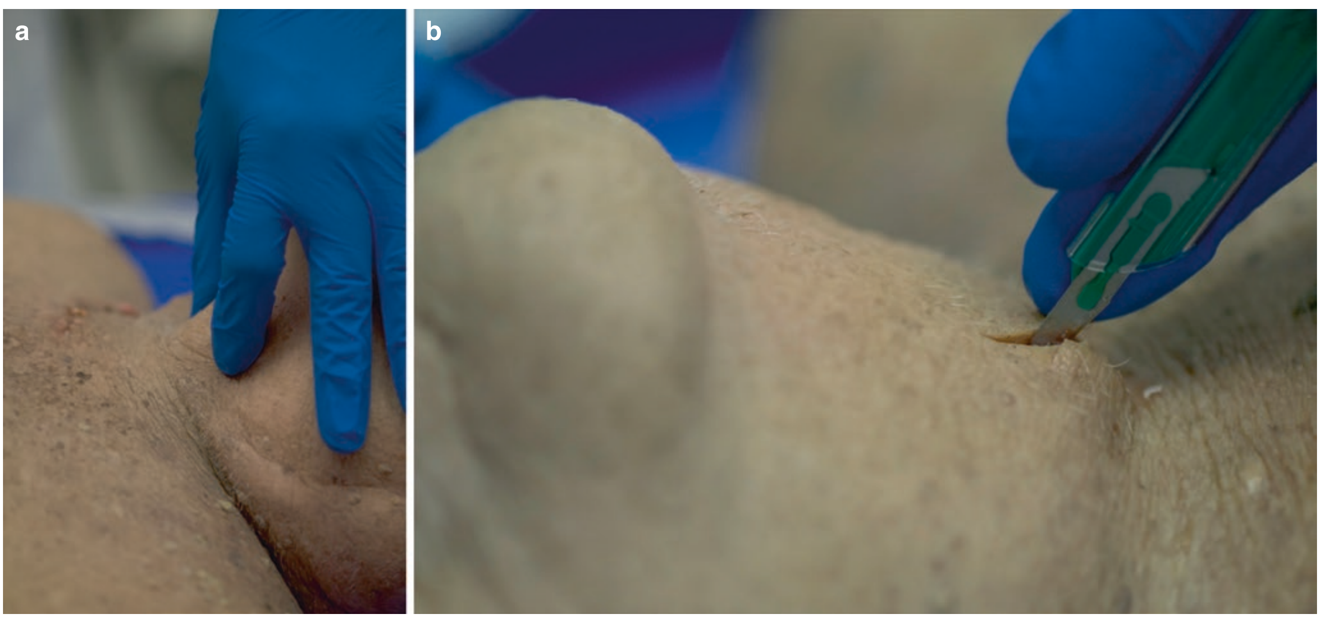

Fig. 18.2 (**a**) Palpate and stabilize the thyroid cartilage; (**b**) make a vertical 2–3-cm incision over the cricothyroid membrane

9. With the scalpel still in the incision, turn it 90°, and insert the bougie into the incision, using the blade as a guide (Fig. 18.3b).
10. Advance the bougie caudally 5–6 cm. Stop if resistance is encountered.
11. Slide the ETT over the bougie into the incision. Insert ETT until the cuff is just past your incision (Fig. 18.4a).
12. Inflate the ETT cuff and ventilate the patient (Fig. 18.4b).
13. Verify the position of the ETT via auscultation, end-tidal CO2 (EtCO2), and chest radiograph.
14. Secure the ETT.

Scalpel-Trousseau

Materials and Medications (Fig. 18.5)

- Scalpel with #11 blade
- Tracheal hook
- Trousseau dilator
- Cuffed tracheostomy tube (TT) (6.5 or 7.0) or ETT (5.0, 5.5, or 6.0)
- Antiseptic preparation

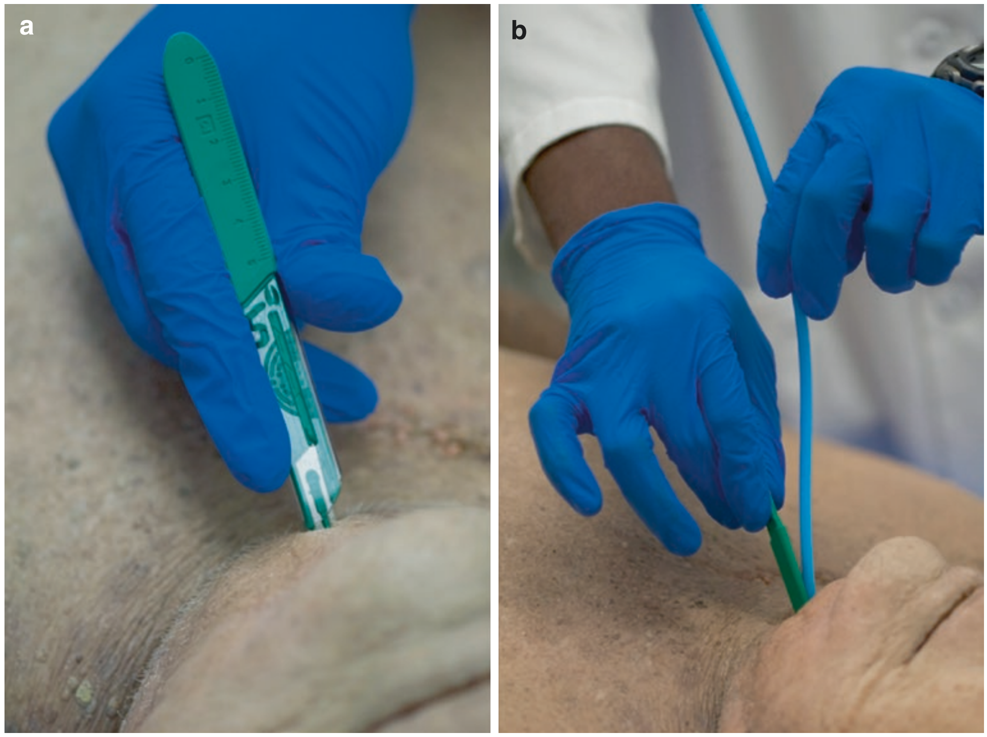

Fig. 18.3 (**a**) Make a horizontal incision into the cricothyroid membrane; (**b**) insert the bougie into the incision made in the cricothyroid membrane

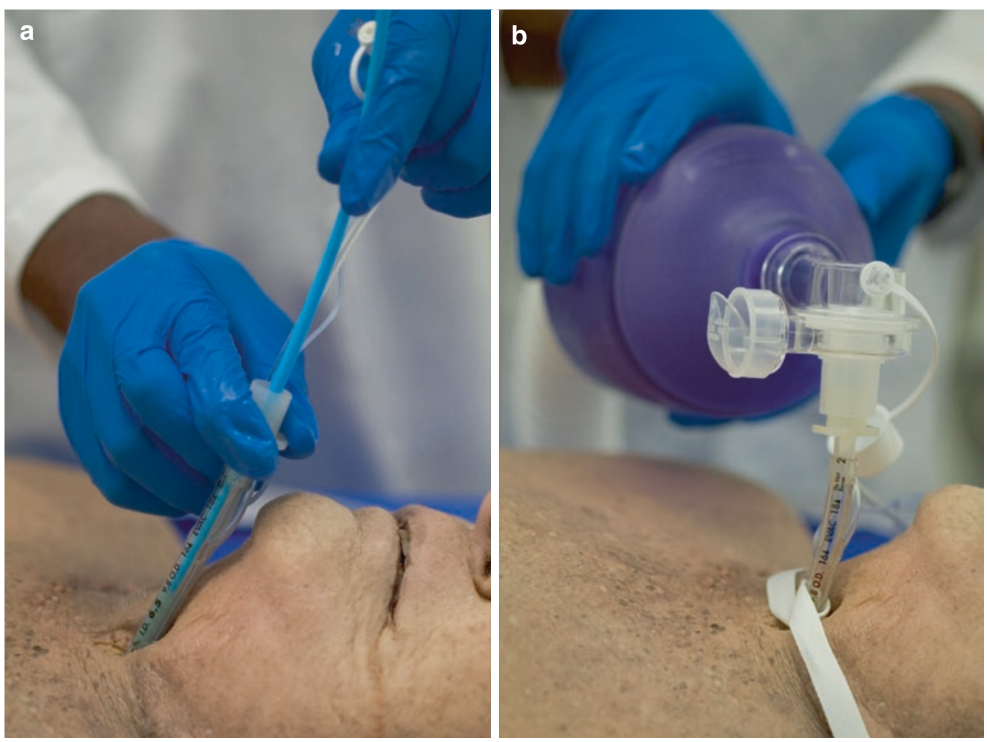

Fig. 18.4 (**a**) Slide the endotracheal tube (ETT) over the bougie into the trachea; (**b**) ventilate the patient

Procedure

1. Apply topical antiseptic.
2. Palpate the thyroid notch, cricothyroid membrane, and hyoid bone for orientation.
3. Stabilize the thyroid between the thumb and the middle finger of the nondominant hand (Fig. 18.6a).
4. Make a vertical skin incision (2–3 cm) over the cricothyroid membrane (Fig. 18.6b).
5. Palpate with the index finger to verify the cricothyroid membrane location.

6. Use stabilization of the thyroid and palpation to maintain orientation of the anatomy.
7. Make a 1.5-cm horizontal incision through the lower half of the membrane (Fig. 18.7a).
8. Insert a tracheal hook into the incision, then rotate such that hook faces superiorly (Fig. 18.7b).

Fig. 18.5 *Top to bottom*, *right to left*: scalpel with #11 blade, tracheal hook, Trousseau dilator, cuffed tracheostomy tube (TT) (6.5 or 7.0) or ETT (5.0, 5.5, or 6.0), antiseptic preparation

9. Withdraw at a 45° angle in a cephalad direction, applying gentle traction to the thyroid cartilage.
10. Place the Trousseau dilator into the incision transversely, and open the membrane incision vertically (Fig. 18.8a).
11. Insert a cuffed ETT (5.0–6.0) or TT (6.5–7.0) into the incision between the prongs of the dilator in the horizontal access (Fig. 18.8b).
12. Rotate both the dilator and the ETT toward the head of the patient, and then direct the tube downward into the trachea while removing the dilator.
13. Inflate the ETT cuff and ventilate the patient.
14. Verify the position of the ETT via auscultation, EtCO2, and chest X-ray.
15. Once placement of the tube has been verified, the tracheal hook can be removed.
16. Secure the ETT.

Complications

- Bleeding
- ETT misplacement (false passage, through the thyrohyoid membrane, unintentional tracheostomy)
- Hoarseness, dysphonia, or vocal cord paralysis
- Subglottic or laryngeal stenosis
- Damage to the thyroid cartilage, cricoid cartilage, or tracheal rings
- Perforated esophagus
- Infection
- Aspiration

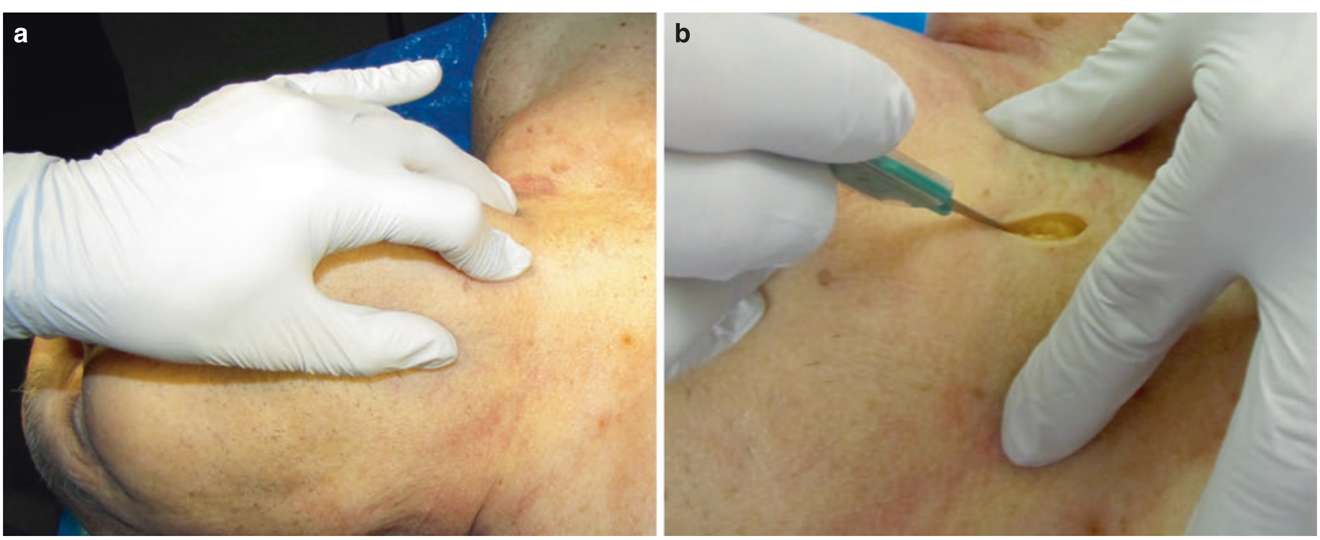

Fig. 18.6 (**a**) Stabilize the thyroid cartilage between the thumb and the middle finger of the nondominant hand; (**b**) make a vertical incision over the cricothyroid membrane

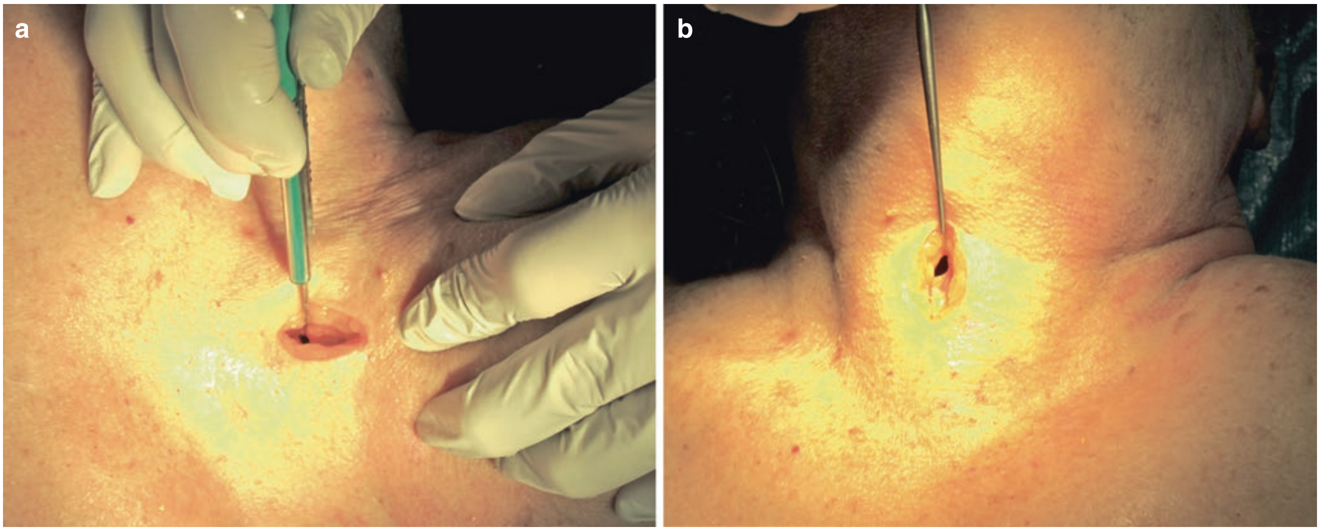

Fig. 18.7 (**a**) Make a horizontal incision in the lower half of the cricothyroid membrane. (**b**) Insert a tracheal hook and apply gentle traction superiorly at a 45° angle

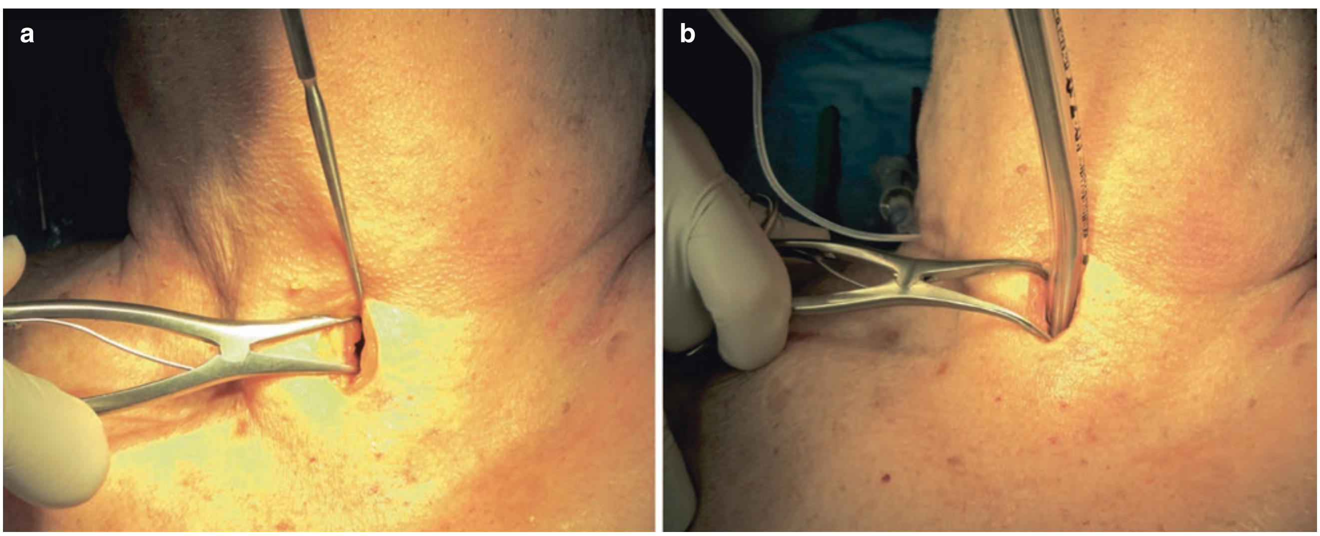

Fig. 18.8 (**a**) Insert the Trousseau dilator into the incision, and open the path for placement of the tracheostomy tube (TT) or the ETT. (**b**) Insert the TT or the ETT into the expanded incision between the Trousseau dilator prongs

Pearls

- Predictors of difficult cricothyrotomy—"SHORT" [1]:
  - Prior *s*urgery or *s*car tissue
  - *H*ematoma
  - *O*bese
  - Prior *r*adiation
  - *T*umor/abscess
- The incision should cut through the skin and subcutaneous tissue down to the cricothyroid membrane and cartilages. Dissecting away the surrounding soft tissue allows better palpation and identification of landmarks.
- Vertical incisions allow for extension in either direction if the cricothyroid membrane is above or below initial incision.
- Blood in the field may hinder visualization of the membrane, but the airway should be established before attempts to control any bleeding. Prior to incision, have copious gauze available and/or surrounding the neck to help minimize bleeding.
- Cricothyroid arteries are located cephalad to the cricothyroid membrane.
- Either a TT or an ETT can be used for the procedure.
  - ETTs are more ubiquitous.
  - TTs are easier to secure.

- If an ETT is used, a stylet can help direct placement.
- Cricothyroidotomy is preferred in the emergency setting over tracheostomy owing to the increased risks of bleeding, the mobility of the trachea, and the risk of lacerating the underlying thyroid gland [2].
- Ultrasound can be used to visualize landmarks in patients in whom landmarks are difficult to identify.
- There are other premade kits and devices available on the market. Familiarize yourself with the kit available in your institution, and practice on a mannequin, cadaver, or 3D printed model.
- If you anticipate a difficult airway that may possibly require a cricothyroidotomy, palpate for your landmarks, and indicate your vertical incision with a marking pen prior to intubation attempt. This step mentally prepares you and your team for the procedure in the event that a "can't intubate, can't ventilate" situation occurs.

References

1. Walls RM, Murphy MF, editors. Manual of emergency airway management. 4th ed. Philadelphia: Wolters Kluwer; 2012.
2. Boon JM, Abrahams PH, Meiring JH, et al. Cricothyroidotomy: a clinical anatomy review. Clin Anat. 2004;17:478–86.

Suggested Reading

DiGiacomo C, Neshat KK, Angus LD, et al. Emergency cricothyrotomy. Mil Med. 2003;168:541–4.

Hamilton PH, Kang JJ. Emergency airway management. Mt Sinai J Med. 1997;64:292–301.

Helm M, Gries A, Mutzbauer T. Surgical approach in difficult airway management. Best Pract Res Clin Anaesthesiol. 2005;19:623–40.

Sagarin MJ, Barton ED, Chng YM, Walls RM. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. Ann Emerg Med. 2005;46:328–36.

Walls RM. Cricothyroidotomy. Emerg Med Clin North Am. 1988;6:725–36.

https://emcrit.org/emcrit/wearable-cric-trainer/

19 Percutaneous Cricothyroidotomy

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Indications

- Endotracheal tube (ETT) placement attempts unsuccessful
- Failed bag valve mask, laryngeal mask airway, Combitube ventilation
- Difficult surgical cricothyroidotomy
- Severe facial trauma affecting the upper airway
- Severe oropharyngeal hemorrhage or profound emesis
- Obstruction (foreign body, mass, mass effect)

Contraindications

- Absolute
  – Transection of the trachea below the cricothyroid membrane

Materials and Medications

- Betadine, chlorhexidine, or similar skin sterilization solution.
- Large bore needle (typically 16 ga).
- 10-mL syringe filled with 4 mL of normal saline.
- Wire.
- Scalpel #11 blade.
- Dilator.
- Cuffed cricothyroidotomy catheter.
- Most of the above supplies can be found together in a prepackaged percutaneous cricothyroidotomy kit (Melker kit) and/or in a central line kit (Figs. 19.1 and 19.2).
- BVM.

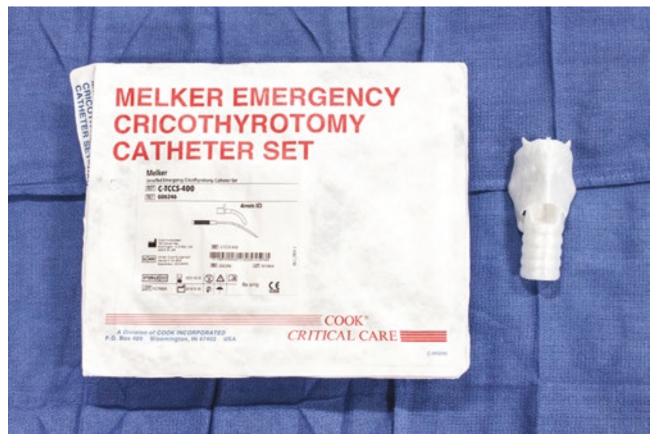

Fig. 19.1 Cricothyrotomy kit

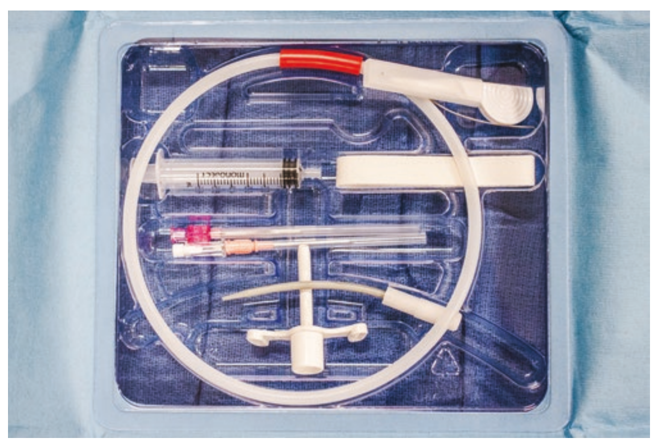

Fig. 19.2 Central line kit

Procedure

1. Apply topical antiseptic.
2. Position yourself on your dominant hand side of the patient. With your nondominant hand, palpate the thyroid notch, cricothyroid membrane, and hyoid bone for orientation.

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3. Stabilize the thyroid cartilage between the thumb and the middle finger of the nondominant hand. These initial steps are identical to the usual surgical cricothyroidotomy.
4. Insert needle through the cricothyroid membrane at a 45° angle aiming caudally while applying constant negative pressure to syringe. The fluid in your 10 cc syringe will bubble when the needle is correctly placed in the airway (Fig. 19.3).
5. Stabilize needle and carefully remove syringe.
6. Now the procedure deviates from a needle cricothyroidotomy. Using the Seldinger method, thread the wire through your needle to maintain your position in the airway (Fig. 19.4).
7. Make an incision through the skin and cricothyroid membrane with your scalpel, and dilate similar to a central line technique.

Fig. 19.3 Insert needle through the cricothyroid membrane at a 45° angle aiming caudally while applying constant negative pressure to syringe. The fluid in the 10-mL syringe will bubble when the needle is correctly placed in the airway

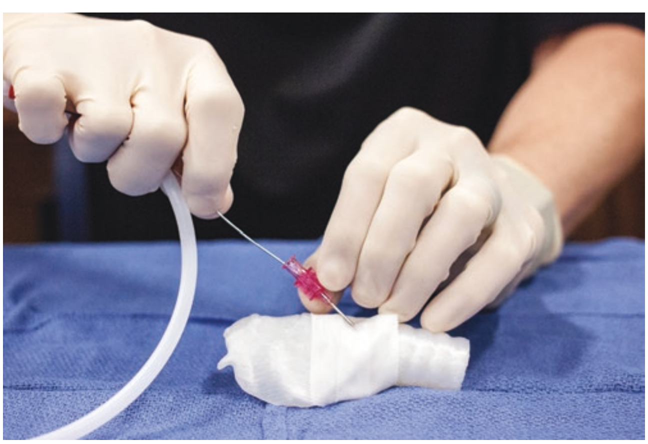

Fig. 19.4 Using the Seldinger method, thread the wire through the needle to maintain the position in the airway

Fig. 19.5 Slide the combined dilator-airway device over the wire into the incision. Insert airway until the cuff is just past incision and device is flush with the neck

8. Slide the combined dilator-airway device over the wire into the incision. Insert airway until the cuff is just past incision and device is flush with the neck (Fig. 19.5).
9. Inflate the cuff and ventilate the patient.
10. Verify the position of the airway via auscultation, end-tidal CO2 (EtCO2).
11. Secure the airway to the neck gently as to not compress vascular structures.

Complications

1. Pneumothorax
2. Pneumomediastinum
3. Bleeding
4. ETT misplacement (false passage, through the thyrohyoid membrane, unintentional tracheostomy)
5. Subcutaneous emphysema
6. Perforated esophagus
7. Infection
8. Aspiration

Pearls and Pitfalls

- Consider this technique in a "can't intubate, can't ventilate" scenario where anatomical landmarks are difficult to palpate or identify.
- A small incision with a No. 11 blade may be made prior to needle insertion to facilitate passage of the needle.
- This procedure does require slightly more time than the "scalpel, finger, bougie" technique for a simple surgical cricothyroidotomy. Benefits are there will be less blood and many proceduralists will feel comfortable with this

approach given its similarities with a Seldinger central line insertion technique.

- If desired, the wire may also be passed cephalad through the vocal cords and out of the mouth. Hold the wire in place at the site of the neck with a hemostat to not lose position. At this point, an ETT can be threaded over the wire into the airway to the appropriate depth. Remove wire, inflate cuff, and attach to BVM. Confirm with EtCO2, breath sounds, and CXR. This approach may be used when there is no obstruction in the upper airway, but intubation from above was unsuccessful. In addition, consider this technique when the prepackaged Melker kit is unavailable.

Suggested Reading

Roberts JR, Hedges JR. Clinical procedures in emergency medicine. Philadelphia: Saunders Elsevier; 2010.

Tintinalli J. Tintinalli's emergency medicine: a comprehensive study guide. 7th ed. New York: McGraw Hill; 2010.

Walls R. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008.

20 Tracheostomy Tube Malfunction

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Indications

- Cuff rupture.
  - Can lead to dislodgment.
- Dislodgment.
  - Most common emergency department TT complication.
  - Can lead to air passage obstruction.
- Obstruction.
  - Caused by blood or thick, dry secretions (formed in the absence of nasopharyngeal air humidification).
  - Dried secretions or blood can act as a one-way valve, allowing air in but restricting outward flow.

Materials and Medications

- Airway suction catheter.
- Oxygen humidifier.
- Bougie/nasogastric (NG) tube (12 French).
- Saline.
- N-acetylcysteine (NAC).
- Appropriately sized endotracheal tube (ETT) or TT.

Procedure

1. Supply high-flow humidified oxygen through a bag valve mask (BVM) or a non-rebreather face mask.
2. Assess clinical indicators to determine TT problem:
   (a) Indicators of cuff rupture: Air leak with BVM and loose TT.
   (b) Indicators of dislodged TT (if TT is still in the stomal opening): Subcutaneous emphysema, crepitus, and diminished or absent breath sounds.
   (c) Indicators of an obstructed TT: ±stridor and diminished or absent breath sounds.
   (d) If time allows, chest radiograph, continuous capnography, and oxygen saturation can be helpful.
3. Obstruction:
   (a) Remove the inner cannula and inspect for obstruction—clean if necessary.
   (b) If this fails, 5–10 mL of saline or NAC can be squirted directly down the TT to loosen secretions.
   (c) Suction thoroughly with a suction catheter (Fig. 20.1).
   (d) In refractory cases, the TT will need replacement.
4. Replacement:
   (a) Ideally, the replacement tube should be of the same type and size as the original TT.
   (b) A smaller size TT or ETT can be helpful in settings of airway compromise.
   (c) A 6–7.5-cm ETT tube may be used if a TT is unavailable.
   (d) Remove the existing TT.
   (e) Hyperextend the patient's head and neck to maximize visualization of the stoma.
   (f) Note: Careful inspection of the area is paramount because the thyroid isthmus may obscure visualization of the tracheal stoma.
   (g) Techniques:
      (i) Direct insertion.
         1. As soon as possible, insert the new TT or ETT into the stoma to prevent stomal narrowing (Fig. 20.2).
         2. Inflate the new TT/ETT cuff.
      (ii) Bougie or NG tube.
         1. Lubricate the TT or ETT tube.
         2. Lubricate a bougie or 12-French NG tube.
         3. Insert the lubricated bougie or NG tube into the TT or ETT.

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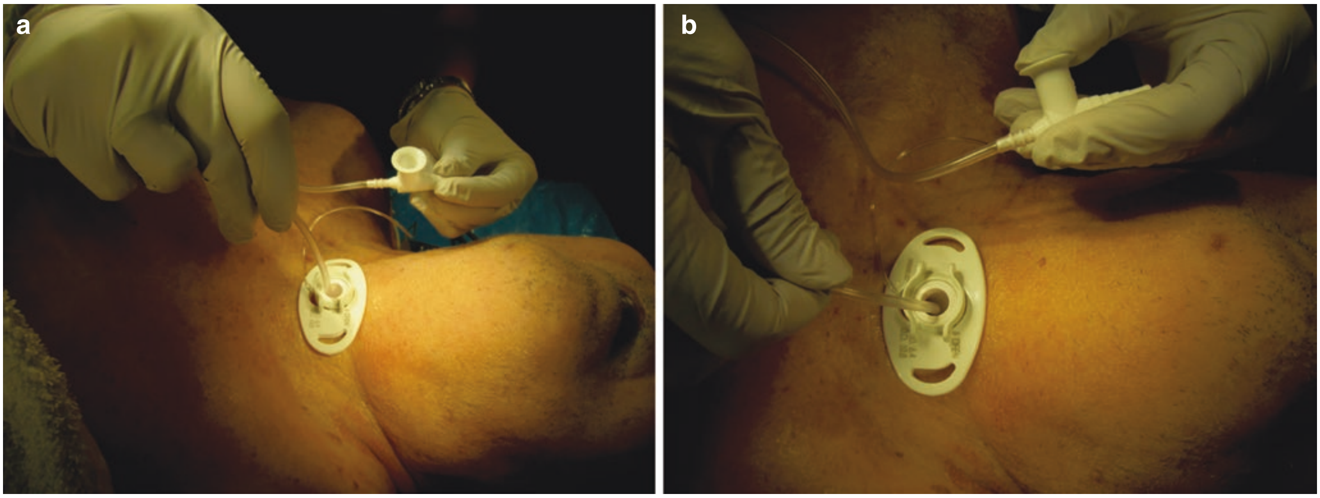

Fig. 20.1 (**a**) Insert the suction catheter to the appropriate depth, keeping the suction port open. (**b**) Slowly withdraw the catheter in a circular motion, keeping the suction port closed

Fig. 20.2 Insertion of the endotracheal tube (ETT) directly into the stoma

4. Insert the bougie or NG tube into stoma and advance into the trachea (Fig. 20.3a).
5. Direct the NG tube or bougie caudad toward the lower tracheobronchial tree.
6. Do not advance more than 7 cm.
7. If resistance is noted:
   (a) Either the operator has reached a terminal bronchiole or is in a false passage.
   (b) Do not force bougie/NG tube farther at this point.
   (c) Use clinical judgment (bougie/ETT depth, palpation) to determine likely placement.
8. Advance TT or NG tube over bougie or NG tube is in the trachea (Fig. 20.3b).
9. After the TT is in place, remove the bougie/NG tube.

(iii) The fingertip technique.
1. Insert a gloved forefinger into tracheal stoma (Fig. 20.4a).
2. Formulate a mental plan as to the direction and path of the stoma.
3. Then place a TT or an ETT into the stoma as the finger is withdrawn (Fig. 20.4b).

5. If placement of a TT or ETT is not possible through the stoma, consider endotracheal intubation.

Pearls and Pitfalls

- Stomas <7 days old require ENT for replacement. Stomas <7 days old with airway obstruction require immediate assistance from ENT or surgery.
- Stomal closing:
  – Stomal constriction begins as soon as the TT is removed or displaced.
  – Forceful attempts to replace a large TT may result in false passages and trauma.
- Tracheal stenosis:
  – Constant TT cuff pressure may cause necrosis, ulceration, and granulation tissue formation, leading to tracheal narrowing.
  – Complicates TT replacement in the setting of dislodgment or obstruction.
  – Bougie use can be helpful to place a small(er) ETT until surgical dilation and/or resection can be achieved.
- Creation of a false lumen during recannulation:
  – Subcutaneous emphysema will be an early indicator of this.

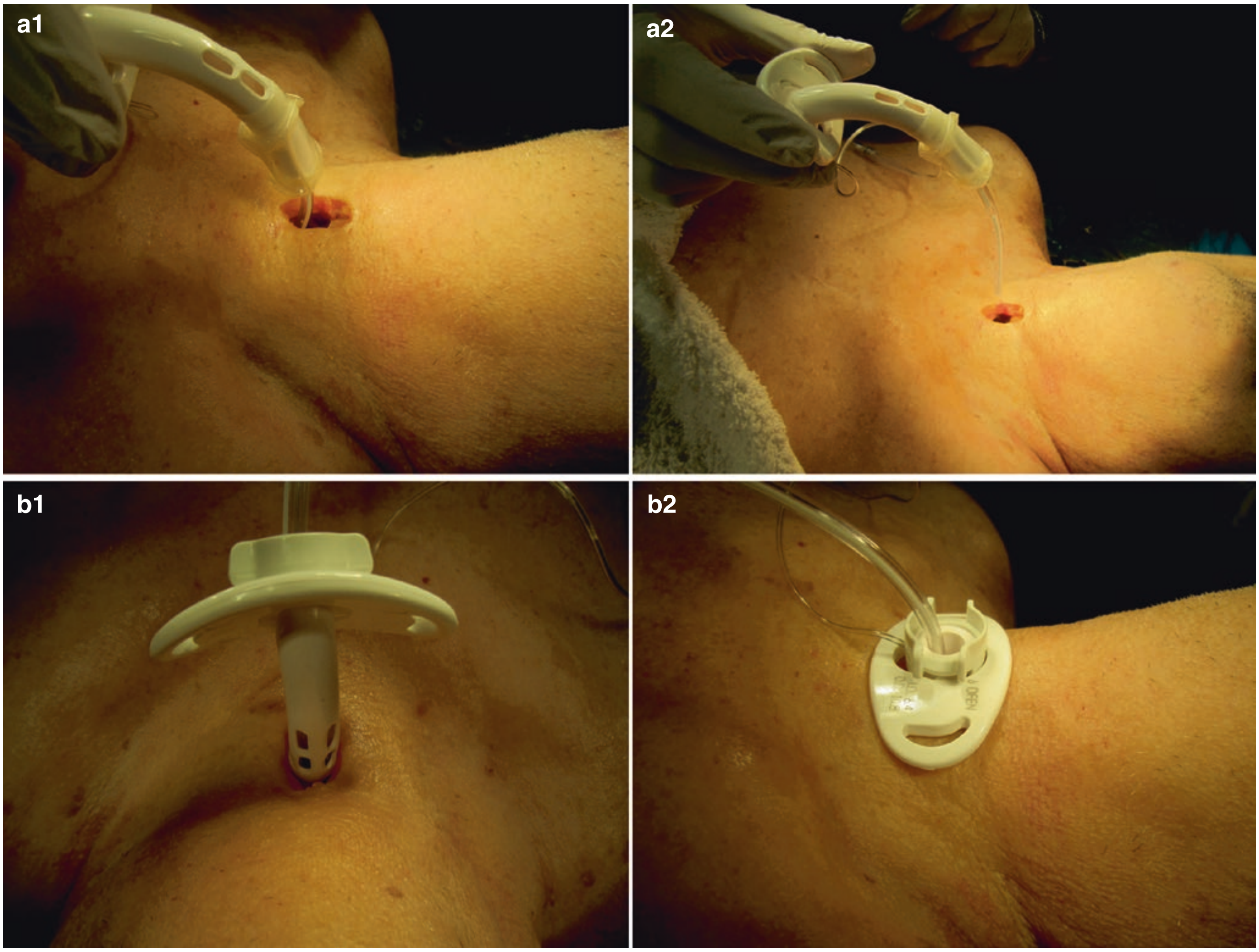

Fig. 20.3 (**a1**, **a2**) Insert the tracheostomy tube (TT) over the nasogastric (NG) tube or bougie, which is first inserted into the trachea. (**b1**, **b2**) Advance the TT over the NG tube or bougie, which serves as a guidewire

  – Early confirmation of correct placement of TT by confirming:
    Continuous end-tidal CO_2 monitoring.
    Equal chest rise.
    Bilateral breath sounds.
- Unrecognized trachea-innominate artery fistula (Fig. 20.5):
  – Usually occurs within 3–4 weeks of placement.
  – Presentation: bleeding around the tracheostomy tube (>10 mL) or massive hemoptysis.
  – Requires:
    ETT cuff overinflation to compress the fistula.
    Digital pressure on stoma may be helpful to tamponade the bleeding.
    Place stomal ETT deep to bleeding fistula to protect airway.
    Definitive surgical intervention in operating room.
  – Associated with high mortality.
- Unrecognized tracheoesophageal fistula:
  – Usually iatrogenic injury from TT placement or NG tube erosion.
  – Presentation: dyspnea, copious TT secretions, recurrent food aspiration, and gastric distention.
  – Requires:
    Bronchoscopy or swallowing studies to confirm diagnosis.
    Surgical repair or stenting.

It is also important to know if the patient has a tracheostomy (upper airway obstruction, mass, inability to manage secretions, etc.). If the patient has had a laryngectomy, you will not be able to bag ventilate or intubate from above.

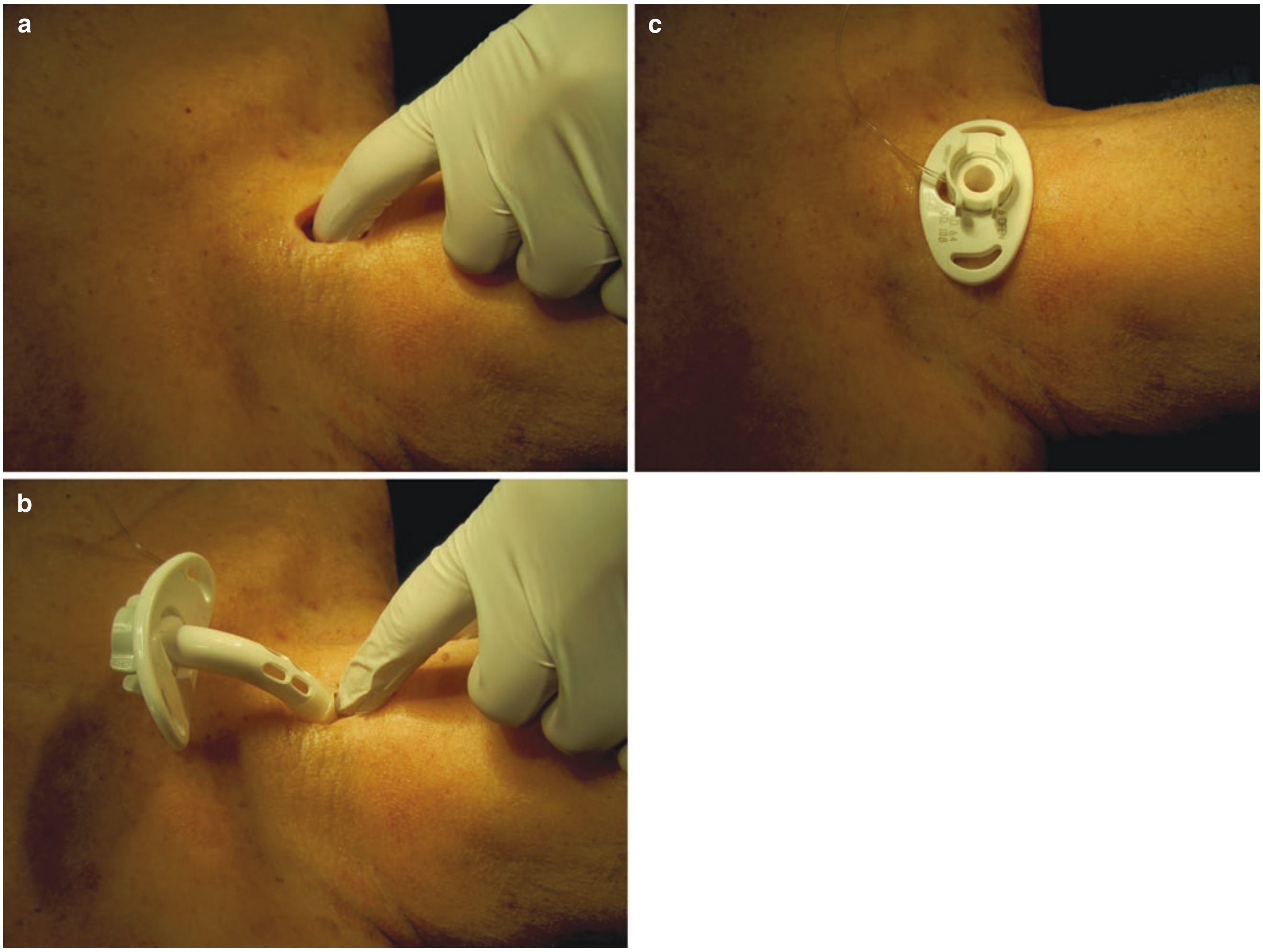

Fig. 20.4 (**a**) Insert a gloved finger into the stoma. (**b**) Insert the TT along the path while withdrawing the gloved finger. (**c**) TT in place

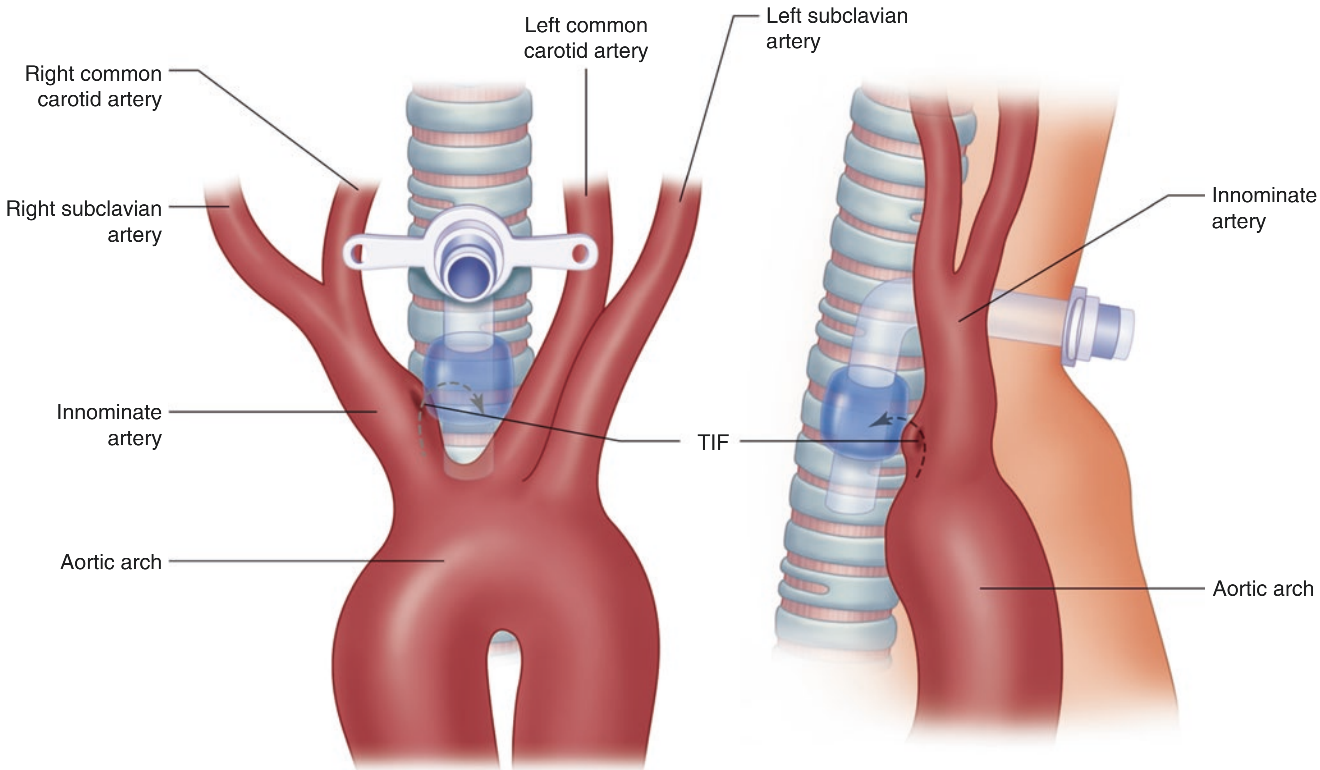

Fig. 20.5 Anatomical relationship between the trachea and the innominate artery. *TIF,* trachea-innominate artery fistula

Suggested Reading

De Leyn P, Bedert L, Delcroix M, et al. Tracheotomy: clinical review and guidelines. Eur J Cardiothorac Surg. 2007;32:412–21.

Dobiesx VA, Miller SA, Pitzele MJ. Complications of tracheostomies. In: Wolfson AB, Hendey GW, Ling LJ, Rosen CL, Scheider JJ, Sharieff GQ, editors. Harwood-Nuss' clinical practice of emergency medicine. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2009.

Epstein SK. Late complications of tracheostomy. Respir Care. 2005;40:542–9.

Friedman M, Ibrahim H. The dislodged tracheostomy tube: "fingertip" technique. Oper Technol Otolaryngol. 2002;13:217–8.

Young JS, Brady WJ, Kesser B, Mullins D. A novel method for replacement of the dislodged tracheostomy tube: the nasogastric tube "~~guidewire~~" technique. J Emerg Med. 1996;14:205–8.

21 Percutaneous Transtracheal Jet Ventilation

Clint Masterson

Indications

- Failure to control the airway by other means
- As a temporary measure while preparing for definitive airway control
- Securing the airway in crash airways in infants and small children

Contraindications

- Absolute
  - Transection of the trachea below the cricothyroid membrane
- Relative
  - Inability to identify the cricothyroid landmarks
  - Anatomical distortion to the cricothyroid membrane
  - Supraglottic obstruction (preventing gas exhalation)

Materials and Medications (Fig. 21.1)

- Betadine, chlorhexidine, or similar skin sterilization solution.
- 12- to 16-gauge angiocatheter or transtracheal jet ventilation (TTJV) purpose-specific catheter.
- 10-mL syringe filled with 4 mL of normal saline, 2% lidocaine, or viscous lidocaine.
- Hand-operated regulator valve.
- Attach oxygen supply.
- Connect kit tubing to wall oxygen or
- Connect 7–0 endotracheal connector to bag valve mask (BVM) attached to oxygen.

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Procedure

1. Attach the tubing and the hand-operated regulator valve to wall oxygen (Fig. 21.2a), and place the distal end of the tubing near the patient in preparation for ventilation.
2. Adjust regulator to maximum pressure, 50 psi if possible (Fig. 21.2b).
3. Palpate the cricothyroid membrane just distal to the thyroid prominence (Fig. 21.3).
   - Sterilize the area with a suitable cleansing agent.
   - Use the thumb and index finger of the nondominant hand to stabilize the trachea for the procedure.
4. Attach the TTJV catheter (or angiocatheter) to the syringe (Fig. 21.4).
5. Advance the catheter through the cricothyroid membrane at a 30–45° caudal direction while aspirating with the syringe (Fig. 21.5).
6. Return of air confirms entry into the trachea.
7. If lidocaine is utilized, it can then be injected to prevent spasm during the procedure.
8. Fully advance the angiocatheter, and secure it while the needle and syringe are withdrawn.
9. Remove the needle, secure it to the skin, and connect it to the regulator hose.
10. Secure the distal end of the oxygen tubing (distal to the hand-operated valve) to the catheter (Fig. 21.6).
11. If a BVM is used as the oxygen source:
    (a) Remove the plunger from a 3-mL syringe and attach it to the angiocatheter.
    (b) Attach the BVM with the 7–0 endotracheal tube (ETT) connector to the end of the plungerless 3-mL syringe (Fig. 21.7).
12. Operate the valve 12–20 times a minute with long periods to allow gas exhalation and exchange (Fig. 21.8).
13. Preparations should be made for a definitive airway as soon as possible—preferably within 15 min.

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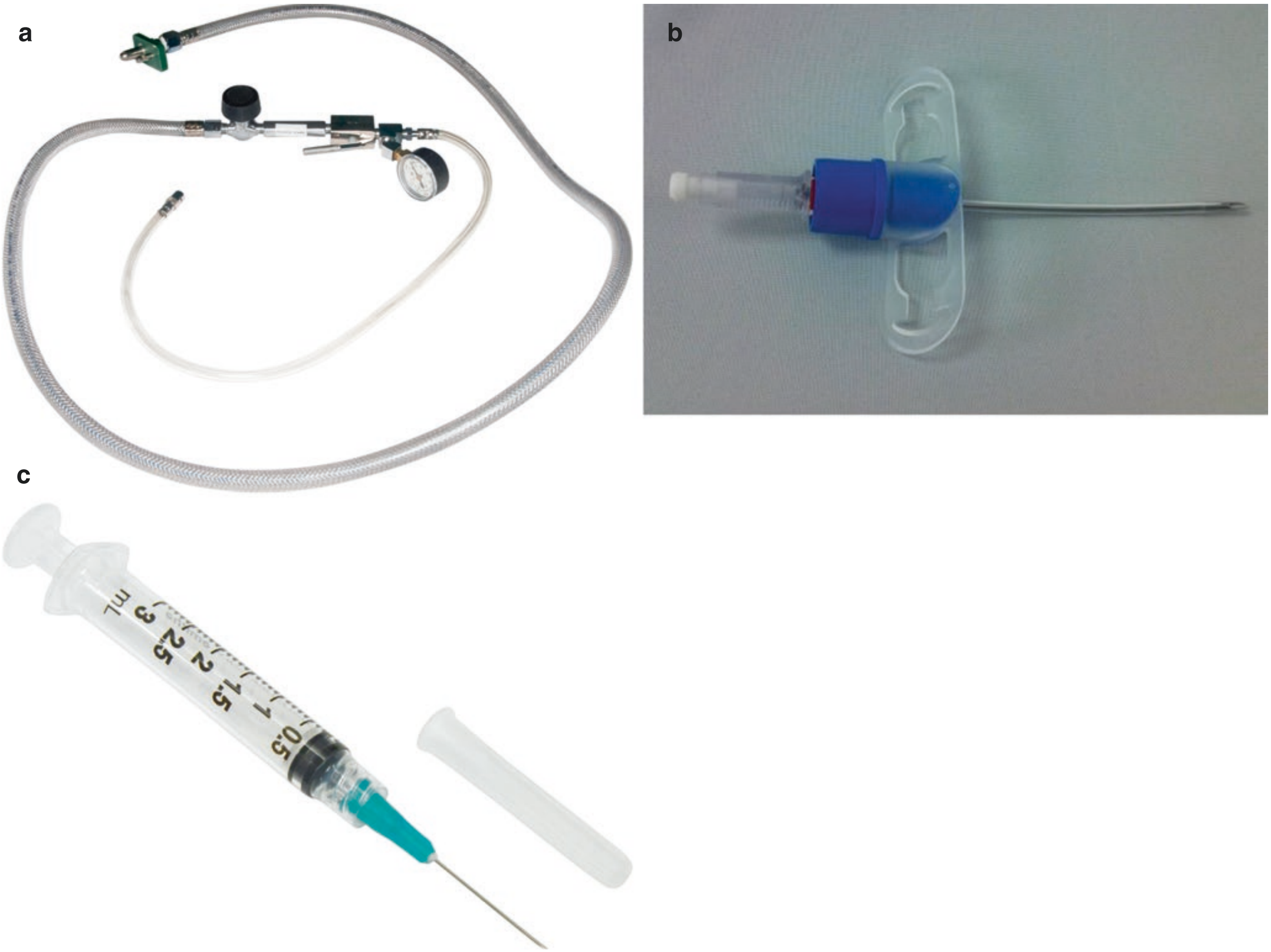

Fig. 21.1 (**a**) Tubing and regulator valve, (**b**) commercially available catheter, (**c**) 3-mL or 10-mL syringe

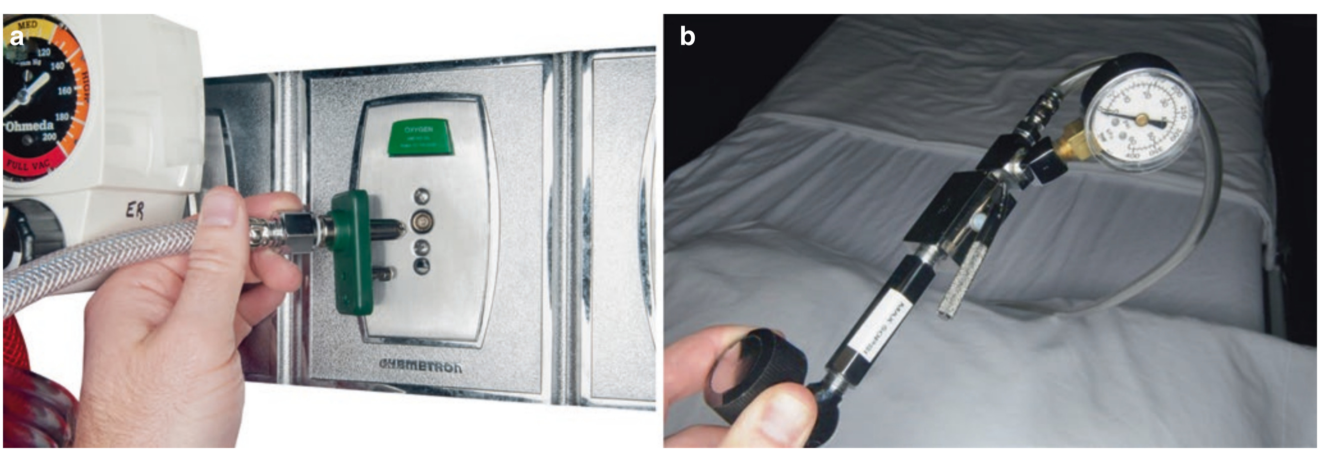

Fig. 21.2 (**a**) Attach tubing and the hand-operated regulator valve to wall oxygen, and (**b**) adjust regulator to maximum pressure (50 psi if possible)

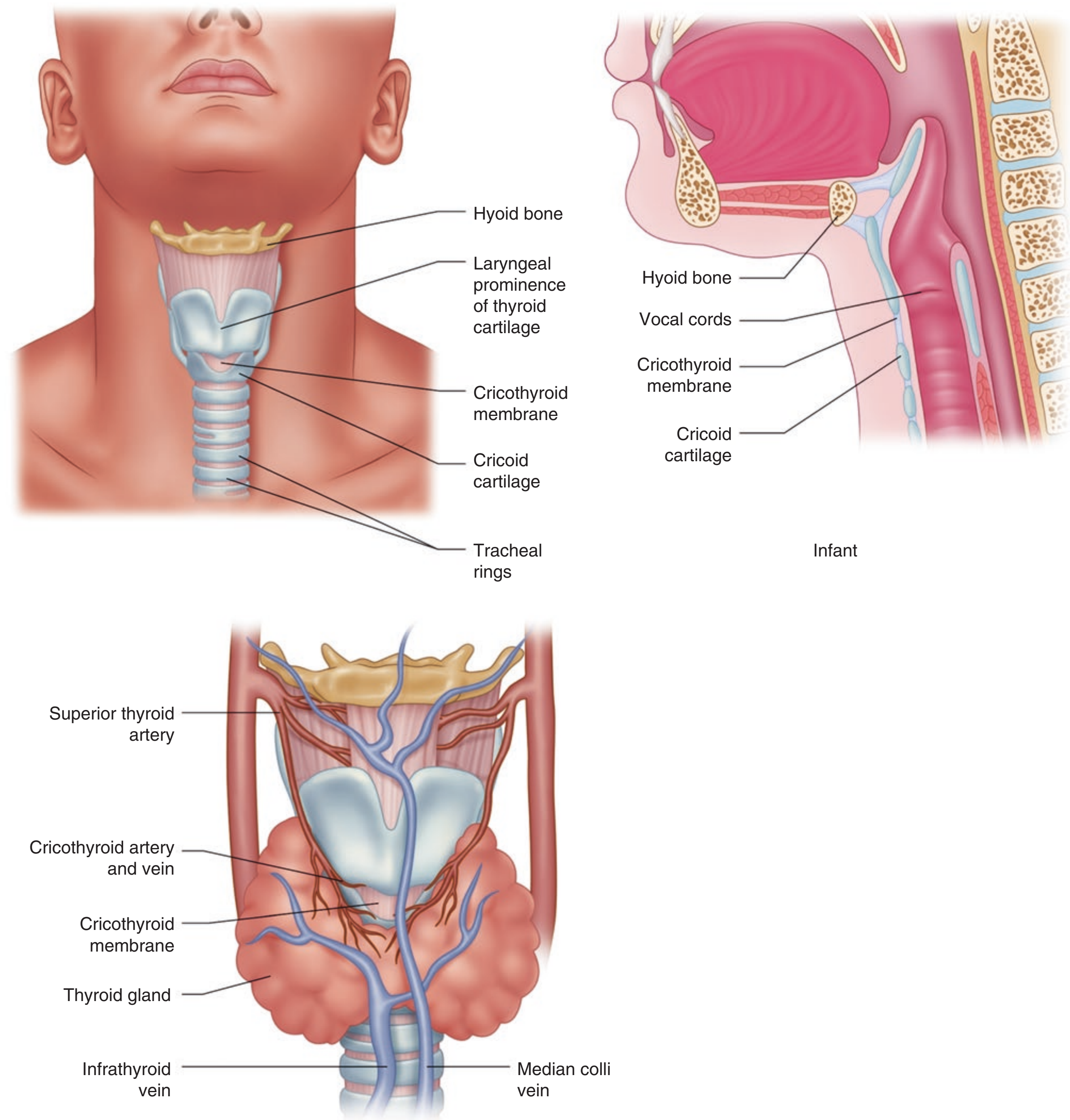

Fig. 21.3 Airway anatomy

Fig. 21.4 Attach the TTJV catheter to the syringe

Complications

1. Pneumothorax
2. Pneumomediastinum
3. Subcutaneous emphysema
4. Catheter kink or misplacement
5. Hypercarbia and respiratory acidosis
   – Use of TTJV for prolonged periods of time without adequate ventilation will elevate CO_2.
6. Barotrauma
7. Coughing in conscious patients
8. Aspiration
9. Persistent stoma

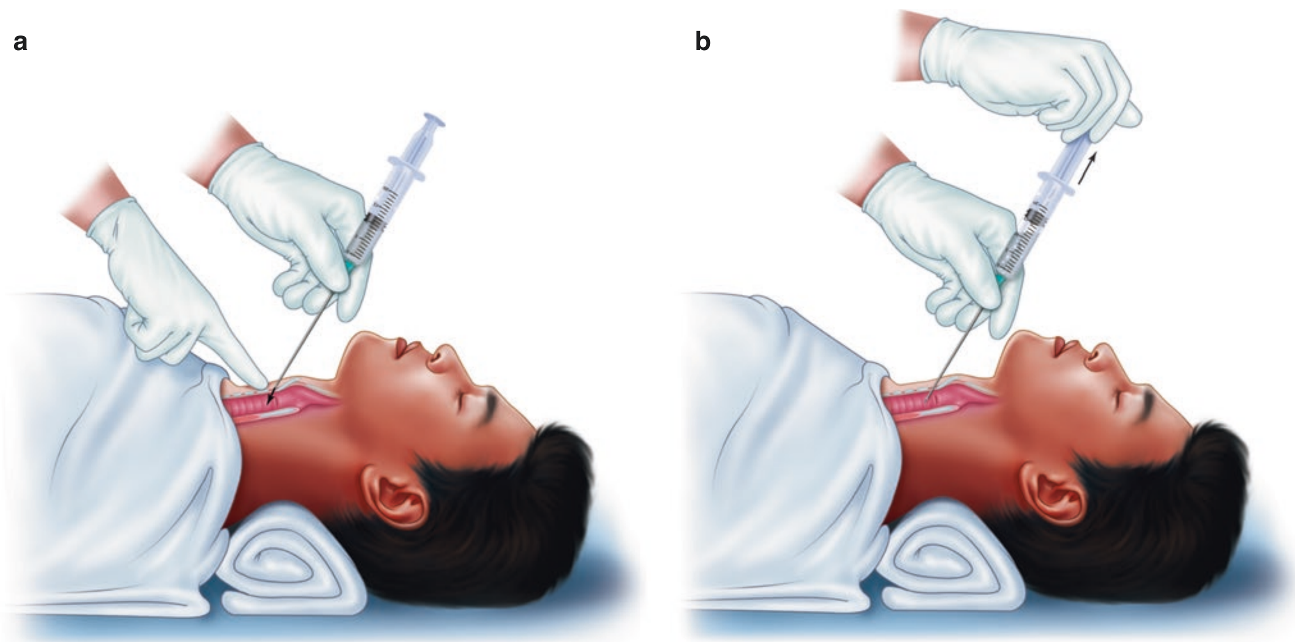

Fig. 21.5 (**a**) Advance the catheter through the cricothyroid membrane at a 30–45° caudal direction (**b**) while aspirating with the syringe

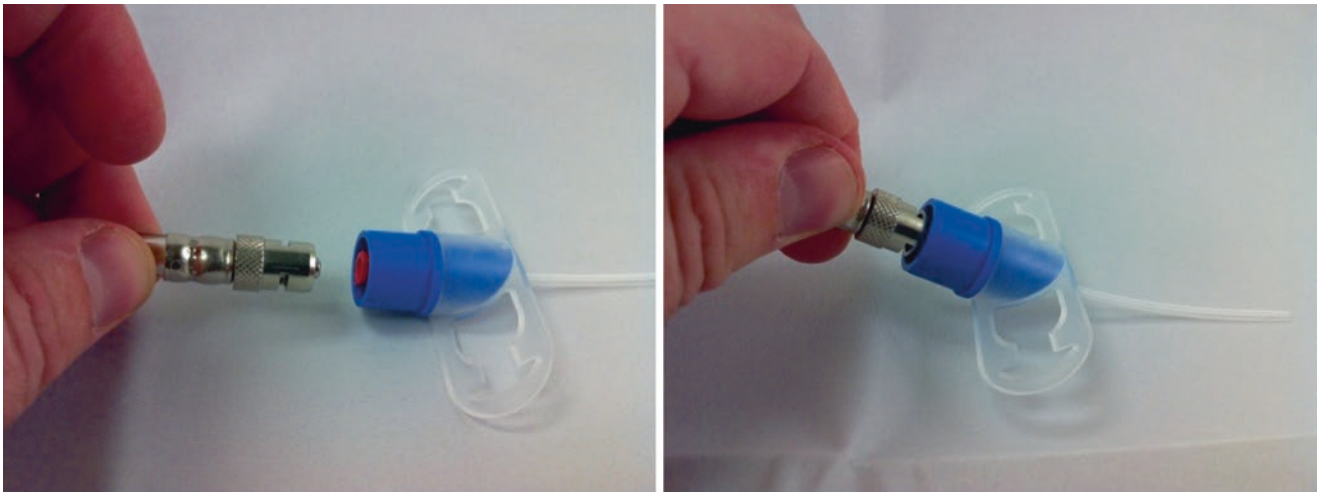

Fig. 21.6 Secure the distal end of the oxygen tubing to the catheter

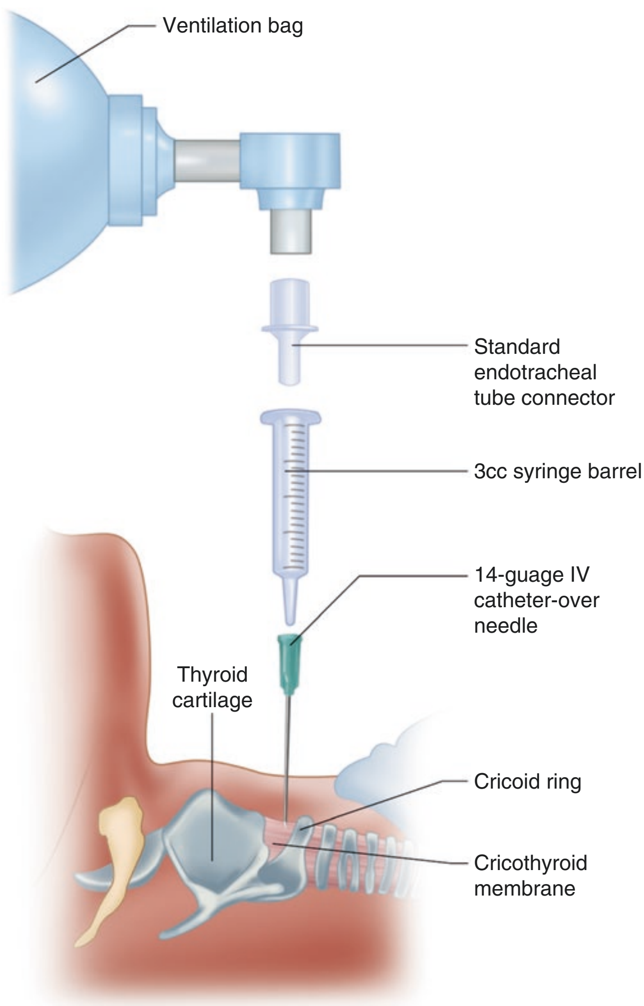

Fig. 21.7 Attach the BVM with the 7–0 endotracheal tube (ETT) connector to the end of the plungerless 3-mL syringe

Fig. 21.8 Operate the valve 12–20 times a minute with long periods to allow gas exhalation and exchange

Pearls and Pitfalls

- If the wall connector does not have a pressure regulator, it can still be used although the risk of barotrauma is greater. Use the endpoint of chest rise to determine the end of each ventilation burst in this case.
- Higher pressures and lack of supraglottic air exchange are risk factors for pneumothorax. If the supraglottic area is obstructed, a Y catheter can be attached to allow gas to escape before the next insufflation.
- TTJV may or may not allow sufficient gas exchange to prevent hypercarbia. Preparations should be made to obtain a definitive airway as soon as possible.
- Endotracheal intubation may be facilitated by the high pressures insufflated in the trachea, and a repeat attempt may be performed after the transtracheal ventilation is achieved.

Suggested Reading

Patel R. Percutaneous transtracheal jet ventilation. A safe, quick and temporary way to provide oxygenation and ventilation when conventional methods are unsuccessful. Chest. 1999;116:1689–94.

Roberts JR, Hedges JR. Clinical procedures in emergency medicine. Philadelphia: Saunders Elsevier; 2010.

Tintinalli J. Tintinalli's emergency medicine: a comprehensive study guide. 7th ed. New York: McGraw Hill; 2010.

Walls R. Manual of emergency airway management. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008.

Part III

Thoracic Procedures

Needle Thoracostomy

22

Lucas McArthur, Christian Fromm, and José A. Rubero

Indications

Needle decompression thoracostomy is a procedure used in the emergent treatment of a tension pneumothorax. Tension pneumothorax is a clinical diagnosis. Decompression treatment should not be delayed in order to obtain radiographic confirmation. The following scenarios illustrate some of the clinical signs that *may* be present in such patients:

- *Awake patient* with suspected or confirmed tension pneumothorax
  - Chest pain
  - Respiratory distress
  - Decreased breath sounds with hyperresonance and/or subcutaneous emphysema
  - Trachea deviated away from the side of the pneumothorax
  - Tachycardia
  - Falling pulse oximetry (SpO_2)
  - Distended jugular veins
  - Shock/Hypotension
- *Ventilated patient* with suspected or confirmed pneumothorax (often insidious)
  - Increased resistance to ventilation
  - Hypotension
  - Elevated central venous pressure
  - Tachycardia
  - Distended jugular veins
  - Decreased breath sounds with hyperresonance and/or subcutaneous emphysema
  - Trachea deviated away from the side of the pneumothorax
  - Falling SpO_2
  - Shock
- *Injured patient* (especially with penetrating chest trauma) with suspected or confirmed tension pneumothorax
  - In arrest
  - Unexplained hypotension
  - Apnea
  - Decreased breath sounds with hyperresonance and/or subcutaneous emphysema

Absolute Indications

- Patient in acute respiratory distress with rapid decompensation secondary to suspected or confirmed tension pneumothorax
- Injured patient in extremis with apnea, unexplained hypotension, or arrest

Contraindications

- No absolute contraindications.

Materials

- Large-bore needle/angiocatheter (minimum of 16 gauge)
- 10-mL syringe (optional)
- One-way valve (optional)
- Betadine (povidone-iodine) swab/chlorhexidine scrub
- Tape

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Procedure

1. Expose the chest wall at the level of the anterior axillary line in the fourth or fifth intercostal space on the affected side (Fig. 22.1). Alternatively, expose the anterior chest at the level of the second intercostal space on the affected side.
2. Cleanse the area with a Betadine swab or chlorhexidine scrub (Fig. 22.2).
3. Using a gloved hand, locate the fourth or fifth intercostal space at the anterior midaxillary line or alternatively second intercostal space at the midclavicular line (use this approach for pediatric and "thin" adult patients).
   - (a) The fourth intercostal space is usually aligned to an imaginary line from the nipple to the midaxillary line.
   - (b) Alternatively, the second rib is felt just below the clavicle.

     Note: The same general steps listed later are employed in both approaches, and care is taken to avoid the neurovascular bundles inferior to the second or fourth/fifth rib.

Fig. 22.1 The preferred site for needle thoracostomy is the fourth or fifth intercostal space in the midaxillary line or alternatively second intercostal space in the midclavicular line

Fig. 22.2 Prepare the skin with povidone-iodine or chlorhexidine

4. Insert the needle/angiocatheter perpendicular to the chest wall into the fourth (or second) intercostal space just above the superior edge of the fifth (or third) rib to avoid the intercostal neurovascular bundle (Fig. 22.3).
   - (a) This step may be done with or without a syringe attached.
   - (b) Local anesthesia is usually unnecessary but may be used if the patient is not in extremis.
5. Carefully walk the needle over the fifth (or third) rib, and advance until the pleural space is entered.
   - Entry into the pleural space is accompanied by a "popping" sound or a sensation of "giving way."
6. If you are able to withdraw air with the syringe or hear a "hiss" of air escaping through the angiocatheter during expiration and inspiration, then placement is considered successful.
7. After removing the needle, secure the angiocatheter in place with tape (Fig. 22.4).

   Caution: Do not reinsert needle into the angiocatheter owing to the danger of sheering the angiocatheter.
8. Assess the patient and evaluate the effectiveness of the procedure.

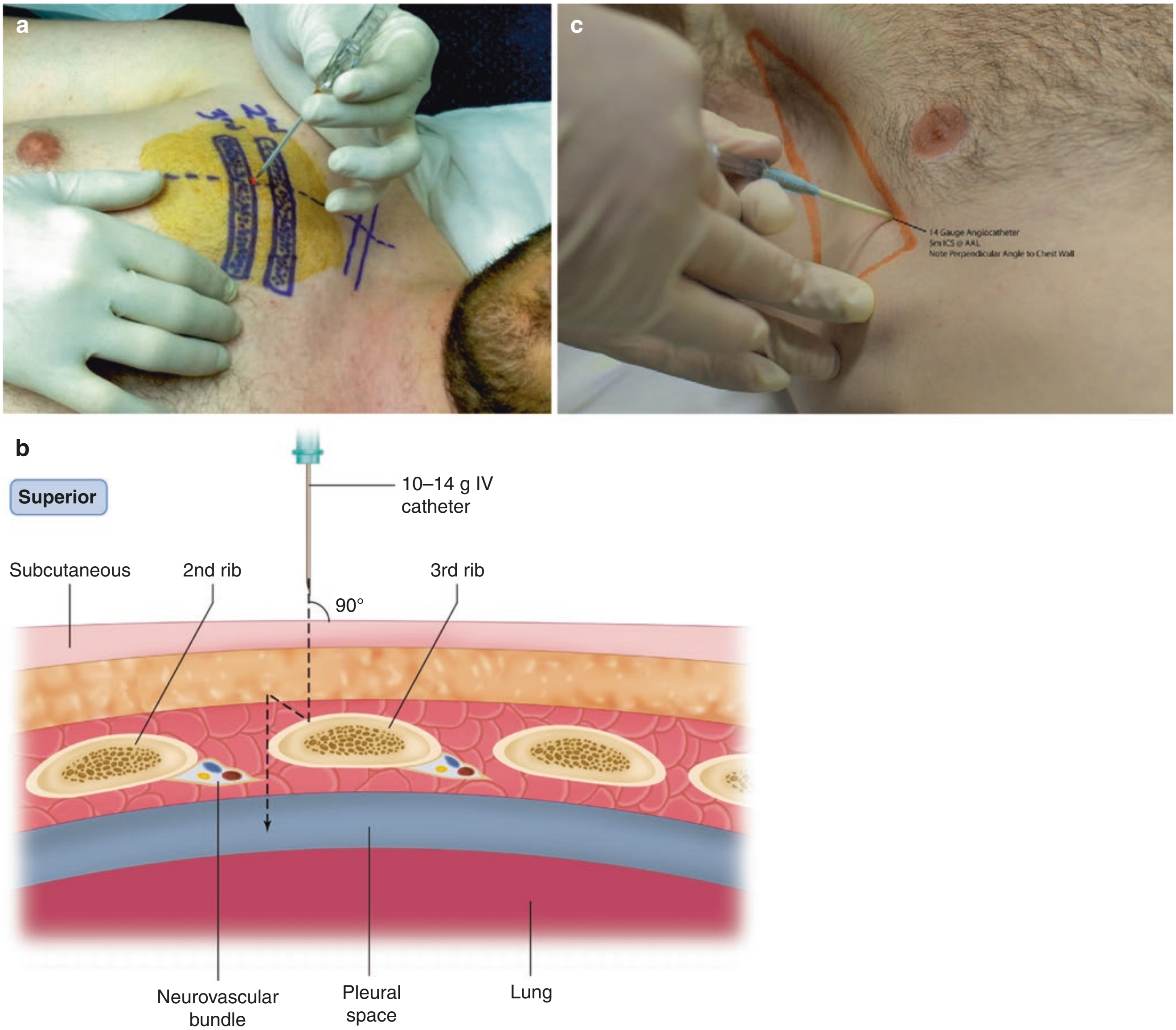

Fig. 22.3 (**a**) Insert the needle into the fourth (or second) intercostal space just above the superior edge of the fifth (or third) rib, and (**b**) avoid the neurovascular bundle by approaching the skin with the needle perpendicular to the chest wall just above the superior edge of the fifth (or third) rib (**c**)

(a) The patient should exhibit immediate and obvious improvement in respiratory status including improved lung sounds and vital signs.
(b) The procedure may be repeated if the patient is not improving.
(c) Excess pleural air may be aspirated through the angiocatheter with a syringe.

9. Obtain a chest radiograph to confirm success.
   (a) Repeat in 6 h.
10. Because needle decompression is only a temporizing measure, tube thoracostomy (see Chap. 23) must be performed for definitive management of the pneumothorax.

Complications

- Failure to resolve the tension pneumothorax.
  – Obese or muscular patients may require a longer needle and catheter to reach the pleural space or, alternatively, may require proceeding immediately to tube thoracostomy.
- Iatrogenic pneumothorax.
- Laceration of intercostal artery or nerve.
- Rapid re-expansion may result in the development of pulmonary edema.
- Infection.

Fig. 22.4 After removing the needle, secure the angiocatheter in place with tape

Pearls and Pitfalls

- Use the nipple as a landmark for the fourth intercostal space.
- Use the sternum as a landmark to more easily locate the second and third ribs.
- Primary pneumothorax is unusual in those older than 40 years. Consider the presence of underlying disease in this population.

Acknowledgments We would like to thank Antonios Likourezos, MA, MPH, and Abraham Lederman for assisting with the photographs.

Suggested Reading

ATLS 10th edition student course manual. American College of Surgeons. p. 345–7.
Britten S, Palmer SH. Chest wall thickness may limit adequate drainage of tension pneumothorax by needle thoracocentesis. Emerg Med J. 1996;13:426–7.
Custalow CB. Color atlas of emergency department procedures. Philadelphia: Saunders; 2005.
Leigh-Smith S, Harris T. Tension pneumothorax—time for a re-think? Emerg Med J. 2005;22:8–16.
Roberts JR, Hedges JR. Clinical procedures in emergency medicine. 7th ed. Philadelphia: Saunders; 2019.

23 Tube Thoracostomy (Chest Tube)

Larissa O. Dub and Latha Ganti

A pneumothorax is the presence of air in the space between the parietal and visceral pleura that results in collapse of the lung. This can be seen on chest radiography (Fig. 23.1) or ultrasonography (see Chap. 78). The hallmark physical exam finding is absence of breath sounds on the ipsilateral side. A tension pneumothorax occurs when a "one-way valve" defect allows air into, but prevents air out of, the pleural space. This results in collapse of vascular structures within the mediastinum, causing decreased venous return to the heart and eventually cardiac arrest. A tension pneumothorax should be a clinical (vs. a radiographic) diagnosis.

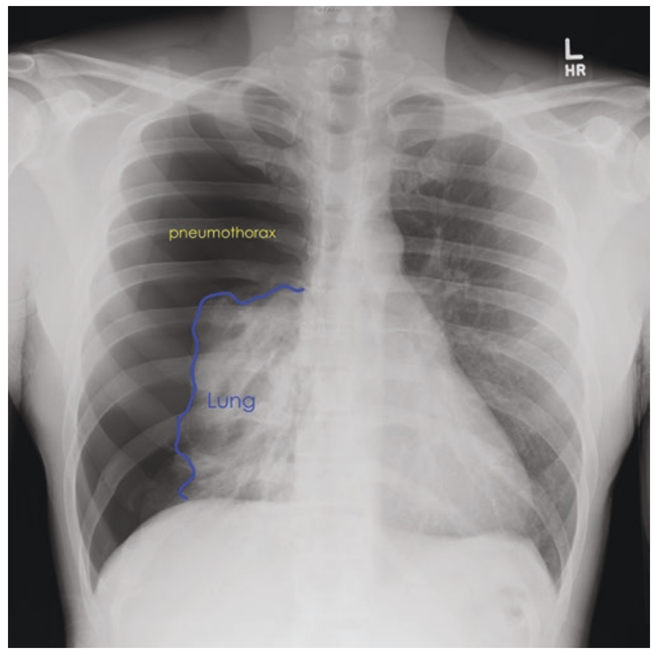

Fig. 23.1 Chest radiograph demonstrating 90% collapse of the right lung

Indications

- Tension pneumothorax (or suspected) should be a clinical (vs. radiographic) diagnosis
- Penetrating chest injuries
- Hemopneumothorax in acute trauma
- Patient in extremis with evidence of thoracic trauma
- Spontaneous pneumothorax (large and/or symptomatic)
- Iatrogenic pneumothorax
- Complicated parapneumonic effusions (empyema)
- Chylothorax/hemothorax
- Post-thoracic surgery
- Bronchopleural fistula

Contraindications

- Absolute
  - Emergent thoracotomy
- Relative
  - Coagulopathy
  - Pulmonary bullae
  - Pulmonary, pleural, or thoracic adhesions
  - Loculated pleural effusion or empyema
  - Skin infection over the chest tube insertion site

Materials and Medications

- Tube thoracostomy tray
  - #10 scalpel; 18-, 22-, and 25-gauge needles; 10-mL syringes; forceps; clamps; scissors; drape; abdominal pads; 0 or 1-0 silk suture; needle driver; curved clamp (Fig. 23.2a)

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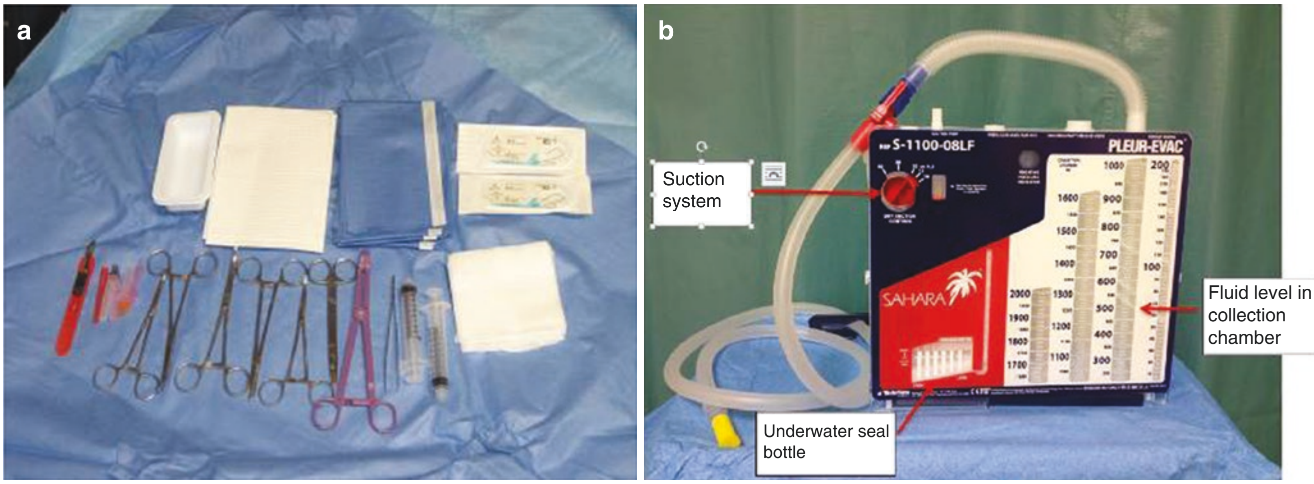

Fig. 23.2 (**a**) Tube thoracostomy tray, (**b**) chest drainage system

- Betadine (povidone-iodine) or other skin antiseptic preparation solution
- Lidocaine (1% or 2% with epinephrine)
- Appropriate chest tube size in trauma (approximate)
  - Adult male: 28–36 French
  - Adult female: 28 French
  - Child: 12–24 French
  - Infant: 12–16 French
  - Neonate: 10–12 French
  - (Note: Where feasible, the American College of Chest Physicians support the use of small-bore catheters such as pigtail catheters of sizes <14Fr.)
- Vaseline gauze
- Chest drainage system (Fig. 23.2b)

Procedure

1. Elevate the head of the bed 30–60° if possible—this lowers the position of the diaphragm, thus reducing risk of iatrogenic injury.
2. Sterile skin preparation with sterile drape.
3. Anesthetize the appropriate area subcutaneously up to and including the rib periosteum with 5 mL of 1–2% lidocaine with epinephrine (Fig. 23.3a).
4. Using a #10 or #11 blade, make an approximately 2-cm skin incision over the desired intercostal level of entry (most often the fourth or fifth intercostal space in the midaxillary line (Fig. 23.2b, c).
   If the incision is placed *below* the fifth intercostal space, the risk of subdiaphragmatic placement into the abdominal space is increased.
5. Bluntly dissect with a hemostat or Kelly clamp through the subcutaneous tissue to the level of the intercostal muscle with intermittent opening of the dissection instrument during advancement (Fig. 23.3d, e).
6. Digitally palpate the selected intercostal space and the superior margin of the inferior rib (pay careful attention to avoid the neurovascular bundle lying inferiorly) (Fig. 23.3f). Move your finger around to confirm correct you are in the pleural space by feeling the lung.
7. Guiding the closed Kelly clamp over the upper margin of the rib, enter the chest wall into the pleural cavity. (This will require some controlled force and a twisting motion.) Once the pleural space is entered, a rush of air or fluid should occur (Fig. 23.3g).
   Uncontrolled force and a lunging motion can result in penetration to the lung, heart, liver, or spleen.
8. Open the Kelly clamp while still inside the pleural space, and then withdraw while the clamp is still open to enlarge the dissected tract of entry and allow easier passage of the thoracostomy tube (TT).
9. Explore the dissected tract with a sterile finger to appreciate lung tissue and possible adhesions.
10. To estimate the length the TT is to be inserted, measure the distance between the skin incision and the apex of the lung. If preferred, place a clamp over the tube at the estimated length (Fig. 23.3h).
11. Grasp the proximal end of the TT with the large Kelly clamp, and pass the tube through the thoracic cavity along the previously dissected tract.
12. Release the Kelly clamp and continue to advance the tube posteriorly and superiorly.

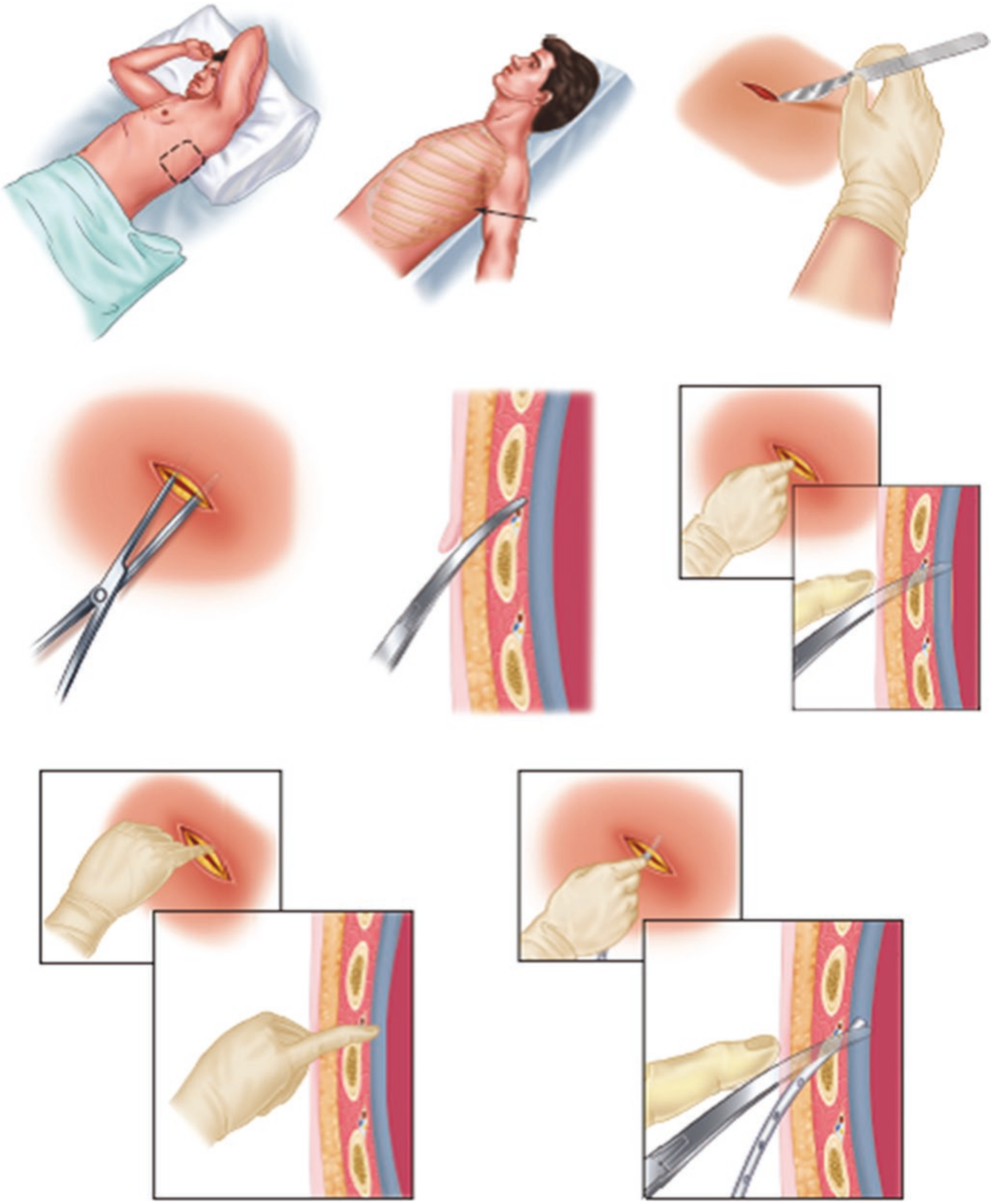

Fig. 23.3 Chest tube thoracostomy procedure

Make sure all of the fenestrated holes of the TT are within the thoracic cavity to prevent unnecessary manipulation and/or replacement of the TT.

13. Once the TT is in the desired position, connect the tube to the drainage device (*see* Fig. 23.2b). Once connected, release the cross clamp on the distal end of the TT.
14. Secure the TT to the skin with 0 or 1-0 silk or nylon suture. A simple, interrupted suture above and below the TT with each stitch wrapped tightly around the TT is recommended.

    Incomplete security of the TT leads to dislodging of the tube with routine patient movements.
15. Apply petrolatum gauze over the skin closure surrounding the TT, and then apply a support dressing with 4 × 4 gauze and adhesive tape (4 in.).
16. Obtain a chest radiograph to confirm placement of the TT.

Complications

1. Improper placement for pneumothorax
   - Reposition if
     - Horizontal (over diaphragm)
     - Subcutaneous
     - Placed too far into the chest (against apical pleura)
   - Remove if
     - Placed into the abdominal space
2. Bleeding (local vs. hemothorax)
3. Hemoperitoneum (liver or spleen injury)
4. Tube dislodgment
5. Empyema (TT introduces bacteria into the pleural space)
6. Retained pneumothorax (may require second TT)
7. Re-expansion pulmonary edema
8. Subcutaneous emphysema
9. Bronchial tree injury (pneumothorax will persist despite well-placed chest tube and requires emergent bronchoscopy)

Pearls and Pitfalls

10. Water seal acts as a one-way valve; if the system bubbles, there is an air leak.
11. In the Pleurevac® systems, there is an orange floater which, when static, means the desired suction pressure (usually 20 cmH_2O) has been reached.
12. The negative pressure in the chest cavity equals the amount of water in water seal plus the amount of suction.
13. A chest tube can be removed when there is no air loss or blood for 24 hours.
14. When removing the tube, have patient exhale, and remove as quickly as possible.
15. Leave petrolatum gauze in place for 48 hours before changing it (allows wound to heal better).

Suggested Reading

Djenfi T, et al. Management of spontaneous pneumothorax. Chest. 2015;148(4) https://doi.org/10.1378/chest.2280584.

Dogrul BN, Kiliccalan I, Asci ES, Peker SC. Blunt trauma related chest wall and pulmonary injuries: an overview. Chin J Traumatol. 2020;23(3):125–38. https://doi.org/10.1016/j.cjtee.2020.04.003.

Hamad AM, Alfeky SE. Small-bore catheter is more than an alternative to the ordinary chest tube for pleural drainage. Lung India. 2021;38(1):31–5. https://doi.org/10.4103/lungindia.lungindia_44_20. PMID: 33402635.

Kamio T, Iizuka Y, Koyama H, Fukaguchi K. Adverse events related to thoracentesis and chest tube insertion: evaluation of the national collection of subject safety incidents in Japan. Eur J Trauma Emerg Surg. 2021:1–8. https://doi.org/10.1007/s00068-020-01575-y.

Lee JH, Kim R, Park CM. Chest tube drainage versus conservative management as the initial treatment of primary spontaneous pneumothorax: a systematic review and meta-analysis. J Clin Med. 2020;9(11):3456. https://doi.org/10.3390/jcm9113456. PMID: 33121119; PMCID: PMC7693596.

Pigtail Catheter Placement

24

Aaron J. Umansky and Bobby K. Desai

Indications

- Pneumothorax
- Hemothorax
- Empyema
- Free-flowing pleural effusion (lateral decubitus CXR to assess mobility/viscosity of fluid)

Contraindications

- Coagulopathies
- Thrombocytopenia

Materials and Medications (Fig. 24.1)

- Fentanyl or other pain medications
- 1% Lidocaine with epinephrine, 10-ml syringe with 25-gauge needle
- 10-ml syringe with 18-gauge needle
- Chlorhexidine
- Sterile gloves, masks, gown
- Sterile tray to include:
  - 4×4s
  - 2×2s
  - Drapes
  - Needle driver
  - Scissors
  - Needle holder
- Sterile pigtail catheter
- Scalpel
- Silk suture on cutting needle
- Petroleum-soaked gauze
- Underwater sealed drainage system or a "Heimlich" valve

Procedure

- Perform time out with all appropriate steps.
- Place patient in supine position with ipsilateral arm over the head.
- Identify the fourth or fifth intercostal space, and mark space between pectoralis major and latissimus dorsi at the anterior axillary line (Fig. 24.2).
- Prep skin with chlorhexidine, allow to dry, and apply drapes while maintaining strict sterile conditions.
- Infiltrate the skin with 1% lidocaine, and apply generous anesthetic down to the rib and along superior aspect of the rib, being sure to draw back prior to anesthetic injection at each depth. When bubbles are drawn into syringe prior to injection, pleural space has likely been reached, and generous anesthetic should be applied. Remove needle from the skin (Fig. 24.3a).
- Attach 18-gauge needle to 10 cc syringe, and insert the needle over the superior aspect of the rib along previously anesthetized tract while drawing back. Once in the pleural space, the syringe plunger will give way to aspirating bubbles in cases of pneumothorax and fluid in those patients with free-flowing pleural effusions.
- Remove syringe and insert guide wire into the needle. Advance guide wire about 2–3 cm beyond the tip of the needle (Fig. 24.3b).
- Firmly hold the guide wire in place as the needle is withdrawn. Using a scalpel, make a small incision in the skin adjacent to the guide wire, and pass dilator over the wire to dilate subcutaneous tissue (Fig. 24.3c).
- Remove dilator while maintaining the guide wire in stable position (Fig. 24.3d).
- Straighten the pigtail catheter tip and insert over the guide wire.

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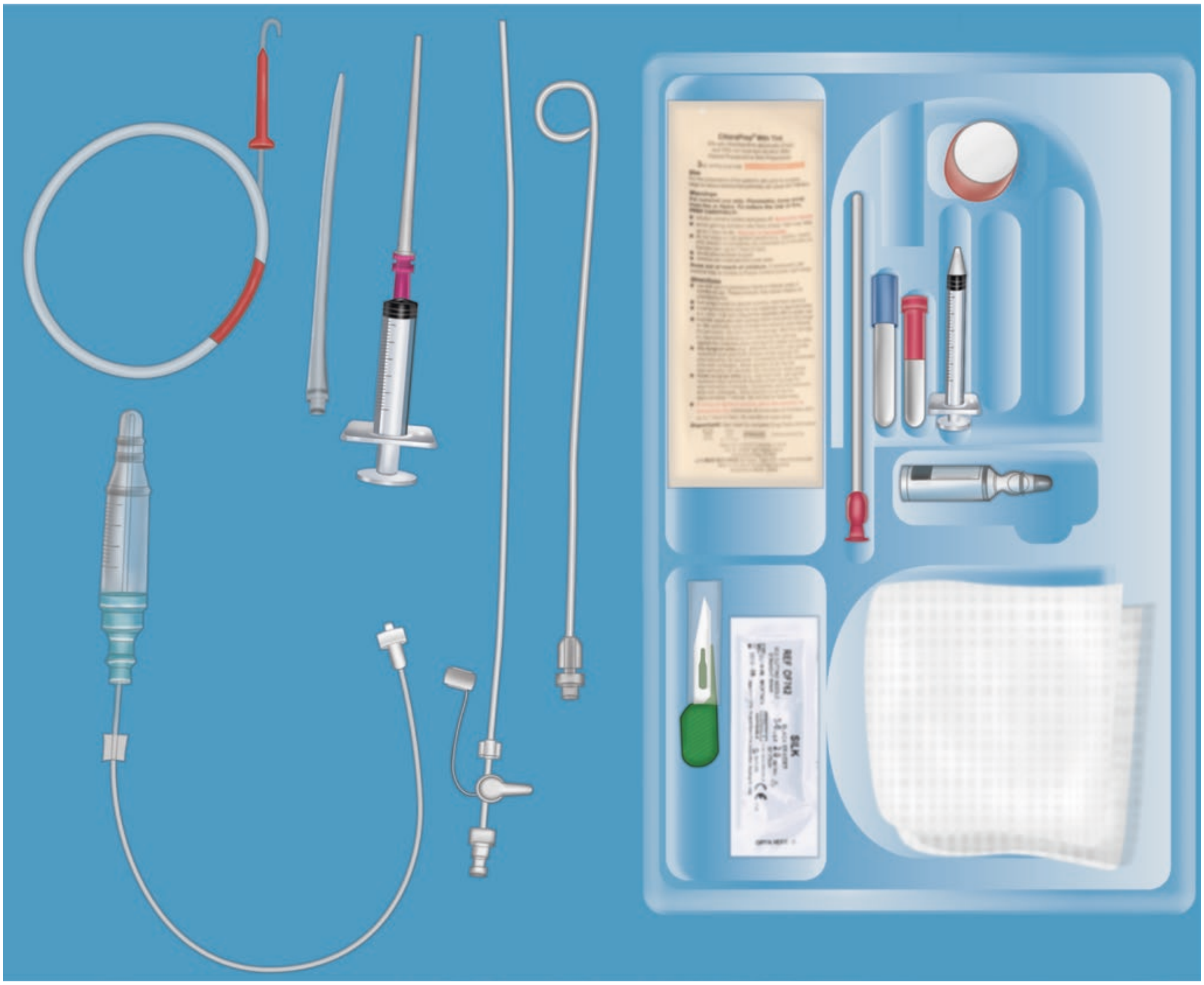

Fig. 24.1 Materials and medications

- Advance until all holes are in the chest, and then extend approximately 1–2 cm further.
- Slowly withdraw the guide wire while holding the pigtail firmly in place. As the guide wire is withdrawn, the pigtail will curl against the chest wall and be parallel with the lung (Fig. 24.3e).
- The pigtail is then immediately connected to underwater sealed drainage or to a one-way "Heimlich" valve to evacuate the pleural space (Fig. 24.4).
- Suture the chest tube securely to the skin.
- Dress insertion site with petroleum-soaked gauze.
- Obtain a repeat CXR to confirm proper placement.

Complications

- Injury to the heart, great vessels, or lung
- Diaphragmatic perforation
- Sub-diaphragmatic placement of the tube
- Open or tension pneumothorax
- Subcutaneous emphysema
- Unexplained or persistent air leakage
- Hemorrhage (especially from mechanical injury to the intercostal artery)
- Recurrent pneumothorax
- Empyema

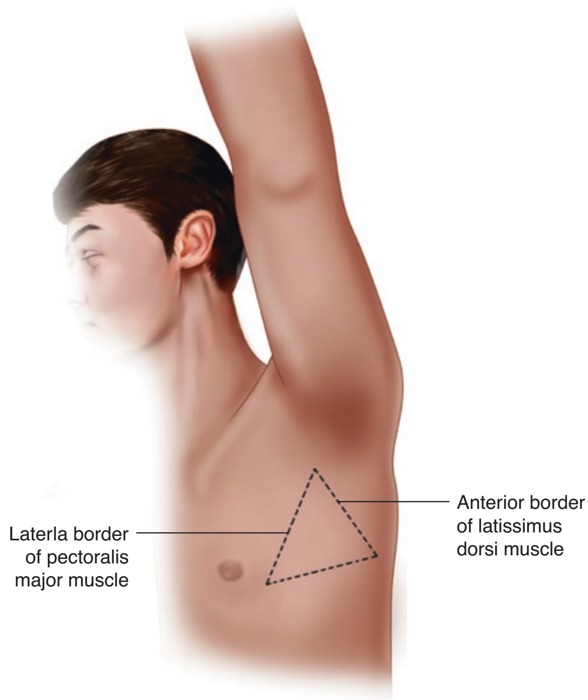

Fig. 24.2 Identify the fourth or fifth intercostal space, and mark space between pectoralis major and latissimus dorsi at the anterior axillary line

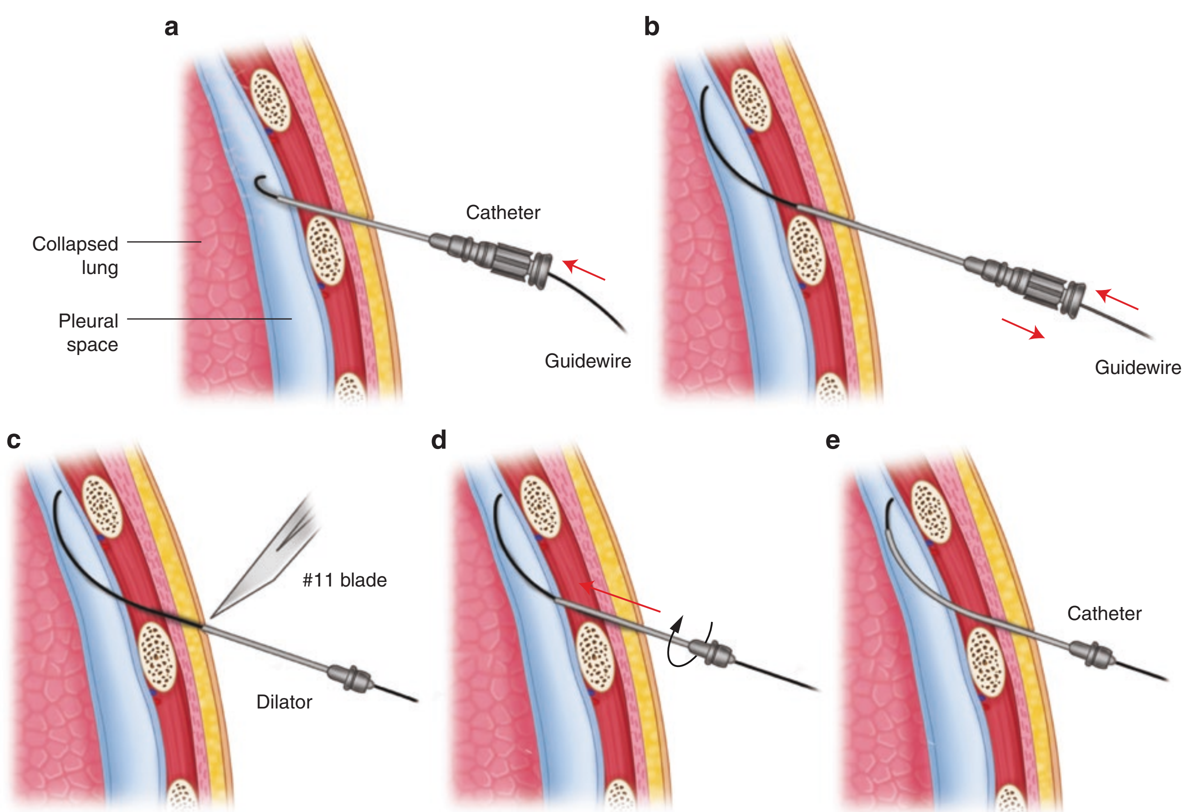

Fig. 24.3 (**a**) When bubbles are drawn into syringe prior to injection, pleural space has likely been reached, and generous anesthetic should be applied. (**b**) Advance guide wire about 2–3 cm beyond the tip of the needle. (**c**) Using a scalpel, make a small incision in the skin adjacent to the guide wire, and pass dilator over the wire to dilate subcutaneous tissue. (**d**) Remove dilator while maintaining the guide wire in stable position. (**e**) Slowly withdraw the guide wire while holding the pigtail firmly in place. As the guide wire is withdrawn, the pigtail will curl against the chest wall and be parallel with the lung

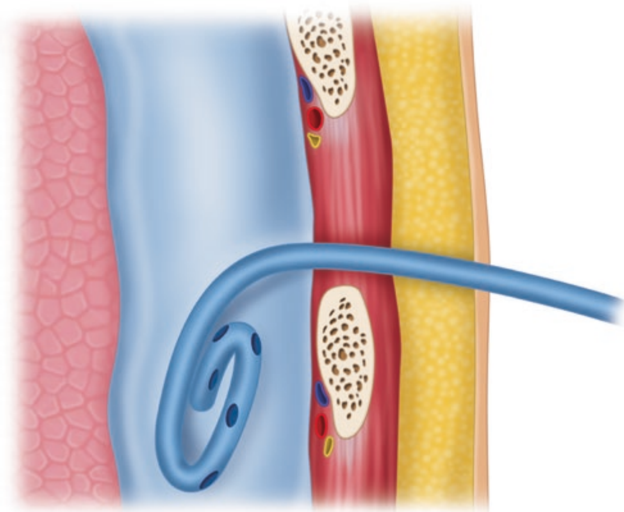

Fig. 24.4 Slowly withdraw the guide wire while holding the pigtail firmly in place. As the guide wire is withdrawn, the pigtail will curl against the chest wall and be parallel with the lung

- Lung parenchyma perforation
- Subcutaneous placement
- Cardiogenic shock (chest tube compression of the right ventricle)
- Infection

Pearls and Pitfalls

- Pigtail catheters are more malleable than large-bore chest tubes and, therefore, allow for more anterior or posterior placement when circumstances do not allow for traditional chest tube placement in the midaxillary line.
- Pigtail catheters are best for the drainage of non-viscid and non-coagulable fluids. They have a higher risk of clogging or kinking in the drainage of thick fluids or hemothorax, so a chest tube may be considered in these cases.

Suggested Reading

Alazemi S. Small-bore drains and indwelling catheters. In: Ernst A, Herth F, editors. Principles and practice of interventional pulmonology. New York: Springer; 2013.

Guthrie J, Azan B, Lim G. Pigtail insertion. 27 Mar 2014. Retrieved 12 Mar 2019, from http://epmonthly.com/article/pigtail-insertion

25 Thoracentesis

Lee Richard Donner and Michael Anana

Indications

- *Therapeutic thoracentesis* is performed to relieve dyspnea, hypoxia, or otherwise compromised respiratory function due to a large pleural effusion.
- *Diagnostic thoracentesis* is performed to aid in the diagnosis and workup of:
  - Pleural effusions of unknown cause
  - Unilateral pleural effusions
  - Pleural effusions originally determined to be due to heart failure but persisting after 3 days of diuresis

Contraindications

- Absolute
  - None
- Relative
  - Coagulopathy, thrombocytopenia.
  - Small or loculated pleural effusion. These will increase the risk of missing the effusion and causing lung injury.
  - Positive pressure ventilation.
  - Skin infection over the needle insertion site.

Materials and Medications

- Thoracentesis tray (commercially available kits generally include the items in the following list) (Fig. 25.1):
  - (1) Fenestrated drape
  - (1) 25-gauge × 1-in. needle
  - (1) 21-gauge × 1.5-in. needle
  - (1) 8-French catheter over 18-gauge needle
  - (1) Small plastic syringe, 5 mL
  - (1) Small plastic syringe, 10 mL
  - (1) Large plastic syringe, 50–60 mL
  - (1) Three-way stopcock
  - Specimen vials and caps
  - (1) Collection bag, 1500 mL, or vacuum container
  - (1) Tubing set
  - (1) Hemostat
  - Betadine (povidone-iodine) or other skin antiseptic preparing solutions
  - 10-mL lidocaine 1% without epinephrine

Procedure

1. Place patient in seated position with arms at rest on a bedside table (Fig. 25.2).
2. The location and height of the pleural effusion are confirmed by physical examination. Auscultation of decreased or absent breath sounds, dullness to percussion, and decreased tactile fremitus are physical findings to confirm the location and height of the effusion (Fig. 25.3).
3. Determine and mark the site of needle insertion. This will be at the midscapular line one or two intercostal spaces below the maximum height of the effusion as determined by a combination of imaging and physical examination (Fig. 25.4).
   - *Do not* attempt thoracentesis inferior to the eighth intercostal space because respiratory cycle and anatomical variation place the diaphragm and intra-abdominal organs at risk.
4. Prepare the skin with the sterile skin preparation and sterile drape.
5. Anesthetize the appropriate area subcutaneously using a 25-gauge needle on a 10-mL syringe. Create a wheal in the skin, and then infiltrate up to and including the periosteum of the rib inferior to the landmarked space with 5 mL of 1% lidocaine.

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Fig. 25.1 Typical commercial thoracentesis tray

Fig. 25.2 Patient in upright, seated position

Fig. 25.4 Marked site for needle insertion

Fig. 25.3 Determining the location and height of the pleural effusion

   – Remember that the neurovascular bundle is found at the inferior border of each rib. Keep this in mind as you approach the rib and throughout the rest of the procedure to avoid injury to these structures (Fig. 25.5).

6. Using a 22-gauge needle, slowly walk the needle up and over the superior border of the rib. Continue to advance the needle along the superior border of the rib with the syringe withdrawn and infiltrating lidocaine intermittently along the way.
7. Pleural fluid will be aspirated once the pleural space is reached. Do not advance the needle further. Deposit 1–2 mL more lidocaine. A hemostat can be placed on the needle at the level of the skin to mark the depth of the pleural space, and the needle can be removed.

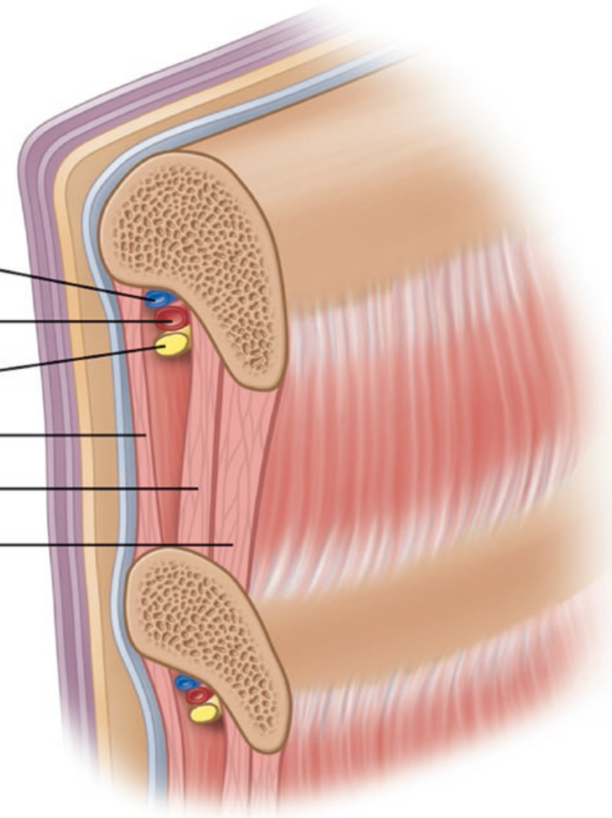

Fig. 25.5 The intercostal neurovascular bundle

8. Some commercial kits may come with an adjustable depth guard to be positioned at the determined depth. On an 18-gauge catheter-over-needle device, position the depth guard to the appropriate depth determined from the prior step. If a depth guard is not available, use the index finger and thumb on the catheter at the appropriate depth. With the 5-mL syringe attached, advance the device over the superior border of the rib while aspirating, expecting pleural fluid to return again at the determined depth (Fig. 25.6).
9. When the pleural space is reached, do not advance the needle further. Advance the catheter over the needle until the hub reaches the skin. Remove the needle during expiration, and immediately cover the open hub with a gloved finger to prevent development of pneumothorax. Some kits provide catheters with one-way valves to prevent air entry.
10. Attach the 50–60-mL syringe to the catheter via the three-way stopcock. Pleural fluid can be drained and transferred to appropriate collection vials for diagnostic thoracentesis. A collection bag may be attached with tubing to the third port of a three-way stopcock for larger volume evacuation in the case of a therapeutic thoracentesis. Employ a syringe pump method to drain 50–60 mL of fluid at a time to the collection bag. Fill the syringe by withdrawing the plunger while the stopcock is closed to the bag. Then, close the stopcock to the patient and pump the contents of the syringe to the bag. Next, close the syringe closed to the bag, and repeat the cycle until the desired volume is drained. A vacuum container is an alternative that simply attaches via tubing to the stopcock (Fig. 25.7).
    – If using a three-way stopcock and a device that does not have a one-way valve on the catheter, be sure to

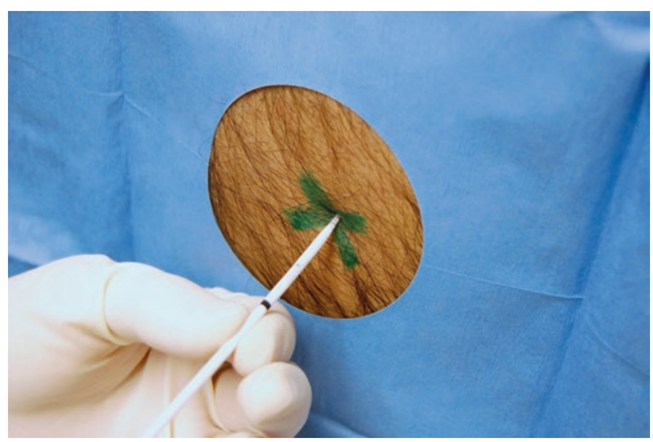

Fig. 25.6 Needle and catheter insertion, thumb and index finger at desired depth

Fig. 25.7 Pleural fluid collection via syringe pump method

always keep the stopcock closed to the patient unless withdrawing fluid in order to decrease the risk of pneumothorax.

11. When the desired amount of pleural fluid is obtained, remove the catheter during expiration, and apply an occlusive dressing.

Complications

- Pneumothorax
- Re-expansion pulmonary edema
- Hemothorax, hematoma
- Intra-abdominal organ injury
- Air embolism
- Empyema

Considerations

- If available, the use of bedside ultrasound is highly recommended because ultrasound guidance has been shown to substantially reduce the risk of pneumothorax. Before the procedure, the height, width, and depth of the effusion can be appreciated by scanning the chest and viewing the effusion through the intercostal spaces. The use of ultrasound aids in selecting the needle insertion site by:
  - Visualizing the distance the needle must pass to reach the parietal pleura
  - Confirming the thickness of the effusion in the site selected is at least a minimum of 1.5 cm
  - Providing the clinician with a view of the effusion and surrounding structures through the complete respiratory cycle

With these items in mind, the needle insertion site can be selected with confidence and marked before beginning the procedure.

- In addition, the use of bedside ultrasound in real time will allow the clinician to visualize the needle as it passes toward and enters the pleural space. This use requires sterile probe covers.
- Re-expansion pulmonary edema is a rare but feared complication of thoracentesis. The cause is not fully understood. Historically, it was thought that re-expansion pulmonary edema was caused by removing too large a volume of fluid from the pleural space (>1–1.5 L). Another theory is that re-expansion pulmonary edema is caused when great negative intrapleural pressures (<20 cmH_2O) are generated during the procedure. The low incidence of this complication has yielded inconclusive evidence.
  - In light of this, it is prudent to continue to limit the volume of pleural fluid removed to no more than 1–1.5 L. Pleural manometry is not widely available for use in the emergency department, but should also be considered if available to maintain intrapleural pressures from reaching more negative values.

Pearls and Pitfalls

- Bedside ultrasound reduces the risk of complications.
- Never attempt thoracentesis below the eighth intercostal space.

- Thoracentesis should not be performed on pleural effusions demonstrated to be less than 1–1.5 cm thick by ultrasound or on a lateral decubitus film.
- Positive pressure ventilation mandates extreme care while performing thoracentesis because the lungs can be punctured during inflation. In addition, ventilated patients will not be able to sit upright and will need to have the procedure performed in lateral decubitus position with the effusion side down and the posterior axillary line as the needle insertion site. Alternatively, the patient can be placed supine with the head of the bed elevated to 45° and the midaxillary line as the needle insertion site.
  - Routine post-procedure radiographs are not necessary to exclude pneumothorax. Indications for post-procedure imaging include onset of chest pain during the procedure, persisting cough or chest discomfort after the procedure, air aspiration along any step of the procedure, or positive pressure ventilation.
  - Pneumothorax rates are higher for inexperienced providers. Although an effusion compromising respiratory function is considered a clear indication for therapeutic thoracentesis, the performance of nonurgent diagnostic thoracentesis might best be delayed for those more practiced in the procedure.

Suggested Reading

Dewitz A, Jones R, Goldstein J. Additional ultrasound-guided procedures. In: Ma OJ, Mateer JR, Blavias M, editors. Emergency ultrasound. 2nd ed. New York: McGraw-Hill; 2008. p. 546–50.

Feller-Kopman D, Berkowitz D, Boiselle P, Ernst A. Large-volume thoracentesis and the risk of reexpansion pulmonary edema. Ann Thorac Surg. 2007;84:1656–61.

Gordon CE, Feller-Kopman D, Balk EM, Smetana GW. Pneumothorax following thoracentesis: a systematic review and meta-analysis. Arch Intern Med. 2010;170:332–9.

Light RW. Pleural effusion. N Engl J Med. 2002;346:1971–7.

Thomsen TW, DeLaPena J, Setnik G. Videos in clinical medicine. Thoracentesis. N Engl J Med. 2006;355:e16.

Open Chest Wounds and Flail Chest

26

Jacob J. Glaser and Carlos J. Rodriguez

Background

Thoracic injuries are commonly associated with penetrating and blunt abdominal trauma and are implicated in 50–70% of trauma deaths [1]. Cardiac tamponade, tension pneumothorax, massive hemothorax, airway obstruction, flail chest, and open pneumothorax represent the six immediately life-threatening injuries attributed to chest trauma [2]. Accordingly, they must be accurately identified and dealt with urgently.

Open pneumothorax ("sucking" chest wound) is seen in penetrating chest injuries. If the associated chest wound is greater than 2/3 the diameter of the trachea (generally anything greater than 1.5–2 cm), air can preferentially enter the intrapleural space, via the trachea, with each inspiration [3] (Fig. 26.1). This allows equilibration of pressure between the pleural space and the atmosphere, causing the lung to collapse and leading to profound hypoventilation and hypoxia.

Flail chest results from high-energy blunt, crushing chest trauma causing two or more fractures in two or more contiguous ribs. Classically, the fractures are lateral or sternal. Posterior rib fractures rarely cause flail physiology (Fig. 26.2). Flail chest has been reported to have mortality as high as 16% [4]. This injury pattern is associated with a high incidence of underlying pneumothorax, hemothorax, pulmonary contusion, and chest wall instability. Mortality from flail chest is thought to be correlated with the degree of underlying pulmonary contusion and attendant hypoxia [2].

Both open pneumothorax and flail chest are immediately life-threatening and require early appropriate management.

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Initial Evaluation of Thoracic Trauma

- To the best extent possible, obtain good patient handover from the prehospital caregivers.
- Initial physical evaluation:
  – Appropriate attention should be given to the ABCs (airway, breathing, circulation) of ATLS (advanced trauma life support) management.
  – Evaluation and resuscitation are to be *concurrent* with diagnostic procedures and immediate interventions.
  – Maintain a high degree of suspicion for open chest wound in impalement injury and destructive penetrating trauma (blast injury or shotgun).
  – Maintain a high degree of suspicion for flail chest in high-energy direct impact trauma (motor vehicle crash, fall, crush injury).
- Administer high-flow O_2 with a non-rebreather mask.
  – If patient is in respiratory distress, is unstable, or has an obvious chest wall defect, consider early intubation to secure the airway.
  – Inspect the chest wall for occlusive dressings.
- Decompress the chest if tension physiology is present or suspected.
  – Immediate decompression of a suspected tension pneumothorax can be readily accomplished by removing any existing occlusive dressings.
  – Place a large-bore cannula over the rib, second intercostal space, or midclavicular line.
- Specific immediate management appropriate to open chest wound and flail chest (see later).
- Monitor continuous pulse oximetry and electrocardiogram.
- Initiate crystalloid resuscitation via large-bore intravenous (IV) access.
  – Early mobilization of blood products if ongoing hemorrhage or expectation of excessive blood loss
  – Placement of resuscitative lines concurrent with management of respiratory parameters

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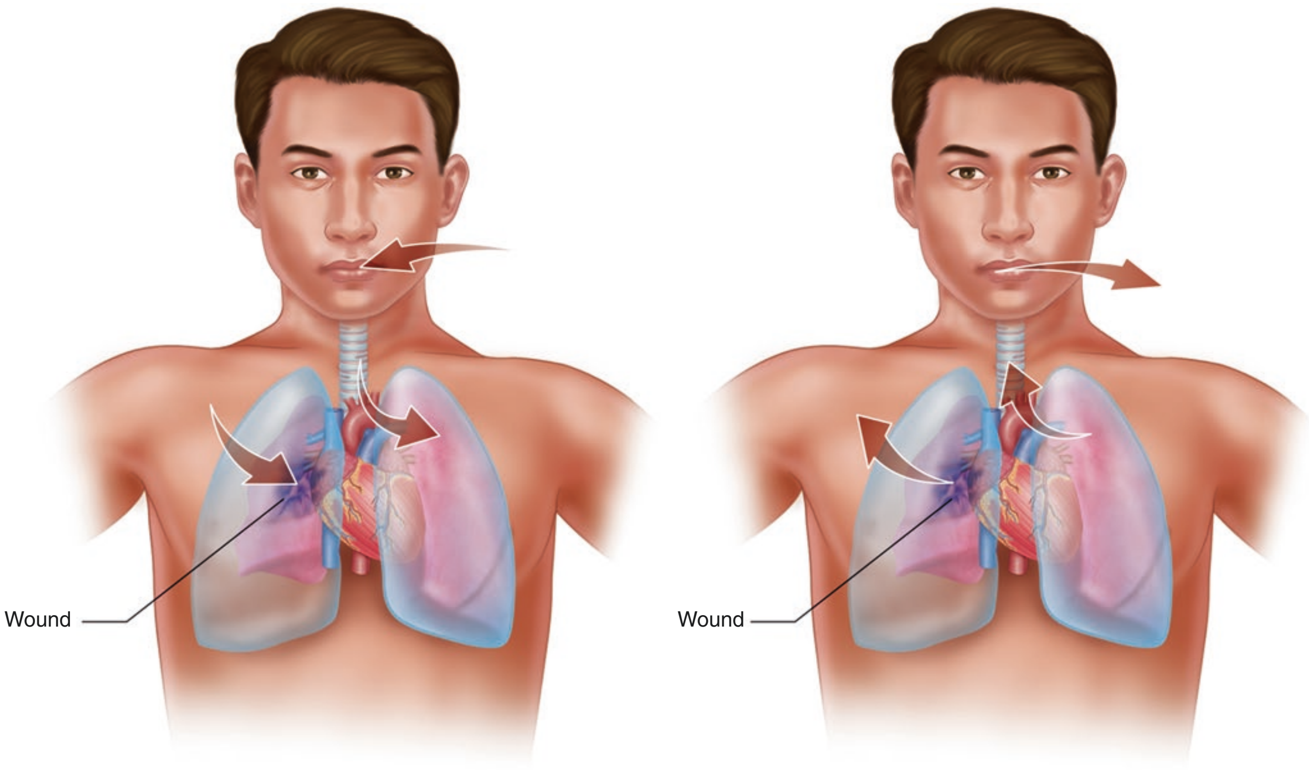

Fig. 26.1 Air preferentially will enter the chest via the wound, collapsing the lung on the affected side

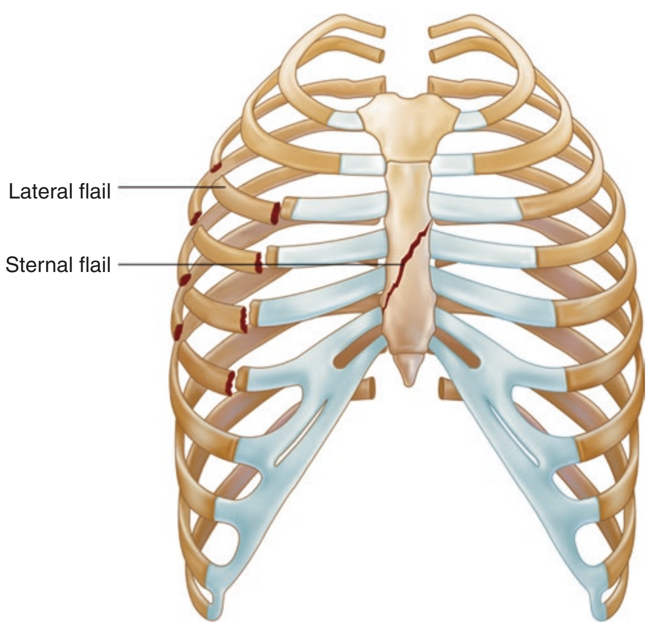

Fig. 26.2 Flail chest: two or more rib fractures in two or more segments. Lateral flail (most common) and sternal flail segments represented below

- Early surgical consultation for management of intrathoracic injuries and management of chest wall defect.

Open Pneumothorax ("Sucking Chest Wound")

- Immediate management requires attention to airway and respirations.
  - If in respiratory distress, *intubate*.
- Close the chest wall defect with an occlusive three-sided dressing.
  - This includes a valve mechanism that allows trapped air to escape, preventing tension (Fig. 26.3).
  - An IV bag cut to fit the wound and then taped on three sides can be useful in an emergent situation.
  - Commercial products are available and appropriate for smaller wounds, including the Asherman Chest Seal and HyFin Vent.
- A completely occlusive dressing may quickly convert an open chest wound into a tension pneumothorax [2, 3, 5] and therefore should *never* be done.
  - The patient and dressing must be serially checked to ensure that trapped air is allowed to escape.
  - If there is any doubt, immediately remove the dressing, and replace it with an appropriate dressing.
- These maneuvers are a bridge to definitive care.
- When the timing is appropriate (i.e., time and resources are available), perform a formal tube thoracostomy,

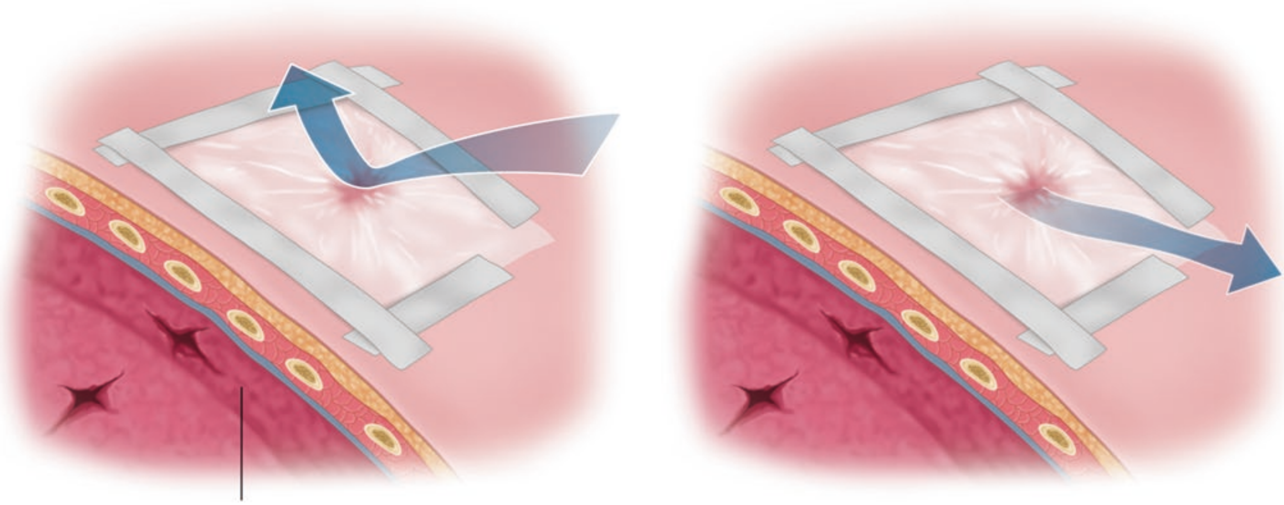

Fig. 26.3 Three-sided dressing, allowing a valve to decompress tension in the chest

and convert to a completely occlusive dressing over the wound.
  – Avoid placing the tube through the open wound.
- Once tube thoracostomy, placement of occlusive dressing, and the airway are secured, the pathophysiology of the open pneumothorax becomes inconsequential.
- Immediate consultation with surgery for definitive care of associated intrathoracic injuries is required.
  – The patient may need urgent thoracotomy to treat associated injuries.
  – Irrigation and debridement should take place in the operating room.
  – Depending on injury severity, the patient may need chest wall reconstruction.

Flail Chest

- Diagnosis is made from mechanism and examination, not radiographically.
  – With inspiration, the affected chest will move inward with negative pressure.
  – With expiration, the affected chest will move outward.
  – Patients who are intubated on positive pressure (and not spontaneously breathing) will often not show this paradoxical chest movement.
- Attention *must* be paid to presumed underlying blunt lung injury and contusion.
  – The degree of underlying contusion (not the flail segment itself) is directly related to the degree of hypoxia and associated morbidity and mortality [2, 3].
  – There should be a low threshold for intubation to manage respiratory distress, hypoxemia, or hemodynamic instability.
  – The patient is at high risk for hemothorax and pneumothorax requiring tube thoracostomy.
- Abdominal injuries may be present in up to 15% of patients [2].
- After initial stabilization, treatment is supportive.
  – Intensive care unit admission for management of underlying pulmonary contusion.
  – Pain control in the form of epidural or regional block for excellent pain control.
  – Close attention to pulmonary toilet and lung re-expansion.
  – Patients require observation and treatment in a monitored setting until ensured that respiratory parameters and oxygenation are improving.
- Surgical stabilization of the chest wall is rarely performed.
  – Early surgical consultation for chest wall fixation in questionable cases is warranted.

References

1. LoCicero J, Mattox KL. Epidemiology of chest trauma. Surg Clin North Am. 1989;69:15–9.
2. Pietzman AB, Schwab CW, Yealy DM, editors. The trauma manual. 2nd ed. Philadelphia: Wolters Kluwer Health; 2000.
3. Weinberg JA, Croce MA. Chapter 33: Chest wall injury. In: Flint L, Meredith JW, Schwab CW, editors. Trauma: contemporary principles and therapy. 1st ed. Philadelphia: Lippincott Williams & Williams; 2007.
4. Clark GC, Schecter WP, Trunkey DD. Variables affecting outcome in blunt chest trauma: flail chest vs. pulmonary contusion. J Trauma. 1988;28:298–304.
5. Borden Institute Walter Reed Army Medical Center. Emergency war surgery. 3rd ed. Washington: Office of the Surgeon General U.S. Army, Borden Institute; 2004.

27 Emergent Resuscitative Thoracotomy, Open Cardiac Massage, and Aortic Occlusion

Kevin M. Jones, Jay Menaker, and José A. Rubero

Indications

- Penetrating chest trauma with recent or immanent loss of vital signs
- Consider in blunt trauma with pericardial tamponade or exsanguination where aortic occlusion may provide proximal control

Contraindications

Absolute
- Prolonged cessation of vital signs
- Injury profile obviously incompatible with life
- Absence of surgical services to whom care can be transferred

Relative
- None

Materials and Medications (Fig. 27.1)

- Betadine (povidone-iodine) for rapid skin preparation
- #10 scalpel
- Mayo or long Metzenbaum scissors
- Finochietto retractor (rib spreader)
- Long DeBakey or other tissue forceps (2)
- Satinsky vascular clamp and/or straight vascular clamp
- Long needle holders (2)
- Lebsche knife or sternal osteotome with hammer
- Lap sponges or gauze pads

Procedure

Resuscitative Thoracotomy and Open Cardiac Massage

1. Rapidly prepare the entire anterior and bilateral chest with Betadine.
2. Using a scalpel, incise the skin and subcutaneous tissue from just right of the sternum to the anterior margin of the left latissimus dorsi, following the curvature of the inframammary crease or the fourth or fifth intercostal space (Fig. 27.2).
   - This incision is often made too low on the patient's chest. It should extend across the sternum, not at the level of the xiphoid. Upward retraction of the breast may help provide access to the fourth or fifth intercostal space, where the incision should be located.
3. Bluntly enter the right pleural space through the fourth or fifth intercostal space.
4. Using scissors, cut the intercostal muscles, dividing between the fourth and the fifth ribs from the sternum to the posterior axillary line.
5. If better exposure to the heart is desired, some practitioners advocate extending the incision across the sternum using a Lebsche knife, sternal osteotome, or bone-cutting forceps at this time (Fig. 27.3).
   - If the thoracotomy incision extends to or through the sternum, tie off the internal mammary arteries before closing the chest should the patient be successfully resuscitated, because these will have been divided with the incision.

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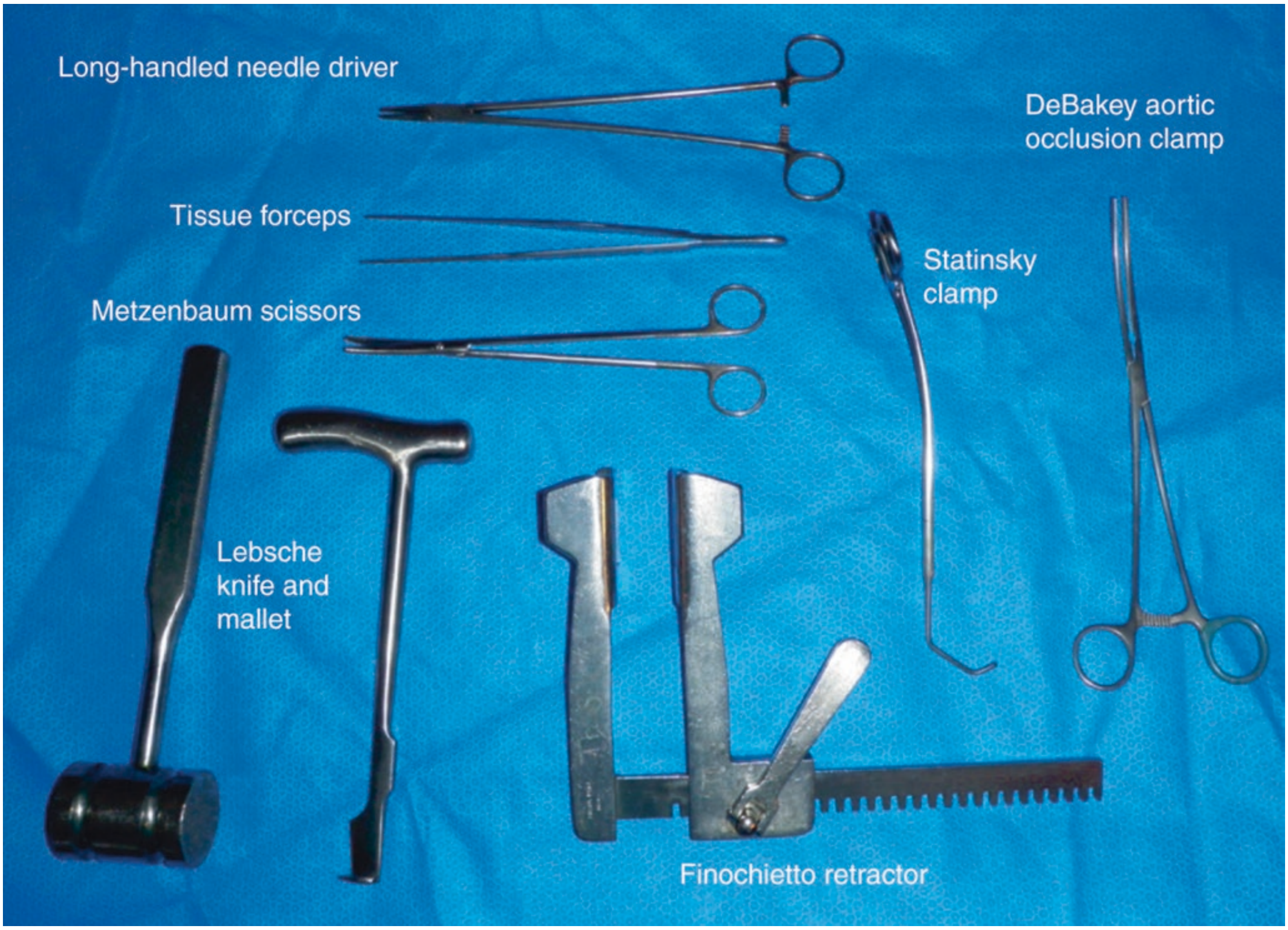

Fig. 27.1 Basic components of an emergency thoracotomy tray: Lebsche knife and mallet for crossing sternum (bone-cutting forceps or sternal osteotome would also suffice), Finochietto retractor, atraumatic vascular clamps (a Satinsky clamp and a DeBakey aortic occlusion clamp), long-handled needle driver, tissue forceps, and Metzenbaum scissors. *Not illustrated* scalpel with #10 or #20 blade, Mayo scissors

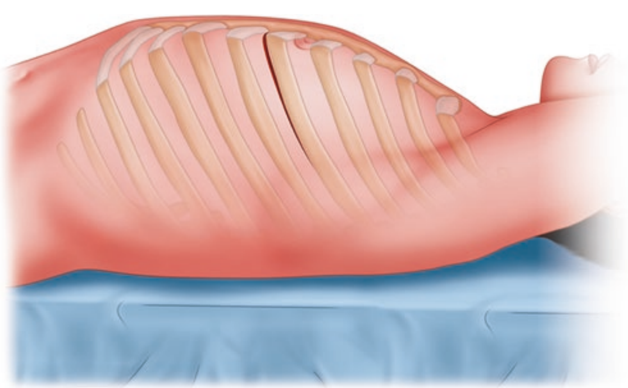

Fig. 27.2 Raise the left arm above the head. Make an incision along the left fourth intercostal space, just below the nipple in a male or at the inframammary crease in a female

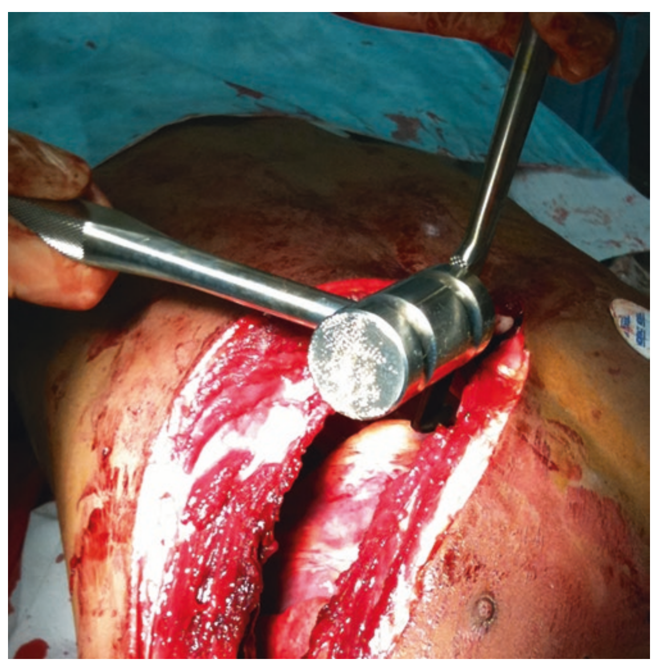

Fig. 27.3 Use a Lebsche knife to extend the incision across the sternum to improve exposure to the heart

6. Insert a Finochietto retractor, and retract the ribs in order to gain access to the left chest and expose the pericardium (Figs. 27.4 and 27.5).

Fig. 27.4 Finochietto retractor placed through the fourth intercostal anterolateral incision. Note the rack and pinion bar placed posterolaterally, where it will not impede access to the midline

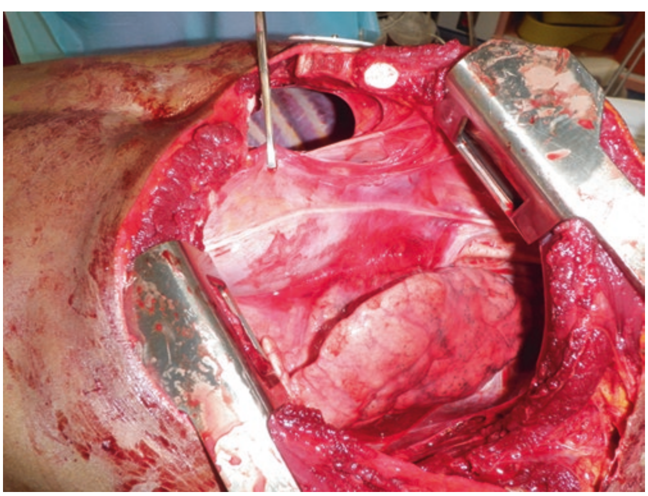

Fig. 27.5 Finochietto retractor extended, exposing the left pleural space and the pericardium. In this case, the sternum has been divided as above, and the resultant window into the right pleural space is seen anterior to the pericardium. The lung is deflated in this postmortem picture but would be far more an obstacle in the actively ventilated patient. The clamp seen in the upper portion of the picture is reapproximating the pericardium, which has previously been divided, for the sake of illustration

- Insert a Finochietto retractor with the rack and pinion bar down and lateral, as in Fig. 27.4, so as not to interfere with extension of the thoracotomy across the sternum into a clamshell maneuver if needed.

7. If massive left pleural hemorrhage is encountered, investigate and control the source at this time.
8. Using tissue forceps, raise a portion of the pericardium anterior to the phrenic nerve, and enter the pericardium using scissors (Fig. 27.6).
9. Widely open the pericardium with scissors, cutting in a cranial-caudal direction anterior to the phrenic nerve, and deliver the heart (Fig. 27.7).
10. If hemopericardium is encountered, investigate for and initiate appropriate repair of identified cardiac injuries.
11. Initiate open cardiac massage by cupping the heart between the flattened palmar aspect of the fingers of both hands and rhythmically compressing the heart from apex to base, relaxing completely between compressions to allow filling (Fig. 27.8).

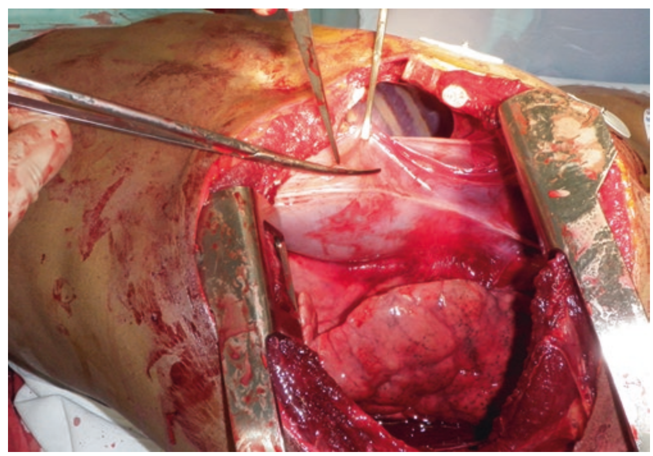

Fig. 27.6 The pericardium is lifted with tissue forceps and opened with a nick using scissors. The phrenic nerve is easily visualized running cranial-caudal just below the scissors in this picture

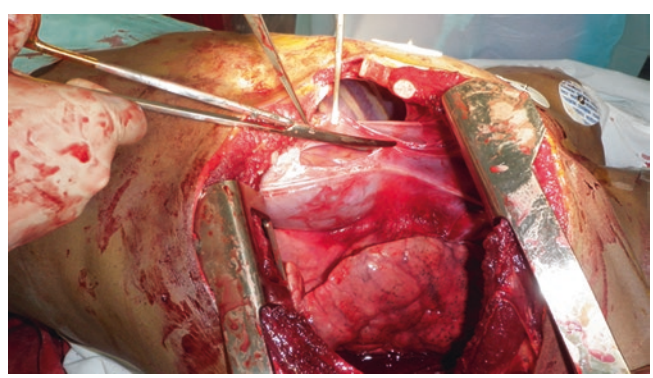

Fig. 27.7 Open the pericardium widely in the cephalad-caudad plane anterior to the phrenic nerve, taking care not to damage the phrenic nerve

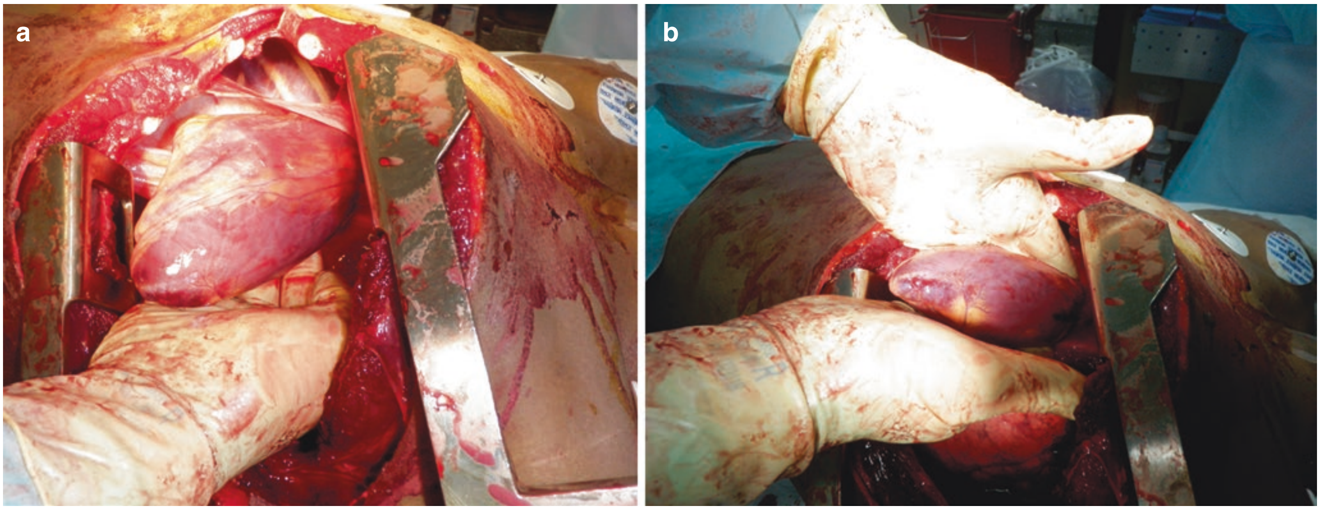

Fig. 27.8 (**a**) Deliver the heart from the pericardium, and rapidly assess for cardiac injury requiring damage control repair; (**b**) initiate open cardiac massage

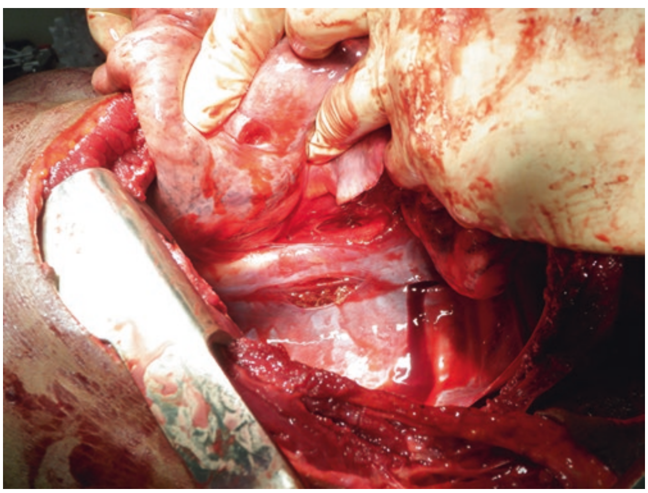

Fig. 27.9 The heart and lung are retracted superomedially, allowing visualization of the left posterior mediastinal pleura; the aorta lies just anterior to the vertebral bodies and has been previously isolated through the pleural interruptions seen here. The heart and lung are assertively retracted here for the benefit of illustration of the posterior mediastinum. Such retraction would completely occlude venous return

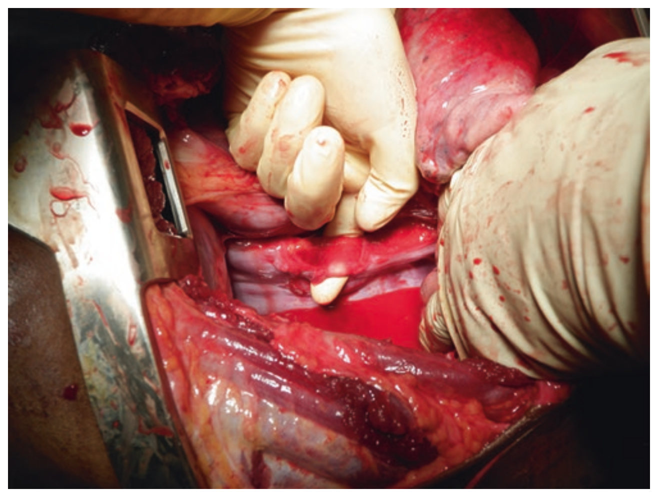

Fig. 27.10 After bluntly dissecting the mediastinal pleura, the aorta is looped using a finger of the nondominant hand

Aortic Occlusion

1. Expose the posterior aspect of the left mediastinum by having an assistant retract the left lung superomedially, dividing the inferior pulmonary ligament if necessary (Fig. 27.9).
2. Bluntly dissect the pleura separating the pleural and mediastinal space just anterior to the vertebral bodies, exposing the aorta (Fig. 27.9).
3. Completely encircle the aorta with the finger of the nondominant hand (Fig. 27.10).
   - Differentiating the aorta from the esophagus when the patient is in a state of profound shock is very difficult. Having an assistant pass, an orogastric tube may help distinguish the two. The aorta should be the most posterior structure, lying immediately on the anterior aspect of the vertebral bodies.
4. With the aorta completely encircled, place a vascular clamp across the aorta, and verify by sight and feel that the complete vessel is occluded within the clamp (Fig. 27.11).

Complications

- Injury to care providers, by means of scalpel, needlestick, or sharp foreign body, is the principal concern.
- Postemergency department thoracotomy infections are rare, even given the less than optimal sterile conditions.
- Damage to the lung parenchyma during the initial incision is common and often leads to air leak in survivors.

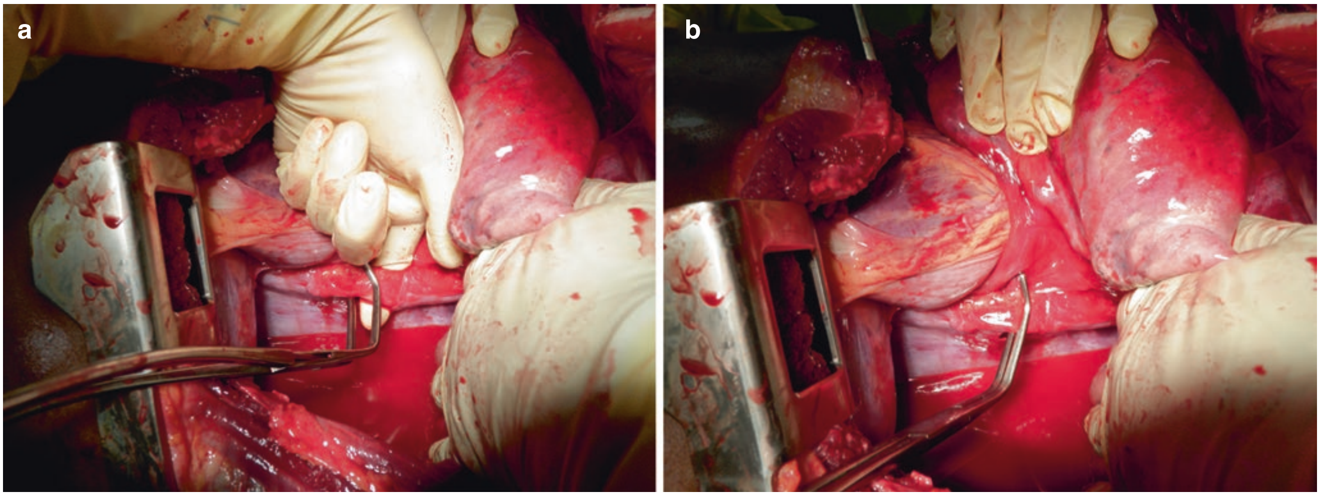

Fig. 27.11 (**a**) A vascular clamp (a Satinsky clamp is used here, although any large atraumatic vascular clamp can be used) is applied across the descending aorta, (**b**) followed by visual and tactile confirmation that the aorta is completely occluded

- Neglect of the mammary arteries, often divided during emergent thoracotomy and not briskly bleeding in the shock state, will result in intrathoracic hemorrhage if not tied off.

Suggested Reading

Jones RF. Resuscitative thoracotomy. In: Roberts JR, Hedges JR, editors. Clinical procedures in emergency medicine. 7th ed. Philadelphia: WB Saunders; 2019.

Feliciano DV, Mattox KL. Indications, technique, and pitfalls of emergency center thoracotomy. Surg Rounds. 1981;4:32.

Siemans R, Polk MC Jr. Indications for thoracotomy following penetrating thoracic injury. J Trauma. 1977;17:493.

Wall MJ Jr, Huh J, Mattox KL. Indications and techniques of thoracotomy. In: Feliciano DV, Mattox KL, Moore EE, editors. Trauma. 6th ed. New York: McGraw Hill; 2008.

Lung Ultrasonography

28

Alfredo Tirado, Ali H. Dabaja, L. Connor Nickels, and Rohit Pravin Patel

Indications

- Undifferentiated respiratory distress or dyspnea
- Evaluation of respiratory failure and insufficiency due to pneumothorax, pleural effusion, pulmonary edema, acute respiratory distress syndrome (ARDS), and alveolar consolidation (atelectasis, pneumonia, contusion, aspiration)
- Monitoring progress of diseases such as pulmonary edema and pneumothorax
- Procedural guidance during pleural fluid removal or pneumothorax treatment
- Procedural guidance for chest tube placement for complex pleural effusions, hemothorax, pneumothorax, and other pleural diseases

Contraindications

- Absolute
- None
- Relative
- Morbidly obese patients
- Patients with chest wall deformities or open wounds
- Patient with subcutaneous emphysema
- Combative or altered patients

Materials

- Ultrasound system, ultrasound gel
- Probe selection: Phased-array, microconvex, or curvilinear probe to evaluate for lung artifact (thoracic or abdominal settings), alternative linear or vascular probes to assess in detail pleura lining and subcutaneous structures (Fig. 28.1a, b), sterile materials and equipment for procedures
- Drapes or towels for patient

Preparations

- Clean ultrasound equipment and use sterile operating procedures and ultrasound conductive gel whenever adequate.
- Ultrasound positioning. Place ultrasound device where it is easily accessible and in adequate view.
- Proper environment. Minimize light interference if possible by deeming lights or closing shades where appropriate.
- Equipment use. Turn on equipment, enter patient data, and select proper probe (phase-array, curvilinear, or linear probes in thoracic or abdomen presets). Depth and gain should be adjusted accordingly, where depths in the range of 4–10 cm give proper evaluation of more superficial and deeper structures, respectively.
- Positioning the patient. This helps optimize and expedite the examination. Supine and upright positioning should be adequate for majority of patients. If having problems obtaining views, ask patient to abduct arms and place above the head to open up intercostal spaces and allow probe placement. Uncover appropriate areas, including anterior and lateral chest walls. Move patients to the edge of the bed to make patient more accessible for imaging.

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L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0_28

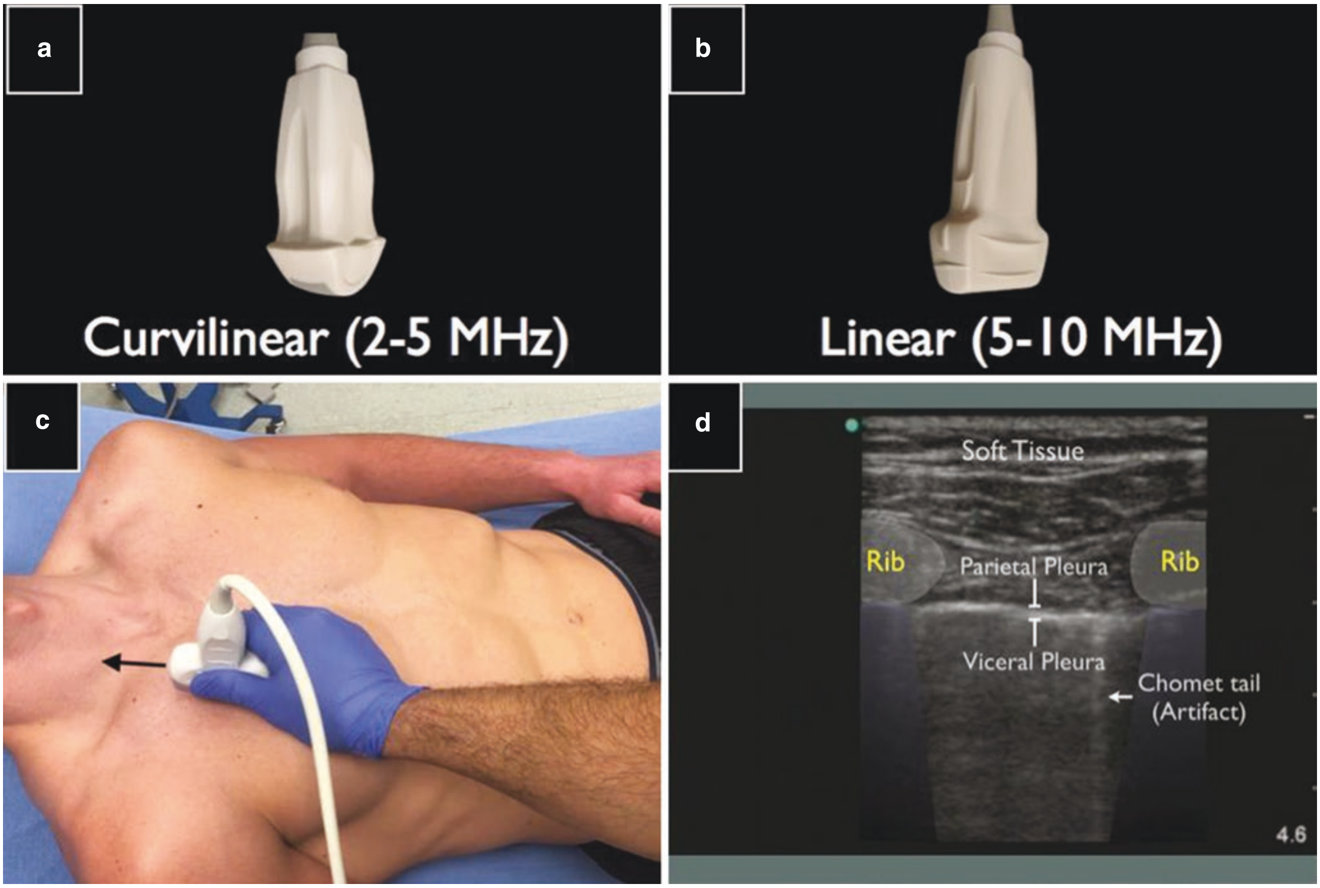

Fig. 28.1 (**a**) Microconvex or curvilinear probe. (**b**) Linear probe. (**c**) Patient positioning for ultrasound scanning with probe marker in cephalic position. (**d**) B-mode ultrasound image obtain with linear probe demonstrating classical batwing sign, visceral, parietal pleura, and comet tail artifact

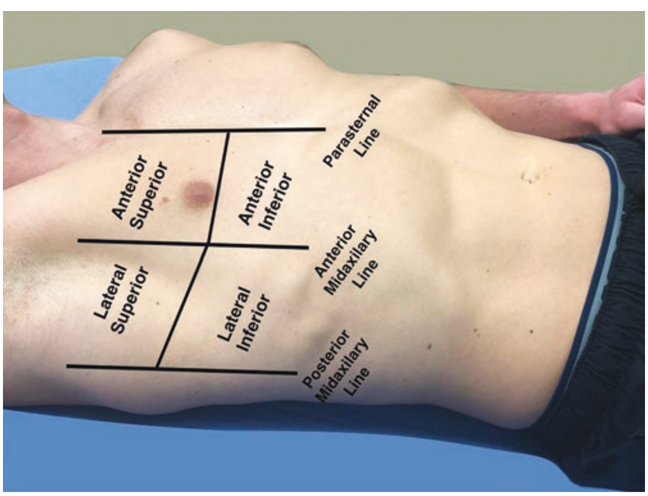

Fig. 28.2 Volpicelli scanning zones. The parasternal, midaxillary, and posterior axillary lines are used to divide each hemithorax into anterior and lateral surfaces. The anterior and lateral surfaces on each side of the chest are divided into superior and inferior zones for scanning

Procedure

1. Probe position (Fig. 28.1c). Start examination at the midclavicular level at the space between the second and the third ribs. Probe positioning should be perpendicular to the ribs (longitudinal positioning) with the ultrasound marker pointed cephalad. This should place the most superficial structures at the top, with deeper structures at the bottom of the monitor. Upon completion, probe positioning should be mapped to evaluate three or four additional areas, typically between the anterior and the posterior axillary lines. Lateral views with the probe should be most posterior, typically along the posterior axillary line, tracking caudad toward the diaphragm. PLAPS (posterolateral alveolar and/or pleural syndrome) pointed posteriorly should also be evaluated, specifically in supine patients. PLAPS is lateral to the scapula and typically requires that the patient be lifted off the bed from one side.

2. Scanning zones. We suggest dividing the chest in eight zones of examination using Volpicelli scanning technique drawing an imaginary line between parasternal, anterior midaxillary, and posterior midaxillary lines and dividing superior and inferior zones above or below the nipple line. This will create four scanning zones per side (Fig. 28.2): the anterior superior and anterior inferior chest and superior lateral and inferior lateral chest areas. Extended views can be performed to better examine for PLAPS. Refer to SARS-CoV-2 (COVID-19) section.
3. Identify the "bat sign" (Fig. 28.1d). The initial view observed should be a window of the lung flanked by two rib shadows. This view, termed the "bat sign," should now allow evaluation of the parietal and visceral pleura, seen most superficial as echogenic line (approximately 0.5 cm below start of rib shadows), subsequent lung sliding, and other findings such as "A" and "B" lines, as well as abnormal lung tissue.
4. Identify lung sliding (Fig. 28.3). Lung sliding identifies movement of a normal parietal-visceral interface. Patient breathing causes a rhythmic movement of parietal against the visceral pleura appearing as movement of the hyperechoic line; this is usually described as ants marching on a string or shimmering at the pleural interface. M-mode can be used to show a timed clip of this through a still image and should only be used as a method of reporting or saving for documentation purposes. Lung sliding (Fig. 28.3a) can be evaluated with M-mode, which can help identify a normal parietal-visceral interface at that level. Obtain an adequate two-dimensional view ("bat sign"), and press the "M-mode" option on the equipment. A normal interface appears as multiple hyperechoic lines, the pleura (termed "seashore," Fig. 28.3b), followed by a sand-like pattern, the lung tissue. This pattern together is termed a "seashore sign." Air that disrupts the parietal-visceral interface, as found within a pneumothorax, is identified as horizontal repeating echogenic lines, similar to a barcode (Fig. 28.3b), and is termed "stratosphere sign." M-mode can be discontinued.
   - Lung sliding can be absent in conditions other than pneumothorax: apnea, right or left bronchial intubation, lung collapse (blebs), pneumonia, and pulmonary fibrosis.
   - A "lung point" is an area adjacent to lung sliding (parietal pleura) that is devoid of movement. This is highly specific for pneumothorax. If one suspects a pneumothorax, quantification of the size can be made by evaluation at the anterior lung points and movement toward the lateral wall of the chest. The more rib spaces found to have absent lung sliding, the larger the pneumothorax.
5. Identify "A lines" (Fig. 28.4). A lines indicate air. These are multiple echogenic lines appearing horizontally in sequence deep to the pleural line. This artifact represents

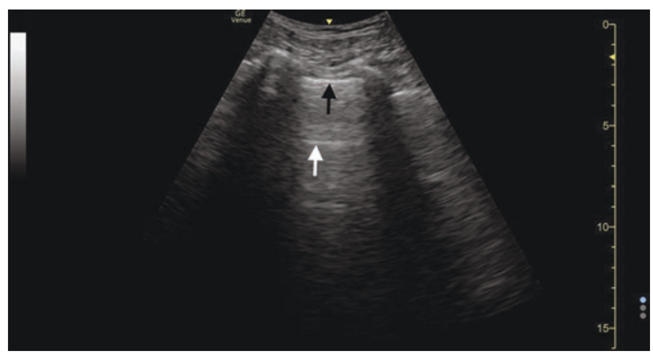

Fig. 28.4 Rib shadows can be seen, with multiple A lines (arrows)

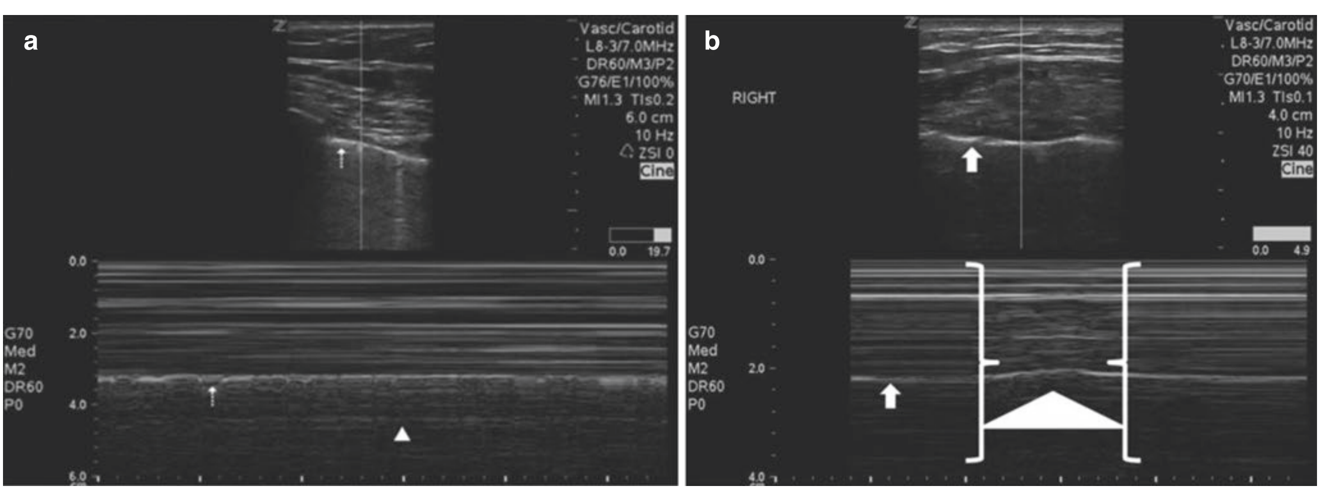

Fig. 28.3 (**a**) M-mode identifies the seashore sign, with the pleura (arrows) and the lung parenchyma (arrowhead) together producing an image similar to a seashore. (**b**) M-mode shows the stratosphere or barcode sign. White arrows indicate the pleura, and the large triangle shows an area of artifact from movement. Artifact from movement can be distinguished by a similar pattern change above and below the pleural line. On either side of the bracket is a continued horizontal line pattern typical of absent lung sliding

reverberations of the pleura and can be found in aerated lungs, which can be normal or abnormal (e.g., pulmonary embolism, chronic obstructive pulmonary disease [COPD]). The first true A line, denoted “A1,” is found equidistant from the chest wall to the pleural line. Many other A lines might be seen and are denoted “A’” lines. Subsequent equidistant A lines are “A2,” “A3,” and so on.

6. Identify “B lines” (Fig.28.5). These artifacts appear in well-aerated lung and are vertical echogenic lines (ray, flashlight, lung rockets) transmitted from the pleura to the deeper parts of the lung on the ultrasound monitor field. They are due to thickened interlobular septa and represent alveolar lung density (in the majority of cases fluid) surrounded by air. True B lines arise from the pleural line and shoot all the way down to the far lung fields, whereas “comet tails” are seen only close to the pleural and are sometimes referred to as “shimmering” or “glimmering” during movement of the pleural line. When multiple B lines are seen in a patient, it is sometimes referred to as “lung rockets” or “flashlights” because many rays are shooting from the pleura. Even though most of the time B lines represent pulmonary edema, they can be seen in other conditions such as aspiration, pulmonary fibrosis, acute respiratory distress syndrome (ARDS), and pneumonia.
7. Identify lung pulse. This appears as a shimmering of the pleural line due to cardiac activity. This is most apparent on the left side of the chest, closest to the heart. This helps to exclude pneumothorax as well.
8. Move posteriorly. Move the ultrasound probe laterally and posteriorly to the PLAPS point. The transducer can be directed toward the center of the patient’s body in supine patients. Pleural effusions and consolidations are found in the dependent areas of the lung.
9. Move caudally. With the marker still pointing cephalad, move along the posterior axillary line in two or three additional rib spaces. Identification of pleural disease and other pathology requires multiple views and will aid in evaluating the extent of the disease. This will also allow for identification of boundaries of the lung, such as the diaphragm. Identification of the diaphragm is most critical to determine location of fluid.
10. Identify the diaphragm and liver and/or spleen (Fig.28.6). Along the posterior axillary line or the posterior chest wall, move the probe caudad to identify the diaphragm. This appears as an echogenic curvilinear structure, with the liver or spleen being subdiaphragmatic and typically of different echogenicity than the lung. Many times, the diaphragm is very high in the supine critically ill patient. Massive edema and obesity may also degrade image quality in this location.
    - Always identify the diaphragm. Hypoechoic fluid surrounding the liver or spleen can appear as a pleural effusion and must not be mistaken as such. In addition, lung tissue may mimic hepatic tissue in certain diseases such as dense consolidations termed “hepatization” of the lung. Proper probe positioning, clear identification of the diaphragm, subdiaphragmatic structures, and the lung are crucial. This is a common error in novice operators owing to the confusion of the hepatorenal or splenorenal recess for the diaphragm.
    - Identifying the diaphragm can be technically difficult depending on patient position, size, and clinical condition. It may be useful to start below the diaphragm, first identifying the hepatorenal recess (liver and kidney view interface) and then moving cephalad until the lung and diaphragm are visualized. In addition, as ribs change their orientation anatomically, the probe may need to be adjusted while still in the longitudinal axis. Moving the probe clockwise and counterclockwise may be of benefit to bring into view the lung, the diaphragm, and the subdiaphragmatic structures.

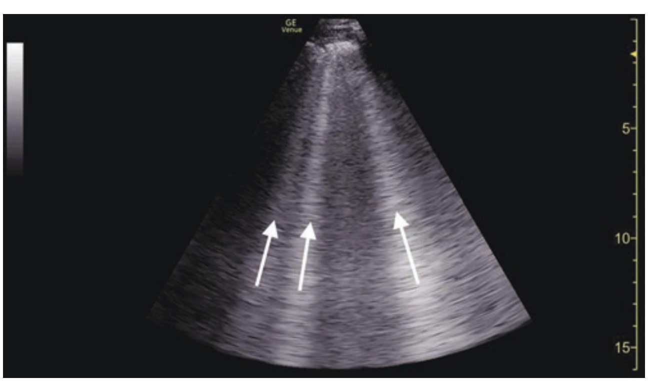

Fig. 28.5 B-mode lung ultrasound demonstrated multiple B lines, also known as rockets (arrows)

Fig. 28.6 Diaphragm (white arrow), liver (white arrowhead), lung (black arrow), and anechoic fluid, likely an effusion (open arrowhead). Incidentally, hyperechoic foci in the lung tissue, likely representing air bronchograms, can be seen

11. Identify pleural effusions (Fig. 28.6). Confirming the presence of pleural effusions requires identifying anechoic material between the pleura and the lung. This can be seen as lung movement in an undulating pattern, which typically is facilitated by cardiac activity and respirations. This is termed “jellyfish sign,” where the lung flaps as it freely floats in the effusion. Floating debris can also confirm effusion, termed “plankton sign.” It is also important to identify the depth of the chest wall to the pleural fluid in order to determine the best location/depth of needle insertion when attempting thoracentesis or chest tube insertion. The challenge is to find a safe path for needle insertion. The key when using ultrasound as guidance is that the angle of the needle/syringe assembly must duplicate the angle of the probe. The time between scan and needle insertion must also be minimized. Real-time guidance is not required. In patients who are obese or edematous, skin indentation during probe placement can result in underestimation of depth of needle insertion required and must be taken into account. Safety margin of thoracentesis is thought to be 10 mm of visceral-parietal distance. Dry taps may be due to loculations the blocking needle, needle plugs, patient movement from scan to tap, and poor angle selection.
    - Exudates, empyemas, and hemothoraces may appear more echogenic, unlike, for example, a transudative effusion that could be anechoic. Complex effusions can also appear as heterogeneous and echogenic. The consistency of the effusion can make identification technically difficult because this can limit lung motion. Sometimes the operator may think there is no effusion when there is an echo-dense effusion.
12. Identify consolidations (Fig. 28.7). Compressed lung appears with alveolar consolidation pattern (tissue-like sign). Alveolar consolidations are typically devoid of air and appear as tissue density; these can be seen with atelectasis, pneumonia, aspiration, or other lung diseases. “Hepatization” of the lung is typical, where the images mimic liver tissue. Images may also have hyperechoic foci representing air bronchograms, which would indicate pneumonia. Probe location should be correlated with an anatomical lobular or segmental area.
    - The lung may slide into the effusion during the respiratory cycle and can be problematic during needle insertion, causing pneumothorax or abnormal wire placement during the performance of pigtail chest tube catheters. This is called a “curtain sign.”
13. Sinusoid sign (Fig. 28.8). M-mode is placed in the center of the visible lung when a large amount of pleural fluid is seen. A sinusoid sign strengthens the operator’s determination that the pleural fluid is present and that the pleural fluid is not necessarily compromising lung dynamics. If the sinusoid sign is absent, it may indicate a “trapped” lung dynamic.
14. Assessment and clinical decision-making. Upon completion of ultrasonography of bilateral lung fields, clinical decision-making tools may be of benefit, especially in undifferentiated respiratory failure. A protocol has been developed to organize the exam of a respiratory failure patient (on noninvasive or invasive ventilation only). The BLUE protocol assesses patients based on findings (e.g., A lines, B lines, lung sliding) of both lungs and incorporates them into an algorithm. With acceptable sensitivities and specificities, practitioners can diagnose pulmonary edema, pneumonia, pneumothorax, and COPD/asthma with the BLUE protocol.

Fig. 28.7 The lung here appears as tissue density, likely representing the alveolar consolidation pattern seen in pneumonia, and is termed “hepatization” and “tissue-like sign”

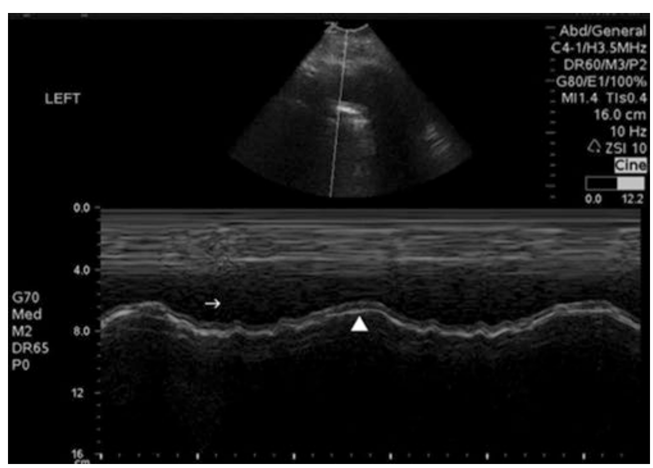

Fig. 28.8 In M-mode, identification of pleural effusion becomes evident with the sinusoidal sign (arrowhead) and identification of pleural fluid (arrow)

- Summary of findings:
  - Pneumothorax: no lung sliding on field of view with associated lung point. M-mode optional with bar code sign.
  - COPD/asthma: predominantly A line pattern, with negative deep venous thrombosis (DVT) study.
  - Pulmonary embolus: predominantly A line pattern, with positive DVT study.
  - Pulmonary edema or heart failure: predominantly B line pattern. To make the diagnosis, you need at least two positive zones one each hemithorax with bilateral findings. A positive zone is defined as at least three B lines per scan area.
  - Pneumonia: A/B line pattern, also hepatization of lung fields with air or fluid bronchograms.
  - Pulmonary contusion: usually an A/B pattern unilateral in area of chest blunt trauma.
  - Pleural effusion: anechoic area within the pleural cavity, with associated spine sign.
  - Alveolar interstitial syndrome: multiple and diffuse B lines. Refer to SARS-CoV-2 (COVID-19) discussion.

Lung Ultrasound Findings in SARS-CoV-2/COVID-19 Patients

- In December 2019, the World Health Organization (WHO) alerted of cluster of unknown pneumonia cases in Wuhan, China. The causative agent was later found to be an RNA virus identified as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), also known as coronavirus disease 2019 or COVID-19. Point-of-care lung ultrasound (LUS) has been reported in the literature as a screening and diagnostic tool for COVID-19.
- Procedure: Refer to section "Procedure" for standard views. The following special considerations should be considered to decrease risk exposure and obtain extra views:
  - Scan patient sitting in upright position, with ultrasound system and operator behind patient (Fig. 28.9a). Alternatively, you can have the patient in prone position as long as he can tolerate it.
  - Findings are typically bilateral and more prominent in the inferior, posterior, and lateral lung zones.

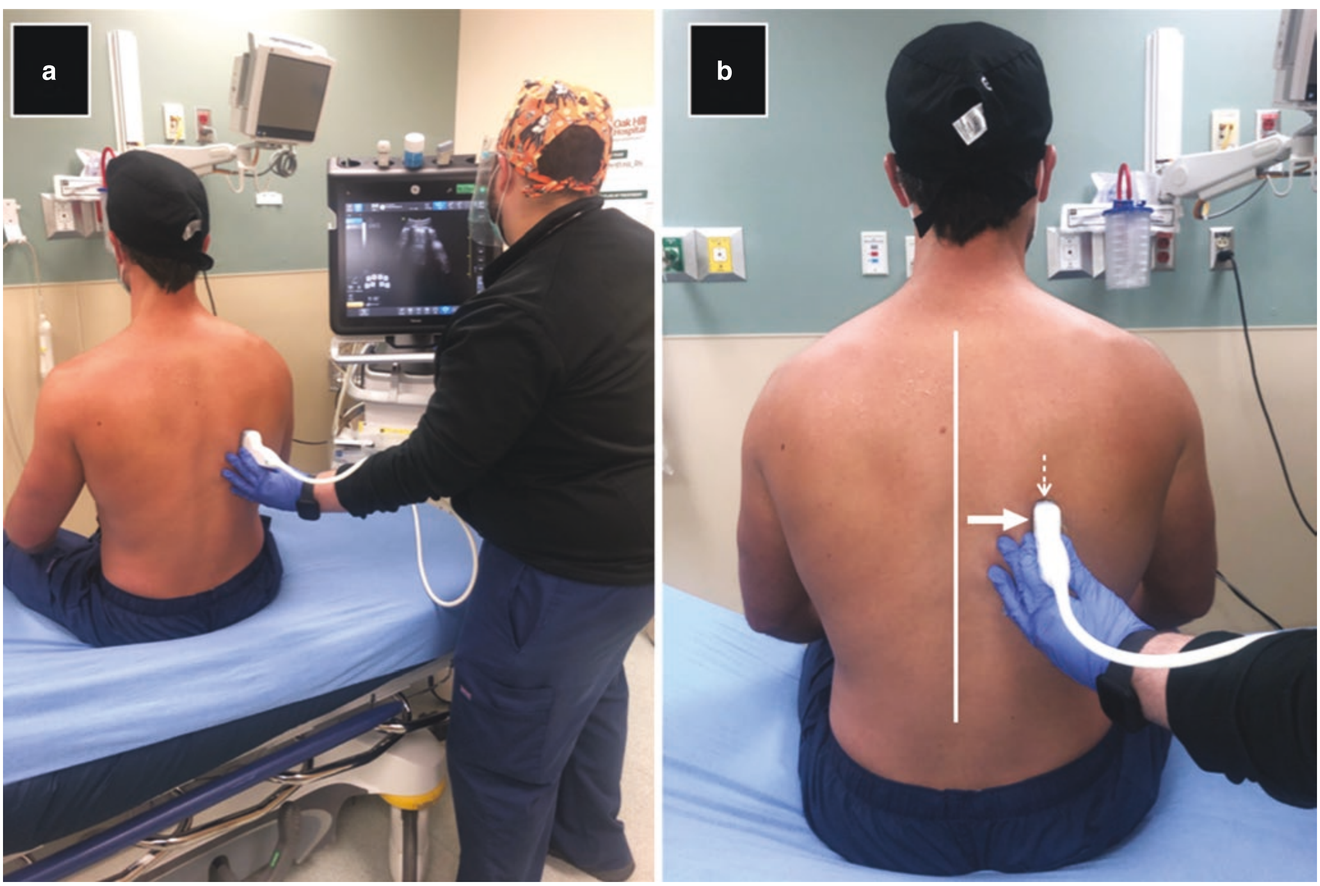

Fig. 28.9 (**a**) Recommended position to acquire images of patients with suspected COVID-19 Both operator and patient should be wearing adequate PPE prior to procedure. Place patient in upright sitting positioning with operator standing behind patient. (**b**) Probe positioning to scan inferior the thorax in posterior zones. The solid vertical line demarks the spine, the dotted arrow line the scapula, and the solid white line scanning technique from paravertebral to midscapular line

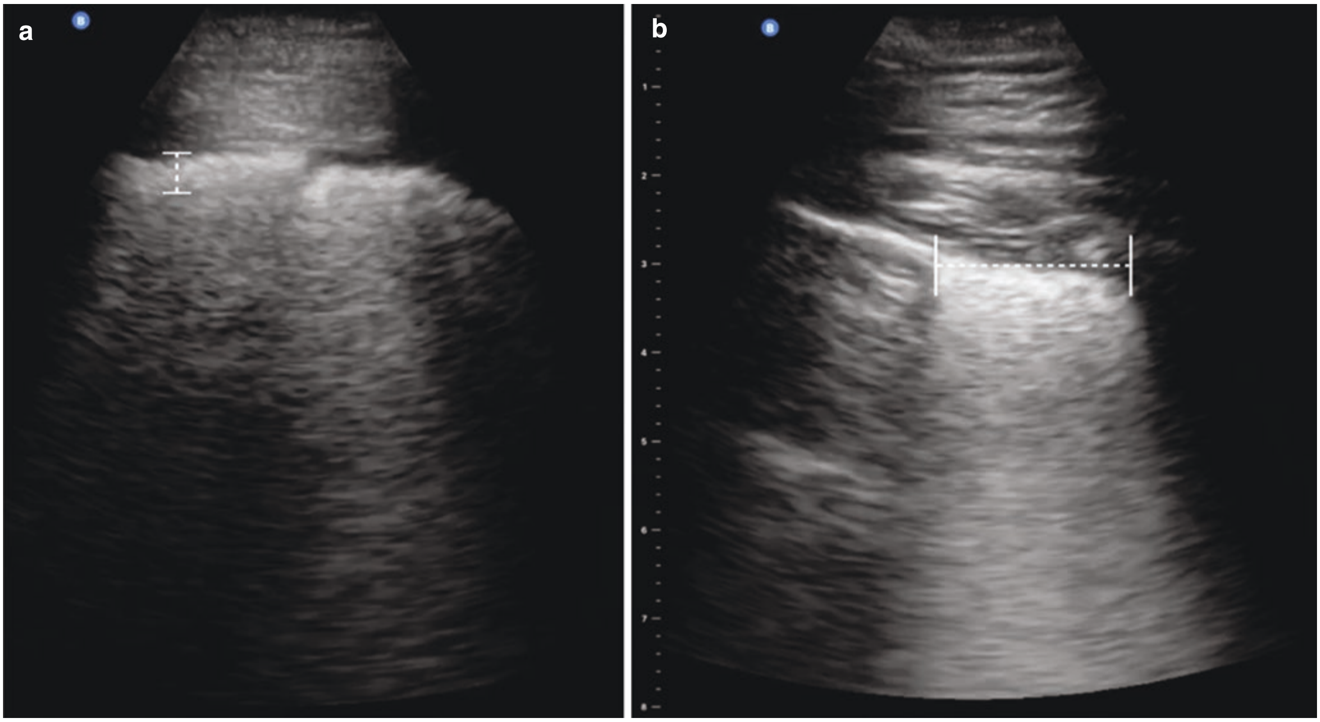

Fig. 28.10 LUS findings associated with COVID-19. (**a**) Dotted lines demonstrate pleural thickened with irregular B lines. (**b**) Example of confluent/coalescing B lines demarcated by dotted lines

  - Scan both hemithoraces, sliding the probe from paravertebral line to midscapular line and so forth, extending to anterior/posterior axillary lines (Fig. 28.9b). Avoid scanning directly over the scapula as it can interfere with the field of view.
- Ultrasound findings in COVID-19 are related to the stage, comorbidities, and severity of disease. Characteristic findings are summarized in Fig. 28.10 and include:
  - Thickening of the pleural line with or without irregularities (also termed shredding) (Fig. 28.10a).
  - B line patters such as focal, multifocal, or confluent/coalescing lines (Fig. 28.10b).
  - Consolidation patterns such as multifocal small, translobar, or non-translobar with mobile air bronchograms.
  - A-line appearance during recovery phase.
  - Pleural effusions are rare.

Suggested Reading

Levitov A, Mayo PH, Slonim AD. Ultrasound evaluation of the lung. In: Critical care ultrasonography. New York: McGraw-Hill; 2009.

Lichtenstein DA, Menu Y. A bedside ultrasound sign ruling out pneumothorax in the critically ill. Lung sliding. Chest. 1995;108:1345–8.

Lichtenstein DA, Meziere GA. A lung ultrasound sign allowing bedside distinction between pulmonary edema and COPD: the comet-tail artifact. Intensive Care Med. 1998;24:1331–4.

Lichtenstein DA, Meziere GA. Relevance of the lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. Chest. 2008;134:117–25.

Lichtenstein DA. Lung ultrasound in the critically ill. Ann Intensive Care. 2014;4(1):1.

Lichtenstein DA. BLUE-protocol and FALLS-protocol: two applications of lung ultrasound in the critically ill. Chest. 2015;147(6):1659–70.

Mantuani D, Frazee BW, Fahimi J, Nagdev A. Point-of-care multi-organ ultrasound improves diagnostic accuracy in adults presenting to the emergency department with acute dyspnea. West J Emerg Med. 2016;17(1):46–53.

Martindale JL, Wakai A, Collins SP, Levy PD, Diercks D, Hiestand BC, Fermann GJ, de Souza I, Sinert R. Diagnosing acute heart failure in the emergency department: a systematic review and meta-analysis. Acad Emerg Med. 2016;23(3):223–42.

Mayo PH, Doelken P. Pleural ultrasonography. Clin Chest Med. 2006;27:215–27.

Mayo PH, Goltz HR, Tafreshi M, Doelken P. Safety of ultrasound-guided thoracentesis in patients receiving mechanical ventilation. Chest. 2004;125:1059–62.

Narinx N, Smismans A, Symons R, Frans J, Demeyere A, Gillis M. Feasibility of using point-of-care lung ultrasound for early triage of COVID-19 patients in the emergency room. Emerg Radiol. 2020;10:1–8.

Peng QY, et al. Findings of lung ultrasonography of novel corona virus pneumonia during the 2019-2020 epidemic. Intensive Care Med. 2020;46(5):849–50.

Sultan L, Sehgal CM. A review of early experience in lung ultrasound in the diagnosis and management of COVID-19. Ultrasound Med Biol. 2020;46(9):2530–45.

Volpicelli G, Mussa A, Garofalo G, Cardinale L, Casoli G, Perotto F, Fava C, Frascisco M. Bedside lung ultrasound in the assessment of alveolar-interstitial syndrome. Am J Emerg Med. 2006;24(6):689–96.

Yasukawa K, Minami T. Point-of-care lung ultrasound findings in patients with COVID-19 pneumonia. Am J Trop Med Hyg. 2020;102(6):1198–202.

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA)

29

Paul R. Banerjee and Sanjiv Gray

Indications

Selected adult patients (aged 18–69 years) with:

- PEA arrest (<15 minutes) secondary to exsanguination from subdiaphragmatic hemorrhage and femoral vessels are immediately accessible
- Profound hypovolemic shock and a systolic blood pressure <90 mmHg or nonresponder/partial responders to rapid volume resuscitation and have had causes of obstructive shock excluded and:
  - Suspected or diagnosed intra-abdominal hemorrhage due to blunt trauma or penetrating torso injuries (Zone I REBOA)
  - Blunt trauma patients with suspected pelvic fracture and isolated pelvic hemorrhage (Zone 3 REBOA)
  - Patients with penetrating injury to the pelvic or groin area with uncontrolled hemorrhage from a junctional vascular injury (iliac or common femoral vessels) (Zone 3 REBOA)
- Other uses for the catheter have been described such for postpartum hemorrhage, gastrointestinal hemorrhage, and nontraumatic cardiac arrest

Contraindications

- Age >70 years or age <17 as there is not enough data to support its use in the pediatric and geriatric population
- PEA arrest greater than 15 minutes (in keeping with ED thoracotomy guidelines) secondary to exsanguination from subdiaphragmatic hemorrhage and:
  - Femoral vessels *not* immediately accessible
  - High clinical/radiological suspicion of proximal traumatic aortic dissection
  - Extensive chest trauma (minor rib fractures are ok)
  - Pericardial tamponade or positive pericardial FAST view

Most REBOA are being done with the use of a 7 French catheter placed in the common femoral artery.

Materials and Medications

- Balloon occlusion and arterial line catheter (Fig. 29.1)
- 7 Fr Pinnacle Precision Access System
- 30-mL luer lock syringe
- 5 Fr catheter clamp with fasteners
- Disposable #11 scalpel
- 0 Silk suture on a 60-mm needle
- 4-oz specimen container
- Blunt needle filter
- Decanter bag
- Decanter vial
- Normal saline 50-mL solution
- ChloraPrep applicator
- Biopatch
- 3-way tap
- 0.9% saline 20 mL, omnipaque contrast solution 10 mL
- Sterile drape
- Sterile gauze 4 × 4
- Two large Tegaderm dressings
- PPE (cap, gown, gloves, goggles, mask)

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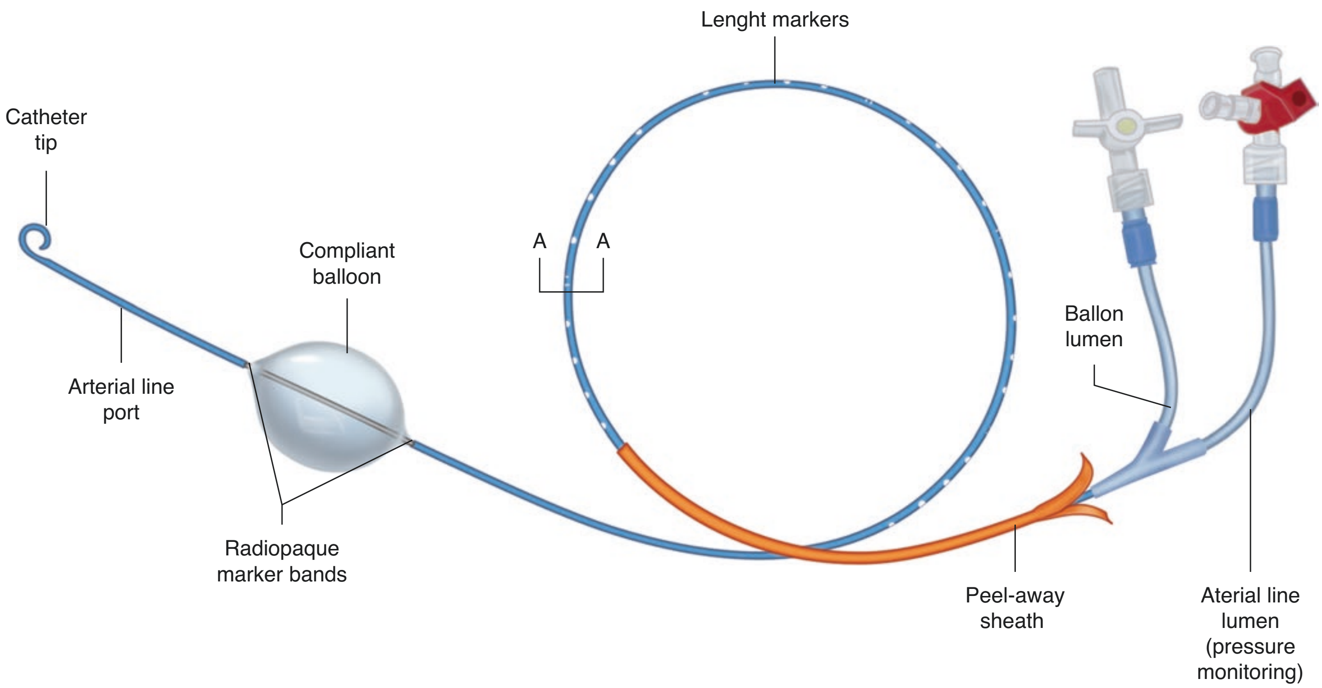

Fig. 29.1 Balloon occlusion and arterial line catheter

Procedure

1. Obtain early common femoral arterial access using the 18-gauge arterial line kit, confirm placement using arterial waveform, and obtain and document arterial blood pressure.
2. Upscale the arterial line catheter to a 7 Fr sheath over the guidewire in femoral site.
3. Prepare the ER-REBOA catheter by flushing the white balloon port (BAL) with sterile saline to test balloon, and then completely deflate the balloon by holding the vacuum for 5 seconds then closing the stopcock with vacuum held.
4. Select the zone to perform the REBOA: The intra-aortic location of the balloon can be divided into three zones for REBOA:
   - Zone 1 extends from the origin of the left subclavian artery to the celiac artery, Zone 3 extends from the lowest renal artery to the aortic bifurcation, and Zone 2 is the area between the Celiac artery and the renal arteries and is considered the segment where the balloon should not be placed (Fig. 29.2).
   - Zone I is measured to the sternal notch (approximately 46 cm), and Zone 3 is measured to the xiphoid (approximately 28 cm).
5. Advance peel-away to cover the catheter including the P-tip into the hub of the sheath. Insert ER-REBOA catheter into 7 Fr sheath. Pull back peel-away to visualize cm measurements on catheter. Use the estimated measurements for the depth for insertion.
6. Once positioned in the intended Zone 1 or 3, the ER-REBOA side port (Red, ART) should then be connected to the arterial line pressure monitor and arterial pressure documented**.**
7. Inflate the balloon with 3:1 sterile saline/contrast into white (balloon) port of ER-REBOA catheter. Begin with 8 mL for Zone 1 and 2 mL for Zone 3, and steadily increase until full occlusion of the aorta. This is indicated by a noted abrupt increase in the arterial blood pressure and loss of contralateral common femoral artery pulse upon effective occlusion.
8. Document the amount of contrasted solution used and the time of balloon inflation. Use minimal pressure required to gain wall apposition in order to prevent aortic injury, generally 2–8 mL, but *never* more than 24 mL of sterile solution.
9. Confirm placement of ER-REBOA with an immediate CXR and/or KUB (Fig. 29.3) or fluoroscopy. Hold catheter in place while X-rays are obtained.
10. Secure catheter using catheter clamp as close to the hub of the sheath as able.
11. Document post-inflation arterial blood pressure.
12. Expedite patient's departure to OR/IR for definitive hemorrhage control.
13. Management and removal:
    (a) Provider to complete and document balloon deflation, including time.
    (b) Ensure all saline is completely removed from balloon prior to removal.
    (c) Remove ER-REBOA catheter.

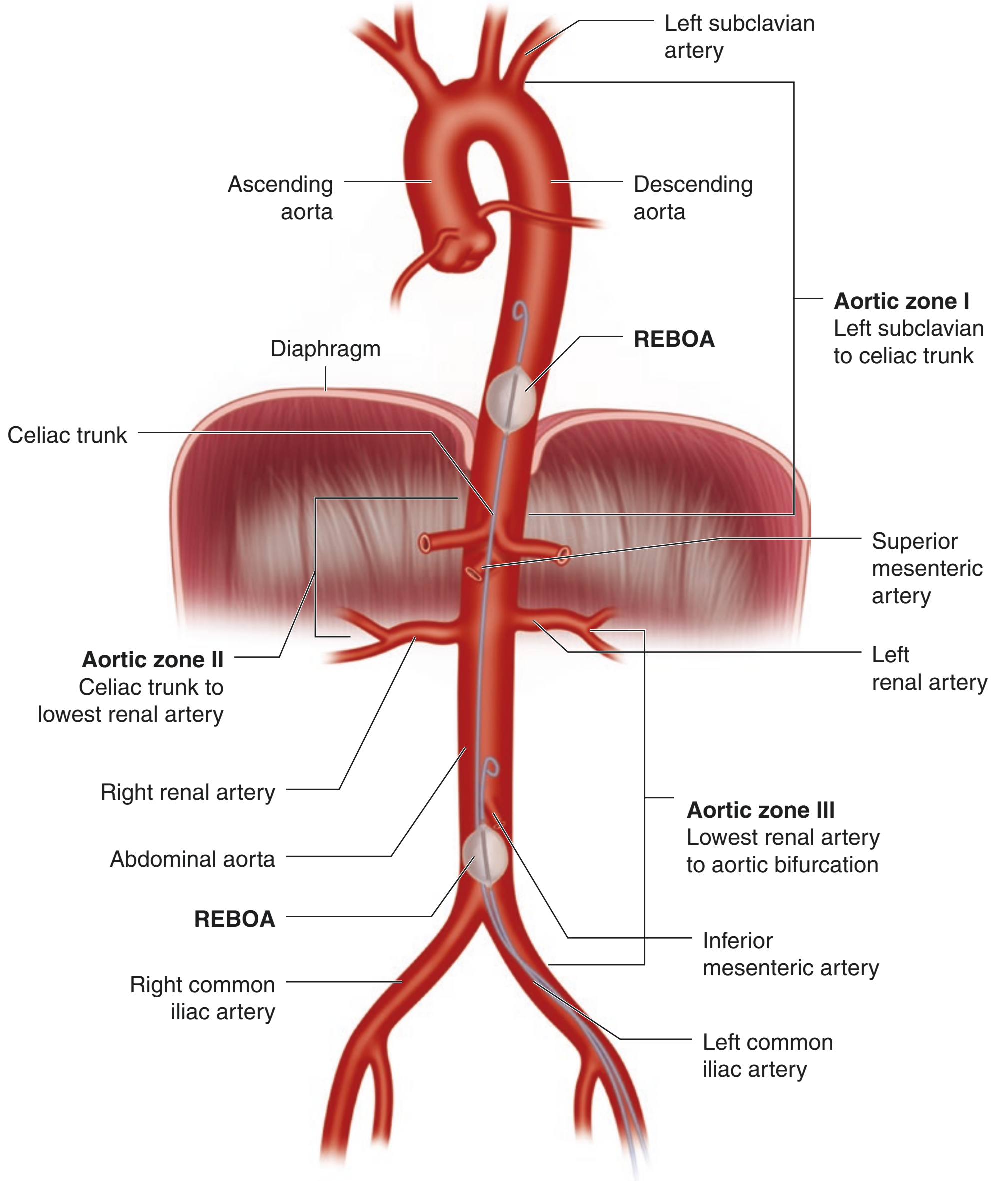

Fig. 29.2 Aorta zones

(d) Sheath may remain in place as intra-arterial access if needed in IR/OR to obtain definitive hemorrhage control.
(e) Careful sheath removal using manual compression versus closure device.

Complications

- Vascular injuries such as hematoma, pseudoaneurysm, intimal flap, and distal embolization
- Spinal cord ischemia
- Limb ischemia
- Renal ischemia
- Ischemia reperfusion injury

Pearls and Pitfalls

- Early common femoral artery access by placement of an arterial line as this is a common rate-limiting step.
- Safe placement and ongoing training are essential to limit complication.
- Prepackage REBOA kits are helpful for easy utilization.
- The use of the small 7 Fr catheter has been associated with less complications.
- Partial REBOA can be used to maintain some distal perfusion and mitigate the effects of prolonged ischemia and reperfusion injury.
- High-quality evidence for the efficacy of REBOA in clinical settings is currently lacking—in particular, an improvement in hemorrhage-related mortality has not been demonstrated.

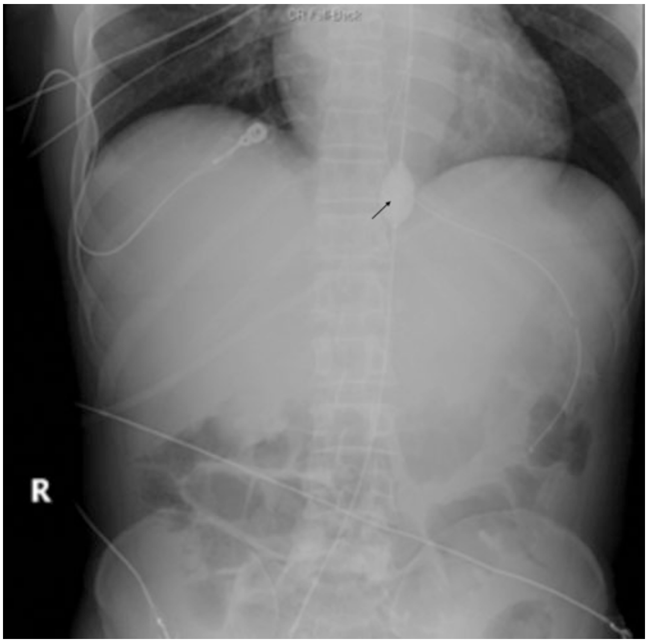

Fig. 29.3 KUB radiograph demonstrating REBOA balloon in zone 1 (arrow)

- REBOA may be better suited to prehospital/remote settings lacking immediate access to definitive surgical therapy.
- Using propensity analysis, found an association between use of REBOA and excess mortality in patients with hemodynamically unstable torso trauma that had a median door-to-primary surgery time of 97 minutes.
- REBOA tends to cause less physiological disturbance and have higher rates of technical success than aortic cross clamping.

Suggested Reading

Biffl WL, Fox CJ, Moore EE. The role of REBOA in the control of exsanguinating torso hemorrhage. J Trauma Acute Care Surg. 2015;78(5):1054–8.

Chaudery M, Clark J, Morrison JJ, Wilson MH, Bew D, Darzi A. Can contrast-enhanced ultrasonography improve Zone III REBOA placement for prehospital care? J Trauma Acute Care Surg. 2016;80(1):89–94.

Daley J, Morrison JJ, Sather J, Hile L. The role of resuscitative endovascular balloon occlusion of the aorta (REBOA) as an adjunct to ACLS in non-traumatic cardiac arrest. Am J Emerg Med. 2017;35(5):731–6.

Gray S, Dieudonne B. Resuscitative endovascular balloon occlusion of the aorta as an adjunct in a patient with neurogenic shock. Cureus. 2018;10(9):e3375.

Inoue J, Shiraishi A, Yoshiyuki A, Haruta K, Matsui H, Otomo Y. Resuscitative endovascular balloon occlusion of the aorta might be dangerous in patients with severe torso trauma: A propensity score analysis. J Trauma Acute Care Surg. 2016;80(4):559–66; discussion 566–7. https://doi.org/10.1097/TA.0000000000000968. PMID: 26808039.

Morrison JJ, Galgon RE, Jansen JO, Cannon JW, Rasmussen TE, Eliason JL. A systematic review of the use of resuscitative endovascular balloon occlusion of the aorta in the management of hemorrhagic shock. J Trauma Acute Care Surg. 2016;80(2):324–34.

Park TS, Batchinsky AI, Belenkiy SM. Resuscitative endovascular balloon occlusion of the aorta (REBOA): comparison with immediate transfusion following massive hemorrhage in swine. J Trauma Acute Care Surg. 2015;79(6):930–6.

Stannard A, Eliason JL, Rasmussen TE. Resuscitative endovascular balloon occlusion of the aorta (REBOA) as an adjunct for hemorrhagic shock. J Trauma. 2011;71(6):1869–72. https://doi.org/10.1097/TA.0b013e31823fe90c.

Part IV

Cardiac Procedures

Repair of Cardiac Injuries

30

Ronald Tesoriero and José A. Rubero

Indications

- Wounds to the heart in patients presenting with pulseless electrical activity (PEA) or asystole with evidence of cardiac tamponade
  - Penetrating wounds: <15 min of prehospital cardiopulmonary resuscitation (CPR)
  - Blunt wounds: <10 min of prehospital cardiopulmonary resuscitation (CPR)

Contraindications

- Absolute
  - Presenting rhythm of asystole and no evidence of pericardial tamponade on focused assessment with sonography for trauma (FAST)
- Relative
  - None

Materials and Medications

- Diagnostic ultrasound
- Emergency department thoracotomy tray (Fig. 30.1)
  - Sterile drapes, #10 scalpel, curved Mayo scissors, Finochietto retractor, Lebsche sternal knife and mallet, forceps, curved Metzenbaum scissors, surgical skin stapler, Foley catheter, clamps, needle driver, 2–0 and 3–0 polypropylene suture on MH or SH (noncutting) needle, Satinsky vascular clamps

Fig. 30.1 Emergency department thoracotomy tray. Left to right: scalpel, curved Mayo scissors, Finochietto rib spreader, DeBakey forceps, Metzenbaum scissors, needle driver, Lebsche knife and mallet, Satinsky vascular clamp, aortic clamp, bone cutter

- Betadine (povidone-iodine) or other skin antiseptic preparing solutions
- Defibrillator and internal cardiac panels
- Epinephrine

Procedure

1. Identify the pericardium anterior to the phrenic nerve, pinch it between the fingers, and enter it by making a nick with the Metzenbaum scissors. Then open the pericardium longitudinally anterior to the phrenic nerve.
2. If the heart is not contracting effectively (PEA, asystole, fibrillation), immediately begin internal cardiac massage.
   - Unless the injury is so large that it cannot be controlled, taking time out at this point to repair the injury may lead to significant acidosis and inability to reestablish a perfusing rhythm.

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3. While continuing internal cardiac massage, identify the area of injury, and attempt to control it with manual pressure; in a larger wound, use a Foley catheter to prevent continued bleeding.
4. If necessary owing to the location of injury, extend the incision to a bilateral anterolateral thoracotomy, and transect the sternum with a Lebsche knife and mallet or heavy shears.
5. If, after several minutes of internal massage and appropriate red blood cell and plasma transfusion, the patient remains in PEA or asystole, irrigate the heart with warmed saline, and administer intravenous (IV) or intracardiac epinephrine.
6. If the heart enters ventricular fibrillation or ventricular tachycardia, cardiovert with internal paddles applied directly to the heart with an energy between 10 and 30 J.
7. Once a perfusing rhythm is reestablished or if on initial evaluation the wound is so large that it cannot be controlled and will require immediate repair before internal massage can be effective, proceed to cardiac repair.
8. Choose the simplest method that will allow control of the injury until definitive repair can be performed in the operating room.
   (a) Injuries to the atrium: The pliable nature of the atria will often allow placement of a Satinsky clamp for control followed by repair with a running 3–0 polypropylene suture (Fig. 30.2).
   (b) Small injuries to the ventricles: Control the injury with direct manual pressure, and close with either an interrupted 3–0 polypropylene suture or a surgical skin stapler (Figs. 30.3 and 30.4).
   (c) Medium to large injuries to the ventricle: Attempt to control the wound by placing a Foley catheter through it, then blow up the balloon, and apply gentle traction. Either staple or suture the wound closed before deflating the balloon and removing the catheter (Fig. 30.5).
      - Place an occluding clamp on the open end of the catheter, or blood loss will continue through the catheter.
      - Avoid excessive traction on the Foley because it will pull through the ventricle and make the hole larger.
   (d) Extensive or inaccessible injury: Perform temporary inflow occlusion to the heart by manually compressing the right atrium against the heart so that it cannot fill. The heart will likely immediately enter PEA, fibrillation, or asystole giving the physician a couple of minutes to gain control of the injury before the patient becomes unrecoverable.
   (e) Injuries in proximity to coronary vessels: To avoid compression of the vessel, perform a horizontal mattress suture that passes beneath the artery. Teflon pledgets may assist in the repair (Fig. 30.6).

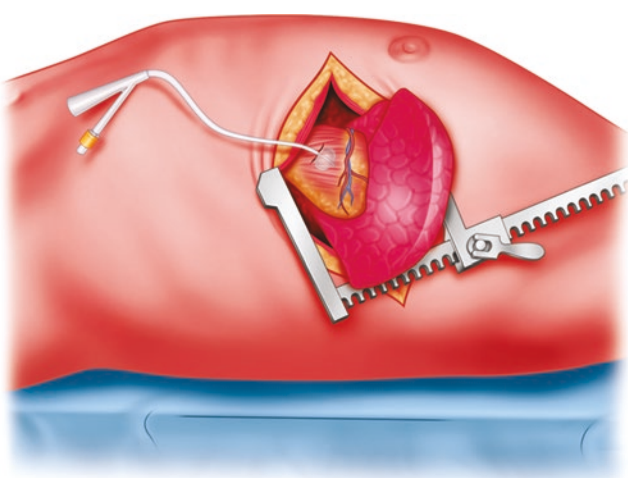

Fig. 30.2 Position the Finochietto retractor with the closed end toward the axilla. A Foley catheter may be used for initial control of large cardiac lacerations

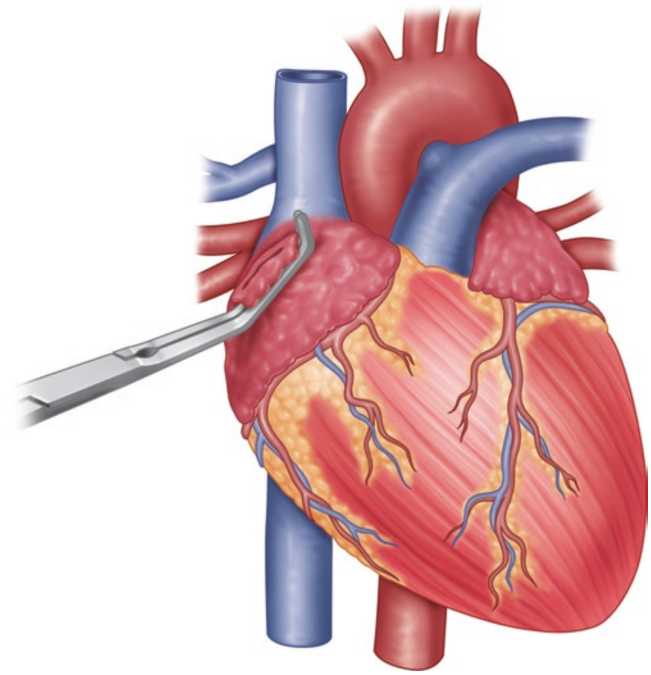

Fig. 30.3 Atrial injuries may be quickly controlled with a Satinsky clamp followed by repair with a 3–0 polypropylene suture

Complications

- Cardiac and/or pulmonary laceration during entry into the chest
- Bleeding

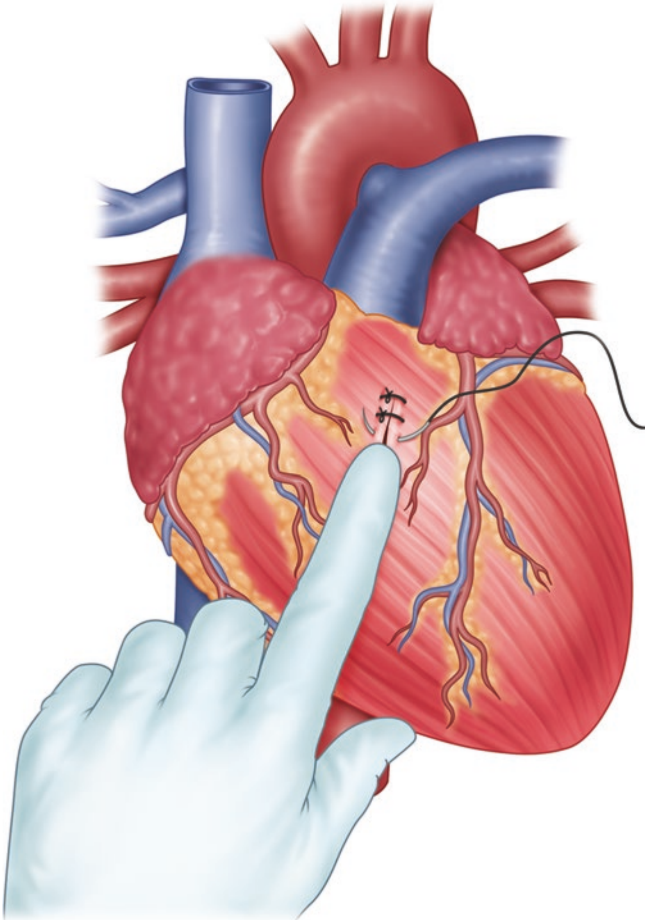

Fig. 30.4 Injuries may be controlled with direct manual pressure and closed with interrupted 3–0 polypropylene suture

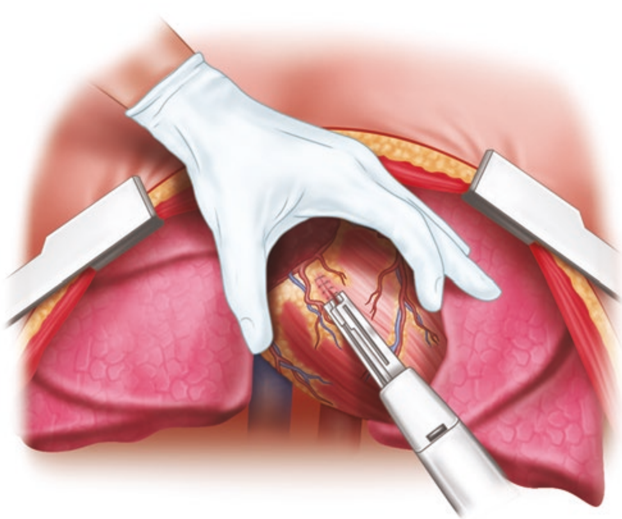

Fig. 30.5 A surgical skin stapler is a quick way to gain initial control of simple cardiac lacerations with minimal risk to the provider

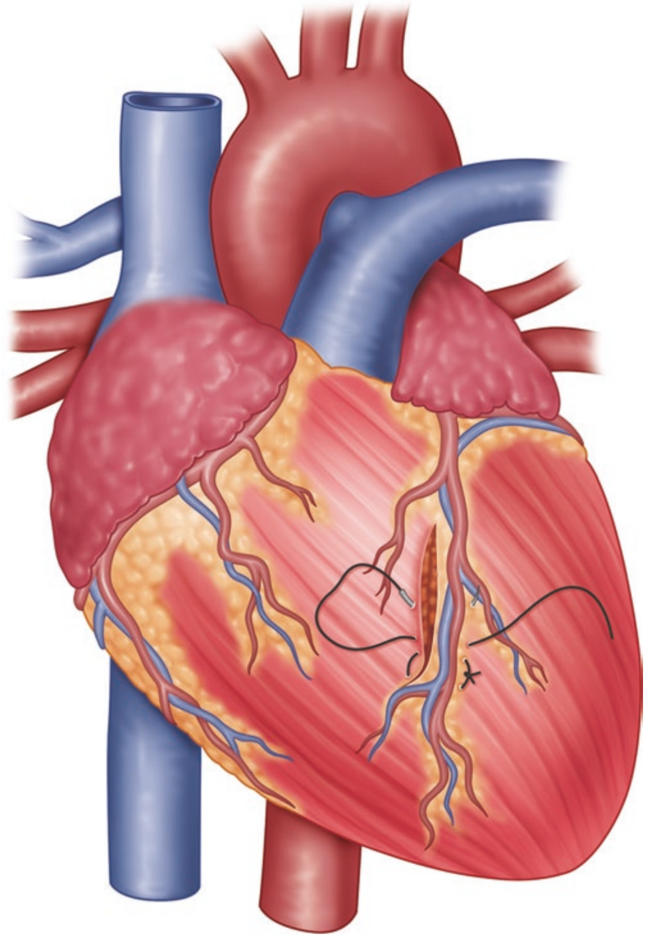

Fig. 30.6 Lacerations in close proximity to coronary vessels can be controlled with horizontal mattress sutures passed beneath the artery to avoid coronary arterial compression

- Delayed hemorrhage (failure to control internal mammary artery, disruption of sutures or staples)
- Infections: empyema and sternal infection
- Missed intracardiac valvular or septal injury (echocardiography should be performed after repair is complete)
- Air embolus

Pearls and Pitfalls

- Pearls
  - There may be more than one wound to the heart (especially with gunshot wounds). Look for them. However, if the wound is posterior and not bleeding with the heart in its natural position, it will be more prudent to leave the injury alone until the patient can be transported to the operating room. Elevating the heart can cause both inflow and outflow obstruction, leading to dysrhythmia that may be difficult to recover from.

  - To avoid sutures pulling through in patients with thin, edematous, or friable myocardium, consider horizontal mattress rather than simple sutures. These may be buttressed with Teflon pledgets for added security.
- Pitfalls
  - The myocardium tears easily. When tying sutures, take care to not tighten them too forcefully.

Suggested Reading

Asensio JA, Trunkey DD. Current therapy of trauma and surgical critical care. Philadelphia: Mosby/Elsevier; 2008.

Feliciano DV, Mattox KL, Moore EE. Trauma. 6th ed. New York: McGraw-Hill Medical; 2008.

Hirshberg A, Mattox KL. Top knife: the art & craft of trauma surgery. Castle Hill Barns: TFM; 2005.

Moore EE, Knudson MM, Clay CB, et al. Defining limits of resuscitative emergency department thoracotomy: a contemporary Western Trauma Association perspective. J Trauma. 2011;70:334–9.

Wall MJ, Mattox KL, Chen CD, et al. Acute management of complex cardiac injuries. J Trauma. 1997;42:905–12.

Synchronized Electrical Cardioversion

31

Alexandra Craen and José A. Rubero

- Tachycardia is defined as a rhythm of >100 beats per minute.
- There are many causes of tachyarrhythmias including but not limited to narrow complexes (<120 msec QRS intervals) and/or wide complexes (>120 msec QRS intervals) that can be either regular or irregular rhythms.
- Synchronized cardioversion delivers a low-energy shock at the peak of the R wave in the cardiac (QRS) cycle when the patient has a tachyarrhythmia that is non-sinus and is unstable.

Indications

- Any non-sinus tachyarrhythmias with a pulse and the patient is unstable:
  – Atrial fibrillation
  – Atrial flutter
  – Monomorphic ventricular tachycardia (VT)
  – Refractory or unstable supraventricular tachycardia (SVT)
  – Reentry tachycardia (i.e., WPW)
- Unstable patients are defined to have one of the following characteristics or combinations:
  – Hypotension
  – Altered mental status
  – Congestive heart failure
  – Signs of shock
  – Syncope
  – Dyspnea
  – Chest pain
  – Acute coronary syndrome
- Tachyarrhythmias that have failed medical management.

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Contraindications

- Absolute:
  – Ventricular fibrillation and pulseless or polymorphic (irregular) VT require unsynchronized electrical cardioversion (defibrillation), not synchronized cardioversion.
  – Known atrial thrombus.
  – Sinus tachycardia.
- Relative:
  – Digoxin toxicity-related tachycardia
    Can cause refractory ventricular fibrillation
  – Stable atrial fibrillation of unknown or more than 48-hour duration without anticoagulation
    Atrial thrombus can be released causing thromboembolism and/or stroke if the patient is cardioverted.
  – Electrolyte abnormalities
  – Patients with sick sinus syndrome or sinoatrial blockage who will require a pacemaker for maintenance of stable rhythm
- Patient refuses procedure either verbally or through legal documents (i.e., DNR and/or advanced directives).

Materials and Medications

- Code cart with resuscitation medications and equipment
- Cardioverter/defibrillator machine with pads
- Razor
- Sedative/anxiolytics agents
- Antiarrhythmic medications
- Supplemental oxygen
- Airway management equipment (laryngoscope, endotracheal tubes)
- Suction
- Rapid sequence intubation medications
- EKG machine

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Procedure

Preparation

1. Place patient on cardiorespiratory monitors.
2. Obtain a 12-lead EKG if the patient's condition is permitted.
3. Obtain at least one intravenous (IV) access.
4. Place patient on supplemental oxygen.
5. Identify the rhythm from monitor or EKG.
6. Place on end-tidal carbon dioxide monitoring if available.
7. Place adhesive pads (8- to 12-cm diameter in adults) or paddles on the patient's anterolateral chest or adhesive pads on the patient's anteroposterior chest/back orientations. Pediatric-sized pads/paddles should be used if the patient is less than 10 kg.
8. The first paddle/pad is placed to the right of the sternum at the second/third intercostal space. The second paddle/pad can be placed in one of two equally efficacious positions:
   (a) Anterolateral position—left fourth/fifth intercostal space in the midaxillary line (Fig. 31.1)
   (b) Anteroposterior position—between the spine and the edge of the left scapula (Fig. 31.1)
9. Discuss risks, benefits, and alternatives (including pharmacological cardioversion) with the patient, and obtain consent.
10. If possible, correct underlying electrolyte abnormalities that may cause or contribute to the patient's arrhythmia.
11. Assess blood pressure and symptoms to determine the need for electrical cardioversion
12. If stable, may give antiarrhythmic medications first.
13. Turn cardioverter/defibrillator machine on and connect pads.
14. Prepare airway equipment and advanced cardiac life support (ACLS) code drugs.

Consider Sedation/Analgesia

1. Choose and give sedative medications alone or in combination (Table 31.1).
2. Consider patient allergies, duration and depth of sedation, and potential side effects.

Cardioversion

1. Press the SYNC button on the defibrillator (Fig. 31.2).
2. Ensure the R wave is being marked and sensed by the machine.
3. Select desired level of energy (Table 31.2) based on the underlying rhythm:
   (a) Regular VT (with pulses): 100 J (monophasic or biphasic), 200 J for subsequent shocks

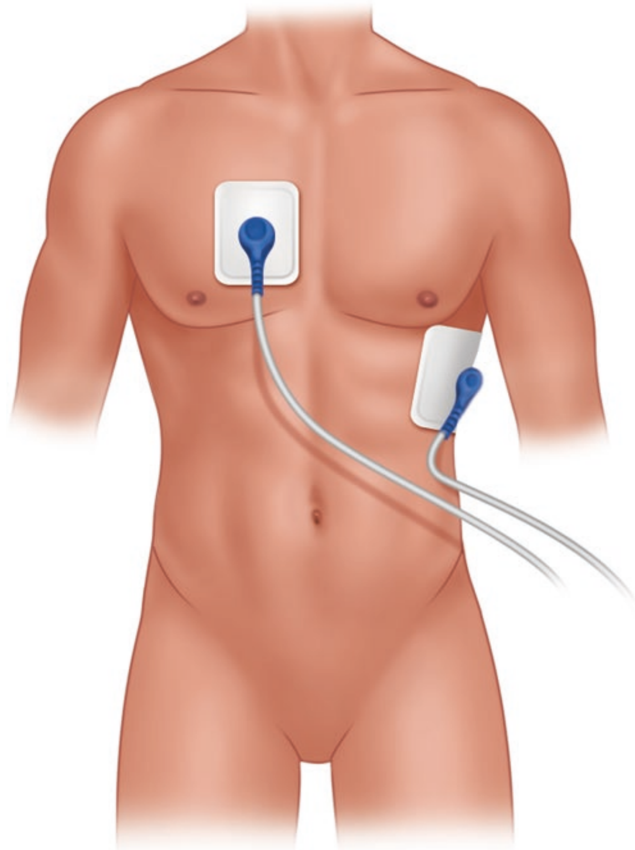

Fig. 31.1 Anterolateral and anteroposterior pad placement

Table 31.1 Commonly used IV sedatives

Propofol	0.5–1 mg/kg
Etomidate	0.15 mg/kg
Ketamine	1–2 mg/kg
Midazolam	1–2.5 mg
Fentanyl	1–2 mcg/kg

Fig. 31.2 Defibrillator with arrow to sync button

Table 31.2 Joule selection (biphasic)

Pediatric	0.5 J/kg then 1 J/kg
Adult[a]	Narrow regular tachycardia: 50–100 J Narrow irregular tachycardia: 120–200 J Wide regular tachycardia: 100 J

[a]Increase in increments as needed

(b) Atrial fibrillation: 120–200 J (biphasic), 200 J (monophasic), 360 J for subsequent shocks
(c) Atrial flutter and paroxysmal SVT: 50–100 J (biphasic), 100 J for subsequent shocks
(d) Pediatric dosage (regular and pulsed VT or SVT): 0.5–1 J/kg, up to 2 J/kg for subsequent shocks

4. Charge the machine.
5. Follow standard precautions to clear patient before delivery of electricity.
6. Press the shock button to cardiovert while remaining clear of patient.
7. Deliver the shock by pressing button marked "SHOCK."
   - If using paddles, apply firm pressure and keep paddles in place until shock is delivered.
8. Reassess rhythm on monitor.

Additional Attempts

1. If the patient's rhythm has not converted, prepare for an additional shock.
2. Continue to assess airway, vital signs, and mental status.
3. Reselect the SYNC button.
4. Select new level of energy and charge machine.
5. After ensuring team is clear of patient, press shock button.
6. Reassess and repeat as needed.
7. Consider and assess for treatable causes of arrhythmia.

Postcardioversion

- Monitor the patient closely until they are awake and vital signs are stable.
- Consider cardiology consultation and start on antiarrhythmic drugs if indicated.

Complications

- Hypotension.
- Respiratory depression, apnea, hypercarbia requiring manual ventilation.
- Induced arrhythmias:
  – Dysrhythmias, including ventricular fibrillation, pulseless VT, or asystole, that require further cardiopulmonary resuscitation
  – Bradycardia in patients with previous inferior myocardial infarction, atrioventricular block
- Thromboembolism and stroke due to atrial clot embolization.
- Skin burns.
- Rarely, fire has occurred as a consequence of poor pad placement and a hyper-oxygenated environment.

Pearls and Pitfalls

- Must reselect the SYNC button in between delivering shocks or disable if defibrillation is required.
- May need to shave chest hair for better chest wall contact of electrodes.
- Avoid placing pads over an implanted device or medications patch.
- If the machine is not sensing, adjust the amplitude (or gain) until marker appears above the QRS complex.
- Biphasic energy is preferable to monophasic because it can defibrillate more effectively at lower-energy levels.
- Handheld paddle electrodes can also be used, and applying force may improve delivery of electricity.
- Need infant size paddles for patient <10 kg.

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Suggested Reading

Al-Khatib SA, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Circulation. 2018;138:e272–391. Originally published 1 Aug 2018. https://doi.org/10.1161/CIR.0000000000000549.

Link MS, Berkow LC, Kudenchuk PJ, et al. Part 7: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132:S444–S464, originally published November 3, 2015. https://doi.org/10.1161/CIR.0000000000000261

Page RL, Joglar JA, Caldwell MA, et al. 2015 ACC/AHA/HRS guideline for the management of adult patients with supraventricular tachycardia: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines and the Heart Rhythm Society. Circulation. 2016;133:e506–74. Originally published 23 Sep 2015. https://doi.org/10.1161/CIR.0000000000000311.

32 Unsynchronized Electrical Cardioversion (Defibrillation)

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- Defibrillation is an emergency procedure performed to terminate ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT).
- Unsynchronized cardioversion or defibrillation is the delivery of a high-energy electrical current across the chest wall through the myocardium shock as soon as the button is pushed on defibrillator. This means it can be delivered anywhere in the cardiac cycle.
- Sudden cardiac arrest due to but not limited to cardiac dysrhythmias, acute coronary syndromes, medications, electrolyte disturbances, and others may end in VF or pulseless VT as a potentially lethal, but survivable, "rhythm."
- In young children and infants, VF or pulseless VT has been associated with hypoxia, congenital malformations of the heart and great vessels.
- Patients with VF or pulseless VT are unresponsive, pulseless, and apneic.
- Following the 2015 American Heart Association (AHA)/ACLS Guidelines, chest compression should be started immediately when VF/pulseless VT is present while obtaining defibrillator and shock is delivered.

Indications

- Ventricular fibrillation.
- Pulseless ventricular tachycardia.
- Cardiac arrest due to or resulting from VF.

Contraindications

- Continued defibrillation is considered futile by healthcare team.
- Absolute:
  - Conscious patient.
  - Presence of a pulse.
  - Pulseless electrical activity (PEA).
  - Asystole.
  - Defibrillation without knowing the rhythm.
  - A second defibrillation before 2 min (or five cycles) of CPR.
  - Patient expressed desire not to be resuscitated either verbally or through legal documentation (DNR or advanced directives).
- Relative:
  - Potential electrical catastrophe (explosive environment [i.e., operating rooms]).
  - Dysrhythmias due to enhanced automaticity such as in digitalis toxicity and catecholamine-induced arrhythmia (because mechanism of tachycardia remains after the shock).
- Factors that are not contraindications:
  - Pregnancy.
  - Chest trauma.
  - Automatic implantable cardioverter defibrillators (AICDs).
  - The patient is on a wet or moist surface.
  - Piercings on the chest.

Materials and Medications

- Electrocardiogram (ECG) monitor/defibrillator.
- Self-adhesive defibrillation pads or defibrillation paddles (paddles may be more successful than self-adhesive pads, but they have more complications and pose more danger to operators).

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- Conductive gel for defibrillation paddles (not ultrasound gel).
- ECG electrodes.
- Supplemental oxygen.
- Airway management/intubation equipment as needed.
- Code cart with resuscitation medications and equipment.

Procedure

1. Preparation.
   - 1.1 Assess for pulse and begin cardiopulmonary resuscitation (CPR) if no pulses.
   - 1.2 At the same time, maintain airway, and apply supplemental oxygen with a bag valve mask (BVM).
   - 1.3 Place patient on cardiorespiratory monitors.
   - 1.4 Obtain at least one intravenous (IV) access.
   - 1.5 Place adhesive pads or paddles on the patient in anterolateral or anteroposterior orientations (Fig. 32.1).
   - 1.6 The self-adhesive defibrillation pads or defibrillation paddles can be used as ECG electrodes to access the rhythm.

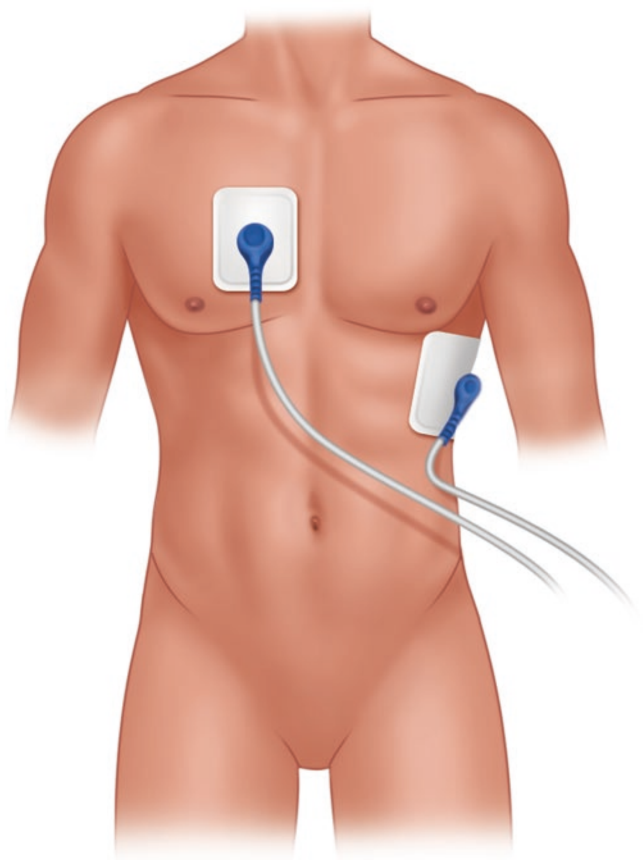

Fig. 32.1 Anterolateral and anteroposterior pad placement

   - 1.7 Paddles: With conductive gel applied to the metal surface, place one paddle on the patient's right chest, just below the clavicle, near the sternal border. The other should be on the left chest, midaxillary line above the fifth or sixth intercostal space (Fig. 32.2).
   - 1.8 Place defibrillator machine into a mode to acquire a rhythm from the pads or paddles.
   - 1.9 Stop CPR and assess for rhythm and pulse for no longer than 10 seconds.

If VF or pulseless VT is observed, proceed with defibrillation.

2. Defibrillation.
   - 2.1 Select desired level of energy (Table 32.1).
   - 2.2 Charge the machine.
   - 2.3 Continue CPR while charging.
   - 2.4 Follow standard precautions to clear patient before delivery of electricity.
   - 2.5 Press the shock button while remaining clear of patient.
   - 2.6 Restart CPR for 2 min or five cycles.
   - 2.7 Another operator may charge (but not fire) the defibrillator while CPR is being performed to expedite the time between pulse/rhythm check and the initiation of a shock increasing the voltage.
   - 2.8 After 2 min or five cycles of CPR, assess the rhythm and pulse and repeat steps 1.8–1.9, and give appropriate advanced cardiac life support (ACLS) medications.
3. Additional Attempts.
   - 3.1 Restart CPR for 2 min or five cycles.
   - 3.2 Reassess rhythm on monitor.
   - 3.3 If the patient's rhythm has not converted, prepare for an additional shock.
   - 3.4 Select new level of energy and charge machine.
   - 3.5 Reassess and repeat as needed following steps 2.8.
   - 3.6 Consider other ACLS medications for refractory VF/pulseless VT.
4. Additional Measures.
   - Continue to provide CPR and maintain airway throughout as needed.
   - Follow ACLS guidelines for delivery of epinephrine and antiarrhythmics.
   - Consider reversible causes.
5. Post Unsynchronized Cardioversion.
   - If patient was pulseless, initiate therapeutic hypothermia.
   - Consider cardiology consultation for further antiarrhythmic recommendations.

Fig. 32.2 Proper placement of defibrillation paddles

Table 32.1 Joule selection (biphasic)

Pediatric	2–4 J/kg
Adult[a]	120–200 J

[a]Increase in increments as needed

Complications

- Skin burns.
- Myocardial necrosis.
- Further cardiac arrhythmias, including asystole or ventricular fibrillation after pulseless ventricular tachycardia.

Pearls and Pitfalls

- Post-defibrillation cardiac dysrhythmias are more common following prolonged VF and higher-energy-level countershocks. Early defibrillation at the recommended energy levels minimizes this complication. Follow ACLS protocols to manage the resulting dysrhythmias.
- Electrical injuries to health-care providers can result if participants remain in contact with the patient during delivery of a countershock because they can serve as a ground for the current discharged.
  - This can be minimized by wearing gloves and using biphasic machines and electrode pads.
- Consider the use of bedside ultrasound for further assessment of cardiac function.
- If polymorphic VT, give magnesium 2 g infusion.
- Consider applying two defibrillators for double sequential external shocks at 200 J if refractory ventricular fibrillation.
- May need to shave chest hair for better chest wall contact of electrodes.
- Avoid placing pads over an implanted device or medication patch.
- Biphasic energy is preferable to monophasic because it can defibrillate more effectively at lower-energy levels.
- Handheld paddle electrodes can also be used, and applying force may improve delivery of electricity.
- Need infant size paddles for patient <10 kg.

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Suggested Reading

Link MS, Berkow LC, Kudenchuk PJ, et al. Part 7: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132:S444–64, originally published November 3, 2015. https://doi.org/10.1161/CIR.0000000000000261.

Ross EM, et al. Dual defibrillation in out-of-hospital cardiac arrest: a retrospective cohort analysis. Resuscitation. 2016;106:14–7.

Pharmacologic Cardioversion for Tachyarrhythmias

33

Alexandra Craen and José A. Rubero

Indications

- Stable patients with tachyarrhythmias

Contraindications

- Unstable patients with hypotension, altered mental status, dyspnea, or concern for acute cardiac dysfunction

Materials and Medications

- Code cart with resuscitation medications and equipment
- Defibrillator machine with pads
- Airway management equipment
- Suction
- Rapid sequence intubation medications
- Supplemental oxygen
- Antiarrhythmic medications
- Electrocardiogram machine

Procedure

1. Preparation
   - Place patient on cardiorespiratory monitors.
   - Obtain at least one intravenous access.
   - Place patient on supplementary oxygen.
   - Assess blood pressure and symptoms to determine the need for emergent electrical cardioversion.
   - Place adhesive pads on patient in anterolateral or anteroposterior orientations in case defibrillation or electrical cardioversion needed.
   - Obtain a 12-lead electrocardiogram.
   - Identify the rhythm to better determine treatment.
   - Identify and treat reversible causes.
2. Cardioversion
   - Categorize tachyarrhythmia according to QRS complex and rhythm.
   - If the QRS complex is narrow and rhythm is regular:
     – Sinus tachycardia
       Identify and treat cause.
     – Supraventricular tachycardia
       Attempt vagal maneuvers.
       Give 6-mg adenosine rapid IV push.
       Give 12-mg adenosine rapid IV push.
       May repeat 12-mg adenosine rapid IV push once.
       If arrhythmia persists, use longer-acting AV nodal blocker, i.e., calcium channel blocker or beta-blocker.
     – Atrial flutter
       Rate control with calcium channel blocker or beta-blocker.
       Consider starting anticoagulation using CHA2DS2-VASc score.
   - If the QRS complex is narrow and the rhythm is irregular:
     – Atrial fibrillation, atrial flutter with variable conduction, or multifocal atrial tachycardia
       Rate control with nondihydropyridine calcium channel blocker, i.e., diltiazem or a beta-blocker.
       Consider starting anticoagulation using CHA2DS2-VASc score.
   - If the QRS complex is wide and the rhythm is regular:
     – Assume ventricular tachycardia:
       Procainamide 17 mg/kg at a rate of 20–50 mg/min, intravenously over 25–30 minutes (max.

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1 gm), or amiodarone 150 mg IV over 10 minutes.

Consider immediate electrical cardioversion.

  – Less likely SVT with aberrancy.
  – Seek expert consultation.
- If the QRS complex is wide and the rhythm is irregular:
  – Atrial fibrillation with aberrancy:

    Procainamide 17 mg/kg at a rate of 20–50 mg/min, intravenously over 25–30 minutes (max. 1 gm), or amiodarone 150 mg IV over 10 minutes

    Electrical cardioversion
  – Torsades de pointes:

    Magnesium 1–2 g and then infusion

    Electrical cardioversion

    Pacing
  – Consider hyperkalemia or accelerated idioventricular rhythm after STEMI treatment.
  – Seek expert consultation.

Complications

- Hypotension
- Increased frequency of original arrhythmia
- Embolic event causing stroke
- Worsening arrhythmia requiring electrical cardioversion or defibrillation

Pearls and Pitfalls

- Use beta-blockers with caution in patients with pulmonary disease or congestive heart failure.
- Assume all regular rhythms with wide QRS complexes are ventricular tachycardia.
- Avoid all AV nodal blockers, including CCB or beta-blockers, in patients with Wolff-Parkinson-White because it can cause fatal ventricular arrhythmias.
  – Suspect in irregular tachycardia with changing QRS morphologies and rates over 250.
  – Consider procainamide 17 mg/kg at a rate of 20–50 mg/min, intravenously over 25–30 minutes (max. 1 gm), or amiodarone 150 mg IV over 10 minutes
- If patient becomes unstable, proceed immediately to electrical cardioversion.

Suggested Reading

Al-Khatib SA, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Circulation. 2018;138:e272–391. Originally published 1 Aug 2018. https://doi.org/10.1161/CIR.0000000000000549.

Link MS, Berkow LC, Kudenchuk PJ, et al. Part 7: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132:S444–64, originally published November 3, 2015. https://doi.org/10.1161/CIR.0000000000000261.

Page RL, Joglar JA, Caldwell MA, et al. 2015 ACC/AHA/HRS guideline for the management of adult patients with supraventricular tachycardia: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Circulation. 2016;133:e506–74. Originally published 23 Sep 2015. https://doi.org/10.1161/CIR.0000000000000311.

34 Transcutaneous Pacing

Nour Rifai and Christian Coletti

Indications

- Hemodynamically unstable (i.e., hypotension, pulmonary edema, chest pain, shortness of breath, or evidence of decreased cerebral perfusion) bradyarrhythmias refractory to medical therapies
- As a bridge to a transvenous or permanent pacemaker
- As an overdrive pacer in tachyarrhythmias
- Controversially, within the first 10 min of a witnessed asystolic cardiac arrest
- In children only with bradycardia associated with a known congenital cardiac defect or after cardiac surgery

Contraindications

- Absolute
  - None
- Relative
  - Bradyarrhythmia associated with hypothermia (ventricles are more prone to defibrillation-resistant fibrillation).
  - Prolonged cardiac arrest (>20 min).
  - Bradyarrhythmia in children (usually secondary to hypoxia or a respiratory issue).
  - Patient is unable to tolerate the procedure despite sedation and analgesia.

Materials and Medications

- Pacemaker device (modern units offer combined pacer and defibrillator functions) (Fig. 34.1)
- One set of standard electrocardiogram (ECG) electrodes
- One set of pacer pads

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Fig. 34.1 Pacemaker device

- Code cart and airway equipment (prophylactically)
- Sedation and analgesia (typically a short-acting benzodiazepine and an opioid)
  - Midazolam: 0.2–0.10 mg/kg intravenous (IV) push and may repeat with 25% of initial dose after 3–5 min. Do not exceed 2.5 mg/dose or a cumulative dose of 5 mg.
  - Fentanyl: 1–2 mcg/kg IV slow push over 1–2 min, may repeat dose in 30 min. (Fentanyl is the opioid of choice because it is less likely to exacerbate any hypotension.)

Procedure

1. Time permitting, clean and dry the skin, and shave any excess hair off the chest.
2. Administer any appropriate sedation and analgesia.
3. Attach the ECG electrodes to both the input port of the pacemaker unit and the patient. On the patient, the white lead is placed just above the right clavicle, the black lead

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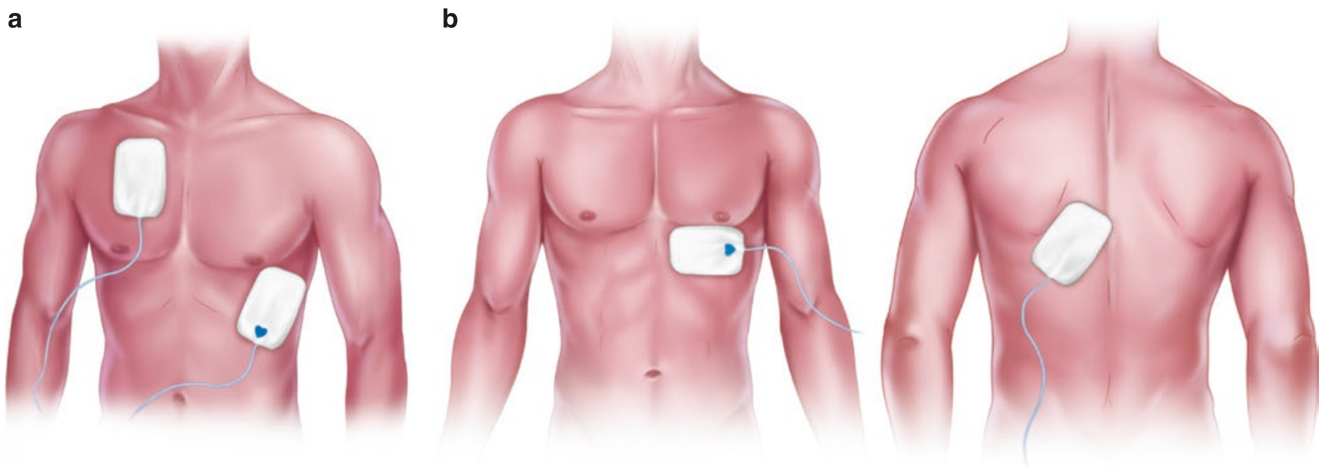

Fig. 34.2 Pacer pads attached in the anterolateral (**a**) or anteroposterior positions (**b**)

is just above the left clavicle, and the red lead is around the left midaxillary line.

4. Attach the pacer pads either in the anteroposterior or anterolateral positions as pictured (avoid placement over an implanted pacemaker or defibrillator, Fig. 34.2).
5. Turn the machine on and switch it to synchronous (or on-demand) mode.
   - Asynchronous (or fixed) mode fires impulses with no regard to the intrinsic cardiac cycle, increasing the likelihood of an R on T phenomenon, which could result in ventricular tachycardia or fibrillation.
   - Synchronous (or on-demand) mode will not fire an electrical impulse when a QRS complex is sensed; this is the preferred mode for transcutaneous pacing.
6. Set the desired heart rate: typically 60–80 beats/min to achieve adequate perfusion.
7. Select a lead on the pacemaker unit and then press Start.
8. Slowly increase the output current until electrical capture is denoted by a visible pacemaker spike, which will precede every QRS complex on the ECG monitor (Fig. 34.3).
   - Electrical capture is usually achieved between 50 and 100 mA.
   - If a patient is unconscious or truly deteriorating quickly or in cardiac arrest, it may be prudent to set the initial currents at maximum to ensure rapid capture and then decrease the current to just above that at which electrical capture was achieved.
9. After electrical capture is appreciated on the monitor, assess for mechanical capture by palpation of a pulse at a rate that corresponds to that which the machine is set at. An improved blood pressure or resolution of chest pain, shortness of breath, or altered mental status also suggests that the heart rate has improved and perfusion has been restored.
10. When pacing in overdrive for tachyarrhythmias, the pacer rate is set 20–60 beats/min faster than the detected tachycardic rate.
    - Bear in mind that rhythm acceleration or the induction of ventricular fibrillation is a possibility with pacing, hence the recommendation of having a code cart and airway equipment in the room at all times.

Pearls and Pitfalls

- Pearls
  – Pacer pads can be prophylactically placed on bradycardic but stable patients in preparation for potential decompensation.
  – It may be prudent to discuss with a stable but bradycardic patient the option of trying the pacemaker not only to ensure that the machine and pads are working but also to gauge an idea of the output current that will be needed to electrically capture for quicker, more efficient, and potentially lifesaving pacing that may prove necessary.
  – When palpating for mechanical capture, the femoral pulse may be easier because carotid palpation may prove difficult with muscular contractions induced by the pacer impulses.
  – If impulses are not capturing, try slightly readjusting the pacer pads, making sure the leads are still on, the settings were not changed, the machine's battery did not die, or the machine is plugged in.
  – If electrical capture is achieved but mechanical is not, increase the rate until adequate pulses are palpated.

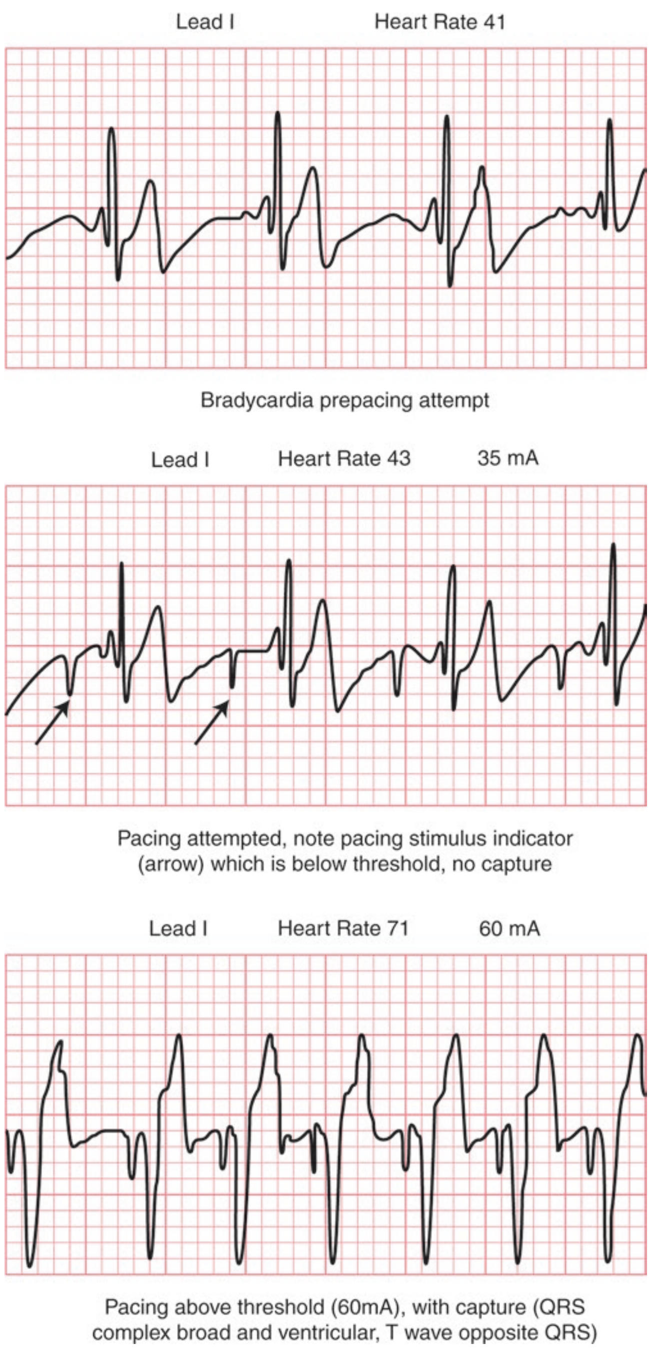

Fig. 34.3 A visible pacemaker spike will precede every QRS complex on the ECG monitor

  – Be careful to not miss an underlying ventricular fibrillation if the monitor is not blanked or dampened by an ECG screen.
  – Cardiopulmonary resuscitation (CPR) can be continued even while transcutaneous pacing is taking place because the pacer pads are insulated and the power delivered in each impulse is minimal, making the risk of injury to health-care workers very low.
- Pitfalls
  – Certain factors including a large body habitus, the presence of large pericardial effusions, scarring secondary to intrathoracic surgeries, or large amounts of intrathoracic air associated with obstructive pulmonary diseases may not only increase the threshold for capture but also may even cause a failure to capture, in which case transvenous pacing should immediately be considered.
  – Be aware that long-term pacing and pacing in children increases the likelihood for cutaneous and soft tissue damage.

Suggested Reading

Bonow JS, Mann DL, Zipes DF, editors. Braunwald's heart disease: a textbook of cardiovascular medicine. 9th ed. Philadelphia: Saunders Elsevier; 2008.

Pfenninger JL, Fowler GC, editors. Pfenninger and Fowler's procedures for primary care. Philadelphia: Saunders Elsevier; 2010.

Roberts JR, Hedges JR, editors. Clinical procedures in emergency medicine. 5th ed. Philadelphia: Saunders Elsevier; 2010.

Tintinalli JE, Stapczynski JS, Cline DM, Ma OJ, Cydulka RK, Meckler GD, editors. Tintinalli's emergency medicine: a comprehensive study guide. 7th ed. New York: McGraw-Hill Medical; 2011.

35 Transvenous Cardiac Pacing

Katrina John, Jeffrey Kile, and Amish Aghera

Indications

Hemodynamic compromise in the presence of:

- Sinus node dysfunction
- Second- and third-degree heart block
- Atrial fibrillation with slow ventricular response
- New left bundle branch block (LBBB)
- Right bundle branch block (RBBB)
- Bifascicular block
- Alternating bundle branch block (BBB)
- Implanted pacemaker malfunction

Contraindications

- Absolute
  - Prosthetic tricuspid valve
- Relative
  - Bradycardia in the presence of severe hypothermia

Materials and Medications (Fig. 35.1)

- Sterile gloves
- Sterile gown and drapes
- Face mask and surgical cap
- Two 10-mL syringes
- One 3-mL syringe

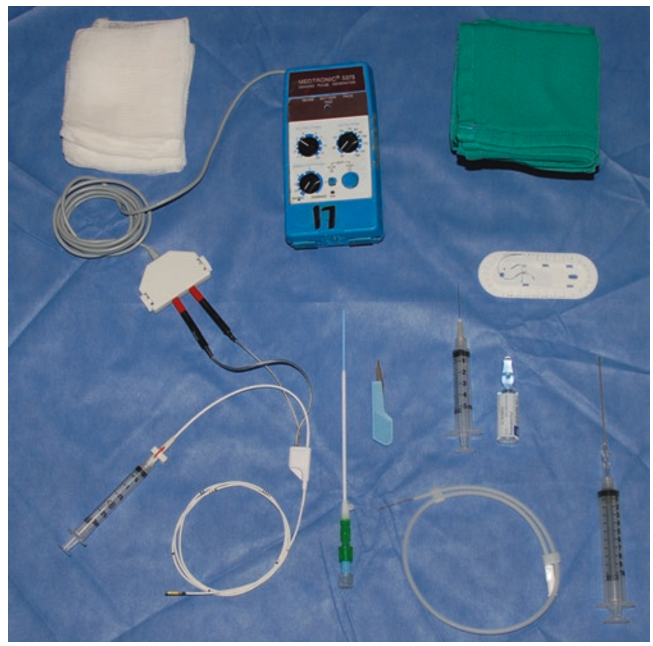

Fig. 35.1 Materials and medications

- Local anesthetic (1 or 2% lidocaine without epinephrine)
- 22-gauge needle
- Povidone-iodine or chlorhexidine/isopropyl alcohol
- Several 4 × 4-in gauze sponges
- Sterile dressing pack
- 4–0 nylon or silk sutures
- Scalpel (#11 blade)
- Needle holder
- Scissors
- Introducer needle
- Guidewire
- Dilator
- Introducer sheath
- Collapsed sterile extension sheath
- Balloon-tipped pacing catheter
- Pacing generator with working battery

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- Insulated cable with alligator clamps or other suitable connectors
- Electrocardiogram (ECG)/cardiac monitor

Procedure

1. Select appropriate catheterization site.
   - Four sites provide superior access to the right atrium: brachial, femoral, internal jugular, and subclavian veins. The right internal jugular and left subclavian veins, respectively, are the most direct routes and, thus, the most commonly used in the emergency department setting.
2. If clinical situation permits, explain the procedure fully to the patient and obtain consent.
3. Sterilize the skin and apply sterile drapes.
4. Anesthetize the intended insertion site with lidocaine.
5. Prepare the pacing wire by inflating and deflating the balloon with 1–1.5 mL of air using a 3-mL syringe, and confirm that locking lever functions correctly to maintain balloon inflation (Fig. 35.2).
6. Using ultrasound guidance by means of a probe covered in a sterile sheath, insert the introducer needle into the vein while applying negative pressure to the attached 10-mL syringe (as with standard central line placement) (Fig. 35.3).
7. When flashback of blood is visualized in the syringe, remove the syringe, stabilizing the introducer needle firmly in place.
8. Pass the guidewire through the needle to a depth of 10–15 cm.
9. Holding the guidewire securely in place, remove the introducing needle.
10. Using a scalpel, make a small incision (approximately the width of the catheter to be used) through the dermis at the insertion site of the guidewire.
    - Avoid severing the guidewire by facing the sharp edge of the scalpel *away* from the guidewire.
11. Pass a dilator over the guidewire to make a tract in the skin and then remove the dilator.
12. Pass the introducer catheter over the guidewire until the hub is in contact with the skin, and then remove the guidewire (Fig. 35.4).
13. Attach the collapsible sterile sheath to the hub of the introducer catheter.
14. Attach the positive and negative connectors of the pacing wire to their respective terminals on the cable(s) connected to the generator.
15. Set generator rate at 80 beats/min, output to 5 mA, and sensitivity to 3 mV.
16. Insert the free end of the pacing wire into introducer catheter with the balloon deflated, and slowly advance the wire.
17. When the tip of the wire is within the superior vena cava, inflate the balloon, lock the valve to ensure that the balloon remains inflated, and continue to advance the pacing wire.
18. Closely watch the cardiac monitor for signs of capture (i.e., a wide QRS preceded by a pacing spike).
    - Markings on the pacing wire indicate its depth of insertion. At 20 cm, the wire should be in the right

Fig. 35.3 Insertion of introducer needle into internal jugular vein with ultrasound guidance

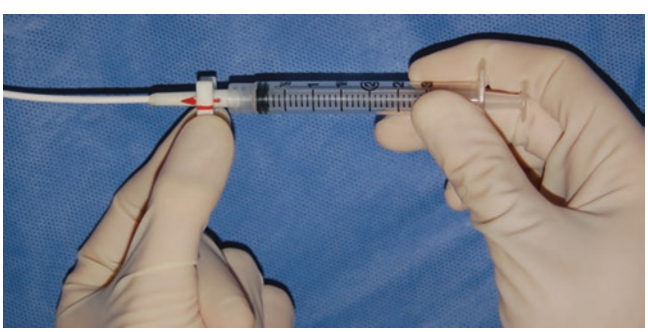

Fig. 35.2 Pacing wire balloon locking lever

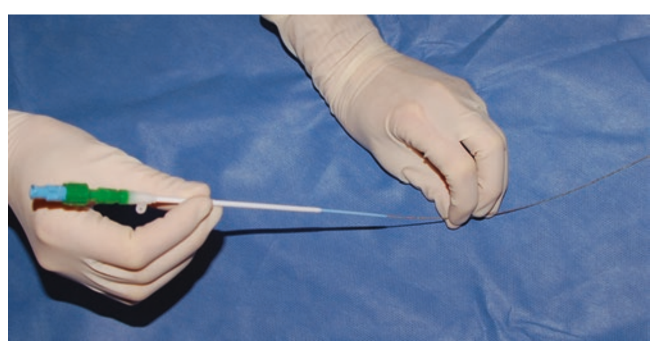

Fig. 35.4 Placement of introducer catheter over guidewire

ventricle. If there is no capture observed by 25 cm, then the wire should be slowly withdrawn and advanced again.
19. Once capture is achieved, deflate the balloon.
20. Advance the wire a further 1–2 cm.
21. Coil the wire that remains outside the extended sterile sheath, and suture it loosely but securely to the skin.
22. Suture the introducer hub to the skin.
23. Reduce generator output to zero, and then increase it slowly to determine the minimum pacing threshold (i.e., the minimum voltage at which capture is achieved), and then set the output to twice this value.
24. Set the generator rate.
25. Stabilize the generator near the catheterization site.
    - For example, the generator can be attached to an intravenous (IV) fluid stand to the right of the patient's head if the pacing wire has been placed via the patient's right internal jugular vein.
26. Obtain a chest X-ray to confirm pacing wire position and absence of potential complications (e.g., pneumothorax) (Fig. 35.5).
27. Obtain a 12-lead ECG (Fig. 35.6).

Complications

- Arterial puncture
- Venous thrombosis
- Thrombophlebitis
- Pulmonary embolus
- Pneumothorax

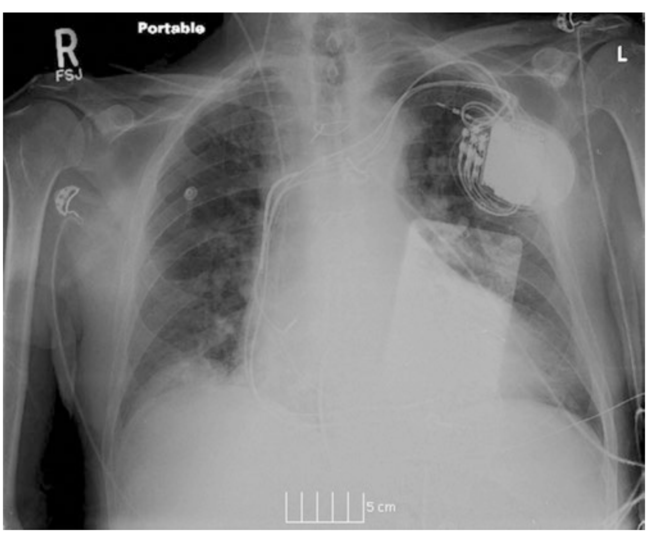

Fig. 35.5 X-ray displaying correct position of pacing wire in the right ventricle

- Fracture of guidewire with embolization
- Hemothorax
- Thoracic duct laceration
- Indwelling line infection (local or systemic)
- Dysrhythmias/premature ventricular contractions (PVCs)
- Insertion of pacing wire into coronary sinus/pulmonary artery
- Left (rather than right) ventricular pacing through atrial septal defect/ventricular septal defect (ASD/VSD)
- Septal perforation
- Ventricular perforation
- Entrapment/twisting of preexisting permanent pacing wires by the temporary pacing wire
- Balloon rupture
- Chordae tendineae rupture
- Pacing wire fractures
- Loss of capture owing to wire displacement or fracture
- Generator failure

Pearls and Pitfalls

- Confirm all necessary equipment is present and functional before beginning the procedure. If a dedicated transvenous pacing set is unavailable, individual components required (e.g., pacing catheter, connector cables, introducer catheter, guidewire) may need to be "cannibalized" from several different procedure kits in an emergency department.
- Become familiar with the locking valve for the pacing wire balloon before beginning the procedure. This small part is essential for inflating and deflating the balloon but is frequently difficult to adjust owing to stiffness (and all the more so if covered in blood).
- The ideal position for the pacing wire tip is against the diaphragmatic aspect of the right ventricle between its midpoint and its apex. This position is confirmed by development of an LBBB pattern with left axis deviation on the cardiac monitor. If difficulty is encountered achieving this position, the tip of the pacing wire can be moved to the right ventricular outflow tract, where the wire is less stable, but adequate pacing can still be achieved. In this latter position, the threshold will need to be kept relatively high, and the monitor should display an LBBB pattern with an inferior axis.
- The use of balloon-tipped catheters enables the catheter tip to be directed with blood flow and its position (and successful capture) to be confirmed with a cardiac monitor. Nonballoon-tipped catheters, however, have typically required insertion with guidance of either constant ECG monitoring or fluoroscopy.

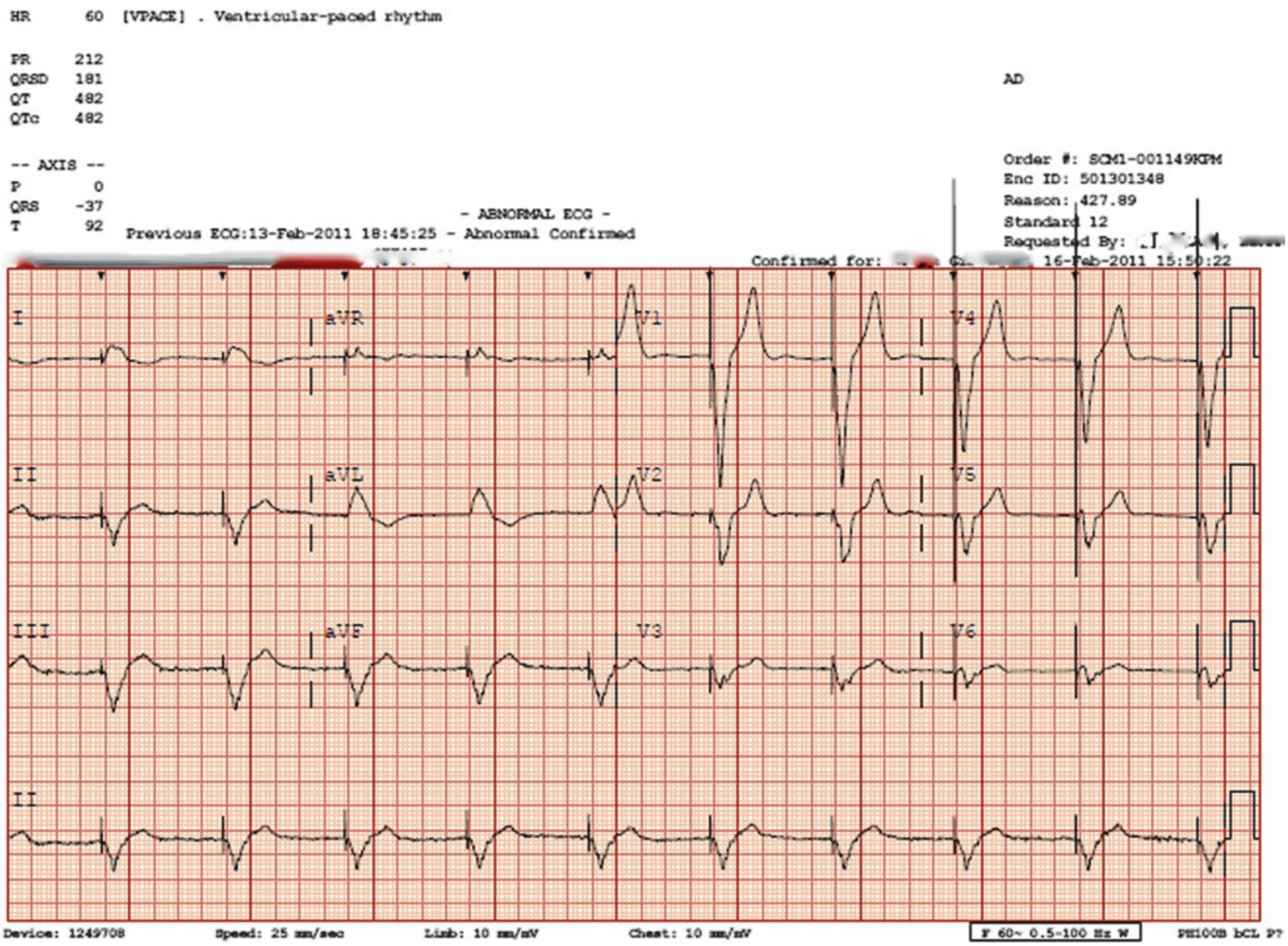

Fig. 35.6 Cardiac monitor displaying wide complex QRS and pacing spike

Suggested Reading

Aguilera PA, Durham BA, Riley DA. Emergency transvenous cardiac pacing placement using ultrasound guidance. Ann Emerg Med. 2000;36(3):224–7.

Birkhahn RH, Gaeta TJ, Tloczkowski J, Mundy T, Sharma M, Bove J, Briggs WM. Emergency medicine-trained physicians are proficient in the insertion of transvenous pacemakers. Ann Emerg Med. 2004;43(4):469–74.

Dalsey WC, Syverud SA, Hedges JR. Emergency department use of transcutaneous pacing for cardiac arrests. Crit Care Med. 1985;13(5):399–401.

Harrigan RA, Chan TC, Moonblatt S, Vilke GM, Ufberg JW. Temporary transvenous pacemaker placement in the Emergency Department. J Emerg Med. 2007;32(1):105–11.

Silver MD, Goldschlager N. Temporary transvenous cardiac pacing in the critical care setting. Chest. 1988;93(3):607–13.

Check for updates

Pericardiocentesis with Ultrasound Guidance

36

Katrina Skoog Nguyen, L. Connor Nickels, Rohit Pravin Patel, and José A. Rubero

Indications

- Treatment of hemodynamic compromise from cardiac tamponade
- To diagnose the cause or presence of a pericardial effusion

Contraindications

- Absolute
  - Aortic dissection
  - Need for immediate surgery for trauma patients
- Relative
  - Coagulopathy
  - Anticoagulant therapy
  - Thrombocytopenia

Materials and Medications

- Antiseptic (e.g., ChloraPrep)
- 1% lidocaine
- 25-gauge needle, 5/8 in long
- 18-gauge catheter-type needle, 1½ inch long
- Syringes (10, 20, and 60 mL)
- Ultrasound (US) machine and cardiac/phased array probe
- Sterile US probe cover
- Cardiac monitor

Procedure

1. Identify the point of maximal effusion with US. Evaluate for hypoechoic or anechoic (dark) effusion around the heart, between the pericardial sac and the myocardium. A patient with hemodynamic compromise from a pericardial effusion or tamponade will have right ventricular collapse, septal bulging, and dilation of the inferior vena cava. Diastolic collapse of the right ventricular free wall can be absent in elevated right ventricular pressure and right ventricular hypertrophy or in right ventricular infarction.
2. Measure the distance from the skin surface to the effusion border to assess the expected needle depth.
3. Choose the needle trajectory based on the point of maximal effusion in the path with the fewest intervening structures. The most commonly used approaches are left parasternal, apical, and subxiphoid. For complex loculated posterior pericardial effusions, optional techniques such as transatrial and transbronchial may be performed by specialists. These types of loculated effusions can occur in autoimmune diseases, in infective pericarditis, after cardiac surgery, and after radiotherapy.
4. Sterile preparation: Prepare the skin of the entire lower xiphoid and epigastric area with antiseptic. Prepare the US transducer with a sterile sleeve.
5. Local anesthetic: If the patient is awake, anesthetize the skin and planned route of the needle.
6. Pericardial needle insertion: depends on approach used.

Subxiphoid Approach (Fig. 36.1)

- The US transducer is placed just inferior to the xiphoid process and left costal margin.
- Insert the needle between the xiphoid process and the left costal margin at a 30–45° angle to the skin.
- Aim for the left shoulder.

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Apical Approach (Fig. 36.2)

- The US transducer is placed at the patient's point of maximal impulse and aimed at the patient's right shoulder for a four-chamber view of the heart.
- Insert the needle in the fifth intercostal space 1 cm lateral to and below the apical beat, within the area of cardiac dullness.
- Aim for the right shoulder.
- A Mayo Clinic review showed, in 80% of total effusions, that the distance to the effusion was least and the size was maximal in the apical approach [1].

Parasternal Long-Axis Approach

- The US transducer is placed obliquely on the left sternal border between the fourth and fifth ribs with the transducer indicator aimed at the right shoulder.
- Insert the needle perpendicular to the skin in the fifth intercostal space medial to the border of cardiac dullness.
  - Visualize and feel a giving way as the needle penetrates the pericardium. Removal of fluid confirms successful entry. Remove fluid with the goal of restoring hemodynamic stability. Aspiration of fluid should

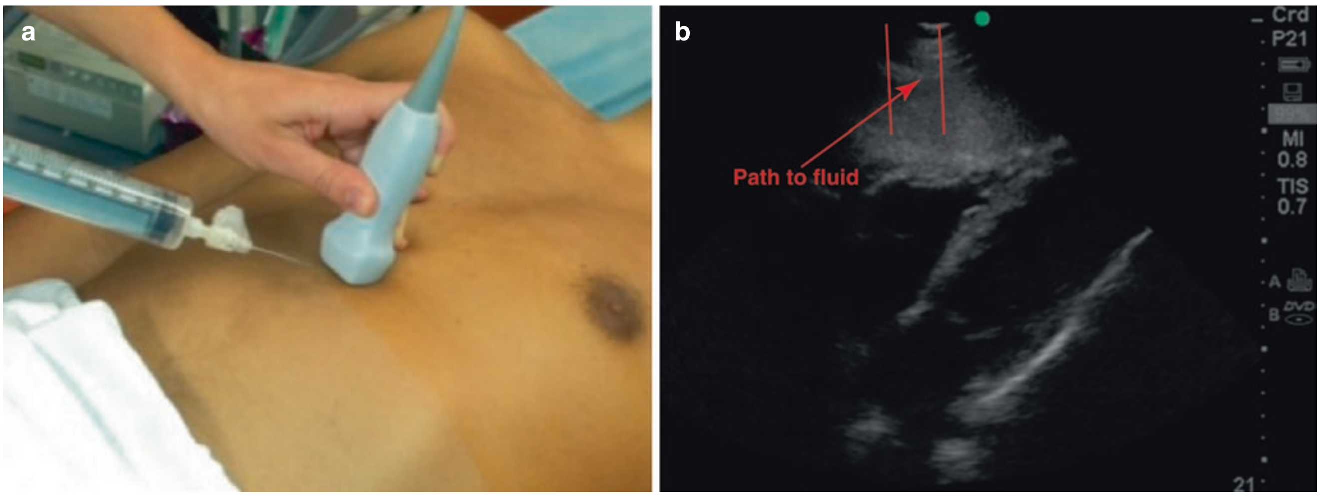

Fig. 36.1 Subcostal approach (**a**) and corresponding ultrasound image (**b**). Red line through the liver to obtain fluid (no fluid present on ultrasound image)

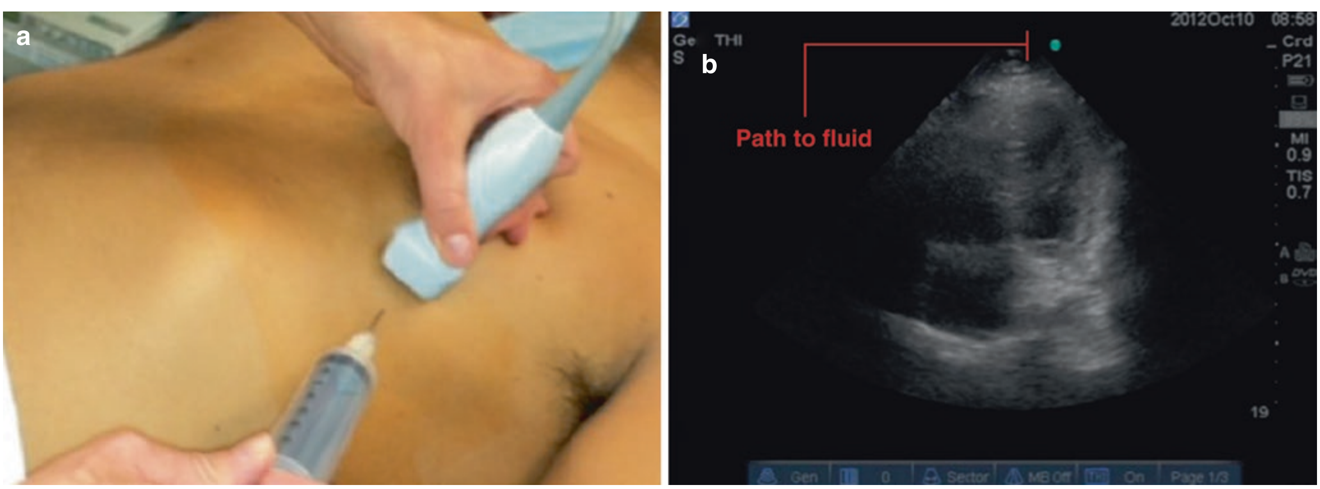

Fig. 36.2 Apical approach (**a**) and corresponding ultrasound image (**b**). Red line with minimal distance to fluid if present (no fluid present on ultrasound image)

   - result in improvement in blood pressure and cardiac output.
   - Remove the catheter and apply a dressing. Optional: Place a pigtail catheter using the Seldinger technique for continued drainage.

Complications

- Blind techniques are associated with 20% morbidity and 6% mortality. The complication rate with US-guided approaches is less than 5% [2].
- Any vital structure within reach of the pericardial needle has the potential for injury: pneumothorax; hemothorax; coronary vessel laceration; hemopericardium; heart chamber lacerations; intercostal vessel injury; dysrhythmias; ventricular tachycardia; puncture of the liver, diaphragm, or gastrointestinal tract; bacteremia; purulent pericarditis; air embolisms; and pleuropericardial fistulas.

Pearls and Pitfalls

- Pearls
  - A scoring index is available that can be obtained at initial presentation in patients without hemodynamic compromise that identifies those who require pericardial effusion drainage later in the course of treatment. The scoring index uses echocardiographic findings, etiological information, and the size of the effusion at end diastole [3].
  - Take care to avoid the left internal mammary artery, which travels in a cephalad-to-caudad direction 3–5 cm lateral to the left sternal border [4].
- Pitfalls
  - Tamponade should always be considered in the differential diagnosis of shock or cardiac arrest owing to pulseless electrical activity (PEA). Complications of acute coronary syndrome, aortic dissection, and decompensations in chronic advanced constriction may also need treatment [5].
  - When cardiac compensation mechanisms are exhausted, small increases in pericardial volume can lead to an increase in ventricular diastolic pressure, systemic and pulmonary congestion, and decrease preload and cardiac output.
  - Use US-guided rather than a blind or an electrocardiogram (ECG)-alone-guided approach for pericardiocentesis to significantly decrease the risk of injury to vital structures [4].
  - Do not delay patient transport to the operating room to perform pericardiocentesis on a traumatically induced effusion unless the patient is hemodynamically unstable and on the verge of cardiac arrest.

References

1. Tsang TS, Enriquez-Serano M, Freeman WK, Barnes ME, Sinak LJ, Gersh BJ, et al. Consecutive 1127 therapeutic echocardiography guided pericardiocentesis: clinical profile, practice patterns, and outcomes spanning 21 years. Mayo Clin Proc. 2002;77:429–36.
2. Guo K, Ding ZP, Tan J. Trans-pleural pericardiocentesis: revisiting an old technique. Catheter Cardiovasc Interv. 2011;78:815–8.
3. Halpern DG, Argulian E, Briasoulis A, Chaudhry F, Aziz EF, Herzog E. A novel pericardial effusion scoring index to guide decision for drainage. Crit Pathw Cardiol. 2012;11:85–9.
4. Seferović PM, Ristić AD, Imazio M, et al. Management strategies in pericardial emergencies. Herz. 2006;31:891–901.
5. Sagristà-Sauleda J, Mercé AS, Soler-Soler J. Diagnosis and management of pericardial effusion. World J Cardiol. 2011;3:135–43.

37 Ultrasound Evaluation of Pulmonary Embolism and Heart Strain

Javier Rosario

Indications

- Undifferentiated respiratory distress or dyspnea
- Unexplained hypotension
- Inability, contraindication, or delay of access to CT scan
- Undifferentiated chest pain
- Recent travel history
- History of prior pulmonary emboli
- Evaluation of other possible differentials:
  – Cardiac tamponade
  – Pericardial effusion
  – Ejection fraction evaluation

Contraindications

- Relative
  – Morbidly obese patients
  – Patients with chest wall deformities
  – Patient with subcutaneous emphysema, pneumopericardium
  – Combative or altered patients

Materials and Medications

- Ultrasound machine
- Probe selection: Phased array (Fig. 37.1) preferred, but curvilinear is an alternative
- Ultrasound gel
- Drapes or towels for the patient

Fig. 37.1 Phased-array probe

Procedure

1. Begin with the parasternal long-axis view. If possible, have the patient turn to the left decubitus side. This maneuver helps move the heart closer to the chest wall.
2. Select the desired probe (ideally the phased array), and then select the Cardiac preset on the machine.
   - Most systems in the Cardiac settings will have the *marker on the screen* to the left of the patient (right upper portion of the screen).
   - The *probe marker* should match the marker on the screen. Meaning, if the marker is pointing to the left of the patient, your probe should be facing that way as well.
   - If desired, this marker can be changed to "EM" settings by flipping the marker to the left of the screen (to the right of the patient) – making it possible to use the probe toward the right of the patient.
3. Place the probe along the left side of the sternum over the fourth to sixth intercostal space. This should produce the image shown in Fig. 37.2.

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4. Measure the diameter of the ventricle during the end of diastole (normal values, 21 mm ± 1 mm; any measurement >25–30 mm is abnormal).
5. Using the aorta as a landmark, evaluate the structures starting with the pericardium (bright white line around the heart), making sure there is no fluid around it. (Fluid above the aorta indicates a pericardial effusion. Fluid below the aorta indicates a pleural effusion.) If a hypoechoic or anechoic stripe appears in the anterior side of the heart, it is most likely a fat pad. Fluid seen "all around" categorizes it as an effusion.
6. While keeping the probe in the same place, rotate the probe marker 90° clockwise toward the left shoulder to obtain the parasternal short-axis view (Fig. 37.3).

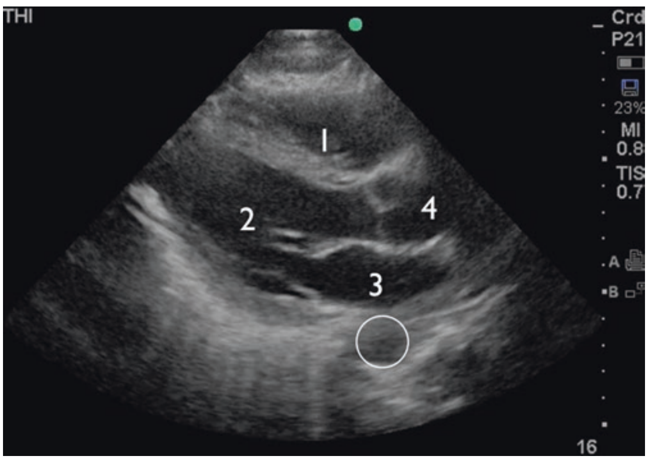

Fig. 37.2 Parasternal long-axis view (PSLA). (1) Right ventricle, (2) left ventricle, (3) left atrium, (4) aortic outflow track; *circle* indicates descending aorta (the right atrium is not visualized in the PSLA). Notice the marker on the top right of the screen (*green dot*). This marker design is frequently changed by manufacturers to match their device for branding

7. The parasternal short-axis view will give information on the contractility of the heart. The right ventricle should be anterior and to the left and the left ventricle to the right. The normal position of the septum bows slightly toward the right ventricle.
8. To obtain a four-chamber view, place the orientation marker to the patient's right. Palpate for the point of maximum impulse (PMI) and place the transducer. All four chambers should appear in one view (Fig. 37.4).
9. Compare the sizes of the ventricles in diastole and note any difference. Notice also the interventricular septum. The normal right-to-left ventricular ratio is less than 0.6. (In an unstable patient, this is probably the most useful because both ventricles can be quickly visualized and the ratio compared.) Globally another assumption is that normally the LV will be 2/3 of the width of the heart and the RV about 1/3 of that total width of the heart.
   - This is useful unless this is visualized post cardiac arrest (see pitfalls).
10. A subxiphoid approach is also possible, this one being less reliable for accurate ventricular size measurement. Make sure the orientation marker is toward the right side of the patient (Fig. 37.5).
11. Use the liver for orientation. The right side of the heart will be nearest to the liver (think that the liver is on the right of the body); again note for any differences in the size ratio.
12. Next take a look at the inferior vena cava (IVC) by placing the curved array transducer just inferior to the xiphoid in a longitudinal fashion. (Switch from the subxiphoid view to the IVC by rotating the probe counterclockwise until the IVC is seen.) Evaluate the IVC. During normal physiological inspiration, the drop in intrathoracic pressure "pulls" blood into the heart, thus decreasing the rela-

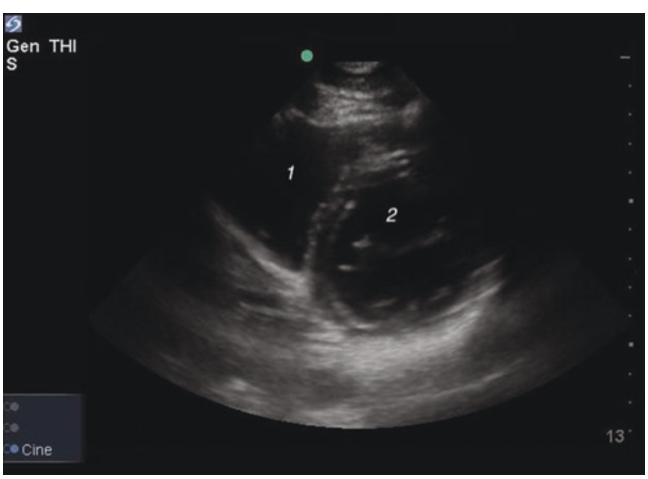

Fig. 37.3 Parasternal short-axis view (PSSA). (1) Right ventricle, (2) left ventricle

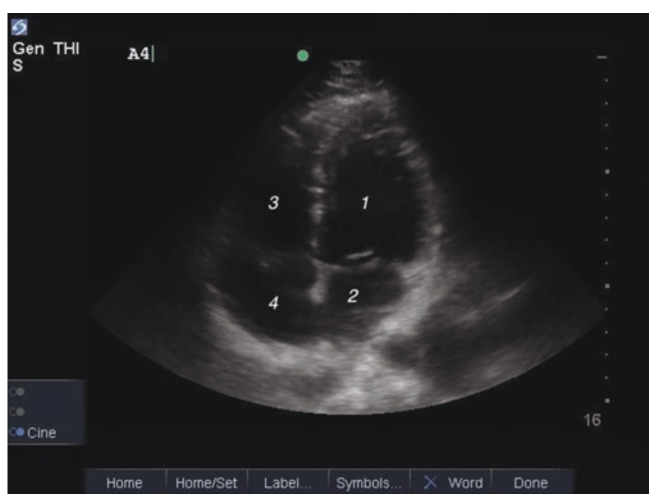

Fig. 37.4 Four-chamber view (4C). (1) Left ventricle, (2) left atrium, (3) right ventricle, (4) right atrium

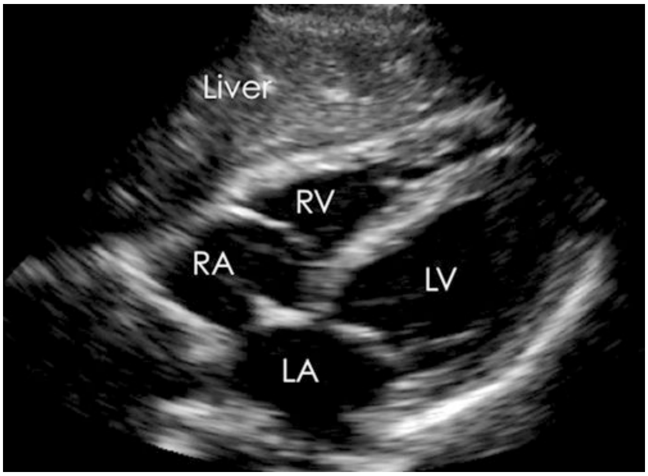

Fig. 37.5 Subcostal/subxiphoid view. RV right ventricle, RA right atrium, LV left ventricle, LA left atrium

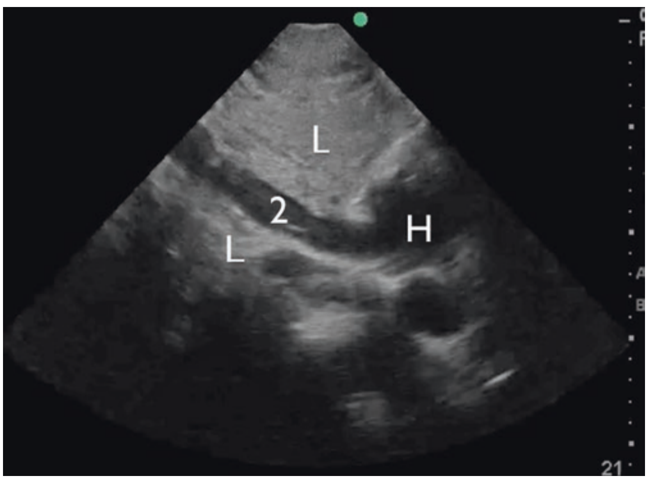

Fig. 37.6 Inferior vena cava. L liver; 2 inferior vena cava, H heart

tive IVC size. If something is preventing venous return, such as a massive PE, collapse will not be as evident, and the suspicion for PE increases (fluid overload and increased central venous pressure [CVP] will also account for this finding). Normal IVC diameter is 1.2–2.3 cm. Total collapse and greater than 50% collapse are usually visualized and less likely related to an RV strain pattern. An increased IVC size and less than 50% or no change could be related to increased right atrial pressures (11 to >20 cm Hg) (Fig. 37.6).

Findings

A right heart that is "strained" or pumping against a higher resistance owing to a PE can have multiple findings, some of which have been discussed above. There are more views, measurements, and calculations that can contribute in the assessment of PE. However, these are outside the scope of this chapter and additional reading is recommended. For purposes of this chapter and the global evaluation of PE, a right heart with signs of PE may show some or all of these changes:

1. Right ventricular dilation (Fig. 37.7). This can be visualized in multiple views.
   - In the parasternal long-axis view, a good "rule of thumb" is comparing the size of the RV with the size of the aortic outflow tract and the left atrium. They should be grossly similar in size.
   - In the parasternal short axis, the RV may be seen grossly larger than the visualized LV. Additionally "bowing" of the interventricular septum may be seen (D-shaped LV; see below)
2. Right ventricular hypokinesis (especially of the middle segment), but normal motion of the apex. This is called McConnell's sign. Caution should be taken with this finding as it may also be seen with other right heart pathologies.
3. Tricuspid regurgitation.
4. Abnormal septal motion: deviated toward the left ventricle (normally it relaxes during diastole toward the right ventricle); as pressure increases, the right ventricle will not empty properly, and septal flattening can be seen. This is sometimes referred to as a "D-shaped" LV, a view frequently obtained in the short-axis approach.
5. Dilated IVC with little or complete loss of changes in diameter with respiration (variability); the IVC collapses less than 50% during inspiration.

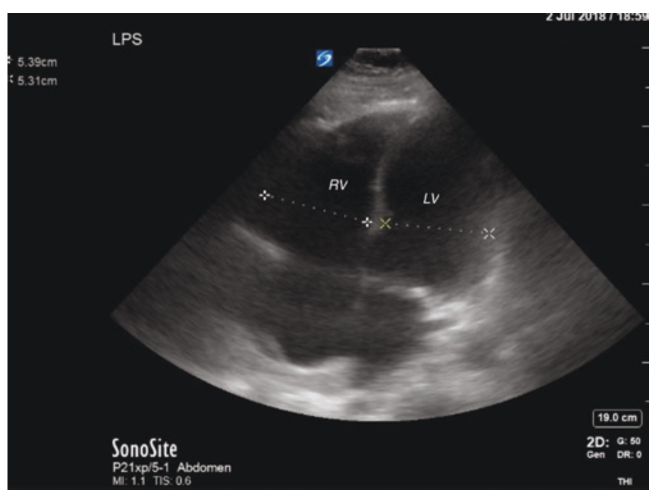

Fig. 37.7 Four-chamber view that shows right ventricular dilatation due to pulmonary embolism. Normally, the left ventricle (LV) is greater than the right ventricle (RV) during diastole, but in the case of increased pressure, the RV will be enlarged

Complications

- No direct complications have been associated with the use of ultrasound for cardiac evaluation.
- Ultrasound has been associated with delays in chest compression resumption during cardiac arrest pulse checks. Despite its benefits for the assessment of pathology, extra caution should be taken when using ultrasound during cardiac arrest.

Pearls and Pitfalls

- Pearls
  - Proper interpretation of the images is necessary because some normal anatomy could be confused with a positive finding. Make sure to properly identify the structures because a common mistake is to identify the aorta thinking it is the IVC. Continuous pulsed-wave Doppler can be used to differentiate between the two. Another hint is that the IVC will be seen emptying into the right side of the heart.
  - Depth: increase to be sure to visualize all structures.
  - Many of these views are best obtained with the patient rotated toward the left lateral decubitus position (specially the apical four chamber).
- Pitfalls
  - Ultrasound is user-dependent, and the acquisition of images will vary with each user, creating the possibility of false negatives if images are not properly acquired.
  - Reversal of the orientation owing to transducer misplacement could "reverse" the anatomy and allow mistakenly identification of structures.
  - Be sure to pay attention to the RV wall. An enlarged right ventricular wall (>5 mm) is considered hypertrophied and would be indicative of a possible more chronic etiology of a right ventricular dilation.
  - Gain problems: Adjust so the heart chambers are anechoic and the walls are echogenic.
  - Patients post cardiac arrest with return of spontaneous circulation (ROSC) may frequently have an abnormally enlarged RV in the absence of a pulmonary embolism making the diagnosis of pulmonary embolism after ROSC more challenging.

Suggested Reading

Dresden S, Mitchell P, Rahimi L, Megan L, Rubin-Smith J, Bibi S, et al. Right ventricular dilatation on bedside echocardiography performed by emergency physicians aids in the diagnosis of pulmonary embolism. Ann Emerg Med. 2014;63(1):16–24.

Kline JA. Thromboembolism. In: Tintinalli J, Stapczynski J, Ma OJ, Cline D, Cydulka R, Meckler G, editors. Tintinalli's emergency medicine. 7th ed. New York: McGraw Hill; 2012.

McConnell MV, Solomon SD, Rayan ME, Come PC, Goldhaber SZ, Lee RT. Regional right ventricular dysfunction detected by echocardiography in acute pulmonary embolism. Am J Cardiol. 1996;78:469–73.

Reardon RF, Joing SA. Cardiac. In: Ma OJ, Mateer J, Blaivas M, editors. Emergency ultrasound. 2nd ed. New York: McGraw Hill Professional; 2007. p. 109–44.

Vanden Hoek TL, Morrison LJ, Shuster M, et al. Part 12: cardiac arrest in special situations: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2010;122(18 Suppl 3):S829–61.

38 Pacemaker Evaluation in the Emergency Department

Joseph Romano, Christian Coletti, and José A. Rubero

Pacemaker Function

There are approximately 500,000 implanted cardiac pacemakers in the United States, and another 100,000 are implanted each year [1]. In the emergency department, a physician may be faced with a pacemaker that is not functioning appropriately. To understand the ways in which a pacemaker can malfunction or lead to medical complications, first it is important to understand how pacemakers work when they do so appropriately.

A common pacemaker system is composed of a pulse generator and insulated wire leads that originate in the pulse generator and end within the myocardium. The pulse generator is implanted in the pectoral region. It contains circuitry, the battery, and creates the electrical impulses that depolarize the myocardium. The leads leave the pulse generator and are directed to the heart by following the venous system. Leads may terminate in the right atrium, the interventricular septum of the right ventricle, or in biventricular pacing, a third lead navigates the coronary sinus to the left ventricular wall (Figs. 38.1 and 38.2).

Early pacemakers produced impulses only at a set rate. Today, however, virtually all pacemakers have sensing leads that detect intrinsic activity and react with electrical impulses when the intrinsic intervals fall outside of a set time threshold. Some pacemakers are programmed to allow for rate changes based on physical activity. To simplify the classification of different pacemaker types, the North American Society of Pacing and Electrophysiology and British Pacing and Electrophysiology Group (NASPE/BPEG) developed a five-letter code to describe each pacemaker (Table 38.1) [2].

Common Pacemaker Codes [3]

- VVI: ventricular paced and sensed, inhibited by normal intrinsic pacing, used for patients with a need for pacing if bradycardia occurs
- VVIR: ventricular paced and sensed, inhibited by normal intrinsic pacing, adaptive to changes in intrinsic rate for physically active patients
- DDD: dual-chamber paced and sensed, inhibited by normal intrinsic atrial and ventricular electrical activity, used in third-degree atrioventricular (AV) block to allow for more physiological conduction
- DDDR: dual-chamber paced and sensed, inhibited by normal intrinsic atrial and ventricular electrical activity, adaptive to changes in intrinsic rate, used primarily in sinoatrial (SA) node dysfunction to closely mimic normal, adaptable heart conduction

Pacemaker Malfunction

Malfunctioning pacemakers can have complicated programming that is best altered after thorough "interrogation" by a trained electrophysiologist. This type of evaluation is beyond the scope of this chapter, and in many clinical settings, subspecialty support is not readily available. In the emergency department, it is vital to stabilize the patient and identify common pacemaker system issues. Pacemaker system malfunctions can be identified as a failure to sense, failure to pace, failure to capture, or pacing at an inappropriate rate [4, 5–7]. Another common abnormality associated with pacing is the "pacemaker syndrome [3]."

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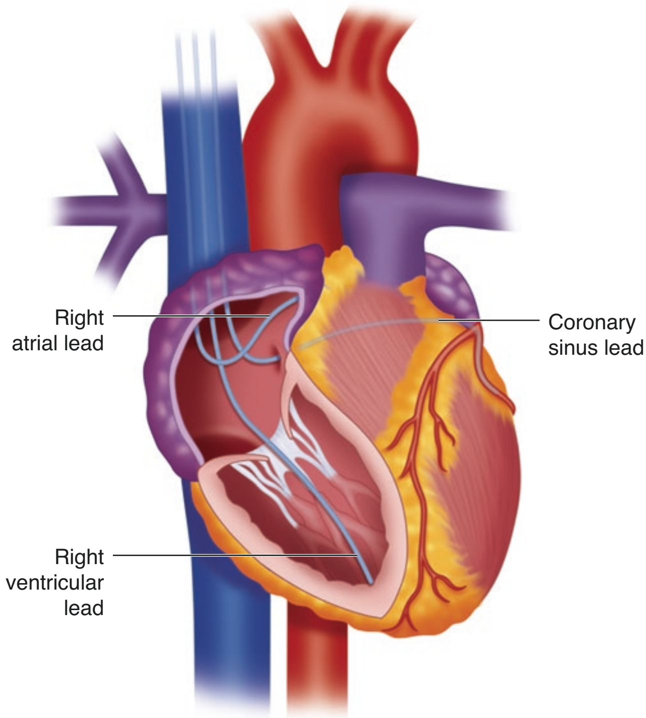

Fig. 38.1 Common pacemaker lead insertion sites

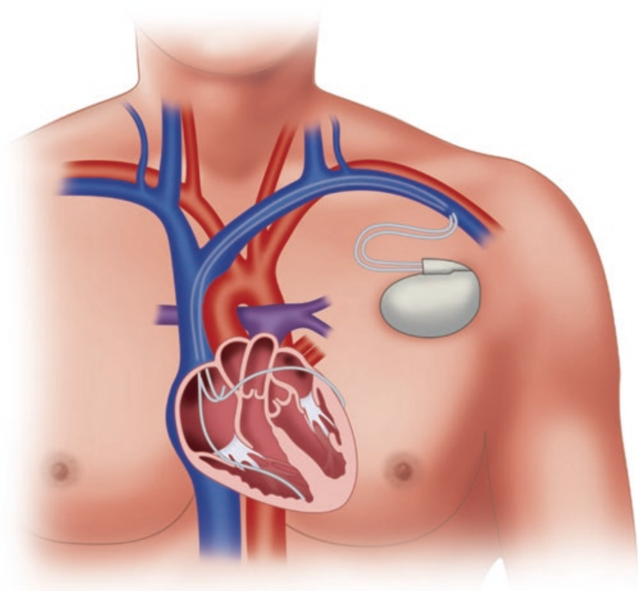

Fig. 38.2 Common generator location and path of pacemaker leads

- Failure to sense
  - Oversensing (Fig. 38.3): The sensor interprets external stimuli as a normal ventricular rate leading to inappropriate inhibition. This may be due to lead fracture, fibrosis of the lead tip, or lead dislodgment. Cross-talk is present when the atrial stimulus is sensed on the ventricular lead causing inappropriate inhibition. Oversensing is rarely due to failure of the generator.
  - Undersensing (Fig. 38.4): Present when there is constant pacing despite cardiac activity that has not exceeded threshold. Results in asynchronous pacing. This can be due to low-amplitude intrinsic cardiac activity, lead dislodgment, battery depletion, new bundle branch block, or metabolic abnormalities. These inappropriate signals may be large P or T waves, skeletal muscle activity, or lead contact problems.
- Failure to pace (Fig. 38.5)
  - Lack of pacing despite appropriate sensing of the intrinsic electrical activity or activity below the threshold rate.
  - Typically caused by lead fracture, battery depletion, or fibrosis of the lead tip.
  - It is rare for any specific part of the device to fail, but suspicion should be high if the patient had recent radiation therapy, electrocautery, defibrillation, electroshock therapy, magnetic resonance imaging (MRI), lithotripsy, or transcutaneous electrical nerve stimulation (TENS) treatments
  - Rarely due to battery depletion.
- Failure to capture (Fig. 38.6)
  - A lack of cardiac response despite appropriate sensing and subsequent pacer stimuli.
  - Commonly due to lead dislodgement but can be due to myocardial perforation, lead fracture, fibrosis of the lead tip, poor lead placement, battery depletion, myocardial infarction, and antiarrhythmic medications.
  - Functional failure to capture occurs when pacer stimuli fall within the refractory period of previous depolarization.
- Pacing at an inappropriate rate (pacemaker-associated dysrhythmias) (Fig. 38.7)
  - Likely due to an endless loop reentry tachycardia known as pacemaker-mediated tachycardia

    More common in DDD pacemakers

    Initiated by a premature ventricular stimulus, which is carried retrograde through the intrinsic conduction system to the atrioventricular node (AVN) and then the atria. This conduction is sensed by the atrial lead and causes triggering of pacing back in

Table 38.1 NASPE/BPEG five-letter pacemaker code

Paced chamber	Sensed chamber	Response to sensing	Rate modulation	Multisite pacing
A = atrial	A = atrial	T = triggered	R = rate modulation	A = atrial
V = ventricle	V = ventricle	I = Inhibited	O = none	V = ventricle
D = dual	D = dual	D = dual		D = dual
O = none	O = none	O = none		O = none

From Bernstein et al. [2]

Fig. 38.3 Ventricle undersensing

Fig. 38.4 Ventricle oversensing

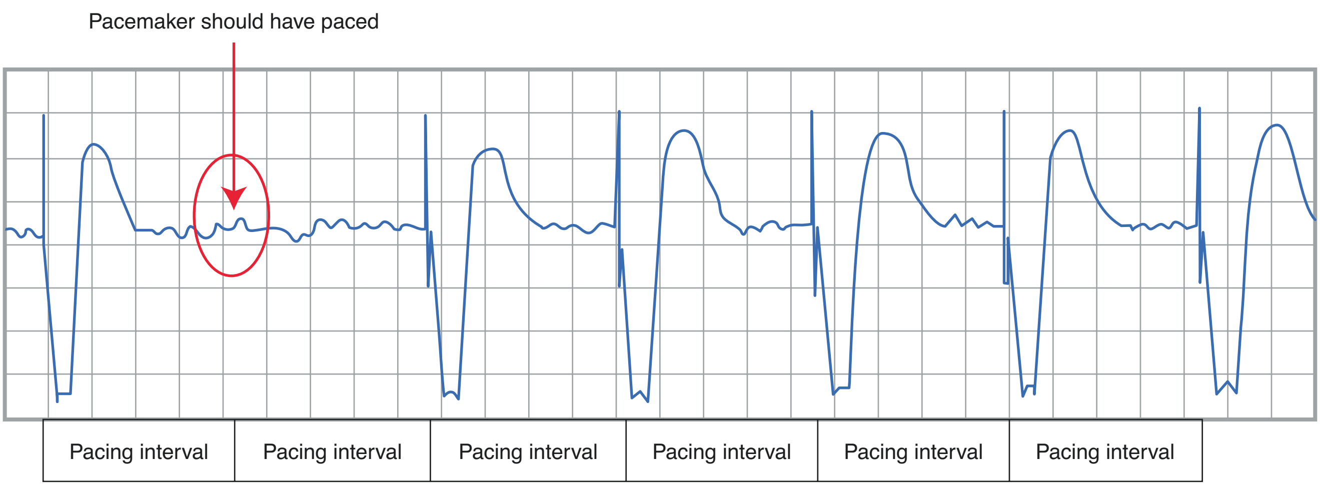

Fig. 38.5 Output failure

Fig. 38.6 Ventricle non-capture

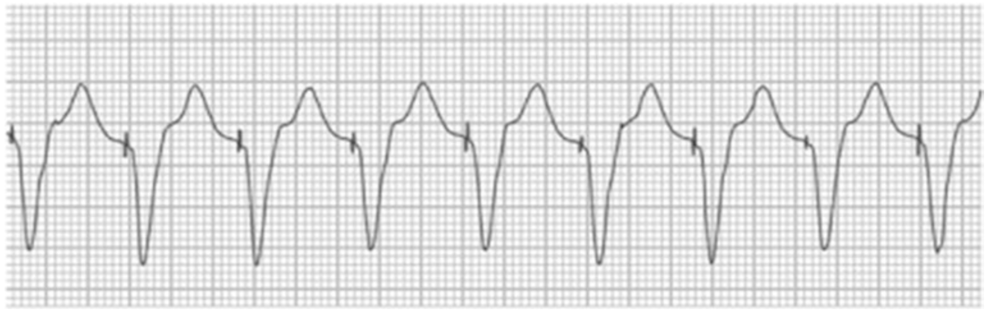

Fig. 38.7 Pacemaker-mediated tachycardia

the ventricle. The ventricular depolarization is then sensed again in the atria, forming a loop. The intrinsic conduction system acts as a retrograde limb, and the pacer circuit acts as the anterograde limb of a reentry tachycardia.

- Sensor-induced tachycardia

  Modern pacemakers are programmed to allow increased heart rates in response to physiological stimuli such as exercise, tachypnea, hypercapnia, or acidosis.

  Sensors may "misfire" in the presence of distracting stimuli such as vibrations, loud noises, fever, limb movement, hyperventilation, or electrocautery (e.g., during surgery). This misfiring leads to pacing at an inappropriately fast rate. The ventricular rate cannot exceed the pacemaker's upper rate limit (usually 160–180 bpm).

  These will also usually terminate with application of a magnet.

- Runaway pacemaker

  This potentially life-threatening malfunction of older-generation pacemakers is related to low battery voltage (e.g., overdue pacemaker replacement).

  The pacemaker delivers paroxysms of pacing spikes at 2000 bpm, which may provoke ventricular fibrillation.

  Paradoxically, there may be failure to capture—causing bradycardia—because the pacing spikes are very low in amplitude (due to the depleted battery voltage) and because at very high rates the ventricle may become refractory to stimulation.

  Application of a magnet can be lifesaving, but definitive treatment requires replacement of the pacemaker.

- Lead displacement dysrhythmia

  A dislodged pacing lead may float around inside the right ventricle, intermittently "tickling" the myocardium and causing ventricular ectopics or runs of VT alternating with failure of capture.

  If the paced QRS morphology changes from an LBBB pattern (indicating RV placement) to an RBBB pattern (indicating LV placement), this suggests that the electrode has eroded through the interventricular septum.

  A chest X-ray will usually help to confirm the diagnosis.

- The "pacemaker syndrome"
  - Constellation of symptoms found in 20% of patients with pacemakers.
  - Symptoms include syncope, near syncope, dizziness, fatigue, weakness, pain, shortness of breath, and cough.
  - Ventricular rates are poorly timed with atrial activity such that atrial contraction occurs against closed mitral and tricuspid valves.
  - Ventricles lose the benefit of the atrial kick, the atria enlarge, and signs and symptoms similar to congestive heart failure ensue.
- Twiddler's syndrome
  - Patient manipulation of the pulse generator (accidentally or deliberately).
  - The pacemaker rotates on its long axis, resulting in dislodgement of pacing leads.
  - Can result in diaphragmatic or brachial plexus pacing (e.g., arm twitching) depending on the extent of lead migration.

Initial Evaluation of the Patient with a Pacemaker [4, 5–7]

- History
  - Symptoms of syncope, near syncope, chest pain, palpitations, irritation at the generator pocket
  - Brand and NASPE/BPEG code
  - Date of implantation
  - Location of generator pocket and any previous locations
  - Most recent electrophysiological interrogation
  - Medications that interfere with function, such as flecainide or lidocaine
  - Recent procedures, such as MRI, lithotripsy, or defibrillation

- Physical examination
  - Check vital signs, listen for heart sounds (paradoxically split S2 is normal).
  - Inspect generator pocket; turning of the leads is associated with Twiddler's syndrome.
  - Look for jugular venous distension.
- Laboratory studies, chest X-ray, and electrocardiogram (ECG)
  - Obtain a chest X-ray to determine effusions, infiltrates, generator placement, and lead placement or fracture (Fig. 38.8).
  - Electrolyte imbalances must be detected and corrected.
  - ECG: The following are examples of appropriate ECG patterns in patients based on type of pacing [3]:

    VOO (asynchronous pacing): Regular pacer spikes lead to immediate QRS waveforms. Left bundle branch block (LBBB) is a normal finding in a right ventricular lead location.

    VVI: Pacer spikes and an LBBB waveform should be seen if the intrinsic rate is below the threshold rate.

    DDD: Various patterns are possible. If the intrinsic rhythm and intervals are normal, then no pacer spikes will be seen. If the atrial rate is slow and AV delay is normal, then an atrial spike will cause a P-wave and a normal QRS. If AV delay is prolonged, then two spikes may be observed: a P wave and a QRS with an LBBB waveform.
- If malfunction is suspected
  - Obtain intravenous (IV) access, place the patient on a heart monitor, and if possible, consult cardiology for interrogation and reprogramming.

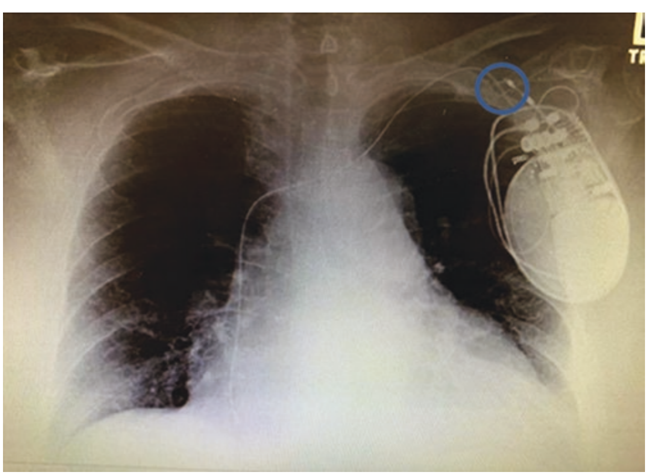

Fig. 38.8 Fracture lead (blue circle)

  - Obtain a ring magnet.

    Positioning over the generator causes the pacing stimuli to revert to an asynchronous ventricular pacing mode at a set rate [8].

Interpreting the Type of Malfunction Based on ECG

The first step in evaluating the ECG of a malfunctioning pacemaker is to determine the presence of pacing spikes [6, 9]:

- If pacing spikes are noted on the ECG, determine whether capture is present by ensuring that an appropriate waveform follows each pacer spike and that there is an associated pulse.
  - If capture is present, check the rate.

    If the rate is appropriate, the pacer is functioning normally.
    - If the rate is slow, suspect oversensing
    - If the rate is rapid, suspect undersensing or pacemaker-mediated tachycardia.
  - If capture is not present, consider metabolic effects or component failure.
- If pacing spikes are not noted on the ECG, determine whether the patient is in an intrinsic rhythm.
  - If the patient is in an intrinsic rhythm and the rate is appropriate, application of a ring magnet will cause pacer spikes to show up at a set rate. This is normal functioning.

    If application of the magnet does not cause pacing, suspect mechanical failure.
  - If the patient is not in an intrinsic rhythm, place a magnet over the generator.

    If magnet application causes pacing, consider oversensing.

    If it does not, consider mechanical failure.
- If a patient is hemodynamically unstable and application of a magnet leads to stability, keep the magnet in place until the patient is able to have the pacemaker interrogated.

Management of Pacemaker-Mediated Tachycardia

- After ensuring adequate IV access, placing a heart monitor, and interpreting a baseline ECG, put a ring magnet over the generator [8].
  - If a normal rhythm results, keep the magnet on the chest.
  - If it does not change the rate, attempt isometric pectoral exercises by having the patient press the left hand against the right shoulder.

This is an attempt to overstimulate the pacemaker sensor and precipitate inhibition of pacer output.

If this is unsuccessful, consider transcutaneous pacing.

If transcutaneous pacing is unsuccessful, then the leads may require surgical adjustment or removal.

References

1. Ford-Martin PA, Spiwak AJ. Pacemakers. In: Gale encyclopedia of surgery: a guide for patients and caregivers; 2004. Encyclopedia.com: http://www.encyclopedia.com/doc/1G2-3406200337.html Accessed 01 April 2011.
2. Bernstein A, Daubert J, Fletcher R, Hayes D, Lüderitz B, Reynolds D, et al. The revised NASPE/BPEG generic code for antibradycardia, adaptive-rate, and multisite pacing. North American Society of Pacing and Electrophysiology/British Pacing and Electrophysiology Group. Pacing Clin Electrophysiol. 2002;25:260–4.
3. Marx JA, Hockberger RS, Walls RM, Adams J, editors. Rosen's emergency medicine. 7th ed. Philadelphia: Mosby; 2009.
4. Bonow RO, Mann DL, Zipes DP, Libby P, editors. Braunwald's heart disease: a textbook of cardiovascular medicine. 9th ed. Philadelphia: Saunders; 2011.
5. Lloyd MS, El Chami MF, Langberg JJ. Pacing features that mimic malfunction: a review of current programmable and automated device functions that cause confusion in the clinical setting. J Cardiovasc Electrophysiol. 2009;20(4):453–60.
6. Chan T, Brady W, Harrigan R. Diagnosis: pacemaker failure to capture. Emerg Med News. 2007;29(1):11. Available from: http://journals.lww.com/em-news/Fulltext/2007/01000/Diagnosis__Pacemaker_Failure_to_Capture.9.aspx
7. Safavi-Naeini P, Saeed M. Pacemaker troubleshooting: common clinical scenarios. Tex Heart Inst J. 2016;43(5):415–8.
8. Roberts JR, Hedges JR, editors. Clinical procedures in emergency medicine. 7th ed. Philadelphia: Saunders; 2019.
9. Kaszala K, Huizer JF, Ellenbogen KA. Contemporary pacemakers: what the primary care physician needs to know [review]. Mayo Clin Proc. 2008;83:1170–86.

Part V

Spine Evaluation

39 Cervical Collar Placement

Justin Bennett and Lars K. Beattie

There are two main subcategories of C-collars: the one-piece and the two-piece. One-piece C-collars include the Stifneck and the Ambu Perfit. Two-piece C-collars have posterior and anterior pieces, with the anterior piece usually the larger of the two. Examples of two-piece collars include the Aspen collar, the Philadelphia collar, and the Miami J collar. The basic features of a C-collar include:

- Adjustable circumference with fasteners (usually Velcro straps).
- Adjustable height with a locking device of different sizes.
- Hooks for a nasal cannula.
- Exposure of the anterior neck for pulse checks and advanced airway procedures.
- Posterior access for cervical palpation.
- Padding to protect the soft tissues of the neck.

Indications

- Prehospital suspicion for spine trauma:
  - Emergency department patients or trauma patients who fail clinical rule-out criteria such as NEXUS (National Emergency X-Radiography Utilization Study) and Canadian C-spine rules (see Chap. 40).

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Contraindications

- Absolute.
  - Cervical dislocation with fixed angulation.
  - Impaled foreign object in the neck.
  - Massive soft tissue swelling in the neck.
- Relative.
  - Unsecured airway.
  - Surgical airway.
  - Vomiting.
  - Mandible or soft tissue injuries with potential for airway compromise.
  - Preexisting anatomical abnormalities.

Materials and Medications

- Properly fitting C-collar.
- Consider:
  - Head blocks, if needed for lateral stabilization.
  - Towels or backboard pads for custom support.
    Under shoulders – pediatric patients.
    Under occiput – adults with poor C-spine mobility.

Procedure (Aspen Collar)

1. Address airway, breathing, and circulation while maintaining in-line immobilization, before placing a C-collar.
2. Gather personnel:
   (a) One person is needed to apply the collar to an awake patient.
   (b) Two or more people may be required when a patient has an altered level of consciousness:
      (i) One to maintain in-line immobilization in the neutral position.
      (ii) One to place the C-collar.
3. While the C-spine is being held in neutral position, assess the airway before placing the C-collar:

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   (a) Anticipate and prepare for airway compromise early to avoid a crash intubation.
   (b) Place airway if necessary.
4. Palpate and inspect the C-spine, head, and shoulders for evidence of trauma *before* placing the C-collar.
5. While maintaining the neutral position of the C-spine, place the C-collar:
   (a) Remove loose clothing, jewelry, and earrings that may cause soft tissue pressure wounds.
   (b) Begin with the piece of C-collar that fits under the occiput (Fig. 39.1).
   (c) Fold the Velcro straps behind the C-collar.
   (d) Gently hold back the hair (Fig. 39.2).
   (e) Slide the occipital section or piece of the C-collar behind the occiput (Fig. 39.3). (Use in-line C-spine stabilization in patients with an altered level of consciousness.)
   (f) Wrap (one-piece) or place (two-piece) the anterior section of the C-collar around the circumference of the patient's neck and snugly under the chin (Fig. 39.4).
   (g) Once the Velcro fasteners are in place, ensure that the height is properly adjusted on the C-collar to minimize C-spine mobility.
      (i) Most C-collars have height adjustments that utilize a locking device that requires releasing a locking mechanism by pulling out.
      (ii) The Aspen collar is adjusted with a combination of pulling out while twisting a round knob at the sternal notch (Fig. 39.5).
      (iii) Pull out (away from patient) and twist for height adjustment of the Aspen two-piece collar.
      (iv) Adjust the height of the Ambu Perfit one-piece collar by simultaneously pulling (away from the patient) the two locking pins out and adjusting the height of the collar before pushing the pins back in (toward the patient) to lock the collar at the desired height (Fig. 39.6).

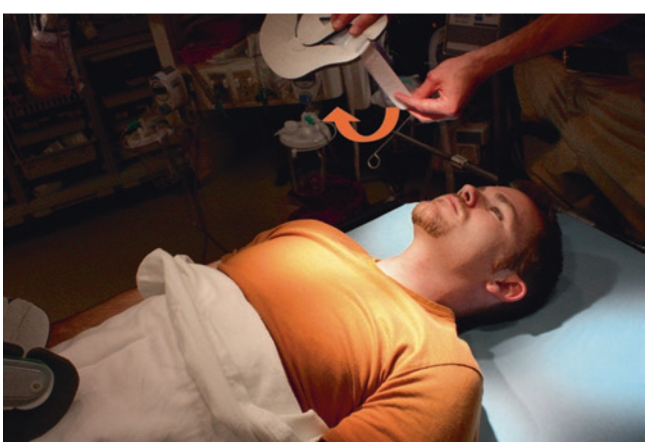

Fig. 39.1 Fold Velcro strap of C-collar posteriorly

Fig. 39.2 Slide occipital section of collar behind occiput flat against stretcher

6. Special cases:
   (a) Depending on the age of the patient, it may be necessary to place towels under the shoulder blades to keep the neck in a neutral position.
   (b) Children:
      (i) Head-to-body ratios are relatively larger than that of adults.
      (ii) Placement on a backboard may cause significant neck flexion because the occiput rests on a flat board.
      (iii) Towels can be placed under a child's shoulders to minimize flexion.
   (a) Adults with excess soft tissue or degenerative changes that prevent C-spine straightening:
   (b) A towel or pad is placed behind the occiput to prevent hyperextension.

Pearls and Pitfalls

- Pearls
  - Airway, breathing, and circulation should be assessed before placement of the C-collar.
  - A high index of suspicion of C-spine injury is needed in intoxicated or comatose patients and the elderly.
  - Always remember to adjust the height and circumference of a C-collar for a snug fit.
- Pitfalls
  - Spinal immobilization increases the risk of aspiration in vomiting patients.
  - Failure to palpate and inspect the C-spine, head, and shoulders before C-collar placement may delay recognition of an impending airway emergency and conceal signs of critical injury needing rapid assessment and care.
  - Lateral C-spine motion is unsecured unless tape, rubber blocks, or towels are used for support.

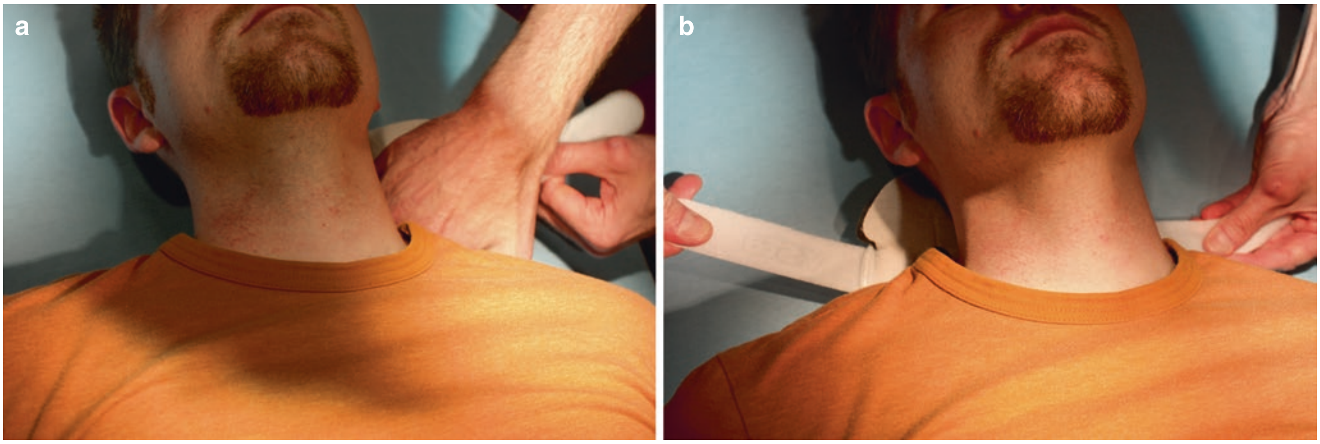

Fig. 39.3 (**a**) Use of hand to guide C-collar behind occiput; (**b**) unfold Velcro strap and position collar behind cervical spine

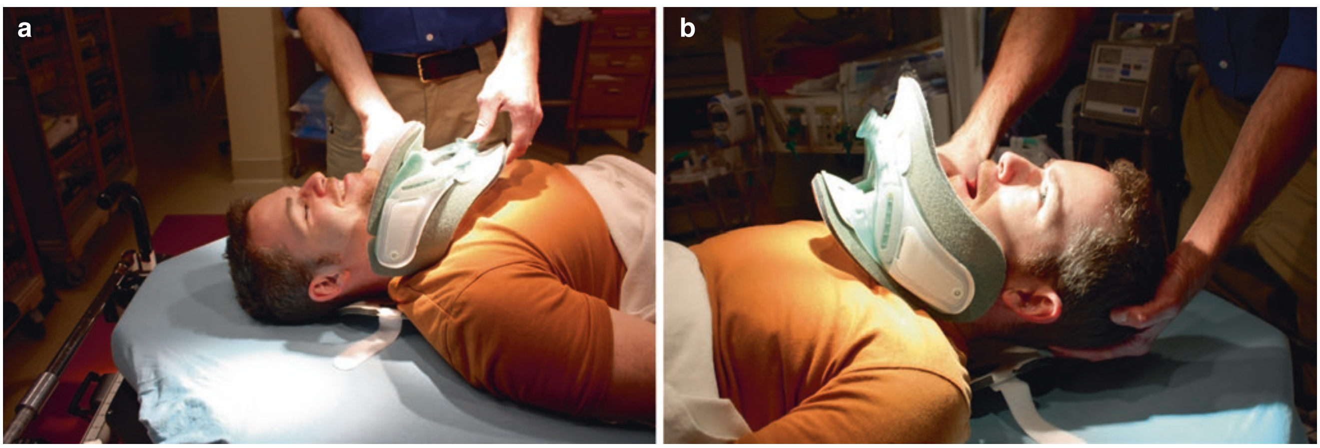

Fig. 39.4 (**a**) Correct orientation of anterior portion of C-collar; (**b**) incorrect orientation of anterior portion of C-collar may cause injury

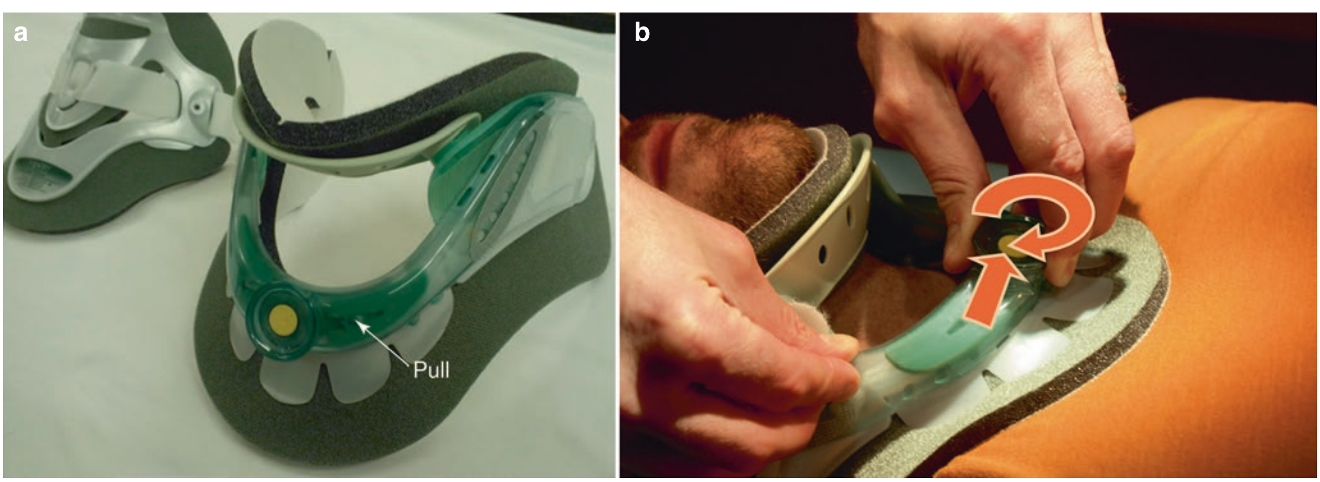

Fig. 39.5 Aspen collar is adjusted with a combination of (**a**) pulling out while (**b**) twisting a round knob at the sternal notch

- Overlooking C-spine stabilization during C-collar placement leaves the C-spine at risk of further injury in patients with an altered level of consciousness.
- C-collars that are too tight may decrease venous return from the head and may increase intracranial pressure.

Fig. 39.6 Adjustment the height of the Ambu Perfit one-piece collar by simultaneously pulling (away from the patient) the two locking pins out and adjusting the height of the collar before pushing the pins back in (toward the patient) to lock the collar at the desired height

Suggested Reading

American College of Surgeons Committee on Trauma. Advanced trauma life support for doctors. 8th ed. Chicago: American College of Surgeons; 2004.

Hankins DG, Boggust A. Prehospital equipment and adjuncts. In: Tintinalli JE, Stapczynski JS, Cline DM, Ma OJ, Cydulka RK, Meckler GD, editors. Tintinalli's emergency medicine: a comprehensive study guide. 7th ed. New York: McGraw Hill; 2012.

Hoffman JR, Wolfson AB, Todd K, Mower WR. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-Radiography Utilization Study (NEXUS). Ann Emerg Med. 1998;32:461–9.

Roberts JR, Hedges JR. Clinical procedures in emergency medicine. 5th ed. Philadelphia: Saunders Elsevier; 2009.

Stiell IG, Clement CM, McKnight RD, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. N Engl J Med. 2003;349:2510–8.

40 Cervical Spine Clearance

Braden Hexom and Tatiana Havryliuk

Indications

- Assessment of the need for radiological imaging in trauma.

Contraindications

– Known unstable cervical spine (C-spine) fracture.
– Known unstable ligamentous injury.
– Intoxication/altered mental status.
– Presence of distracting injury.

National Emergency X-Radiography Utilization Study (NEXUS) and Canadian C-Spine Rules (CCR) to Assess the Need for Imaging

- *The NEXUS clinical criteria*:
  1. Tenderness at the posterior midline of the C-spine.
  2. Focal neurological deficit.
  3. Decreased level of alertness.
  4. Evidence of intoxication.
  5. Clinically apparent pain that might distract the patient from the pain of a C-spine injury.
- The presence of any one of the above findings is considered to be clinical evidence that a patient is at increased risk for C-spine injury and requires radiographic evaluation.
- *CCR*:

For alert (Glasgow Coma Scale [GCS] 15) and stable trauma patients:

1. Any high-risk factor that mandates radiography? *YES → Radiography.*
   - Age older than 65 years.
   - Dangerous mechanism (Table 40.1).
   - Paresthesias in extremities.

   ↓ *NO*
2. Any low-risk factor that allows safe assessment of range of motion? *NO → Radiography*:
   - Simple rear-end motor vehicle crash (MVC).
   - Sitting position in emergency department.
   - Ambulatory at any time.
   - Delayed onset of neck pain.
   - Absence of midline C-spine tenderness.

   ↓*YES*
3. Able to actively rotate neck? *NO → Radiography*:
   - 45° left and right.

     ↓*ABLE*

     No radiography
   - CCR found to have higher sensitivity (99.4% vs. 90.7%) and specificity (45.1% vs. 36.8%) and a lower rate of imaging (55.9% vs. 66.6%) than NEXUS criteria for C-spine clearance of low-risk alert trauma patients.

Table 40.1 Dangerous mechanism

Fall from elevation ≥3 ft/5 stairs
Axial load to head (e.g., diving)
Motor vehicle crash at high speed (>100 km/h), rollover, ejection
Motorized recreational vehicles
Bicycle crash

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Type of Imaging

- Bones
  – C-spine computed tomography (CT)—the new gold standard.
  – Plain X-rays—less sensitive than CT; in one study X-rays missed 45% of injuries that were picked up by CT [1].
- Ligaments
  – C-spine magnetic resonance imaging (MRI)—consider for possible ligamentous injuries and for further evaluation of obtunded patients.
  – Flexion-extension X-rays—less sensitive than MRI for detection of ligamentous injuries in the acute phase. Delayed flexion-extension films are more sensitive for ligamentous injury than those done the day of injury, but less sensitive than MRI.

Materials

- Cervical collar (C-collar) (Fig. 40.1).

Procedure (Fig. 40.2)

1. Apply C-collar to stabilize spine. Select appropriate size.
2. Perform a brief neurological examination and assess the patient's mental status; proceed only if both are normal.
3. Loosen the collar to palpate the midline while the patient holds his or her head still. If spinal tenderness exists, replace the C-collar, and proceed to imaging (Fig. 40.3).
4. Instruct the patient to rotate the neck 45° to each side and flex the neck. If the patient is pain-free and with no neurological comprise, the C-collar may be removed, and no imaging of the C-spine is required (Fig. 40.4).

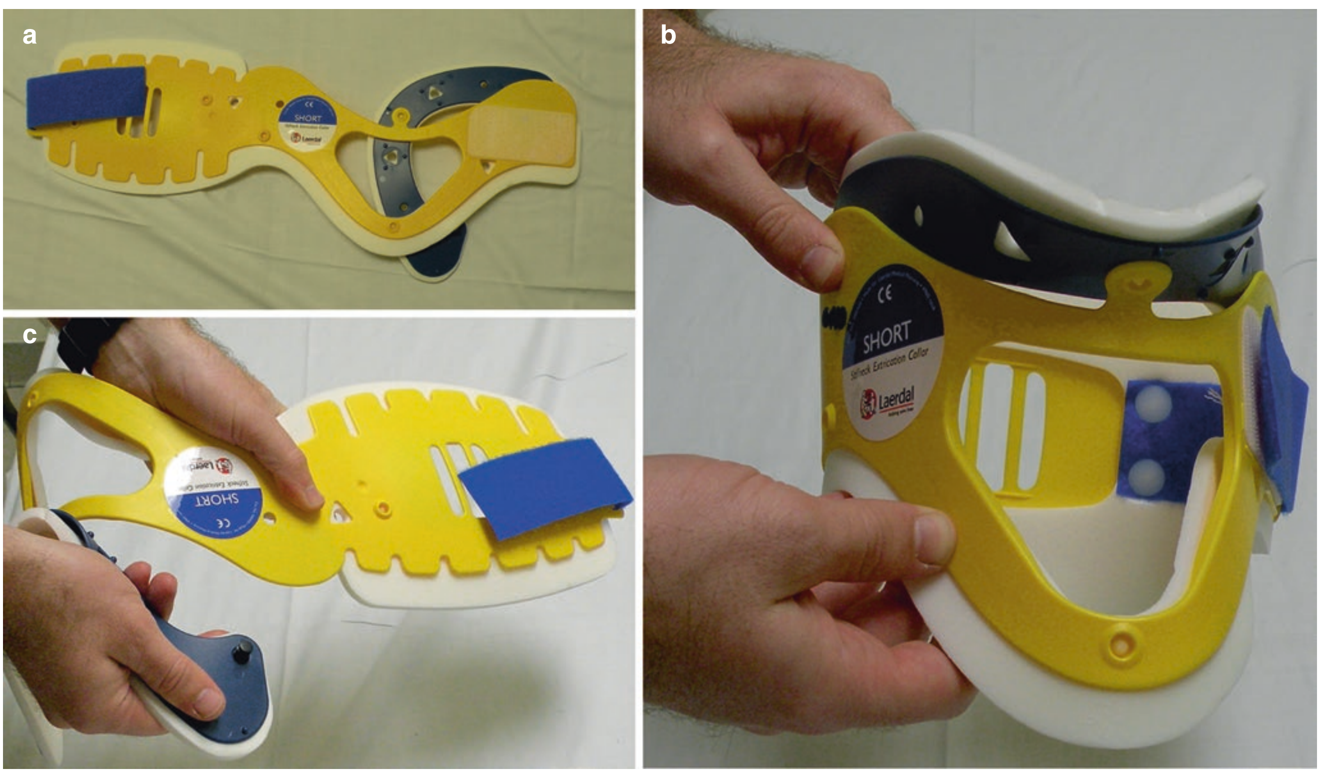

Fig. 40.1 Assembly of C-collar: select appropriate size (**a**). Invert chinstrap and snap into place (**b**). Assembled C-collar (**c**)

Fig. 40.2 Proper placement of C-collar: slide C-collar under the neck while keeping the neck immobilized (**a**). Secure the collar (**b**). Correct C-collar placement (**c**)

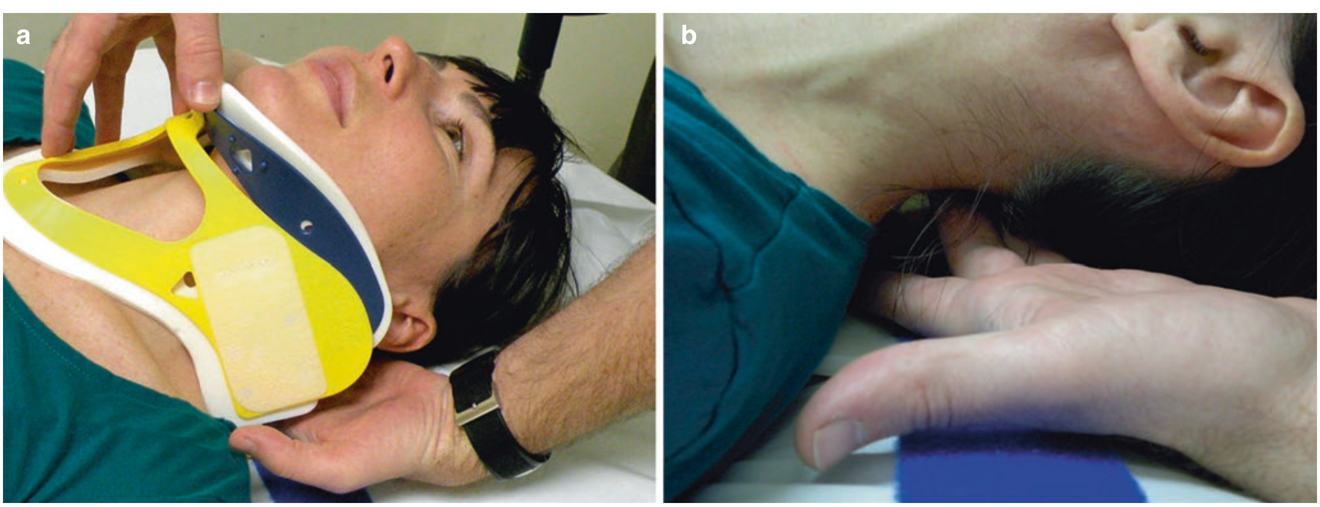

Fig. 40.3 Assessment of C-spine tenderness: loosen C-collar while keeping the neck immobilized (**a**). Palpate midline of C-spine (**b**)

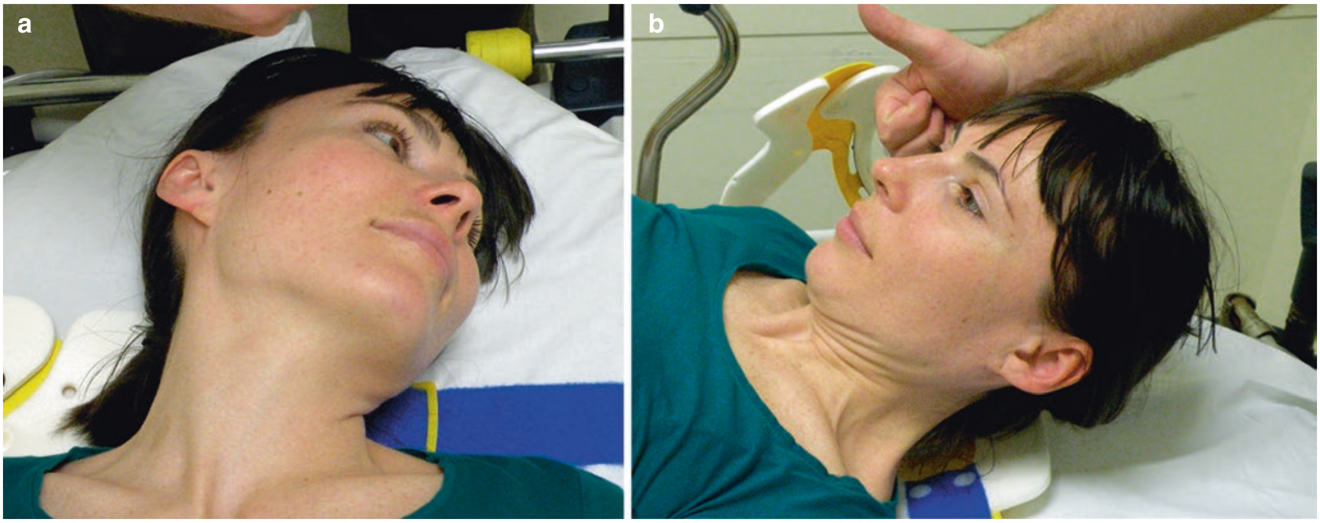

Fig. 40.4 C-spine clearance: instruct patient to rotate the neck 45° each way (**a**). Instruct patient to flex the neck (**b**)

Complications

- Missing clinically important C-spine injury.
- Pressure ulcer from prolonged use of C-collar.

Pearls and Pitfalls

- Pearls
  – Select appropriate size of C-collar.
  – Ensure adequate mental status because further imaging might be required in obtunded/intoxicated patients.
- Pitfalls
  – Avoid prolonged use of C-collar because this can lead to a pressure ulcer.

References

1. Schenarts PJ, Diaz J, Kaiser C, Carrillo Y, Eddy V, Morris JA Jr. Prospective comparison of admission computed tomographic scan and plain films of the upper cervical spine in trauma patients with altered mental status. J Trauma. 2001;51:663–8. discussion 668–9.

Suggested Reading

Hoffman JR, Schriger DL, Mower W, Luo JS, Zucker M. Low-risk criteria for cervical-spine radiography in blunt trauma: a prospective study. Ann Emerg Med. 1992;21:1454–60.

Platzer P, Jaindl M, Thalhammer G, et al. Clearing the cervical spine in critically injured patients: a comprehensive C-spine protocol to avoid unnecessary delays in diagnosis. Eur Spine J. 2006;15:1801–10.

Stiell IG, Clement CM, McKnight RG, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. N Engl J Med. 2003;349:2510–8.

Stiell IG, Wells GA, Vandemheen K, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. JAMA. 2001;286:1841–8.

Log Roll

41

Justin Bennett and Lars K. Beattie

Indications

- Any patient arriving on a rigid backboard in the emergency department.
- Assessment of posterior traumatic injuries.
- Performed as early as possible after arrival to prevent skin breakdown from pressure ulcers.

Contraindications

- Improperly fitted cervical collar (C-collar) or unsecured cervical spine (C-spine) before log roll.
- Unsecured endotracheal tube before log-rolling intubated patients.

Materials and Medications

- Personnel: three or four people.
  – One to stabilize the C-spine.
  – One or two to roll the patient.
  – One to palpate the length of the spine.
- Properly fitting hard C-collar.
- Trauma shears for removing transport straps.

Procedure

1. Ensure that the airway, breathing, and circulation (ABCs) are established before attempting to remove the patient from the backboard.
2. Gather personnel, at least three, but preferably four people. Larger patients will often require additional assistance.
3. For intubated patients, an additional person will be needed to secure the endotracheal tube during the log roll.
4. Ensure the height is properly adjusted on the C-collar to minimize C-spine mobility (Fig. 41.1).
5. Position the stretcher at an ergonomic lifting position for the person responsible for stabilizing the C-spine.
6. Clothing and transport straps should be removed before the log roll to improve visualization of injuries.
7. The patient is asked to cross his or her hands over the chest.
8. C-spine stabilization (at head of bed):
   - Grasp the patient's trapezoids at the midclavicular line.
   - Secure the sides of the patient's head between the operator's forearms.
   - Stabilize the patient's head in neutral anatomical position relative to the body using the operator's forearms (Fig. 41.2).
9. Thoracic and lumbar spine stabilization:
   - One or two (preferably two) people should stand next to the patient on the side to which the patient will be rolled.
     – One person: Place hands over the patient's shoulder and hip.
     – Two people:
       First person places hands on the patient's shoulder and hip.
       Second person places hands on the patient's hip and knees.

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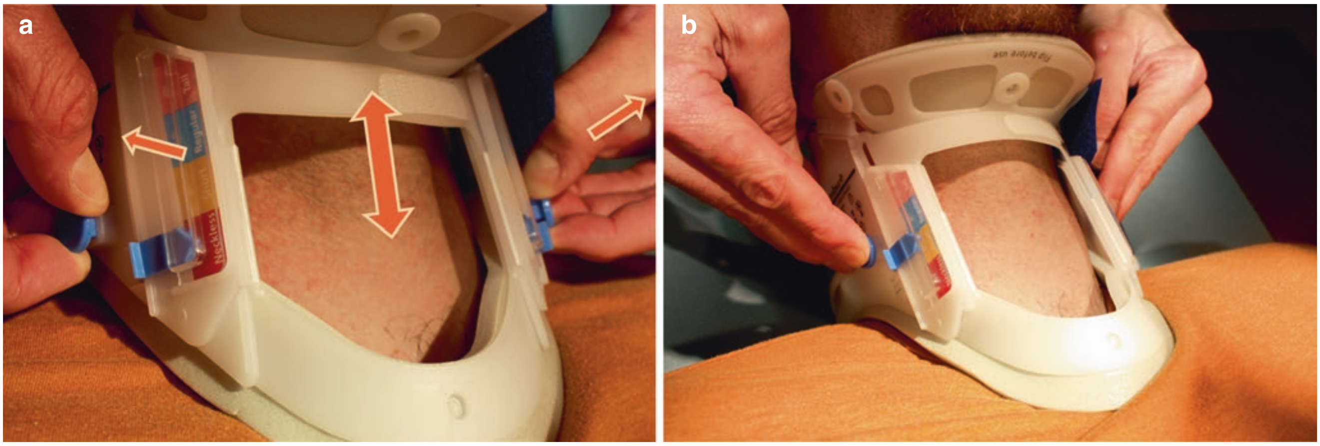

Fig. 41.1 (**a**) The height of the Ambu Perfit one-piece collar is adjusted by simultaneously pulling the two locking pins out (away from the patient) and adjusting the height of the collar, (**b**) then pushing the pins back in (toward the patient) to lock the collar at the desired height

Fig. 41.2 (**a**) Incorrect: single-point stabilization does not keep head and C-spine in line with torso (**b**, **c**). Correct: the two-point stabilization technique keeps the head and C-spine in line with the torso during the log roll

- The decision to roll to the left or right side is determined by injury sites, to minimize injury exacerbation and pain, and to minimize risk of endotracheal tube dislodgment.

10. The person at the head of the bed signals the initiation of a synchronized log roll when everyone is in position.
11. Attention should be directed at maintaining a neutral axis along the anatomical line of symmetry during the roll (Fig. 41.3).
12. While the patient is on her or his side, the rigid backboard should be removed and secured to prevent injury of caretakers.

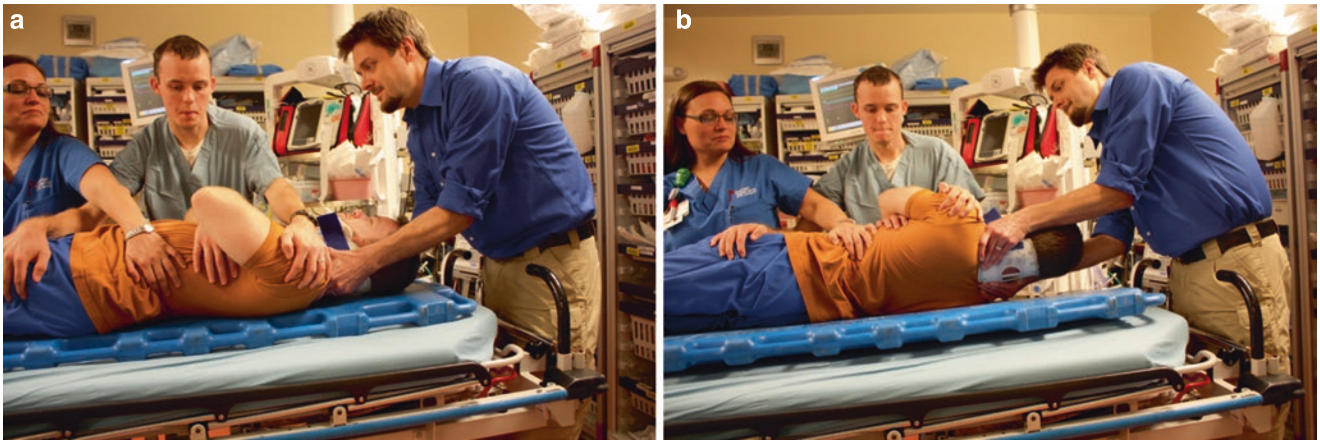

Fig. 41.3 (**a**) The interlocking hands of operators performing lateral log roll help maintain spine immobilization and minimize twisting. (**b**) Two-point cervical spine stabilization is maintained in neutral axis relative to the anatomical line of symmetry during the roll. Appropriate bed height adjustment will increase the ease of the procedure

Fig. 41.4 (**a**–**c**) After backboard has been removed, the entire length of the spine can be appropriately palpated and assessed for injury to the thoracic and lumbar spine

13. The patient's entire posterior should be exposed and examined, taking care to note lacerations and obvious deformities.
14. The entire length of the spine is examined by inspection and then by palpation to be assessed for tenderness, step-offs, and deformities (Fig. 41.4).

15. Before returning the patient back onto the stretcher, ensure that any debris, glass, lumps of clothing, or blankets are removed.

Pearls and Pitfalls

- Pearls
  - The log roll should be performed in unison to avoid segmental rotation.
  - The ABCs should be established before initiating the log roll, which is part of the secondary survey in the trauma evaluation.
  - A proper log roll begins with stabilization of the C-spine because it is the most freely mobile part of the spine and, therefore, most frequently injured.
  - Take the patient off the backboard as soon as possible to prevent formation of pressure sores.
- Pitfalls
  - Failure to establish a two-point stabilization between the patient's body and the head leaves the C-spine at risk of further injury during the log roll.
  - Patients should not be left on the backboard for spinal precautions.
  - Failure to ensure that the ABCs are established before attempting a log roll.

Suggested Reading

American College of Surgeons Committee on Trauma. Advanced trauma life support for doctors. 8th ed. Chicago: American College of Surgeons; 2008. ISBN 1880696312.

Roberts JR, Hedges JR. Clinical procedures in emergency medicine. 5th ed. Philadelphia: Saunders Elsevier; 2009.

Part VI

Neurologic and Neurosurgical Procedures

42 Burr Hole Craniotomy

Latha Ganti

Indications

- Extradural hematoma (EDH) or subdural hematoma (SDH) with Glasgow Coma Scale (GCS) <8 and unavailability of timely neurosurgical intervention in the face of increased intracranial pressure.
- Signs of increased intracranial pressure [1].
  - Deteriorating level of consciousness.
  - Slowing of the pulse.
  - Dilating pupils.
  - Focal seizures.
  - Hemiparesis.
  - Extensor posturing of the limbs.

Contraindications

- Absolute
  - GCS >8.
  - Immediate availability of neurosurgeon.
- Relative
  - Lack of imaging (in this case, decision is guided by neurologic findings and signs of increased intracranial pressure or impending herniation).

Materials and Medications

- Razor to shave area.
- 2% lidocaine with epinephrine to numb scalp
- 10% povidone-iodine or chlorhexidine prep
- Light, suction, cautery, dressing tray.
- Gelfoam.
- Penrose drain.
- 3–0 silk
- #10 scalpel blade and #3 handle
- Small self-retractors or rakes.
- Drill and drill bits: can be manual (Fig. 42.1) or automatic stopping variety (Fig. 42.2).
- Bone wax or electric cautery apparatus.
- Suction apparatus.
- Saline irrigation (IV tubing connected to a saline bag with clamp set so flow is low or a saline syringe flush).

Procedure

Preparation

1. Patient should be supine, intubated, with appropriate C-spine precautions:
   - Hypertonic saline and/or mannitol can be considered for medical management of increased ICP if/as directed by neurosurgery.

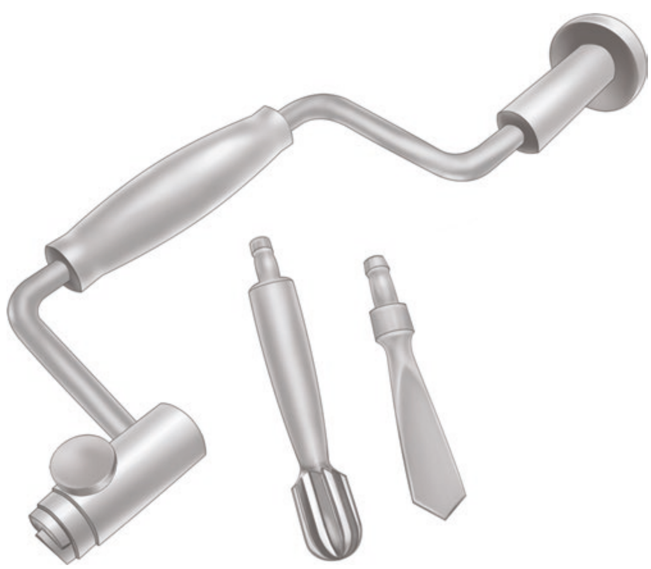

Fig. 42.1 Hudson brace, burr, and perforator

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2. Determine location and depth for burr hole placement (Figs. 42.3 and 42.4):
   - Have CT images immediately available for viewing.
   - Most common location for EDH or SDH is temporal:
     – Temporal burr hole placement: two fingerbreadths above the ear, two fingerbreadths forward (Fig. 42.5).
     – Parietal burr hole placement: two fingerbreadths above the ear, three fingerbreadths backward (behind the ear).
     – Frontal burr hole placement: three fingerbreadths from midline, three fingerbreadths above hairline.
   - Estimate depth of hematoma by counting the number of slices the hematoma is as seen on CT scan and multiplying by the slice thickness [2].
3. Shave hair around area of hematoma.
4. Prep skin with Betadine and chlorhexidine.
5. Anesthetize scalp skin with lidocaine and epinephrine.

Accessing Hematoma

6. Make a vertical incision approximately 4 cm long down to bone.
7. Use periosteal elevator or end of scalpel blade to scrape muscle and periosteum away from bone.
8. Place self-retaining retractors (or rakes) to keep field open (Fig. 42.6).
9. Using a drill with a clutch mechanism [2], drill through outer table (resistance), diploic space (no resistance), and then inner table.
   - Burr hole needs to be placed over the *center* of the hematoma (Fig. 42.7).
10. Control bone bleeding with bone wax; control bleeding from veins and/or muscle with Gelfoam sponge or cautery (diathermy).
    - Wound edges may also be cauterized or tamponaded with manual pressure +/− epinephrine gauze.

Fig. 42.2 Automatic stopping craniotomy drill set

Fig. 42.3 Positionsof burr hole placement

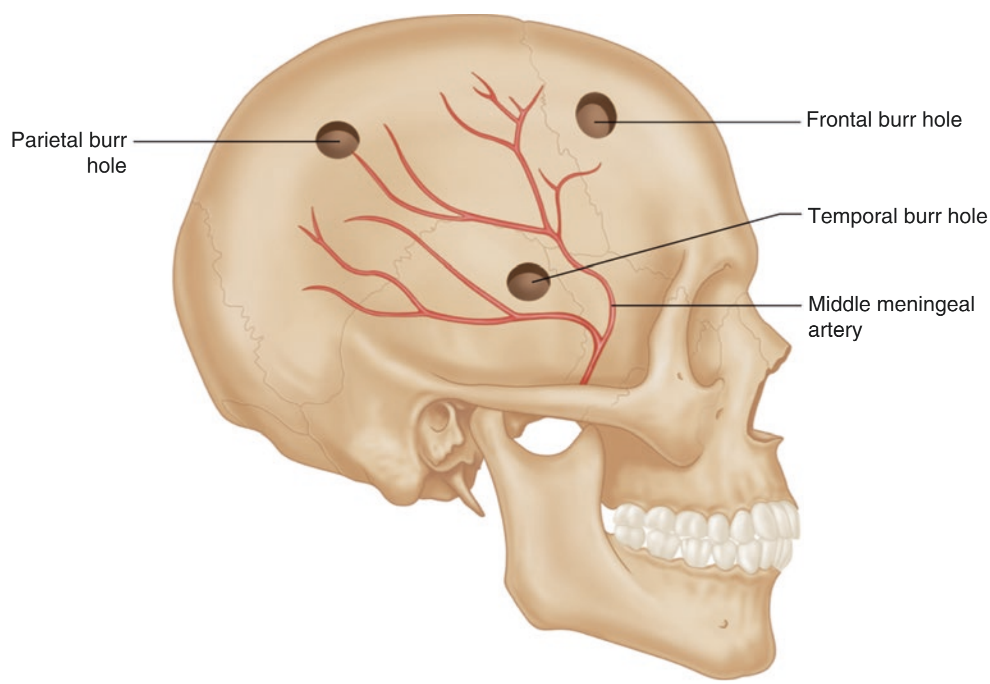

Fig. 42.4 (**a**, **b**) Anatomy for temporal burr hole placement (most common location)

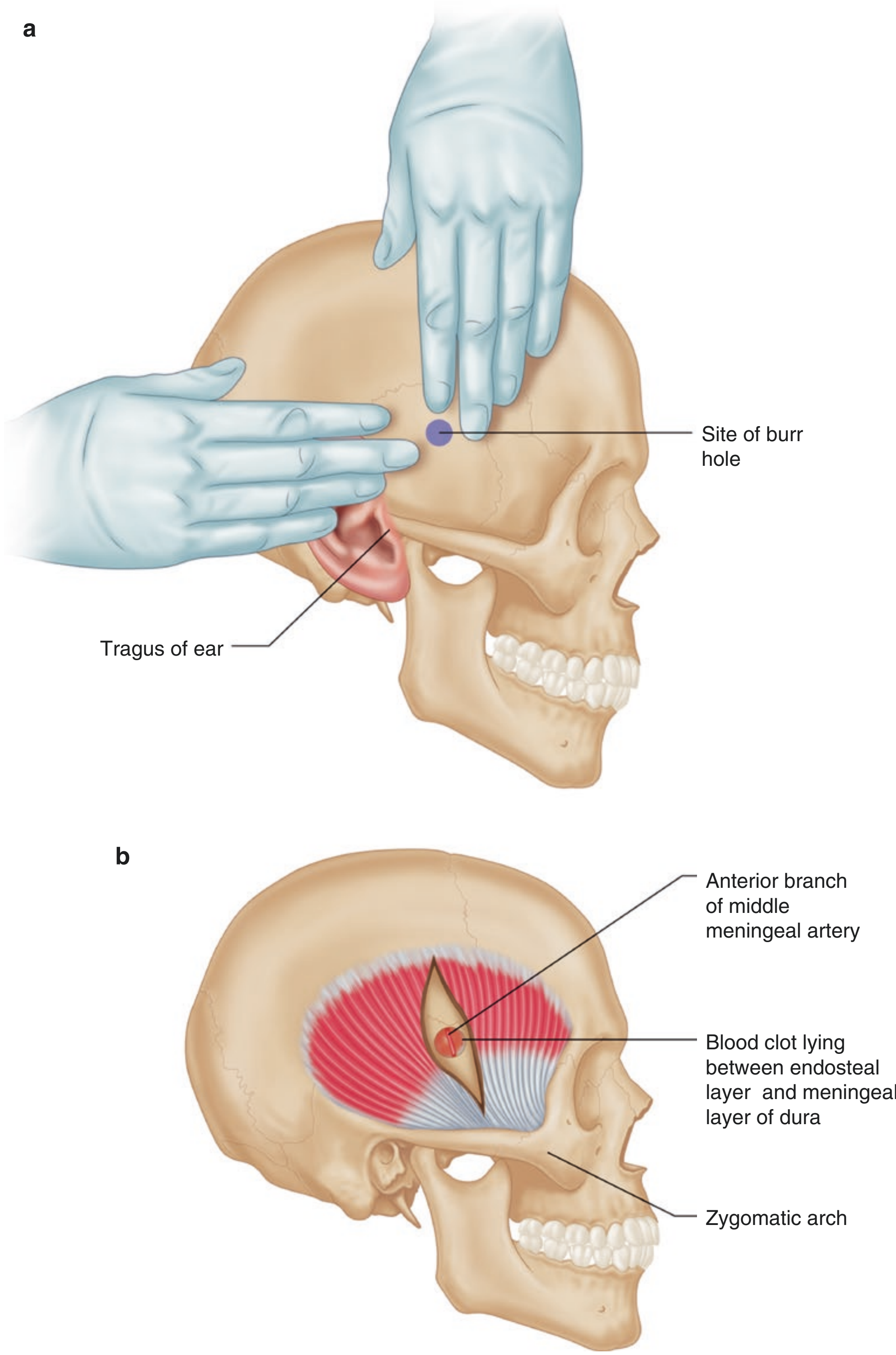

Fig. 42.5 Landmark for temporal burr hole above zygoma; make 5-cm incision over site

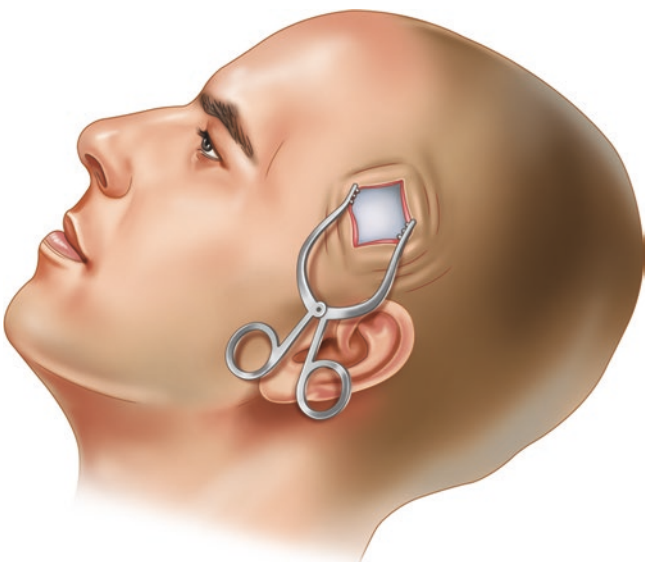

Fig. 42.6 After incision is made, use retractors (preferably self-retaining) to visualize field

11. Once in the inner table, separate dura from bone.
12. Enlarge opening by switching to a conical or cylindrical burr or use a rongeur.

Evacuating Hematoma

13. EDH blood will be visible at this point and should be gently suctioned out.

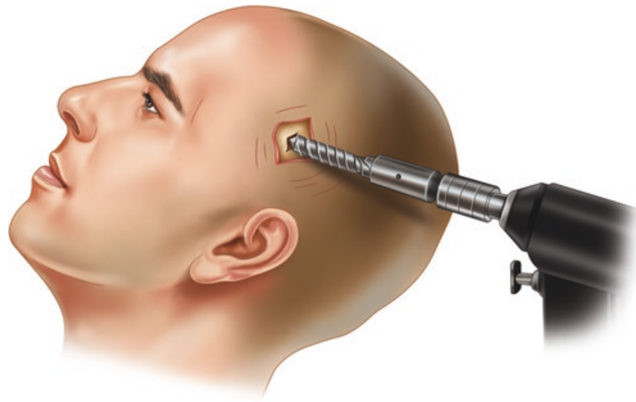

Fig. 42.7 Use penetrator drill to get through outer table. Follow up with a burr to get through the rest of the layers. Can also use an automatic stop craniotomy drill

14. SDH blood will be seen as a tenting of the dura and may be clotted: lift the dura with a hook, or make an incision with a fresh scalpel through it to expose the clot and drain.
15. Irrigate with saline (this can be via a hand syringe or via IV tubing connected to a saline bag at low speed flow).
16. Repeat gentle suction.

Closure

17. For temporal burr holes, ligate middle meningeal artery (if visible) or cauterize.
18. Place Penrose drain (Fig. 42.8), and close the dura first with a 3–0 absorbable suture, ensuring there is no dural leak (will lead to infection if present).
    - A watertight seal of the duraplasty is essential to minimize cerebrospinal fluid leakage.
19. Loosely suture scalp using 3–0 silk.

Complications

- Brain laceration/perforation.
- Temporal artery laceration.
- Wrong location (minimized when viewing images during procedure).
- Facial artery laceration.
- Meningitis.
- Brain abscess.

Pearls and Pitfalls

- Pearls
  – If brain herniates through the burr hole, there is likely a hematoma at another location.

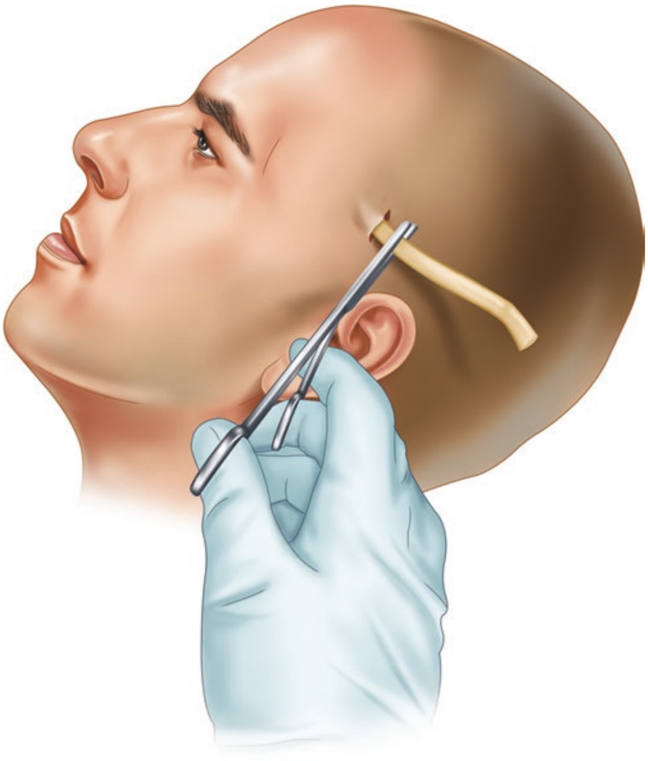

Fig. 42.8 Suture in Penrose drain and close the wound

  - Remember this is only a lifesaving procedure that is to be done when timely neurosurgical intervention is not possible. *Do not delay transfer* of the patient.
- Pitfalls
  - Bone in temporal area is quite thin; if not using an automatic stop drill, be very careful not to go too far and perforate the brain.

References

1. Wilkinson DA, Skinner MF. The primary trauma care manual for trauma management in district and remote locations. World Health Organization (WHO). http://www.steinergraphics.com/surgical/006_17.6.html. Accessed 22 May 2014.
2. Wilson MH, Wise D, Davies G, Lockey D. Emergency burr holes: "how to do it". Scand J Trauma Resusc Emerg Med. 2012;20:24. https://doi.org/10.1186/1757-7241-20-24.

Suggested Reading

http://www.viewmedica.com/vm/pages/library/L_df8516c9#vm_A_ac54d3a1. Accessed 29 June 2014.

43 External Ventricular Drain placement

Latha Ganti

An external ventricular drain (EVD), also known as a ventriculostomy tube, is placed via a burr hole in one of the ventricles of the brain (Fig. 43.1) to drain excess cerebrospinal fluid (CSF) that causes elevated intracranial pressure.

Indications

- Emergent need for intracranial pressure (ICP) monitoring and/or management.
- Enlarged ventricles on neuroimaging with Glasgow coma scale <12.
- Subarachnoid hemorrhage with Hunt-Hess grade ≥ 3 (Table 43.1).
- Coma.
- Obstructive hydrocephalus.
- Intraventricular hemorrhage.
- Signs of increased intracranial pressure.

Contraindications

- Absolute
  - Immediate availability of a neurosurgeon who can do the procedure.
- Relative
  - Coagulopathy.
  - Scalp infection.

Materials and Medications

- Intubation equipment and medications for sedation as needed.
- Sterile gloves, gown, mask.
- Ruler.
- Surgical marking pen.
- 1–2% lidocaine with epinephrine to numb scalp
- 5 cc syringe and needles to give anesthetic
- 10% povidone-iodine solution and swabs
- Razor to shave area.
- Fenestrated clear drape.
- Scalpel #11 blade (for scalp) and #15 blade (for periosteum) with #3 handle (Fig. 43.2a).
- 4 × 4 sterile gauze
- Adson forceps.
- Mosquito forceps.
- Self-retaining eyebrow retractor (Fig. 43.2b).
- 3–0 nylon suture and needle holder and/or skin stapler
- Scissors.
- A hand drill with variable chuck.
- One or more drill bits with depth guards in 5/32″ (3.97 mm), 13/64″ (5.31 mm), and 1/4″ (6.35 mm) sizes.
- A hex wrench for depth guard adjustment.
- Ventricular catheter.
- Primed ventricular drainage collection system.

Procedure

Patient Preparation

1. Patient is intubated and placed supine in neutral position with the head of the bed elevated 30–45°.
2. Administer one dose of intravenous antibiotics that covers skin flora.
3. Make precise measurement of where the hole and incision will be made. Most commonly, EVDs are placed in the right frontal scalp, as this is the nondominant hemisphere in >95% of the population.
4. Using a sterile skin/surgical marker, draw a line 11 cm back from nasion and then a point 3 cm to the right of that, which corresponds to the mid-pupillary line. This is called Kocher's point (Fig. 43.3).

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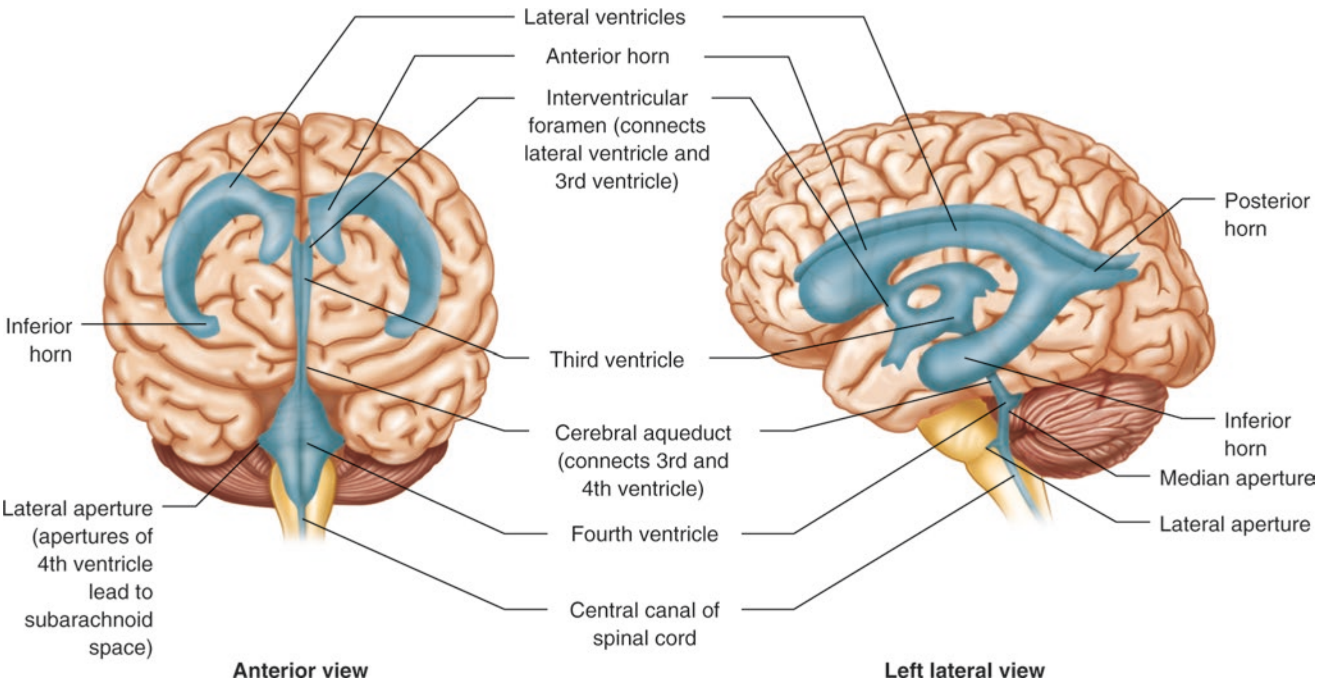

Fig. 43.1 Ventricles of the brain that contain CSF

Table 43.1 Hunt and Hess scale for subarachnoid hemorrhage [1]

Grade	Signs and symptoms
1	Alert and oriented, mild headache, slight or no nuchal rigidity
2	Alert and oriented, moderate to severe headache, nuchal rigidity, no neurologic deficit
3	Drowsiness, confusion, mild focal neurologic deficit
4	Stupor, moderate-severe hemiparesis
5	Coma, decerebrate posturing

5. Once Kocher's point is marked, shave the skin, and remove loose hairs so field is wide enough for subcutaneous catheter placement and tunneling.
6. Prep area with povidone-iodine.
7. Place sterile clear drape over field.
8. Prep area of incision once more.
9. Infiltrate scalp with 1–2% lidocaine with epinephrine (the epinephrine acts as a hemostatic agent, keeping surgical field clean) (Fig. 43.4).
10. Make a 2-cm linear stab incision and extend incision to the skull (Fig. 43.5).
11. Use eyebrow self-retaining retractors to hold skin edges back.
12. Drill burr hole with hand drill (Fig. 43.6).
13. Irrigate burr hole with sterile saline.

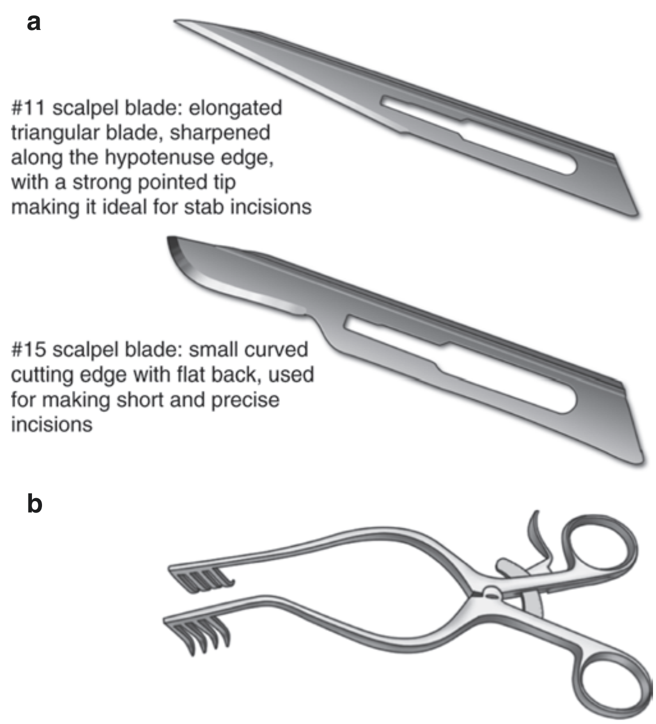

Fig. 43.2 (**a**) Surgical scalpel blades. (**b**) Self-retaining eyebrow retractors

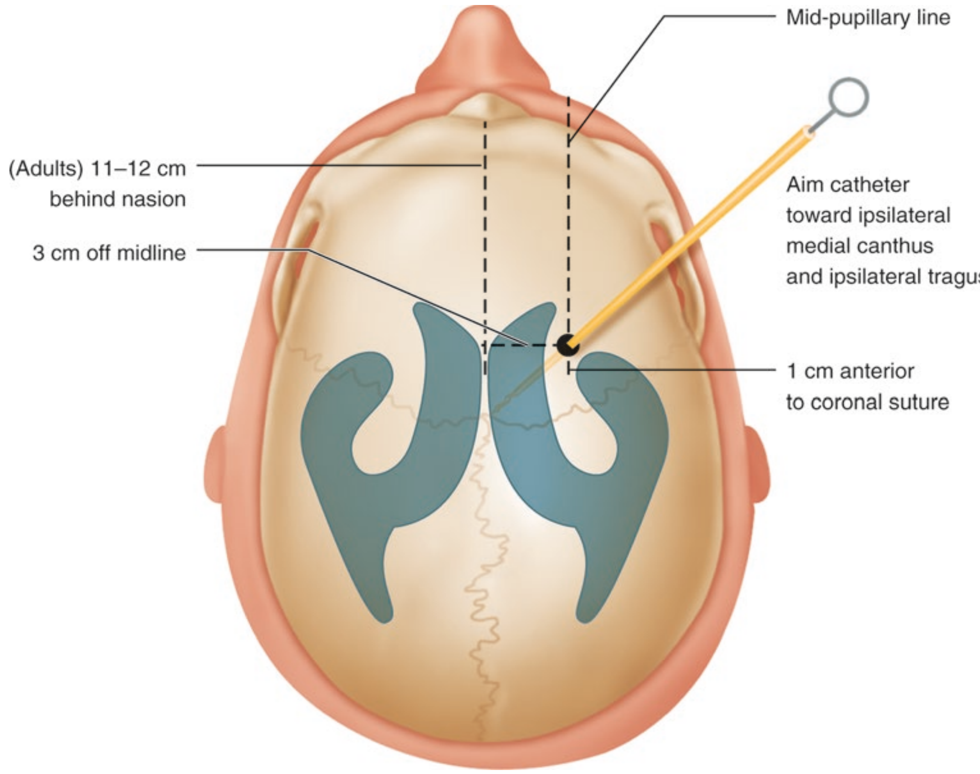

Fig. 43.3 Kocher's point for frontal EVD placement

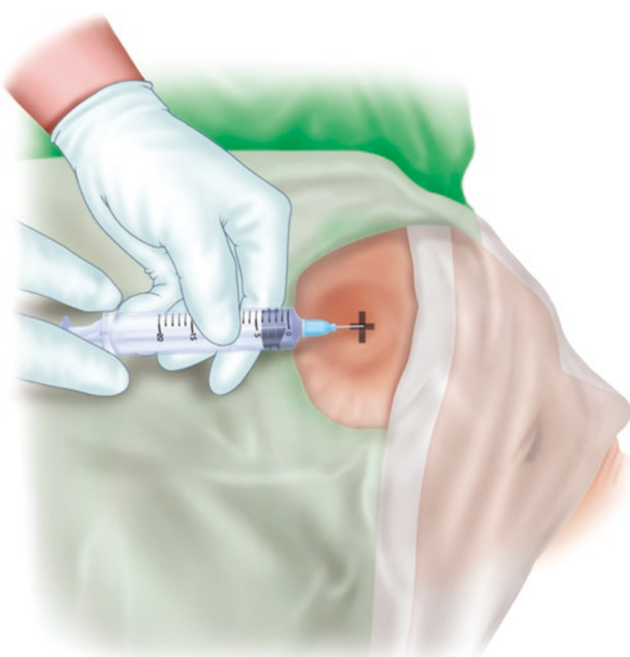

Fig. 43.4 Anesthetize the skin

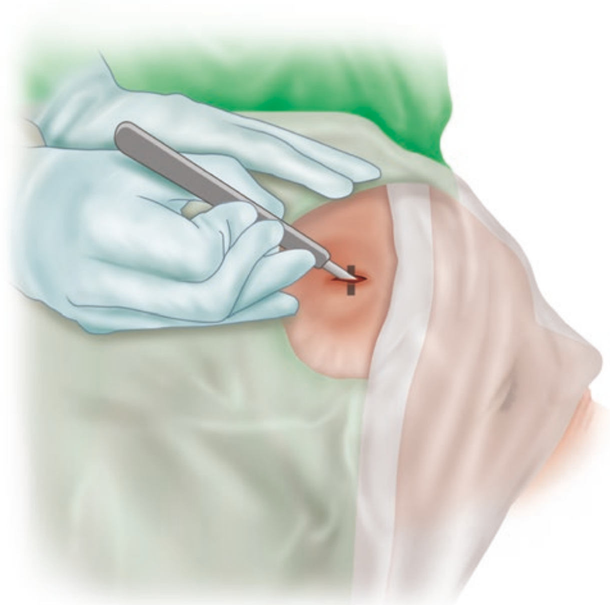

Fig. 43.5 Make stab incision

Fig. 43.6 Make burr hole

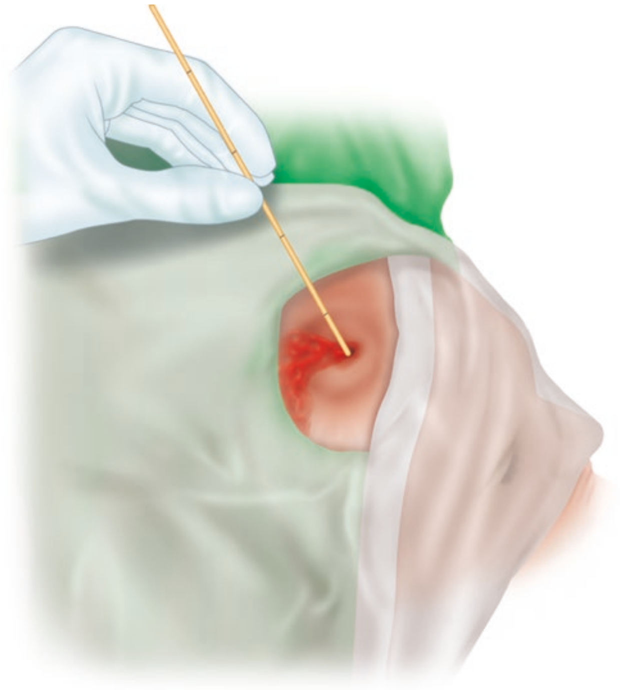

Fig. 43.7 Advance ventriculostomy catheter with stylet

14. Put on a new pair of sterile gloves (prior to handling ventriculostomy catheter).
15. Remove ventricular tubing from sterile package. It has markings on it that are 1 cm apart.
16. Insert ventriculostomy catheter perpendicular to the skull at the point of insertion. Catheter is aimed at the ipsilateral medial canthus of the eye (anteroposterior plane) and tragus of the ear (lateral plane).
17. Advance ventriculostomy tube 5–6 cm with stylet from outer skull table so it sits in the anterior horn of the lateral ventricle (Fig. 43.7).
18. Ensure ventriculostomy catheter is draining CSF.
19. Attach metal trocar to the tip of ventriculostomy catheter and tunnel the trocar and catheter under the galea approximately 3–5 cm to the right of the original incision. Bring trocar out through separate stab incision in the scalp.
20. Remove trocar, make sure ventriculostomy catheter is still draining CSF.
21. Place temporary cap on ventriculostomy catheter to prevent overdrainage of CSF.
22. Close the original incision with either sutures or staples.
23. Secure catheter to the scalp using staples.
24. Cover incision with sterile transparent dressing.
25. Suture stopcock to ventricular catheter to ensure it does not come off (take care not to make suture too tight or it will occlude ventriculostomy catheter).
26. Remove blind end of stopcock, and attach ventricular catheter to ventricular drain system once it is primed.

Priming, Setup, and Maintenance of Ventricular Drainage System

27. Prepare drainage system by priming system with sterile, preservative-free saline.
28. Place zero point of drainage system at the midbrain (level of patient's ear tragus) or above the midbrain at 15–20 cm of H_20 (target ICP set by neurointensivist and will change depending on patient's situation) (Fig. 43.8).
29. Attach drainage tubing.
30. Patients who require an EVD should be closely monitored by nurses trained and competent in assessment and management of the drain and in recognizing signs of increased ICP in the patient.
31. Assessment of the drainage system should be done a minimum of every 4 h, which includes inspecting the EVD from the insertion site along the entire drainage

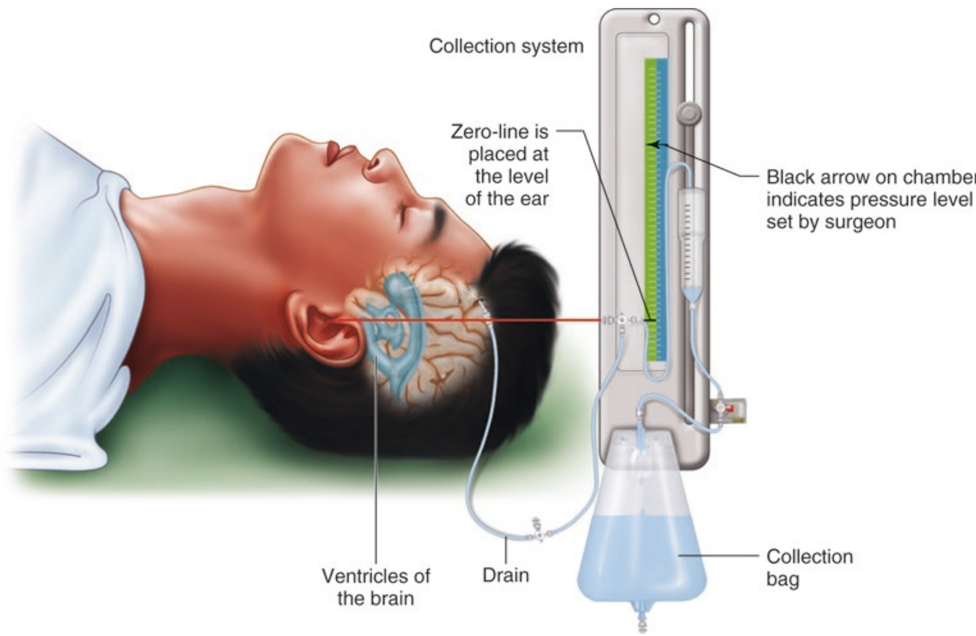

Fig. 43.8 Zero point of drainage system placed at the midbrain (level of patient's ear tragus)

system, checking for cracks in the system or fluid leaking from the insertion site [2].

Post-procedure

32. Obtain CT scan of the brain to verify placement (Fig. 43.9).

Fig. 43.9 CT scan demonstrating typical placement of ventriculostomy catheter in ipsilateral anterior horn of lateral ventricle [3]. (Reproduced with permission from Jaffe et al. [3])

Complications

- Hemorrhage.
- Infection: meningitis, ventriculitis.
- Tract hematoma.
- Migration/dislodgement.

Pearls and Pitfalls

- Pearls
  – EVD needs to be re-leveled every time the patient moves. Family and all visitors must be informed that any patient movement or change in elevation of the head of bed will require re-leveling of EVD in order to ensure it is a the appropriate level for CSF drainage.
  – CSF collection chamber should remain upright to prevent reflux/leakage.

  - EVD placement in the parieto-occipital scalp or frontotemporal or trans-sylvian locations is generally not done at the bedside due to higher rate of complications. This is performed in the operating room.
- Pitfalls
  - If the drain is leveled too low: CSF will drain too easily, which can lead to re-rupture of an unrepaired ruptured cerebral aneurysm or cause a subdural hematoma due to shearing of bridging veins.
  - If the drain is leveled too high, CSF will not drain or will not drain at desired rate, leading to hydrocephalus. The ICP will need to be higher in order for the CSF to drain.

References

1. Hunt WE, Hess RM. Surgical risk as related to time of intervention in the repair of intracranial aneurysms. J Neurosurg. 1968;28(1):14–20.
2. Care of the patient undergoing intracranial pressure monitoring/external ventricular drainage or lumbar drainage. AANN clinical practice guideline series. 2011. http://www.aann.org/uploads/AANN11_ICPEVDnew.pdf. Accessed 27 Sept 2014.
3. Jaffe J, Melnychuk E, Muschelli J, et al. Ventricular catheter location and the clearance of intraventricular hemorrhage. Neurosurgery. 2012;70(5):1258–64.

44 Lumbar Puncture in Adults

Kevin Tench, L. Connor Nickels, and Rohit Pravin Patel

Indications

- Diagnostic
  - Evaluation for the possibility of a central nervous system (CNS) infection: viral, bacterial, and fungal meningitis and encephalitis.
  - Evaluation for inflammatory processes: multiple sclerosis, Guillain-Barré syndrome.
  - Evaluation for spontaneous subarachnoid hemorrhage (SAH).
  - Suspicion of CNS diseases: oncological and metabolic processes.
- Therapeutic
  - Therapeutic reduction of cerebrospinal fluid (CSF) pressure.
  - Procedures requiring lower body analgesia or anesthesia.
  - Intrathecal antibiotic administration for some types of meningitis.
  - Chemotherapy and methotrexate for some forms of leukemia and lymphomas.

Contraindications

- Presence of infection in tissues at or around puncture site.
- Increased intracranial pressure (ICP) from a space-occupying lesion, patients with signs of cerebral herniation or with potential of increased ICP and focal neurological signs.
- Bleeding diathesis (thrombocytopenia, anticoagulant therapy, hemophilia), may increase the risk of spinal hematoma, but level of coagulopathy that increases risk is unclear.
- Patients with cardiorespiratory compromise may worsen owing to position.

Patients with prior history of lumbar surgery, osteoarthritis, ankylosing spondylitis, kyphoscoliosis, or degenerative disk disease might have more success if lumbar puncture is performed by an interventional radiologist using imaging techniques and should be considered.

Materials and Medications

- Spinal needle(s) with stylet.
  - Adults: 3.5-in 20-gauge needle; obese may require 5.0-in 22- to 24-gauge needle.
  - Children: 2.5-in 22-gauge needle.
  - Infants: 1.5-in 22-gauge needle.
- Three-way stopcock (optional: drainage catheter).
- Manometer (optional: extension tube for higher opening pressures).
- Specimen tubes (# may vary, but in general labeled 1–4, important to obtain from 1, 2, 3, and 4 owing to cell count obtained from tubes 1 and 3).
- Local anesthetic (lidocaine 1 or 2%), 5- to 10-mL syringe and needle (25-gauge) for local anesthesia.
- Sterile drapes and gauze**.**
- Mask, sterile gown, sterile gloves.
- Antiseptic solution for skin preparation (ChloraPrep or iodine).

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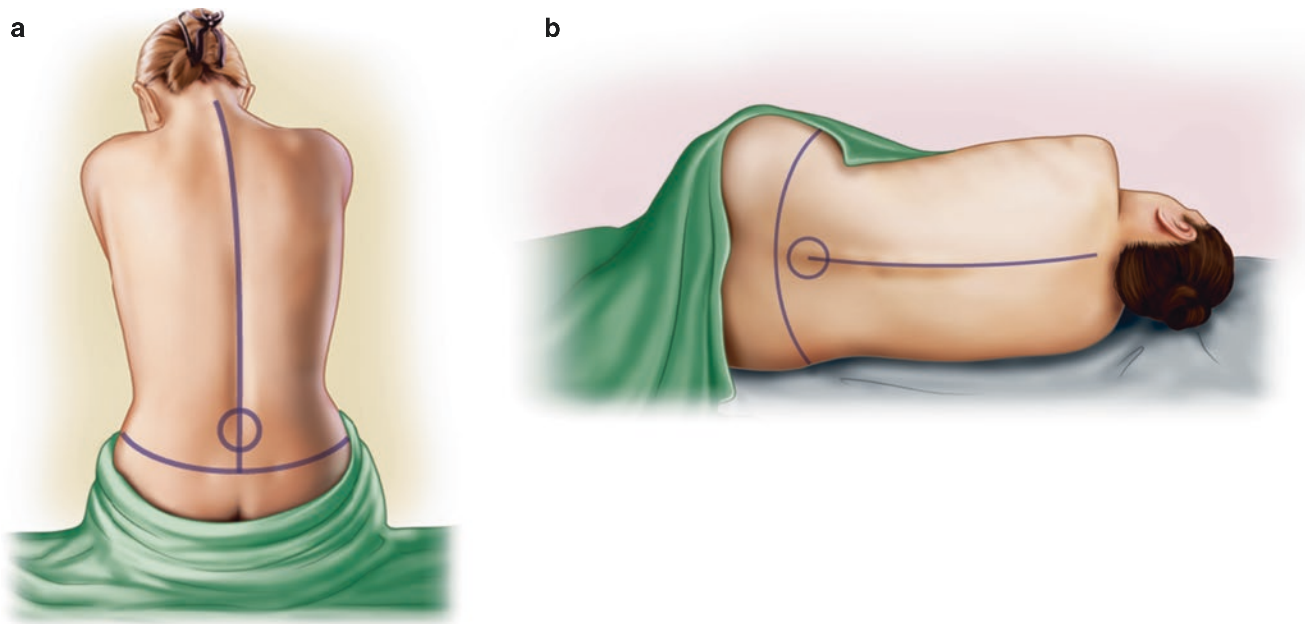

Fig. 44.1 Sitting position (**a**) left lateral decubitus position, (**b**) with general areas of insertion of needle

Procedure

1. Positioning.
   - Determined by practitioner preference or patient capability.
   - Options: lateral recumbent position, upright sitting position (Fig. 44.1).
   - Lateral recumbent position is preferred to obtain accurate opening pressure and to reduce the risk of post-puncture headache.
   - Both positions require the patient to arch the lower back toward the practitioner in order to open up the intervertebral spaces (obtain the "fetal position" or arch "like a cat").
   - Shoulders and hips should remain aligned during process.
2. Landmarks.
   - Determined by palpation.
   - Draw a visual line between the superior aspects of the iliac crests that intersect the midline at the L4 interspace. L3– L4 and L4– L5 spaces are preferred because these points are below the termination of the spinal cord.
   - Palpate the posterosuperior iliac crests with the midpoint of a visual line that connects the two crests representing the L4 spinous process.
   - Palpate the space between the L3–L4 and the L4–L5 spinous processes, and mark where the needle will be placed.
3. Ultrasound guidance (optional).
   - Helpful in obese patients, patients with previous surgical scarring, or anyone in whom palpation of the spinous processes is not easily done.
   - Sonographic measurement of the dura mater strongly correlates with needle depth needed to obtain CSF.
   - Identify the spinal process in the short and long axis to determine the midline and the interspinous space.
   - Identify the interspinous ligament for estimation of the depth of needle insertion.
   - Commonly only the spinous processes are well visualized, and the interspinous ligament, ligamentum flavum, and subarachnoid space are less clearly seen.
   - High-frequency (5–10 MHz) linear probe to best evaluate anatomy.
   - A marking pen can be used to create a cross-hair-type figure (Fig. 44.1).
   - After placing the patient as described, locate the midline at the lumbar spine in transverse and longitudinal orientations.
   - Bright echogenic structures with shadowing posteriorly identify the spinous processes.
   - Transverse probe positioning to identify midline (Fig. 44.2) and then longitudinal probe positioning to identify interspinous space (Fig. 44.3).
4. Sterile preparation.
   - After positioning and palpating the appropriate landmarks, the practitioner should then dress in the appropriate protective gear: mask, gown, and sterile gloves.

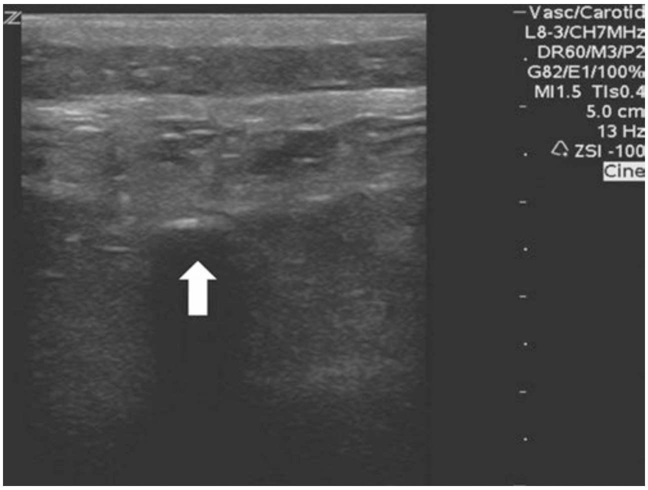

Fig. 44.2 Transverse view; *white arrow* indicates spinous process. Place in the middle of ultrasound view to locate appropriate midline access point

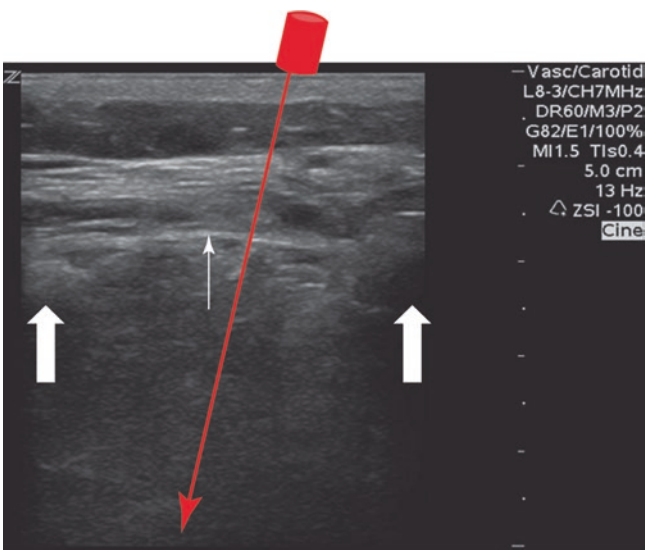

Fig. 44.3 Longitudinal view of lumbar spine. *Thick white arrows* indicate vertebral shadows; *thin white arrow* indicates supraspinous ligament. *Red arrow* indicates trajectory of needle

- After dressing, the practitioner can then sterilely prepare the patient.
- Make sure the patient's back is completely exposed.
- Clean the patient's back with an antiseptic solution (ChloraPrep should be scrubbed in an up/down and side/side fashion, iodine in a circular motion starting from the center of the anticipated insertion point).
- Apply sterile drapes with the puncture site exposed.
- This is an optimal time to make sure all equipment in a standard lumbar puncture tray connects properly and that the stopcock for opening pressure measurement is assembled. Make sure the stopcock is closed away from the patient so that CSF can flow from the patient

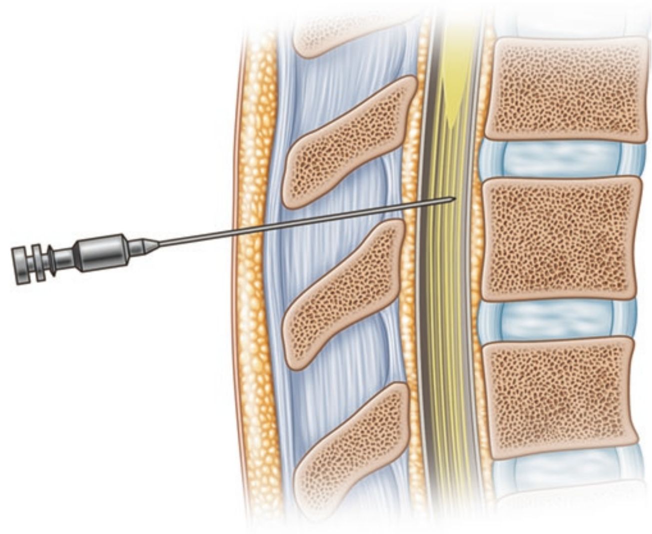

Fig. 44.4 Angle of insertion of needle, cephalad with bevel up

to the manometer. If the assembly is done, it will decrease the amount of CSF lost after the puncture.
- Local anesthesia:
  - 1% Lidocaine or anesthetic cream topically before preparing the skin.
  - For injection, form a skin wheal over the insertion site.
  - Inject into the deep tissues below the wheal in all directions while only breaking the skin once.
  - Systemic sedatives and analgesics may also be used.

5. Needle insertion.
   - Needle should be inserted in the midline between the L3–L4 and the L4–L5 spinous processes, and the stylet should be firmly in place.
   - Initially parallel to the bed, but once into the subcutaneous tissue, the needle should be angled toward the umbilicus (slightly cephalad, 15°) with the bevel facing upward (Fig. 44.4). This sagittal plane orientation spreads rather than cuts the fibers of the dural sac, which run parallel to the spinal axis.
   - If properly positioned, the needle passes through the skin, subcutaneous tissue, supraspinous ligament, interspinous ligament between the spinous processes, ligamentum flavum, and epidural space including the internal vertebral venous plexus, dura, and arachnoid, into the subarachnoid space, and between the nerve roots of the cauda equina.
   - In most cases, a "pop" will be felt when the needle penetrates the ligamentum flavum, entering into the subarachnoid space; then intermittent withdrawal should be done in 2-mm intervals to assess for CSF flow.

- If the bone is encountered during insertion, the needle should be withdrawn partially without exiting the skin and readjusted to a different angle more cephalad.
- If the tap is traumatic, CSF may be blood-tinged but should clear as more is collected. If it does not clear, it may indicate intracranial hemorrhage or subarachnoid blood. Also in traumatic patients, clotting will be seen in the tubes; clotting does not occur in SAH owing to defibrinated blood being present in the CSF. Blood-tinged CSF can also be seen in herpes simplex virus (HSV) encephalitis.
- A dry tap is usually due to incorrect positioning and misdirection of needle, often due to a superior direction of the needle with obstruction by the lamina or spinous process of the superior or inferior vertebra. If the needle is too lateral, an inferior or superior articular process may be hit.
- If flow slows down, rotate the needle 90° because a nerve root may be obstructing the opening.

6. Opening pressure measurement.
   - Must be performed in the lateral recumbent position. Although there are some conversion formulas from the sitting position, these are not standard of care.
   - Once the needle is in the subarachnoid space and CSF is flowing from the needle, the three-way stopcock should be attached to the needle and the manometer should be attached to the stopcock to take a measurement. Use the flexible tube to connect the manometer to the hub of the needle.
   - Note the height of fluid in the manometer after it stops rising (normal opening pressure, <20 cm Hg); it may be possible to see pulsations from cardiac or respiratory motion.
     – Elevated CSF pressure is seen with meningeal inflammation, hydrocephalus, pseudotumor cerebri, SAH, and CHF.
     – Decreased CSF pressure is seen in leakage of CSF and severe dehydration.
7. Collecting CSF fluid.
   - Collect at least 1–2 mL of CSF fluid in each tube, going from 1 to 4, and never aspirate because this can cause hemorrhage.
   - After collecting the fluid, replace the stylet and remove the needle, clean the skin, and place a bandage over the puncture site.
   - General recommendations:
     – Tube 1: glucose, protein, protein electrophoresis.
     – Tube 2: Gram stain, bacterial and viral cultures.
     – Tube 3: cell count and differential.
   - When ruling out SAH, cell count should be performed in tubes 1 and 3 or 1 and 4 to differentiate between SAH and traumatic tap.
     – Tube 4: any special tests: Myelin basic proteins, lactate, pyruvate, and smear on cell concentrates all depend on suspicion.

Complications

- Implantation of epidermoid tumors: from introducing skin plug into the subarachnoid space and can be avoided by using stylet when advancing.
- Postlumbar puncture headache: most common, occurring in 36.5% of patients within 48 h.
- CSF leak: causes headache when CSF leak through puncture site exceeds rate of production.
- Bleeding: most common in patients with bleeding diathesis, may result in spinal cord compression.
- Epidural hematoma.
- Infection: local cellulitis, abscess (local or epidural), or meningitis.
- Herniation syndromes: High risk can be identified by computed tomography but may not completely identify all patients with increased ICP.
- Backache: local or referred pain.
- Cardiorespiratory compromise.

Pearls and Pitfalls

- Pearls
  – Positioning the patient is key to a successful procedure.
  – In adults, the spinal cord may terminate higher than previously thought, and it may be okay to go one interspace higher than recommended; but in infants owing to the differential in longitudinal growth of the spinal canal and cord, the spinal cord usually ends in L3. So in children, the tap must go L4–L5 or L5–S1.
  – Always keep the stylet in place until after the skin barrier is penetrated because this will avoid introduction of epidermoid tissue.
- Pitfalls
  – Postspinal headaches can be avoided with smaller needles and intravenous (IV) fluids.
- Having the patient lie on the back for 1 h after the procedure has no change in incidence of headache.
- Treatment consists of IV fluids initially, then caffeine, and, ultimately, if the headache persists, a blood patch.

Suggested Reading

Boon JM, Abrahams PH, Meiring JH, Welch T. Lumbar puncture: anatomical review of a clinical skill. Clin Anat. 2004;17:544–53.

Ellenby MS, Tegtmeyer K, Lai S, Braner DA. Videos in clinical medicine. Lumbar puncture. N Engl J Med. 2006;355:e12.

Ferre RM, Sweeney TW, Strout TD. Ultrasound identification of landmarks preceding lumbar puncture: a pilot study. Emerg Med J. 2009;26:276–7.

Peterson MA, Abele J. Bedside ultrasound for difficult lumbar puncture. J Emerg Med. 2005;28:197–200.

45 Reflex Eye Movements (Doll's Eyes and Caloric Testing)

Thomas T. Nguyen, Tina Dulani, and Saadia Akhtar

Doll's Eyes (Oculocephalic Reflex Testing)

Indications: Doll's Eyes

- To assess brain stem function of a comatose patient.
- To assess cerebral function in a comatose patient if brainstem function is intact.

Contraindications: Doll's Eyes

- Absolute
  - Occult cervical spine injury; rule out radiographically and clinically.
  - Basilar skull fracture.
- Relative
  - Rheumatoid arthritis, increased risk of atlantoaxial subluxation resulting in spinal cord compression.
  - Osteoporosis, increased risk of cervical spine injury.
  - Cervical spine ankylosis, increased risk of cervical spine injury.

Procedure: Doll's Eyes (Fig. 45.1)

1. Stand at the head of bed and grasp the patient's head with both hands.
2. Use the thumbs of both of hands to open the patient's eyelids.
3. Rapidly move the patient's head to one side and hold.
4. Simultaneously observe for the presence or absence of horizontal movements.
   (a) Head movement to one side should result in conjugate eye movement to the opposite side and then in spontaneous return of the eyes to the midline (normal test).
   (b) Normal oculocephalic reflex is the observation of conjugate eye movements to the opposite side of head turning. This indicates a functionally intact brainstem in a comatose patient.
   (c) Abnormal oculocephalic reflex: incomplete or absent horizontal eye movements. The eyes remain in the midline. This indicates impairment of the brainstem; caloric testing should be done if not contraindicated.
   (d) A partially abnormal oculocephalic reflex: conjugate eye movement opposite to head turning but does not return to the midline means the brainstem is intact but cerebrum function is not.
5. Repeat by rotating the head to the opposite side.
6. Vertical oculocephalic response can be tested by moving the patient's head up and down. A compensatory vertical eye movement should be observed.
   (a) This test is useful only if the horizontal oculocephalic reflex is negative. An intact vertical oculocephalic reflex with a negative horizontal oculocephalic reflex suggests a pontine lesion.
7. Document the observations.

Pearls and Pitfalls: Doll's Eyes

- Oculocephalic reflex may not be present in the first 10 days of life and is unreliable until 2 years of age.
- Do not attempt the doll's eye maneuver in patients with cervical spinal injuries.

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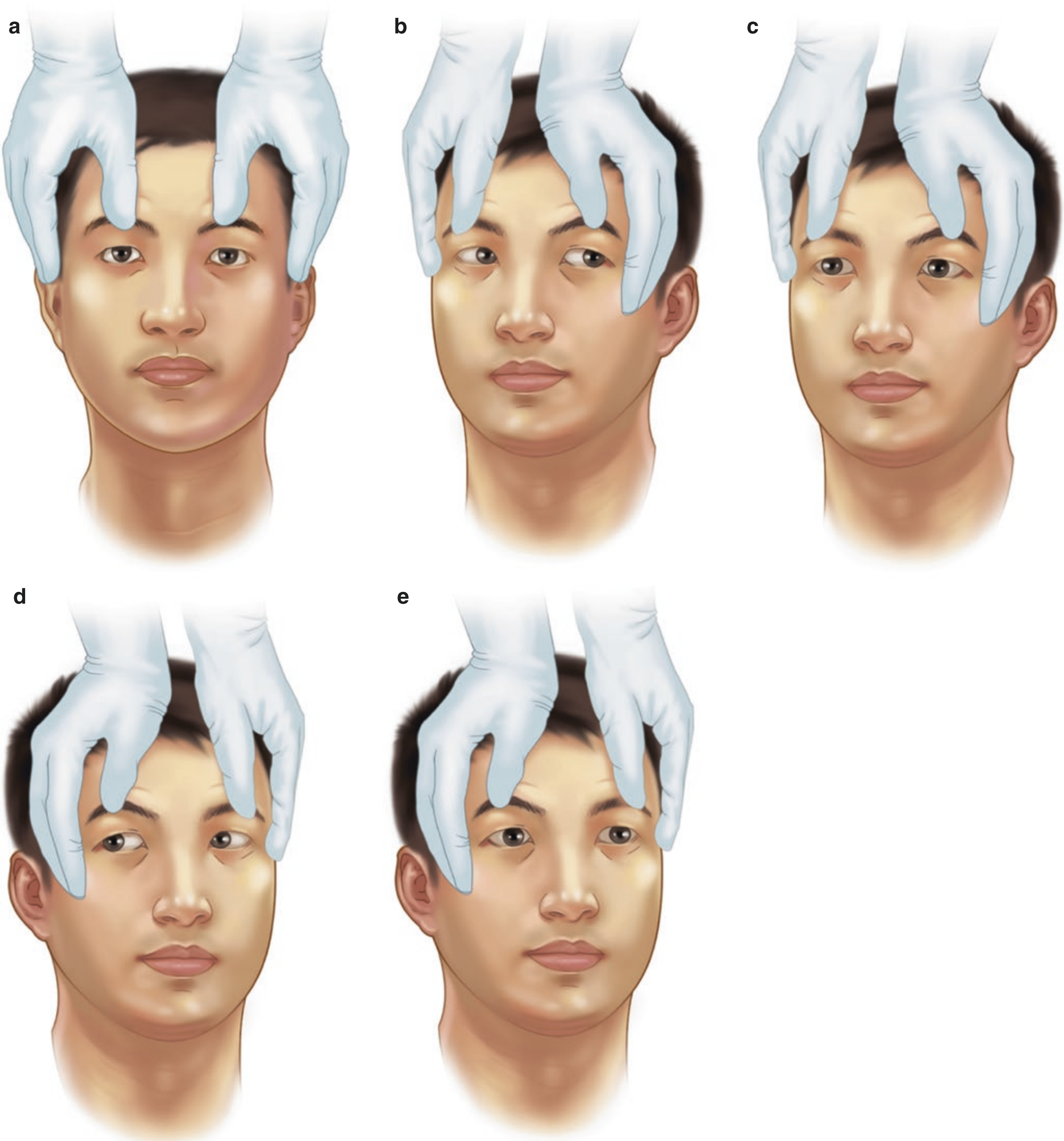

Fig. 45.1 The oculocephalic (doll's eyes) reflex in a patient with an intact brainstem. (**a**) Start with the head facing upright and grasp as depicted using both thumbs to keep the eyes open. (**b**) Rotate the head 90° to the right and the eyes deviate to the left (opposite side). (**c**) The eyes will spontaneously return to the midline. (**d**) Then rotate the head 180° to the left, and the eyes should deviate to the right (opposite side). (**e**) The eyes will spontaneously return to the midline

- The doll's eye reflex can be absent or partial in patients with ocular muscle nerve palsy (e.g., cranial nerve [CN] 6).
- Make sure the patient does not have a neuromuscular blockade agent or other toxins present.
- A conscious person can suppress the doll's eye or oculocephalic reflex.

Caloric Reflex Testing (Vestibuloocular Reflex)

Indications: Caloric Reflex Testing

- In any comatose patient with abnormal doll's eye or if it cannot be performed.
- To assess brainstem function of a comatose patient.
- To assess asymmetrical function in the peripheral vestibular system.

Contraindications: Caloric Reflex Testing

- Absolute
  – Perforated tympanic membrane.
  – Presence of tympanostomy tubes.
  – Basilar skull fracture, petrous bone fracture.
  – Suspicion of cerebrospinal fluid (CSF) otorrhea.

Materials and Medications: Caloric Reflex Testing

- Otoscope.
- 60-mL syringe
- 16- to 18-gauge angiocatheter
- Thermometer.
- Ice cold water (30–33 °C).
- Warm water (44 °C).
- Emesis basin (to collect water).
- Towels or Chux.

Procedure: Caloric Reflex Testing (Fig. 45.2)

1. Place the patient supine, and elevate the head to 30° to bring the lateral semicircular canal into the upright position to optimize its stimulation.
   (a) Careful otoscopic examination should be done before caloric testing to make sure there are no contraindications such as a perforated tympanic membrane.
   (b) Remove any cerumen from the external auditory canal (EAC); the irrigation fluid should be able to reach the tympanic membrane.
2. Get a 60-mL syringe with an 18-gauge angiocatheter. Remove the plastic angiocatheter from the needle and discard the needle.
3. Place the angiocatheter on the 60-mL syringe and fill it with ice water (30 °C).
4. Place the angiocatheter in the EAC and squirt the water in over a period of 30–40 s. The water should freely enter and exit the auditory canal.
   (a) The stimulus depends upon the temperature of the water and not on water pressure.
   (b) Reflex horizontal movements may be delayed for up to 1 min after irrigation of the EAC.
5. Observe: Have an assistant hold the eyelids open with the head still and facing forward.
   (a) Normal test: Cold water induces slight deviation of the eyes to the side being irrigated followed by a latent period of approximately 20 s and then nystagmus to the opposite side (direction of the fast phase).
   (b) Abnormal test: Eyes do not deviate; this implies brainstem problems.
   (c) The quick phase may return in patients in a persistent vegetative state. Search for the slow, full eye deviation in response to caloric stimulation and not nystagmus when assessing a comatose patient.
6. Pause at least 5 min so the auditory canal can warm up.
   (a) The same EAC can be irrigated with warm water if the contralateral side cannot be tested for any reason.
7. Repeat steps 3–5 in the opposite ear.
   (a) Warm water testing can be used if there is no response to cold water testing. Use warm water (44 °C), and repeat testing, starting with one ear and then, after 5 min, with the other ear.
   (b) Warm water induces nystagmus to the same side (direction of the fast phase).
   (c) COWS: Cold opposite, warm same (referring to the compensatory fast phase of eye movement, the nystagmus).
8. Dry the patient off, and reexamine the tympanic membranes to assess for testing-related injury.

Complications: Caloric Reflex Testing

- If contraindications are excluded, no significant complications are expected.

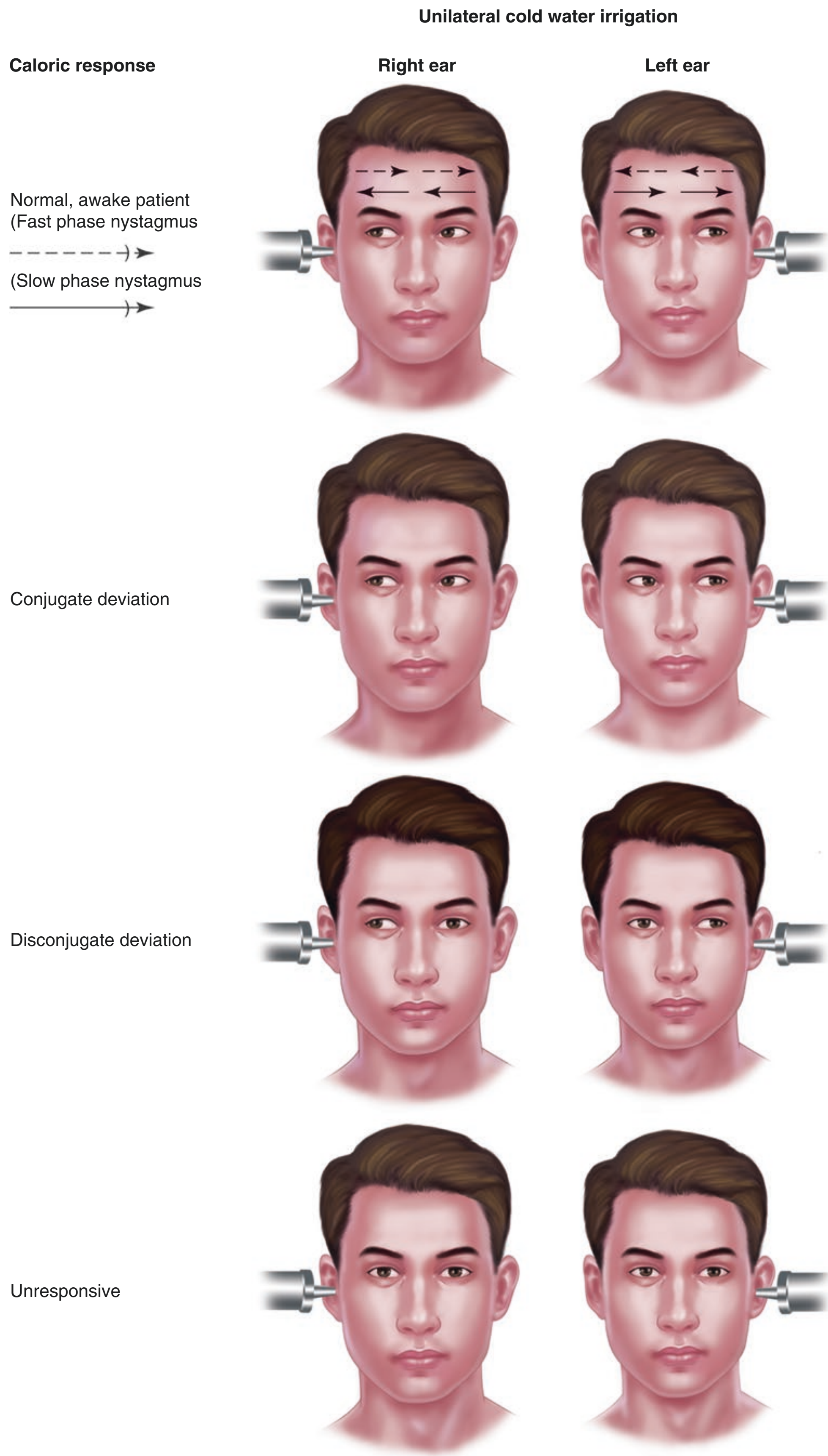

Fig. 45.2 Depiction of the vestibuloocular reflexes with unilateral cold water irrigation

- Tympanic membrane injury or EAC injury can occur from the angiocatheter, forceful irrigation, or injury during cerumen removal.
- Potential complications from caloric testing include meningitis, otitis media, and vomiting.

Pearls and Pitfalls: Caloric Reflex Testing

- A positive response to caloric testing indicates intact brainstem function.
- In an awake patient, excessive reflex vagal activity may occur (i.e., nausea, vomiting, dizziness).
- Absence of horizontal eye movement means comatose brainstem injury.
- Disconjugate or impaired reflex horizontal eye movements indicate impaired brainstem function at or below the level of the oculomotor nucleus.
- A comatose patient with intact full-reflex horizontal eye movements indicates that the lesion causing coma is in the cerebral hemisphere.

Suggested Reading

Gomella LG. Central nervous system. In: Clinician's pocket reference. 11th ed. New York: McGraw-Hill; 2007.

McCann J, et al. Rapid assessment: a flowchart guide to signs and symptoms. Philadelphia: Lippincott William & Wilkins; 2004.

Reeve A, Swensen R. Auditory and vestibular function. In: Disorders of the nervous system: a primer. Hanover, NH: Dartmouth Medical School; On Line; 2009.

Reichman EF, Simon RR. Chap. 103. Reflex eye movements (caloric testing and doll's eyes). In: Emergency medicine procedures. New York: McGraw Hill Education; 2004.

Ropper AH, Samuels MA. Chap. 15. Deafness, dizziness, and disorders of equilibrium. Chap. 17. Coma and related disorders of consciousness. In: Adams and Victor's principles of neurology. 9th ed. New York: McGraw Hill; 2009.

Simon RP, Greenberg DA, Aminoff MJ. Chap. 3. Disorders of equilibrium. In: Clinical neurology. 7th ed. New York: McGraw Hill; 2009. http://www.accessmedicine.com.elibrary.einstein.yu.edu/content.aspx?aID=5146162.

Dix-Hallpike Maneuver

46

Rui Domingues and Muhammad Waseem

The Dix-Hallpike maneuver, also termed the "head-hanging positioning maneuver," is helpful in confirming the clinical suspicion of benign paroxysmal positional vertigo (BPPV). This maneuver provokes abnormal nystagmus, which is a characteristic feature of BPPV.

Indications

- BPPV is one of the most common types of vertigo.
  - The pathophysiology of BPPV, in brief, is believed to be due to free-moving densities (canaliths/otoliths) in the posterior semicircular canal; with head movement, the particles would alter the flow of the endolymph and cause the stimulation of the ampulla. The particles in the canal cause slow or even reversal of the movement of the cupula and create signals that do not correlate with the actual head movements, therefore causing the sensation of nystagmus.
  - This maneuver locates the cause of vertigo as either the inner ear or the brain; if the problem is in the ear, this maneuver helps localize which ear is affected.
- This maneuver is indicated for patients presenting with vertigo, which is evoked by a change in position and has no symptoms at rest.
- This maneuver is inexpensive, easily done, and part of the physical examination when a patient presents with the complaint of dizziness or vertigo.

Contraindications

- Severe cervical spine disease.
- Unstable spinal injury.
- High-grade carotid stenosis.
- Unstable heart disease.
- Elderly patients may not tolerate this maneuver.
- There is no need to perform this test in the presence of nystagmus at rest.

Materials

- Examination table.
- Flat cushion.
- Frenzel goggles: These high-powered (+20 diopters) magnifying glasses can be placed on a patient during the performance of the maneuver and have shown to increase the sensitivity of the Dix-Hallpike maneuver by preventing the patient from visually fixating on an object, thereby preventing suppression of nystagmus. They are not required to perform the maneuver; they usually are used by specialists.

Procedure (Fig. 46.1)

1. Have the patient sit at the edge of a bed. The patient is instructed to maintain eye contact with the physician throughout the maneuver.
2. With the patient seated, the examiner will extend the neck, approximately 20°, and turn the head to one side, approximately 30–45°.
3. The examiner then assists the patient by lowering the patient quickly into a supine position, so that the head hangs over the edge of the bed or table, with the neck in a hyperextended position. A flat cushion can be placed beneath the person's back in the shoulder blade area to assist with obtaining head extension.
4. This position is held, and the examiner observes for nystagmus for up to 60 s.
   (a) Nystagmus is a rapid, rhythmic movement of the eyes and usually appears after a brief period and lasts less than 30 s.

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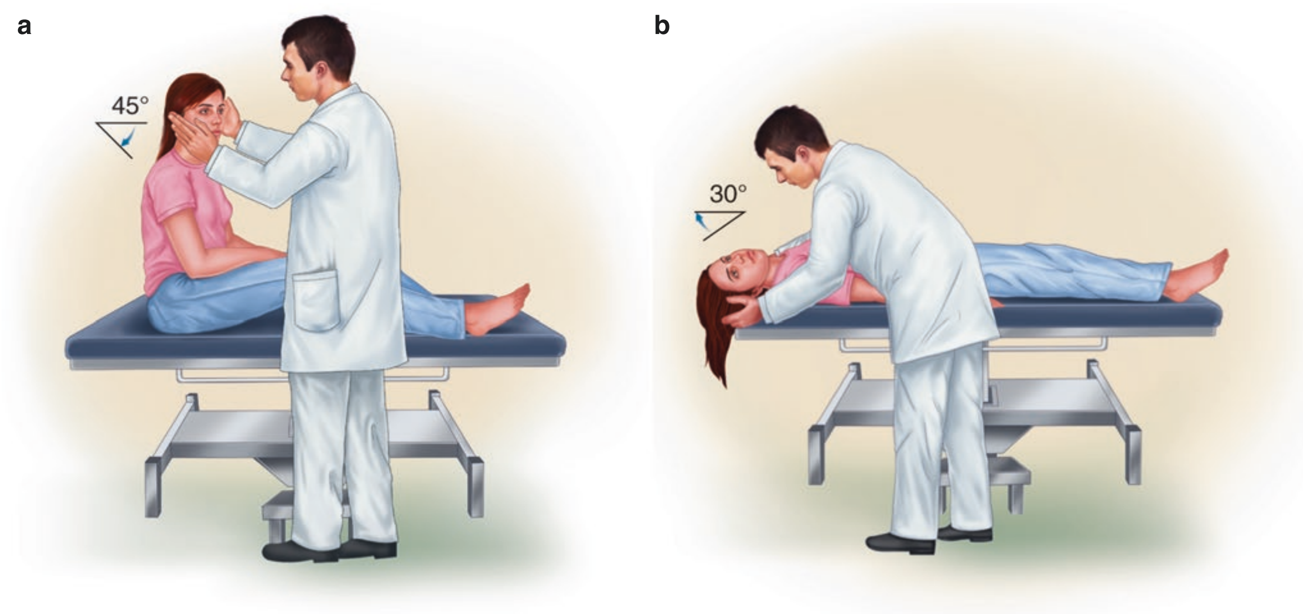

Fig. 46.1 (**a**) With the patient seated, the doctor will extend the neck, approximately 20°, and turn the head to one side, approximately 30–45°. (**b**) The physician then assists the patient by lowering the patient quickly into a supine position, so that the head hangs over the edge of the bed or table, with the neck in a hyperextended position

   (b) The direction of the nystagmus is usually up and twisted; therefore, the eyes will beat toward the ground.
   (c) If the patient becomes dizzy or the doctor sees nystagmus, the test is positive for the ear that is pointed to the floor.
5. The patient is then returned to the upright position and is again observed for nystagmus for 30 s.
6. If nystagmus is not provoked, the maneuver is repeated with the head turned to the opposite direction.
7. If nystagmus is provoked, the patient should have the maneuver repeated to the same side.
   (a) With each repetition, the intensity and duration of nystagmus should decrease.

Complications

- Vertigo.
- Nausea.

Pearls and Pitfalls

- The maneuver can be uncomfortable to the patient because it can cause vertigo and nausea.

Suggested Reading

Brandt T, Steddin S, Daroff RB. Therapy for benign paroxysmal positioning vertigo, revisited. Neurology. 1994;44:796–800.

Buckingham RA. Anatomical and theoretical observations on otolith repositioning for benign paroxysmal positional vertigo. Laryngoscope. 1999;109:717–22.

Fife TD, Iverson DJ, Lempert T, et al. Practice parameter: therapies for benign paroxysmal positional vertigo (evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology. 2008;70:69–74.

Halker RB, Barrs DM, Wellik KE, Wingerchuck DM, Demaerschalk BM. Establishing a diagnosis of benign paroxysmal positional vertigo through the Dix-Hallpike and side-lying maneuvers: a critically appraised topic. Neurologist. 2008;14:201–4.

Herdman SJ. Treatment of benign paroxysmal vertigo. Phys Ther. 1990;70:381–8.

Lanska DJ, Remler B. Benign paroxysmal positioning vertigo: classic descriptions, origins of the provocative positioning technique and conceptual developments. Neurology. 1997;48:1167–77.

Li JC, Meyers AD. Benign paroxysmal positional vertigo. http://emedicine.medscape.com/article/884261-overview . Accessed 20 Dec 2015.

Von Brevern M, Radtke A, Lezius F, et al. Epidemiology of benign paroxysmal positional vertigo: a population based study. J Neurol Neurosurg Psychiatry. 2007;78:710–5.

47 HINTS Exam for Evaluation of the Dizzy Patient

Nicholas Fusco and Ayanna Walker

The HINTS exam is used as a screening tool to help distinguish central causes from peripheral causes of acute vestibular syndrome (AVS). The exam consists of three components that can be completed quickly at the bedside. Compared to an MRI, a reassuring HINTS examination can rule out a stroke better in the first 24 to 48 hours after symptom onset with a specificity of 96% and a sensitivity of 100%.

Indications

- Patient actively experiencing vertigo.
- Symptom onset within 24–48 hours.

Contraindications

- Patient does not have symptoms during the administration of exam maneuvers.
- Head trauma.
- Neck trauma.
- Unstable cervical spine.
- Symptoms and history concerning for vertebral artery dissection.
- Patients with known carotid artery stenosis.

Materials and Medications

- The patient.
- The examiner.

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Procedure

Components of the HINTS examination include head impulse, nystagmus, and test of skew (Table 47.1).

Head Impulse

- With the patient sitting and facing you, have them focus on the tip of your nose.
- Make the patient aware that you will move their head from side to side in rapid motion and to relax their neck.
- Rotate the head to the right about 20 degrees and then rapidly back to midline.
- Repeat for the opposite side.
- Evaluate for a catch-up saccade where the eye is required to re-fixate on the object of focus (i.e., your nose).
- An abnormal test (positive catch-up saccade) indicates an issue with the vestibulocochlear nerve (a peripheral nerve) via the vestibulo-ocular reflex. This finding points to a peripheral cause of the patient's vertigo. This is a reassuring sign.
- If there is no catch-up saccade, this indicates that the vestibulocochlear nerve (a peripheral nerve) is intact and points toward a central cause of the patient's vertigo, a non-reassuring sign (Fig. 47.1).

Table 47.1 Examination findings

Reassuring (peripheral)	Non-reassuring (central)
Abnormal head impulse testing	Normal head impulse testing
No nystagmus or if present nystagmus is unidirectional only	Any other form of nystagmus besides unidirectional horizontal (i.e. rotary, bidirectional)
No skew deviation	Positive skew deviation

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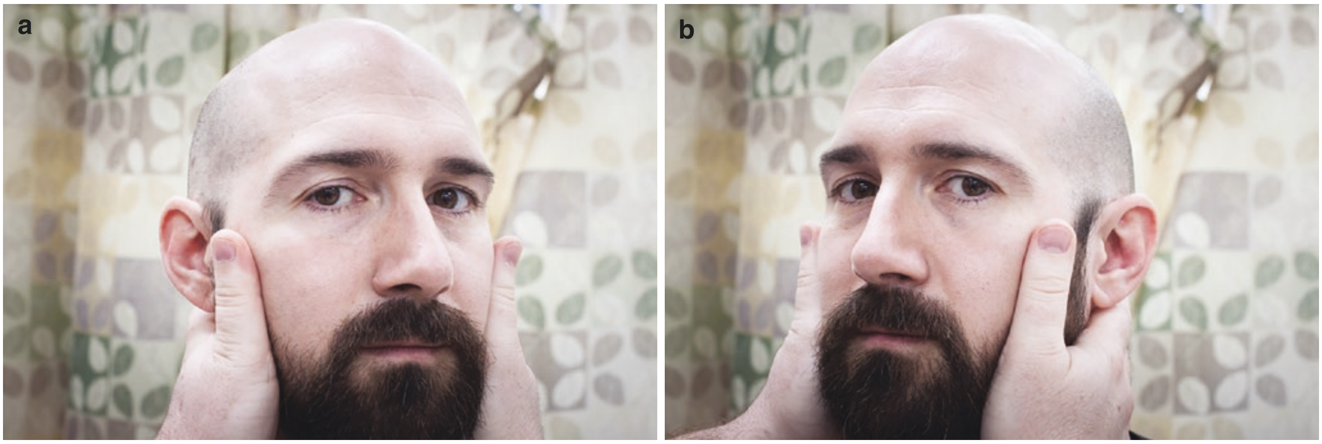

Fig. 47.1 (**a** and **b**) Test for head impulse. (Model: Adam Benzing, MD, with consent)

Fig. 47.2 Test for nystagmus. (Model: Adam Benzing, MD, with consent)

Nystagmus

- Hold your finger in front of the patient at midline.
- Move your finger to the right, having the patient follow your finger with their eyes only and keeping their head stationary.
- Have the patient look to the limit of their horizontal vision, hold your finger there, and observe for nystagmus.
- Repeat for the opposite side.
- No nystagmus or unidirectional horizontal beating nystagmus is a reassuring (peripheral) finding. Any other form of nystagmus or bidirectional beating nystagmus is a concerning (central) finding (Fig. 47.2).

Test of Skew

- Have the patient focus on the tip of your nose.
- Alternate covering each of the patient's eyes.
- Observe for any vertical re-fixation onto the object of focus during the uncover phase of the eye you are evaluating.
- No evidence of vertical re-fixation is a reassuring (peripheral) finding. Any evidence of vertical re-fixation is a non-reassuring (central) finding (Fig. 47.3).

For a video demonstration of the HINTS exam, please visit http://content.lib.utah.edu/cdm/singleitem/collection/ehsl-dent/id/6.

Pearls

- All reassuring findings must be present in order to use the HINTS exam to show the patient likely has a peripheral lesion causing symptoms.
- INFARCT (Impulse Normal, Fast-phase Alternating, Re-fixation on Cover Test) is an acronym advised by a prospective study on the HINTS exam used to remember the non-reassuring or concerning findings.
- The head impulse maneuver tests the vestibulocochlear nerve.
- Test of skew points to disorders of the brain stem.

Fig. 47.3 Test for skew (Model: Adam Benzing, MD, with consent)

Pitfalls

- Confirm that the patient is having active symptoms during the administration of the test; otherwise, the test is not valid.
- Based on a prospective study of the HINTS exam, this method is unable to evaluate patients with recurrent peripheral audiovestibular disease (Meniere's disease, otosclerosis, migrainous vertigo, etc.).

Suggested Reading

HINTS to diagnose stroke in the acute vestibular syndrome: three-step bedside oculomotor examination more sensitive than early MRI diffusion-weighted imaging https://www.ahajournals.org/doi/full/10.1161/strokeaha.109.551234.

LaPlant W, Parmar M. 2018, Jan 15. Vertigo: A hint on the HiNTS exam. [NUEM Blog. Expert Review By Chang P]. Retrieved from http://www.nuemblog.com/blog/hints.

Epley Maneuver for Vertigo (Particle Repositioning or Canalith Repositioning Procedure)

48

Rui B. Domingues and Muhammad Waseem

During the Dix-Hallpike test (see Chap. 46), the particles move in the canal and trigger a burst of upbeat-torsional nystagmus. The Epley maneuver causes resolution of positional nystagmus. This maneuver is effective in about 80% of patients with benign paroxysmal positional vertigo (BPPV). The differential diagnosis for peripheral vertigo includes BPPV, Meniere's disease, vestibular neuritis, labyrinthitis, acute otitis media, and trauma to the labyrinth. The differential diagnosis for central vertigo includes acoustic neuroma, meningitis, encephalitis, vertebrobasilar insufficiency, cerebellar hemorrhage, and temporal lobe epilepsy.

Indications

- Performed to alleviate the symptoms of posterior canal BPPV.

Contraindications

- Back or spine injuries or other problems.
- Presence of detached retina.

Materials and Medications

- Pillow or pad.
- Padded table or bed.

Procedure (Fig. 48.1)

1. The patient is positioned on the bed with the head slightly extended and turned 45° to the affected side; hold this position for 60 seconds.
   - The patient may hold the physician's arm for support.
2. The patient is then assisted by the physician to a supine position, with the head in extension, with a pillow or pad placed at the shoulder level allowing for extension; this position is held for a 60 seconds. This position will likely provoke transient dizziness and vertigo.
3. The head is then turned 90° to the opposite side; this position is held for 60 seconds. This position will likely provoke transient dizziness and vertigo.
4. The head is then turned through a further 90° while the patient rolls onto the unaffected side; this position is held for 60 seconds.
5. The patient then sits up slowly, by rolling up from lying on the unaffected side; this position is held for 60 seconds.
6. The patient should wait for 10 to 15 minutes before discharge.
7. Discharge instructions are then provided. Home instructions:
   - Instruct the patient to sleep in a semi-recumbent position for the next two nights; the patient should sleep at a 45° angle, which is most easily done by sleeping in a recliner or with several pillows arranged on a couch.
   - Sleep on the nonaffected side.
   - During the day, try to keep the head in a vertical position; no sudden head movements to the right, left, up, or down.
   - When men shave under their chins, they should bend their bodies forward in order to keep their heads vertical.
   - Do not go to the hairdresser or dentist because these require head movements.
   - Care should be taken when putting in eye drops because it requires head extension.
   - No vacuuming or mopping the floor.

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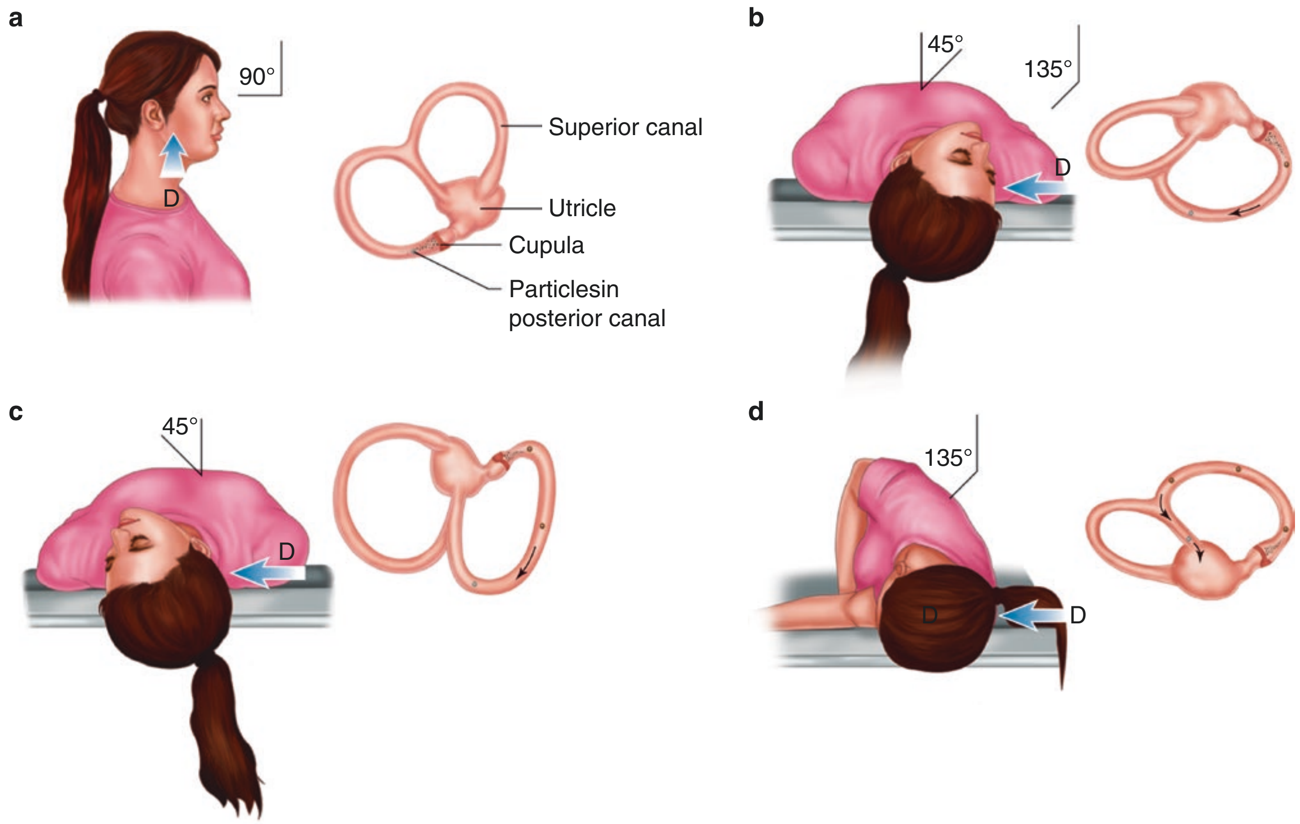

Fig. 48.1 (**a**) Patient seated on the table; (**b**) patient in supine position, with the head turned 45° to the affected side; (**c**) the head then turned to the unaffected side (45°), (**d**) the head turned additional 90° on the unaffected side. D—direction of view of labyrinth

- Try not to wear clothing that needs to be pulled over the head. Try to avoid bending down to tie shoes.

Complications

When performing the previous maneuver, caution is advised should neurological symptoms occur. Occasionally such symptoms are caused by compression of the vertebral arteries; if it persists for a long period of time, a stroke can occur.

Pearls and Pitfalls

- Pearls
  – This maneuver should initially be performed by a physician or trained therapist.
  – It is best to perform the Epley maneuver before going to bed at night.
  – There are several variations that can be performed by the patient at home following demonstration by the physician or therapist.
- Pitfalls
  – The patient should not drive herself or himself home after the procedure.
  – Avoid rapid changes in head position that might provoke BPPV.

Suggested Reading

Gebhart I, Götting C, Hool SL, Morrison M, Korda A, Caversaccio M, et al. Sémont maneuver for benign paroxysmal positional vertigo treatment: moving in the correct plane matters. Otol Neurotol. 2021;42(3):e341–7.

Jiang X, He L, Gai Y, Jia C, Li W, Hu S, et al. Risk factors for residual dizziness in patients successfully treated for unilateral benign posterior semicircular canal paroxysmal positional vertigo. J Int Med Res. 2020;48(12):300060520973093.

Lee CJ, Lee CY, Wu PH, Wang CH, Chen HC, Shih CP. Efficacy of combined canalith-repositioning procedure and supine to prolonged lateral position in treating posterior canal benign paroxysmal positional vertigo. Auris Nasus Larynx. 2021;S0385–8146(21):00027–4.

Nguyen CT, Basso M. Epley maneuver. 2020 Oct 1. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.

Sachdeva K, Sao T. The clinical response time of Epley maneuvers for treatment of BPPV: a hospital based study. Indian J Otolaryngol Head Neck Surg. 2020;72(4):503–7.

49 Clinical Brain Death Examination in Adults

Ilya Aleksandrovskiy, Eric S. Papierniak,
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and Deborah M. Stein

Indications

- Deep coma without any identifiable reversible conditions that may mimic brain death.
- Suspected brain death in a mechanically ventilated patient.

Contraindications

- Metabolic derangements.
- Neuromuscular paralysis, such as in severe and acute polyneuropathies such as Guillain-Barre syndrome.
- Acid-base disorders.
- Electrolyte abnormalities sufficient to cause the coma.
- Profound hypotension.
- Hypothermia (core body temperature < 36 °C).
- Drug overdose or toxic exposure.
- Locked-in syndrome.
- Cervical spine injury in oculocephalic testing.
- Tympanic perforation or impacted external auditory canal in oculovestibular testing.

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Materials and Medications

- A bright light.
- Intravenous (IV) catheter.
- 30-mL syringe
- 50-mL of ice water
- Endotracheal suction catheter.
- Long swab or tongue depressor.
- 4 × 4 Gauze or saline eye drops.

Procedure

1. Evaluate the Motor Response to Pain
   - Apply pressure to the supraorbital nerve and nail beds. No motor response is consistent with brain death (Figs. 49.1 and 49.2).
2. Test for the Absence of Brainstem Function
   - Check pupillary light reflex using a bright light. Persistently dilated pupils imply brain death.
   - Check the oculocephalic reflex. With the eyelids held open, quickly turn the head to the side. The normal response is for the eyes to move in the opposite direction, maintaining the focus forward. Failure of the eyes to deviate during head rotation is consistent with brain death (Fig. 49.3).
   - Check the oculovestibular reflex with cold caloric testing. Elevate the head of the bed to 30°. Attach an IV catheter to the tip of a 30-mL syringe. Inject 50 mL of cold water into the external ear canal. Observe the pupils for 1 minute for deviation toward the ear with the cold stimulus. Wait 5 minutes before testing the other side. No deviation of the pupils is consistent with brain death (Figs. 49.4 and 49.5).
   - Check for bulbar paralysis.
     – Check for a cough response to bronchial or tracheal suctioning.
     – Stimulate the posterior pharynx with a long swab or tongue depressor and observe for a gag.

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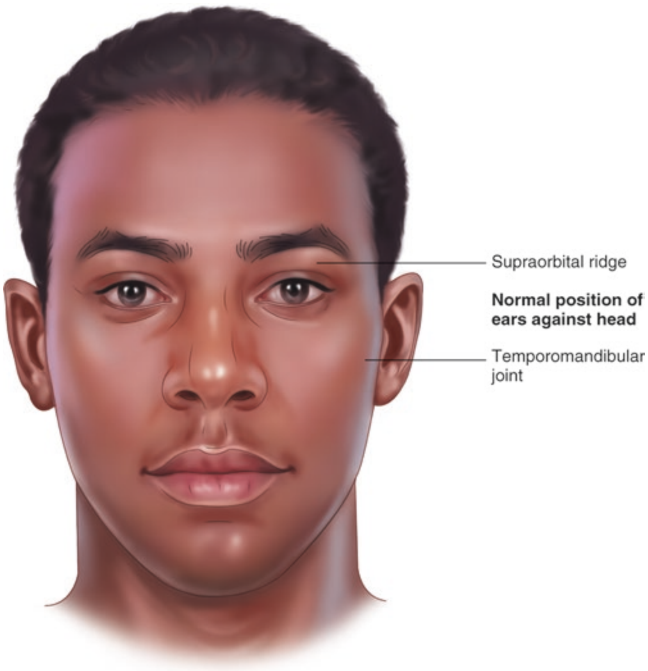

Fig. 49.1 Motor response to pain 1. Temporomandibular joint and supraorbital ridge test supraorbital nerve function

Fig. 49.2 Motor response to pain 2: firm pressure can be applied to the nail beds with a penlight or similar instrument

– Check the corneal reflex by lightly touching the cornea with a cotton swab, corner of gauze, or drops of sterile saline, and observe for blinking of the eyelids (Fig. 49.6).

3. Check for respiratory effort by performing an apnea test. Before starting the apnea test, the following conditions must be met:
   (a) The patient must not be hypothermic. The core temperature must be greater than 36 °C.
   (b) The patient must be hemodynamically stable with a systolic blood pressure greater than 100 mm Hg.
   (c) The arterial blood gas (ABG) must demonstrate a normal arterial partial pressure of carbon dioxide ($PaCO_2$). The arterial partial pressure of oxygen (PaO_2) may be elevated with preoxygenation to minimize the risk of hypoxemia prematurely ending the examination.
   - Monitor the patient with a pulse oximeter.
     – Disconnect the ventilator, and deliver oxygen at 6 L/min by cannula into the endotracheal tube.
     – Alternately the patient can remain connected to the ventilator with no applied support, which allows for an in-line negative pressure monitor to be attached to the circuit. Note: Most ventilators are too sensitive to be used as the sole method of sensing respiratory effort as they can produce false-negative results.
     – Watch the chest and abdomen for respiratory motion, or monitor for negative inspiratory force on the pressure gauge. Check an ABG every 10 minutes and when the test ends.
     – If the $PaCO_2$ increases by 20 mm Hg or the $PaCO_2$ is greater than 60 mm Hg and there was no respiratory effort, the test is consistent with brain death.
     – The test must be aborted and the patient reconnected to mechanical ventilation if the patient becomes hypotensive, desaturates, or develops cardiac arrhythmias.
     – If there is respiratory effort, the patient must be reconnected to mechanical ventilation (Figs. 49.7 and 49.8).

Pearls and Pitfalls

- Pearls
  – The clinical examination should be performed by someone with experience or training in brain death examinations. Local regulations as well as hospital policies should be reviewed in order to determine the requirements for brain death. Some locales require a repeat examination by a different practitioner.
  – A patient with a cervical spine injury causing quadriplegia may not feel nail bed pressure and may be unable to respond to pain with more than facial movements.
- Pitfalls
  – Pupillary constriction less than 3 mm is not consistent with brain death.

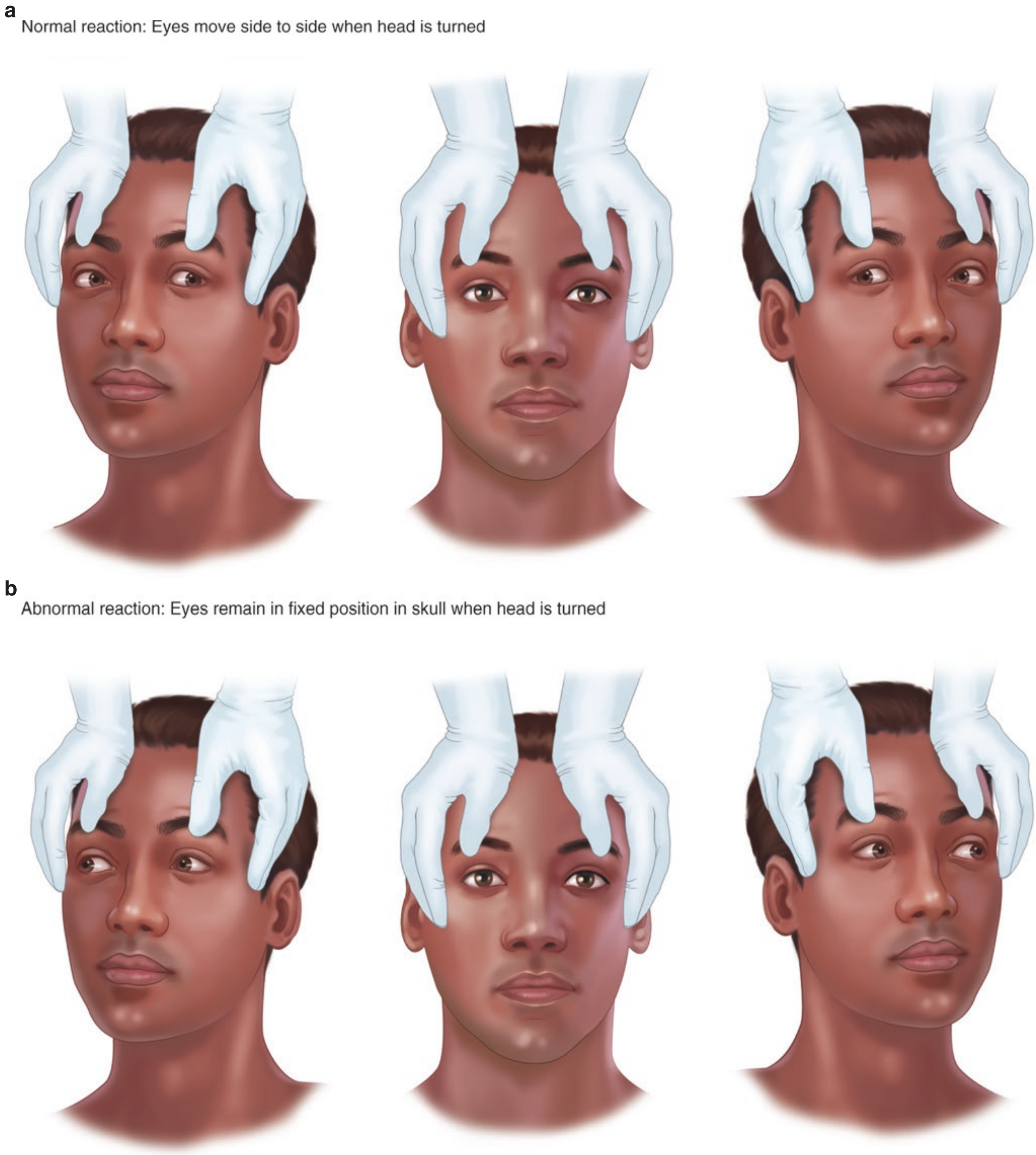

Fig. 49.3 (**a** and **b**) Oculocephalic reflex or "doll's eyes." Movement of the eyes away from the direction of head turning (i.e., to keep the gaze forward) indicates intact functioning

Fig. 49.4 Preparation of cold saline for testing of the oculovestibular reflex or "cold calorics"

- Do not test oculocephalic reflex (doll's eyes) on patients who may have a cervical spinal cord injury from trauma.
- Do not test the oculovestibular reflex with cold caloric testing in patients with a ruptured tympanic membrane.
- A large number of patients may demonstrate spinal reflex movements during brain death. These reflexes may be triggered by touch, noxious stimuli, or removal of the ventilator. These movements can include plantar flexion, upper extremity posturing, eye opening, and the "Lazarus sign" (the arms raise off the bed and cross). Although these movements can be disconcerting to the health care team and family, they do not preclude a diagnosis of brain death.

Controversies

- Repeat examinations.
  - The American Academy of Neurology guidelines recommend repeating the brain death examination at 6 hours. The guidelines acknowledge that this is an arbitrary interval. Recent evidence suggests that the second examination may be unnecessary.
- Confirmatory testing.
  - Confirmatory testing is an option if specific elements of the clinical examination cannot be performed. For

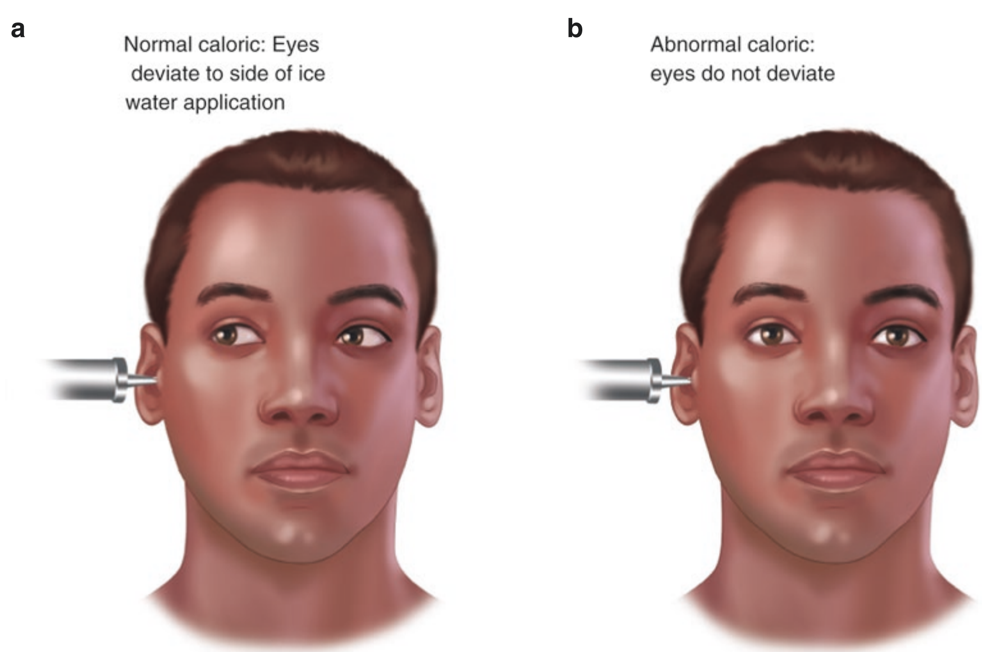

Fig. 49.5 (**a** and **b**) Oculovestibular reflex. Intact functioning is demonstrated by deviation of the gaze toward the side being tested

Fig. 49.6 The use of a cotton ball or unwound tip of a cotton swab for testing of the corneal reflex. A piece of sterile gauze ("4x4") is also commonly used

Fig. 49.8 Ventilator waveform in a patient without spontaneous respirations during the apnea test

Fig. 49.7 Ventilator waveform before apnea test

Fig. 49.9 "Empty skull sign" on nuclear medicine flow study confirms brain death

example, a trauma patient with suspected cervical spinal cord injuries precluding the oculocephalic reflex test would be a candidate for confirmatory testing.

– Conventional cerebral angiography is the traditional gold standard and will demonstrate absent filling at or beyond the carotid bifurcation or within the circle of Willis. Electroencephalography demonstrates no electrical activity. Transcranial Doppler ultrasonography will demonstrate vascular resistance associated with elevated intracranial pressure. Technetium-99 m hexamethylpropylene-amineoxime brain scans demonstrate the "hollow skull" sign or no uptake of isotope in the brain (Fig. 49.9).
– Newer modalities of confirmatory testing include computed tomography (CT) angiography and magnetic resonance imaging/magnetic resonance angiography (MRI/MRA). These tests are being used in some hospitals; however, the recent review by the American

Academy of Neurology finds evidence insufficient to recommend using these newer modalities to confirm brain death.

Suggested Reading

Greer DM, Shemie SD, Lewis A, et al. Determination of brain death/death by neurologic criteria: the world brain death project. JAMA. 2020;324(11):1078–97. https://doi.org/10.1001/jama.2020.11586.

Lustbader D, O'Hara D, Wijdicks EF, et al. Second brain death examination may negatively affect organ donation. Neurology. 2011;76:119–24.

Practice parameters for determining brain death in adults (summary statement). The Quality Standards Subcommittee of the American Academy of Neurology. Neurology. 1995;47:1012–4.

Saposnik G, Maurino J, Saizar R, Bueri JA. Spontaneous and reflex movements in 107 patients with brain death. Am J Med. 2005;118:311–4.

Wijdicks EF. Current concepts: the diagnosis of brain death. N Engl J Med. 2001;344:1215–21.

Wijdicks EF, Varelas PN, Gronseth GS, Greer DM. American Academy of Neurology. Evidence-based guideline update: determining brain death in adults: report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology. 2010;74:1911–8.

Ventriculoperitoneal Shunt Tap

50

Aaron Umansky, Samyr Elbadri, and Bobby K. Desai

Ventriculoperitoneal (VP) shunts are used to drain excess CSF from the brain in order to prevent elevation of intracranial pressure. There are several complications that can occur with VP shunts. These include breaks or kinks (most common in the neck), dislodgement, leakage, and overdrainage. This is especially a concern in children, whose physical growth can additionally contribute to these complications. Figure 50.1 summarizes causes of VP shunt malfunction.

Indications

- Relieve severely elevated intracranial pressure (emergent indication).
- Investigate for infection (ventriculitis, meningitis).

Contraindications

- Infection over the site of entry.
- Bleeding disorder due to coagulopathy.
- Lack of information regarding shunt design or reservoir location.

Materials and Medications (Fig. 50.2)

- Sterile gloves and drapes.
- Chlorhexidine solution or 4x4 with povidone-iodine solution.
- 25-gauge butterfly needle
- 3 or 5 cc syringe
- Sterile culture tubes.
- Gauze.
- Wound dressing.
- Consent forms.

Procedure

1. Consult neurosurgery.
2. Determine the type of shunt valve present and palpate the reservoir (Fig. 50.3). Be sure to review imaging.
3. Perform time-out.
4. Place patient in supine position with VP shunt reservoir facing up.
5. Clear area over reservoir of hair. Use razor to shave area if necessary.
6. Prep skin over reservoir site with chlorhexidine solution or povidone-iodine solution. Apply sterile drapes.
7. Attach tubing of 25-G needle to three-way stopcock and manometer. Manometer should be at level of patient's ear.
8. Insert butterfly needle perpendicular or at 45-degree angle into reservoir, and advance until bevel is fully inside reservoir (Fig. 50.4).
9. While holding needle securely in place, observe spontaneous flow into tubing. If manometer is present, use to measure opening pressure (Fig. 50.5).
10. Slowly collect 5 cc of CSF into separate culture tubes.
11. Withdraw needle from reservoir and apply gentle pressure of entry site with gauze.
12. Send CSF for Gram stain, cell count with differential, culture, protein, and glucose.

Complications

- Leakage of CSF or bleeding at the puncture site.
- Introduction of infection.
- Malfunction of the valve mechanism.

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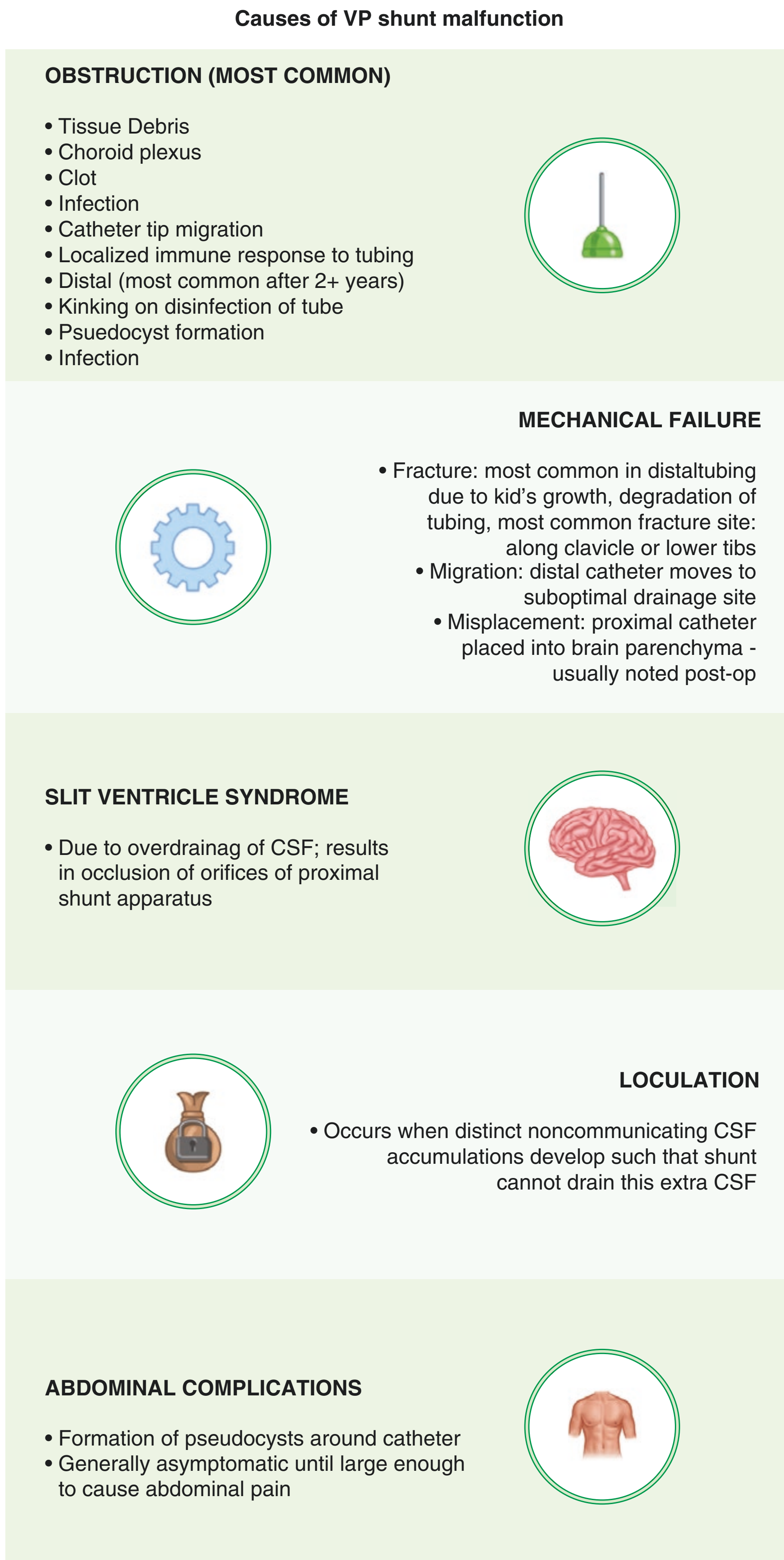

Fig. 50.1 Causes of VP shunt malfunction [1]

Fig. 50.2 VP shunt tap equipment

- Congestion of the shunt system with clots.
- Collapse of the ventricles due to rapid aspiration of the CSF.
- Subdural hematoma due to ventricular collapse.

Pearls and Pitfalls

- Strict aseptic technique is essential, as introducing infection may result in shunt replacement.
- A shunt tap should only be considered after performing CT or MRI and shunt series imaging.
- Note that brain CT can be negative and the skull radiograph positive for VP shunt malfunction and thus is recommended not to forego the skull radiographs.
- Manometry and documentation of the flow rate are important. High opening CSF pressure (>25 cm H2O above the level of the ventricle) is associated with distal shunt obstruction in approx. 90% of cases. Poor flow is associated with proximal shunt obstruction in 90% of cases) [2–5].

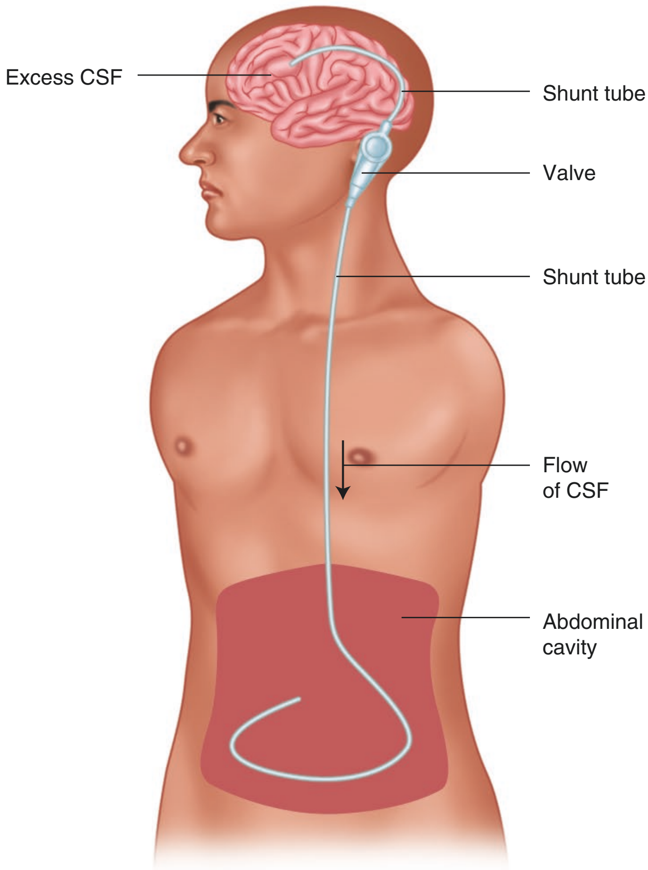

Fig. 50.3 Trajectory of a VP shunt

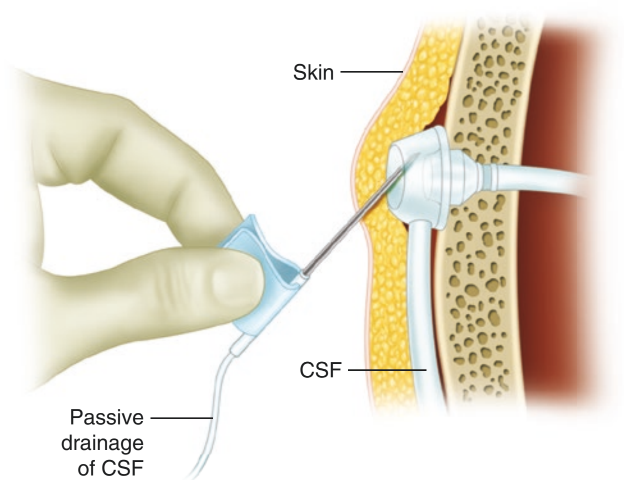

Fig. 50.4 Placement of butterfly needle at a 45-degree angle to shunt

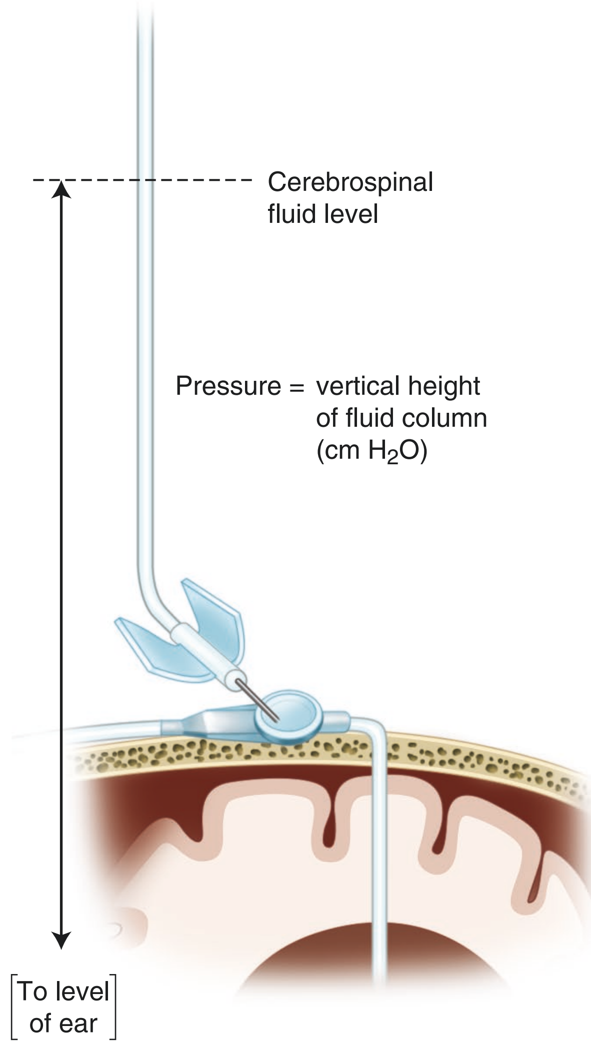

Fig. 50.5 Measuring opening pressure in a VP shunt tap

Suggested Reading

Ferras M, Mccauley N, Stead T, et al. Ventriculoperitoneal shunts in the emergency department: a review. Cureus. 2020;12(2):e6857. https://doi.org/10.7759/cureus.6857.

Murphy A, et al. Shunt Series. https://radiopaedia.org/articles/shunt-series. Accessed 10 Nov 2020.

Roepke C, et al. The lowdown on ventriculoperitoneal shunts. Annals Emerg Med. 2016;67(3):414–6.

Sood S, Kim S, Ham SD, Canady AI, Greninger N. Useful components of the shunt tap test for evaluation of shunt malfunction. Childs Nerv Syst. 1993;9(3):157–61; discussion 162.

Spiegelman L, Asija R, Da Silva SL, Krieger MD, McComb JG. What is the risk of infecting a cerebrospinal fluid-diverting shunt with percutaneous tapping? J Neurosurg Pediatr. 2014;14(4):336–9.

51 Occipital Nerve Block for Migraine

Latha Ganti

Indications

- To alleviate acute or chronic refractory headache.

Contraindications

- Posterior fossa craniotomy.
- Skull base abnormalities (increases risk of injecting into wrong spot).
- Allergy to anesthetic or corticosteroid agent.

Materials and Medications (Table 51.1)

- 3–5 cc syringe.
- 25–30 G needle (0.5 to 1.0 inches long).
- Povidone iodine skin prep.
- Anesthetic agent: 1–2% lidocaine without epinephrine and/or 0.25–0.50% bupivacaine.
- Optional steroid such as triamcinolone (5–40 mg), methylprednisolone (20–160 mg), dexamethasone (4 mg), or betamethasone (18 mg).
- NSAIDs should not be used for occipital nerve blocks.

Procedure (Fig. 51.1)

1. Prepare mixture: If using mixture of both lidocaine and bupivacaine, then ratio should be 1:1, 1:2, or 1:3. Volume should be 1.5–3.0 ml per nerve block.
2. If using corticosteroid as well, easy rule of thumb is 1 ml anesthetic +1 ml corticosteroid.
3. Patient should be positioned comfortably in either the sitting or prone position with head flexed forward.
4. The greater occipital nerve (GON) can be located by drawing an imaginary line from the occipital protuberance (OP) to the mastoid process. The GON is 1/3 the distance from the OP. Note the greater occipital artery runs medical to the nerve, so care must be taken not to perform an intra-arterial injection.
5. The lesser occipital nerve (LON) is located along the same line but 2/3 distance from the OP.
6. Consider ultrasound-guided localization of GON/LON if available.
7. Create sterile field using povidone iodine skin prep.
8. Insert the needle to a depth of 3–4 mm.
9. Withdraw the needle slightly, and pull the plunger to verify that the needle is not within a blood vessel.
10. Inject in a single injection or use a fan-like distribution.
11. Patients will experience relief approximately 15 minutes after injection.

Complications

- Corticosteroid injection can cause both local and systemic complications such as myotoxicity at the site of injection, alopecia, cutaneous atrophy, hyperpigmentation, and Cushing's syndrome, especially with frequent injections at high doses of the drug. Additional caution should be used for patients with diabetes and glaucoma and pregnant patients.

Pearls and Pitfalls

- Pearls
  - Patients generally obtain headache relief for days to weeks from procedure.
  - Addition of bupivacaine to lidocaine prolongs duration of analgesia.
  - In the emergency department setting, GON and LON blocks are best limited to lidocaine/bupivacaine injections only, without corticosteroid.

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Table 51.1 Drugs used for occipital nerve blocks

Drug	Class	Half-life (hrs)	Dose	Volume
Lidocaine 1–2%	Anesthetic	1.5–2.5	10 mg	1 ml
Bupivacaine 0.25–0.5%	Anesthetic	2.7	5 mg	1 ml
Triamcinolone	Corticosteroid	18–36	40 mg	1 ml
Methylprednisolone	Corticosteroid	18–36	20–160 mg	40 mg = 1 ml, 125 mg = 2 ml
Dexamethasone	Corticosteroid	36–54	4 mg	1 ml
Betamethasone	Corticosteroid	36–54	18 mg	3 ml

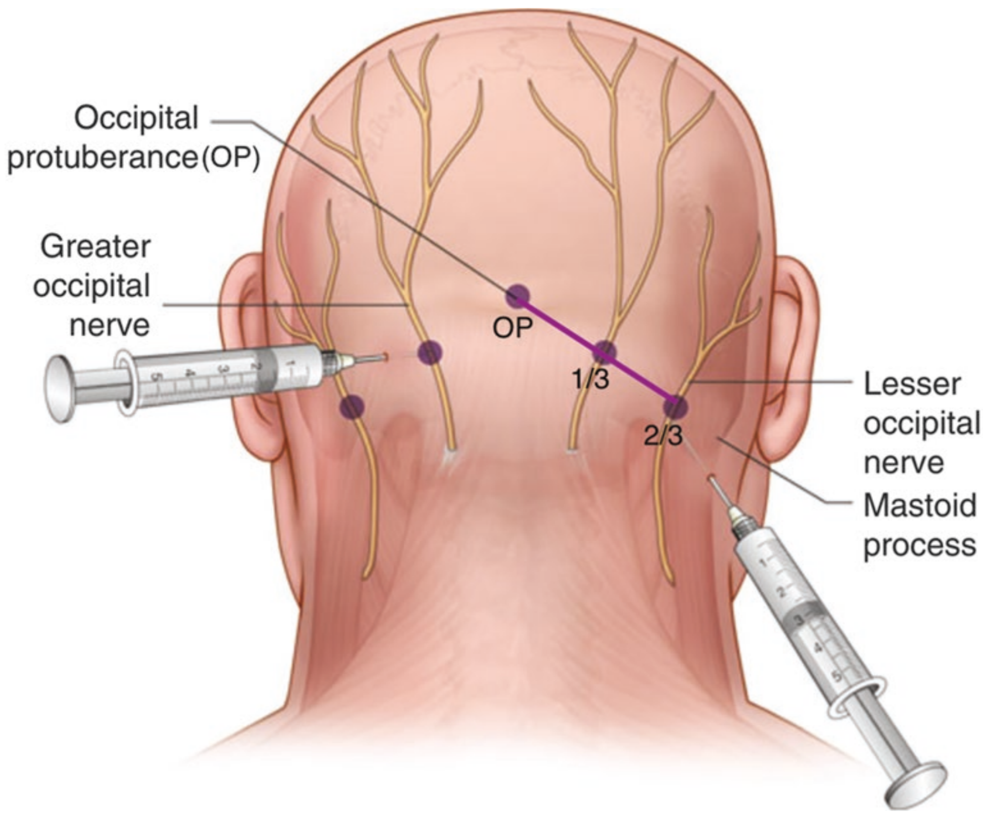

Fig. 51.1 Note purple line from occipital protuberance (OP) to mastoid. 1/3 distance from OP along this line is the injection site for the greater occipital nerve. 2/3 from the OP is the injection site for the lesser occipital nerve. (Modified from Mays and Tepper [1]; with permission)

  – Have patient lie down (rather than sit up) if prone to syncope.
  – In elderly patients with hypertension, consider only unilateral block.
- Pitfalls
  – Neuroimaging should be performed before proceeding with GON/LON injection if there is any suggestion of past neurosurgical intervention.
  – Caution in patients who have unique anatomic considerations such as Arnold Chiari malformation.
  – Lidocaine (pregnancy category B) preferred in pregnant patients over bupivacaine (pregnancy category C).
  – Caution with any corticosteroid use in pregnancy, all are category C.

References

1. Mays MA, Tepper SJ. Occipital nerve blocks. In: Narouze S, editor. Interventional management of head and face pain. New York: Springer; 2014.

Suggested Reading

Caponnetto V, Ornello R, Frattale I, Di Felice C, Pistoia F, Lancia L, et al. Efficacy and safety of greater occipital nerve block for the treatment of cervicogenic headache: a systematic review. Expert Rev Neurother. 2021;12

Ornello R, Lambru G, Caponnetto V, Frattale I, Di Felice C, Pistoia F, Sacco S. Efficacy and safety of greater occipital nerve block for the treatment of cluster headache: a systematic review and meta-analysis. Expert Rev Neurother. 2020;20(11):1157–67.

Pincherle A, Bolyn S. Cerebellar syndrome after occipital nerve block: a case report. Cephalalgia. 2020;40(10):1123–6.

Blumenfeld A, Ashkenazi A, Napchan U, Bender SD, Klein BC, Berliner R, et al. Expert consensus recommendations for the performance of peripheral nerve blocks for headaches--a narrative review. Headache. 2013;53(3):437–46.

52 Sphenopalatine Ganglion Block

Thor Stead and Cherian Plamoottil

Indications

The sphenopalatine ganglion (SPG) is a nerve that propagates parasympathetic signals, such as nausea, emesis, and lacrimation, which are often observed with migraines. The SPG block can be used as a "rescue procedure" to alleviate headache disorder symptoms, especially in cases where IV access is difficult. The procedure can be used to treat acute migraine headaches, cluster headaches, and trigeminal neuralgia.

Contraindications

- Allergy to local anesthetics.
- Patient has altered mental status.
- Patient has an infection in the intranasal canal.

Materials and Medications

- 10 cm cotton-tipped applicator
- 3 mL syringe connected to angiocath without a needle
- Small container to hold the anesthetic.
- (Optional) atomizer
- Anesthetic to numb the nasal canal:
  - 1 mL viscous lidocaine 2% (without atomizer)
  - 2 mL viscous lidocaine 1% (with atomizer)
- Anesthetic for SPG block:
  - Lidocaine 1%, 2%, or 4% (onset, 15 minutes; duration, 30 minutes–2 hours).
  - Bupivacaine 0.25% or 0.5% (onset, 10–20 minutes; duration, 2–4 hours).

Procedure

- Have the patient lie supine, and tilt the head up so the nostrils are easily accessible (Fig. 52.1).
- Using the angiocath connected to the 3 mL syringe, anesthetize the nasal passage by injecting 0.5 mL of 2% viscous lidocaine into each nostril and asking the patient to sniff, thereby applying anesthetic to the posterior area.
  - Alternatively, an atomizer can be used to aerosolize and administer 1 mL of 1% lidocaine per nostril.
- After allowing the anesthetic to take effect, soak the cotton-tipped applicator in either lidocaine or bupivacaine.
- Slowly move the applicator through the left nostril and middle turbinate until the applicator contacts the mucosa atop the SPG (Fig. 52.1). Leave the applicator in place, and repeat the procedure on the right nostril.
  - The applicators can be left in that position for 10 minutes or until the patient reports relief from symptoms.
- Gently remove the applicators.

Pitfalls and Complications

- Nausea.
- Trauma to the nasal canal resulting in epistaxis.
- Light headedness.
- Numbness in the throat (pharynx).
- Resultant hypotension.

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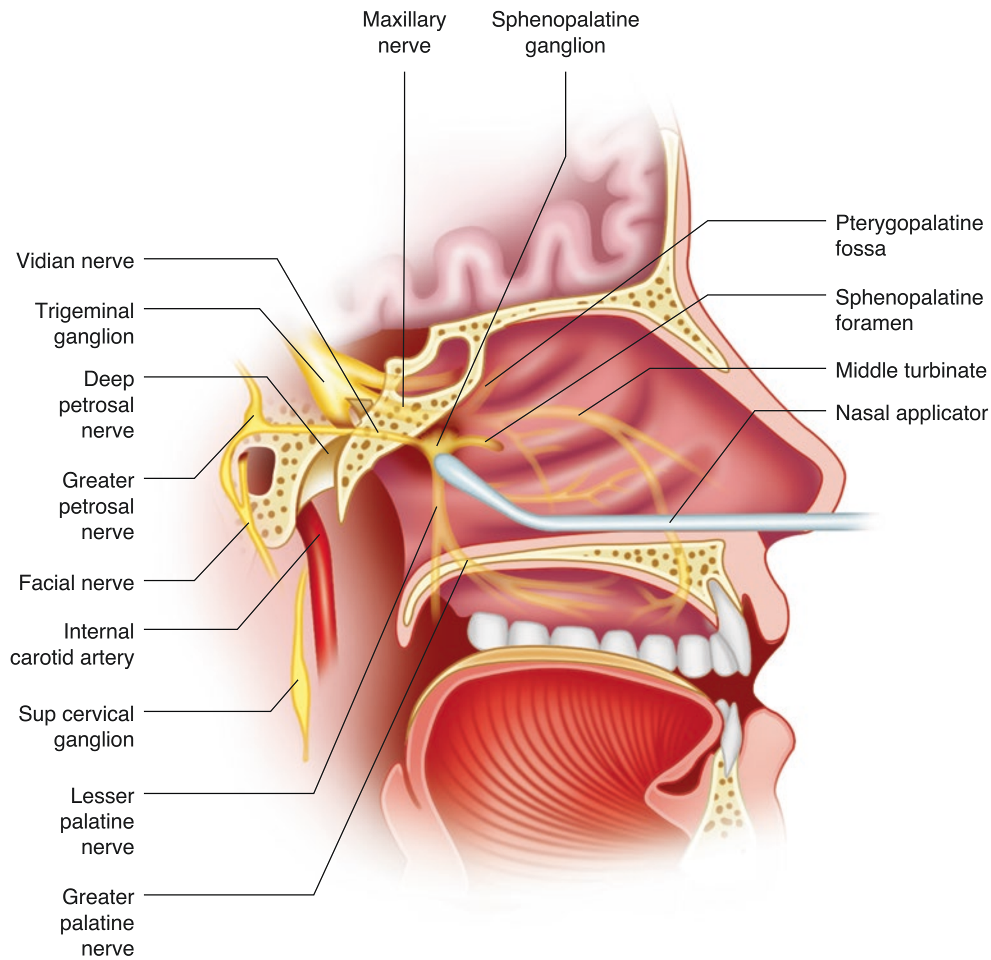

Fig. 52.1 Location of SPG and procedure schematic

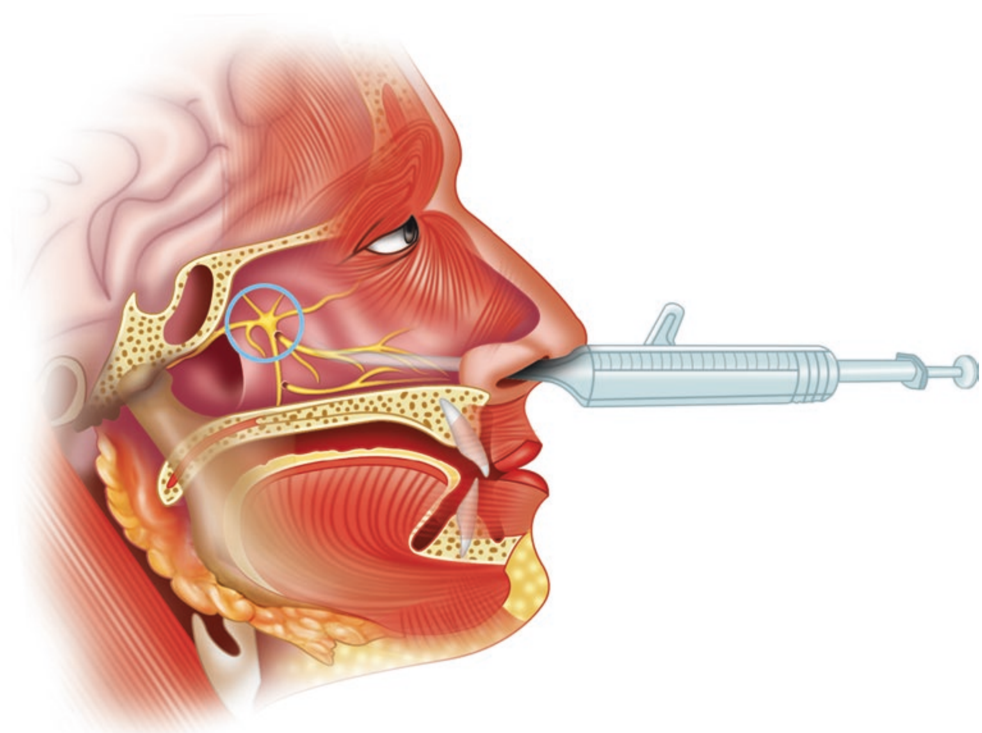

Fig. 52.2 The tip of the applicator should contact the mucosa atop the SPG

Suggested Reading

Binfalah M, Alghawi E, Shosha E, Alhilly A, Bakhiet M. Sphenopalatine ganglion block for the treatment of acute migraine headache. Pain Res Treatment. 2018;2018:1–6. https://doi.org/10.1155/2018/2516953.

Gadsden J. Local anesthetics: clinical pharmacology and rational selection. In: Hadzic's Peripheral Nerve Blocks and Anatomy for Ultrasound-Guided Regional Anesthesia, 2nd. McGraw-Hill, New York, NY.

MAP: Sphenopalatine Ganglion Block. https://www.acep.org/patient-care/map/map-sphenopalatine-ganglion-block-tool. Accessed 4 May 2021.

Viguri A, Perez YP. (2020, March 2). Migraine Care: Why and How to Block the Sphenopalatine Ganglion Nerve. https://www.acepnow.com/article/migraine-care-why-and-how-to-block-the-sphenopalatine-ganglion-nerve. Accessed 4 May 2021.

Part VII

Ophthalmic Procedures

53 Slit Lamp Examination

Bobby K. Desai

Indications

- A slit lamp magnifies structures of the eye (Fig. 53.1).
- Gives the operator a three-dimensional view of the area visualized.
- Used to delineate abnormalities that cannot be visualized by other means.
- Helpful in foreign body removal.

Contraindications

- Not to be used in patients who cannot tolerate an upright posture (e.g., trauma patients).
  - In these cases, if a slit lamp examination is required, a portable slit lamp may be beneficial (Fig. 53.2).

Materials

- The slit lamp is an eye-specific binocular stereoscope specifically designed to examine the eye and its structures and gives the practitioner a three-dimensional assessment of the eye.
- The operator has full movement of the microscope in all directions, and the apparatus can be locked in place if required.
- Its light source can be manipulated to change the characteristics of the beam from its intensity to the angle at which it projects (Fig. 53.3).
  - A low-power setting is typically used for normal examination.
  - A higher-intensity beam is used when evaluating the anterior chamber with a narrow slit beam.

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It has colored filters typically built within the slit lamp.

- Cobalt blue: Used with fluorescein dye to evaluate for corneal abrasions and avulsions; the dye will collect where the corneal epithelium is absent. It results in a yellow glow or hue visible through the microscope.
- Green filter: Used to increase contrast of blood vessels. They appear black and the filter is useful for the assessment of hemorrhage.

- The operator is able to adjust the magnification of the microscope typically through dial controls.
  - Low magnifications are most helpful for general examination.
  - Higher magnifications are used for examination of a particular area in fine detail.

Procedure

1. As part of a complete eye examination, informed consent is not generally required.
2. An explanation of the procedure and reassurance are helpful.
3. Lock the slit lamp before positioning the patient because unintended movement may inadvertently damage the equipment or cause injury to the operator or patient.
4. The apparatus has a chin and a head rest. Ask the patient to place the chin and forehead in the respective areas (Fig. 53.4).
5. Adjust the height of the apparatus and the patient's chair for optimum comfort (Figs. 53.5 and 53.6). It may be necessary for children to stand during the examination.
6. The patient may place his or her hands on the sides of the table that the lamp is mounted on; this ensures stability of both the lamp and the patient.
7. Adjust the eyepieces of the microscope to fit the operator.
8. Turn on the slit lamp at its lowest setting to avoid a sudden power surge that could potentially damage the bulb.

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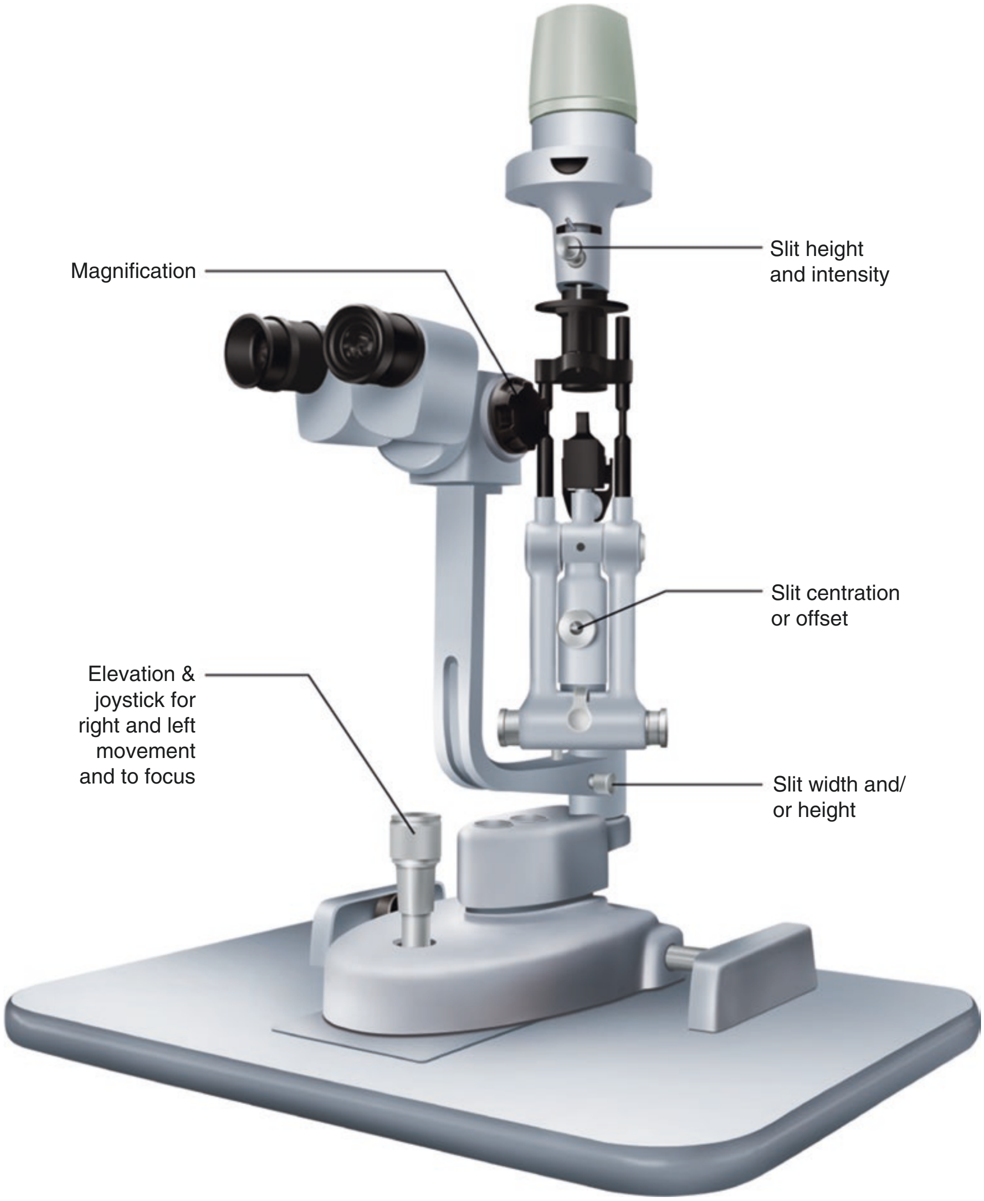
Fig. 53.1 A basic slit lamp



9. Move the stage forward and narrow the beam and angle it at 45° to the patient. Aim the beam laterally so as not to cause the patient discomfort.
10. Focus the beam by manipulating the joystick to move the apparatus forward and backward so that the beam is clearly visible and its lines are sharp.
11. For each area of the eye to be examined, inspect the area thoroughly using the joystick to slowly manipulate the slit lamp across the eye in all directions, using the height adjustment of the joystick to slightly raise and lower the slit lamp as needed.
    - The operator may find that the slit lamp may move too freely; in that case, she or he may find slightly tightening the locking nut of the C-arm may provide better and more precise control.

Complications

There are no complications following routine slit lamp examination.

Pitfalls

- Ensure a working bulb.
- Appropriately set the microscope's oculars for the operator's pupillary distance.
- Ensure all dials and knobs are firmly set.
- Inadequate focusing.
- Patient noncompliance.

Fig. 53.2 A portable slit lamp

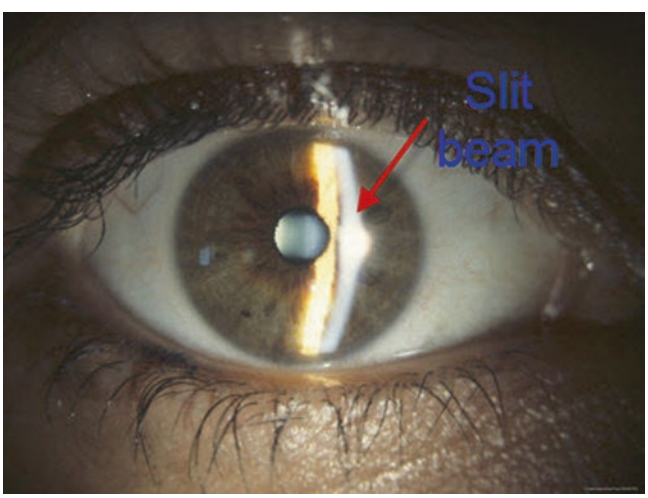


Fig. 53.3 The slit lamp beam and the reflection of the beam

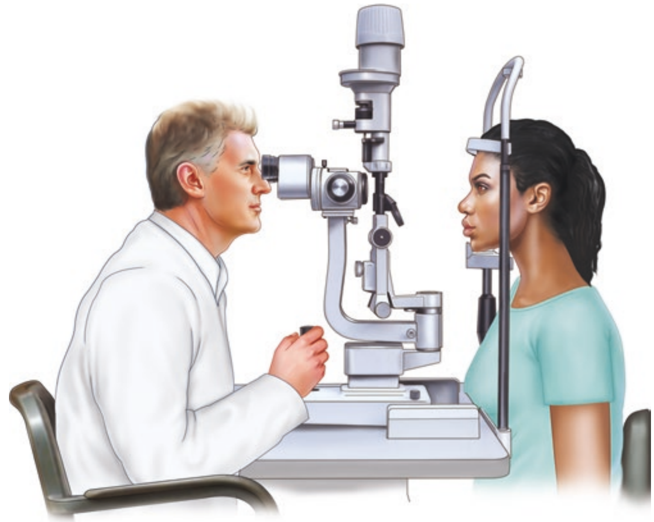


Fig. 53.4 Appropriate positioning for a slit lamp examination

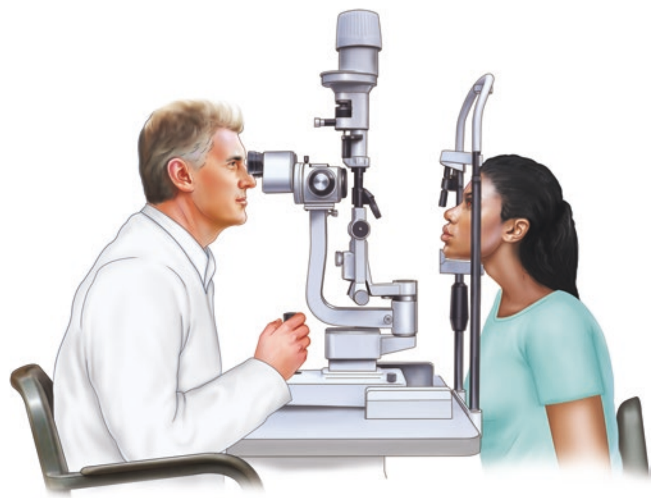


Fig. 53.5 The slit lamp is too high

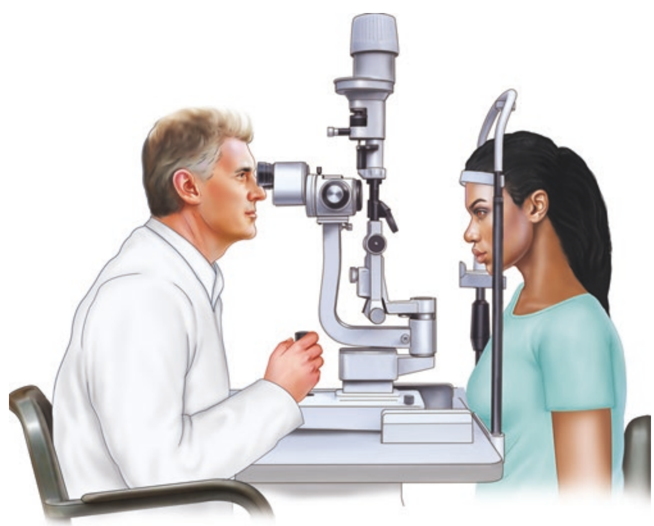


Fig. 53.6 The slit lamp is too low

Fluorescein Testing

Indications and Uses

- Examination of the cornea under a cobalt blue filter on a slit lamp or Wood's lamp: The chemical fluoresces under blue light and appears green under these circumstances.
- Useful for detecting corneal abrasions, corneal foreign bodies, and infections of the eye.

Procedure

- Fluorescein is typically used after installation of a topical anesthetic, which provides patient comfort especially for those with significant pathology.
- The fluorescein strip comes packaged in single-use wrappers (Fig. 53.7).
- Hold the strip by the white end, and wet the orange end *lightly* because heavily moistening the strip may cause a significant amount of dye to be present, obscuring the examination.
  – A dry strip may be used, but it may irritate the patient's eye especially if already sensitive.
- If this occurs, the clinician may use tissue paper to gently blot the excess solution away.
  – The exception to this is the performance of the *Seidel test*, which is used to assess the eye for potential perforation (Fig. 53.8).
  – The clinician will instill a large amount of dye into the eye by wetting the orange strip copiously.
  – The clinician will next examine the eye for a stream of fluid leaking from the ruptured globe.

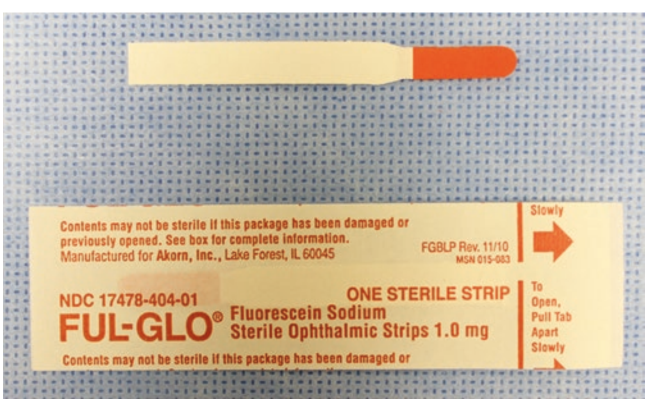


Fig. 53.7 A typical fluorescein strip package

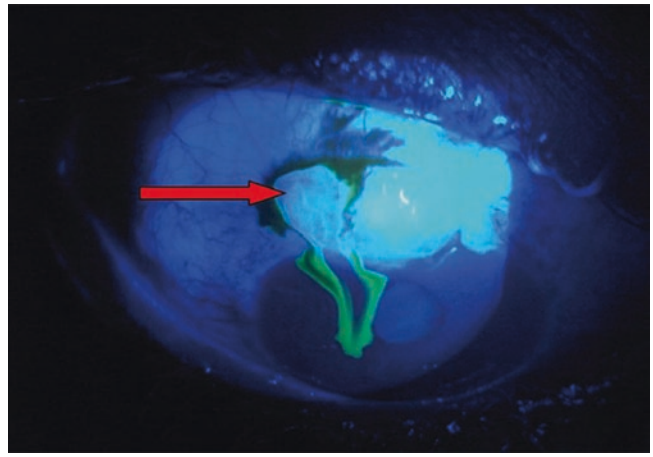


Fig. 53.8 A positive Seidel test. (*From* Lingam et al. [1], *with permission from the Indian Journal of Ophthalmology*; Creative Commons Attribution License)

  – This stream will fluoresce green or blue in distinction to the rest of the globe, which appears orange.
- The choice of solution to wet fluorescein strip is up to the clinician because saline, tap water, or the recently used anesthetic solution may be used safely.
- Place the now wet orange end on the lower lid of the patient's eye.
- Ask the patient to blink several times to allow the solution to spread evenly.
- The clinician may use a Wood's lamp, penlight, or the cobalt blue filter on the slit lamp to examine the now stained eye.
  – The slit lamp is preferable owing to the potential for missing small abrasions.

Complications

- There is a theoretical risk of the development of superficial punctate keratitis from instillation of topical anesthetic before fluorescein testing.
- Discoloration of soft contact lenses.
- Potential for infection using premixed fluorescein solution.

Pitfalls

- Contact lens wearers should remove their lenses because the fluorescein will permanently stain the lens.
  – The wearer should not put the contacts back in for several hours.

Reference

1. Lingam V, Panday M, George R, Shantha B. Management of complications in glaucoma surgery. Indian J Ophthalmol. 2011;59(Suppl1):S131–40.

Suggested Readings

DuBois L. The slit lamp examination. In: DuBois L, Ledford JK, Daniels K, Campbell R, editors. Clinical skills for the ophthalmic examination: basic procedures. 2nd ed. Thorofare: Slack; 2006. p. 61–70.

Galor A, Jeng BH. Red eye for the internist: when to treat, when to refer. Cleve Clin J Med. 2008;75:137–44.

Lang GK. Ophthalmology: a short textbook. Stuttgart: Thieme; 2000.

Ledford JK, Sanders VN. The slit lamp primer. 2nd ed. Slack: Thorofare; 2006.

54 Eye Irrigation

Bobby K. Desai

Indications

- Chemical burns to the eye.
- Removal of superficial foreign bodies.

Contraindications

- For suspected globe perforation, extreme care must be taken to not exacerbate the injury.

Materials and Medications

- Irrigating device—the Morgan lens (Fig. 54.1).
- Saline solution or lactated Ringer's (preferably warmed).
- Topical anesthetic drops (Fig. 54.2).
- Basin to secure the extruded solution.
- Intravenous (IV) tubing to attach the IV bag to the Morgan lens.
- pH paper (Fig. 54.3).

Procedure

1. Informed consent is generally not required, although a thorough explanation to the patient is warranted.
2. Obtain pH of the eye *before* instilling anesthetic drops.
3. Anesthetize the eye(s) with topical anesthetic of choice by instilling drops within the lower lid and then asking the patient to blink several times in order to evenly distribute the solution.
4. Ensure there are no foreign bodies on the inside of the upper lids by inverting the upper lid.

Fig. 54.1 The Morgan lens and packaging

- Particulate foreign bodies may be removed with moistened cotton tip applicators.

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Fig. 54.2 Examples of topical anesthetics

5. After adequate anesthesia is ensured, place one end of the Morgan lens within the fornix of the upper lid (Fig. 54.4).
6. Next, gently retracting the lower lid will ensure smooth placement of the remaining portion of the Morgan lens (Fig. 54.5).
7. Using the end of the Morgan lens, screw in the prepared IV tubing (Fig. 54.6).
8. Attach the end of the IV tubing to the saline bag, and place at height to allow for gravity to ensure a smooth flow of solution.
   - Continue to irrigate the eye until desired pH is obtained.
9. To remove the Morgan lens, use the opposite technique for insertion.

Complications

- Corneal abrasions may be caused by the Morgan lens and are treated in the usual fashion.
- Deep corneal injury may occur with inadequate irrigation.

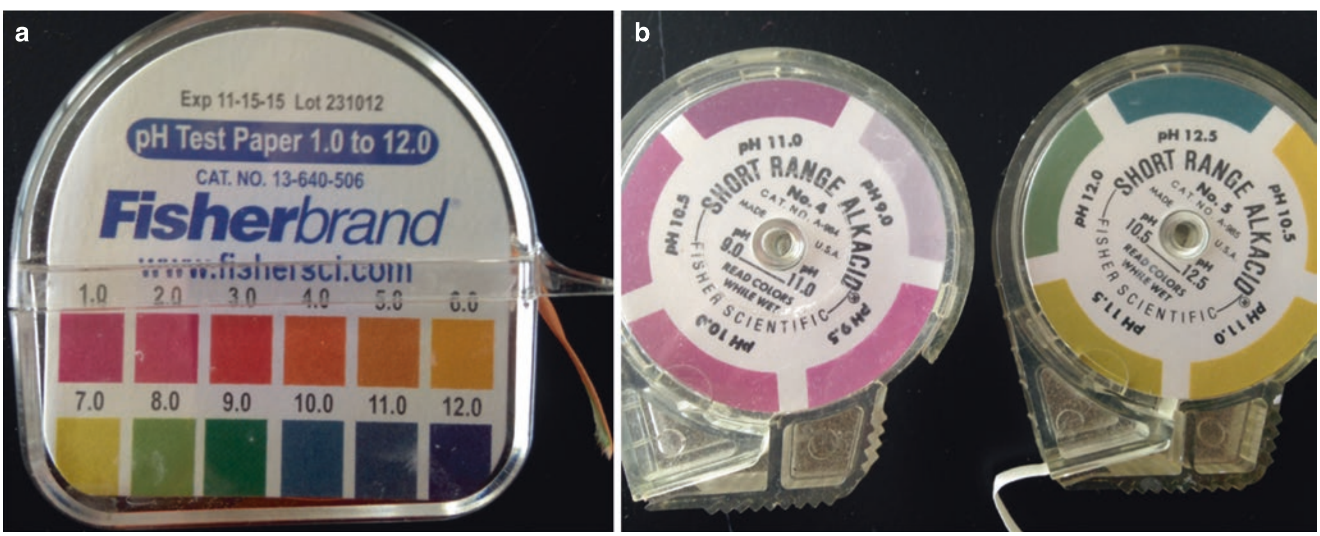

Fig. 54.3 (**a**, **b**) Examples of pH paper.

Fig. 54.4 Inserting the Morgan lens under the upper lid

Fig. 54.5 Inserting the Morgan lens under lower lid

Fig. 54.6 The Morgan lens in place, ready to be attached to IV tubing for saline irrigation

Pearls and Pitfalls

- Note that alkali burns will require significant irrigation and more topical anesthesia may be required.
- Ophthalmological consultation may be required, especially for alkaline and hydrofluoric acid burns.

Suggested Reading

Lang GK. Ophthalmology: a short textbook. Stuttgart: Thieme; 2000.
Rhee DJ, Pyfer MF, Rhee DM, editors. The Wills Eye manual: office and emergency room diagnosis and treatment of eye disease. third ed. Philadelphia: Lippincott Williams & Wilkins; 1999.

55 Corneal Foreign Body Removal

Bobby K. Desai

Indications

- Presence of a corneal foreign body (Fig. 55.1).

Contraindications

- An uncooperative patient may require ophthalmological consultation as well as sedation.
- Suspected foreign bodies from high-velocity injuries must be referred to an ophthalmologist subsequent to initial evaluation.
- Any signs of globe penetration (e.g., hyphema) require emergent ophthalmological consultation.
- Overt globe rupture.
- Evidence of an inflammatory process such as iritis requires emergent ophthalmological consultation.
- Foreign bodies associated with corneal burns secondary to chemical exposure such as alkaline corneal burns will require emergent ophthalmological consultation.

Materials and Medications

- Eye chart for visual assessment.
- Cotton tip applicator.
- Slit lamp or other sources of magnification.
- 27-Gauge needle or ophthalmic foreign body needle (Fig. 55.2)
- Topical ophthalmic anesthetic.
- Ophthalmic burr (Fig. 55.3).

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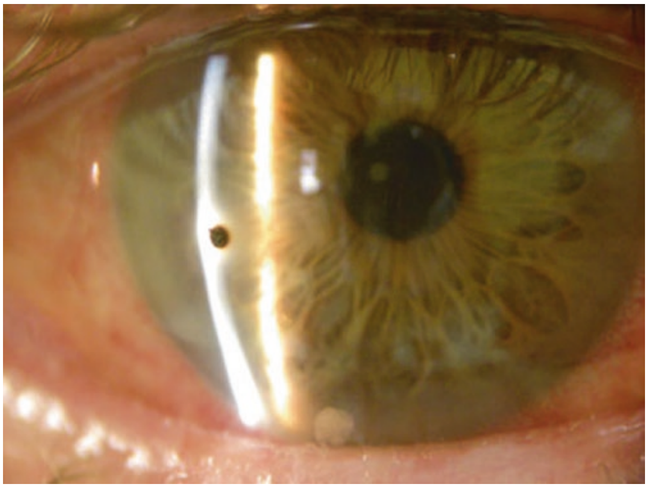

Fig. 55.1 Corneal foreign body. (*From* Zuberbuhler et al. [1], *with permission*)

Procedure

1. Informed consent may be required.
2. Visual acuity and a formal assessment of the eye should be done and documented.
3. Consider intraocular foreign body.
   - Computed tomography (CT) scan may be used to assess for the presence of an intraocular foreign body.
4. Eversion of the upper lid should be performed to evaluate for retained foreign body under the lid.
   - These usually can be removed by:
     – A moistened cotton tip applicator.
     – Irrigation.
5. Magnification is preferable, but some foreign bodies may be large enough to see with the naked eye.
6. Anesthetize the eye with topical anesthetic.
7. For multiple loose foreign bodies, removal may be attempted with irrigation after appropriate anesthesia.
8. Removal of the foreign body may be attempted with a moistened cotton swab.

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Fig. 55.2 Foreign body needle

Fig. 55.3 Ophthalmic burr drill

- Metallic foreign bodies recently embedded within the cornea may be difficult to remove in this fashion.
- However, during the healing process, some metallic foreign bodies may be pushed closer to the surface during reepithelialization of the cornea. These potentially can be removed with this technique.
  - Care must be taken to avoid leaving a rust ring that could permanently stain the cornea.

9. A 27-gauge needle bent at a 90° angle may be used to remove foreign bodies by gently prying it out.
   - An advantage of using a needle is that any rust ring as well as any metallic foreign body can potentially be removed.
10. Technique: A slit lamp may be used to magnify the area.
    - See slit lamp chapter (Chap. 53) for details.
    - The patient should be informed about the procedure; formal informed consent may not be required.
    - Proper positioning is critical for success.
    - The patient's head should be fully forward and firmly placed against the head rest.
    - The patient's hands may be placed on the sides of the slit lamp stage for stabilization.
    - Apply topical anesthesia to the cornea.
11. Using the patient's cheek as a bolster potentially avoids significant movement of the needle if the patient unexpectedly moves.
12. Other modalities for stabilization include supporting the elbow by placing on a box or using towels.
13. Have the patient gaze at one point in the far distance.
    - Using the needle or burr as a scoop, gently manipulate the foreign body out.
      - Using a burr can allow for the total removal of any rust ring.
14. Once the foreign body is removed, patching is not required.
15. Consider application of topical antibiotics.
16. Tetanus prophylaxis should be given as for open other wounds.
17. Arrange follow-up with a primary care physician or preferably an ophthalmologist.

Complications

- Forceful attempts to dislodge a foreign body may result in corneal perforation.
- Incomplete removal of a foreign body.

Reference

1. Zuberbuhler B, Tuft S, Gartry D, Spokes D. Ocular surface and reconstructive surgery. In: Corneal surgery. Berlin/Heidelberg: Springer; 2013. p. 29–48.

Suggestevd Readings

Lang GK. Ophthalmology: a short textbook. Stuttgart: Thieme; 2000.

Rhee DJ, Pyfer MF, Rhee DM, editors. The wills eye manual: office and emergency room diagnosis and treatment of eye disease. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 1999.

Thomas SH, White BA. Foreign bodies. In: Marx J, Hockberger R, Walls R, editors. Rosen's emergency medicine: concepts and clinical practice. 7th ed. Philadelphia: Mosby; 2010. p. 715–32.

56 Ultrasound Evaluation of Ocular Pathology and Retinal Detachment

Javier Rosario, Shalu S. Patel, L. Connor Nickels, and Rohit Pravin Patel

Ultrasound Evaluation of Ocular Pathology

Indications

- To aid in the evaluation of acute vision loss.
- Evaluation of an acute change in vision.
- Evaluation of "floaters" described in vision change.
- To aid in the identification of foreign bodies.
- To aid in the evaluation and determination of elevated intracranial pressures.

Contraindications

- Relative: Suspicion of increased intraocular pressure.
- Absolute: Suspicion or evidence of globe rupture.

Materials and Medications

- Bedside ultrasound machine with high-frequency (13–6 MHz or similar) linear transducer.
- Transparent adhesive such as Tegaderm® or similar (recommended).
- Sterile ultrasound gel or single lube packet.
- Sterile gauze.

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Procedure

1. Position the patient supine with his or her eyes closed. The eyelid should be taped closed with a transparent adhesive (i.e., Tegaderm® or similar) (Fig. 56.1). Start from medial to lateral in an attempt to take as much of the air out between the eyelid and the adhesive.
2. Place a liberal amount of ultrasound gel over the covered eyelid.
3. Place the ultrasound probe over the eye in transverse or sagittal position (Fig. 56.2). Gently brace your hand or fingers over a stable area of the patient's face. This will help you be aware of how much pressure you are applying over the eye and give you additional stability.
4. Adjust the depth of the ultrasound so that the whole eye fills the screen.
5. Scan through the eye fully in the transverse and sagittal planes.
6. When viewing the ultrasound image, the normal eye is a circular hypoechoic structure (Fig. 56.3). The structures should be evaluated from anterior to posterior.
7. Identify the cornea. This is the first thin hypoechoic line in the anterior eye.

Fig. 56.1 Placing covering film over gently closed eyelid

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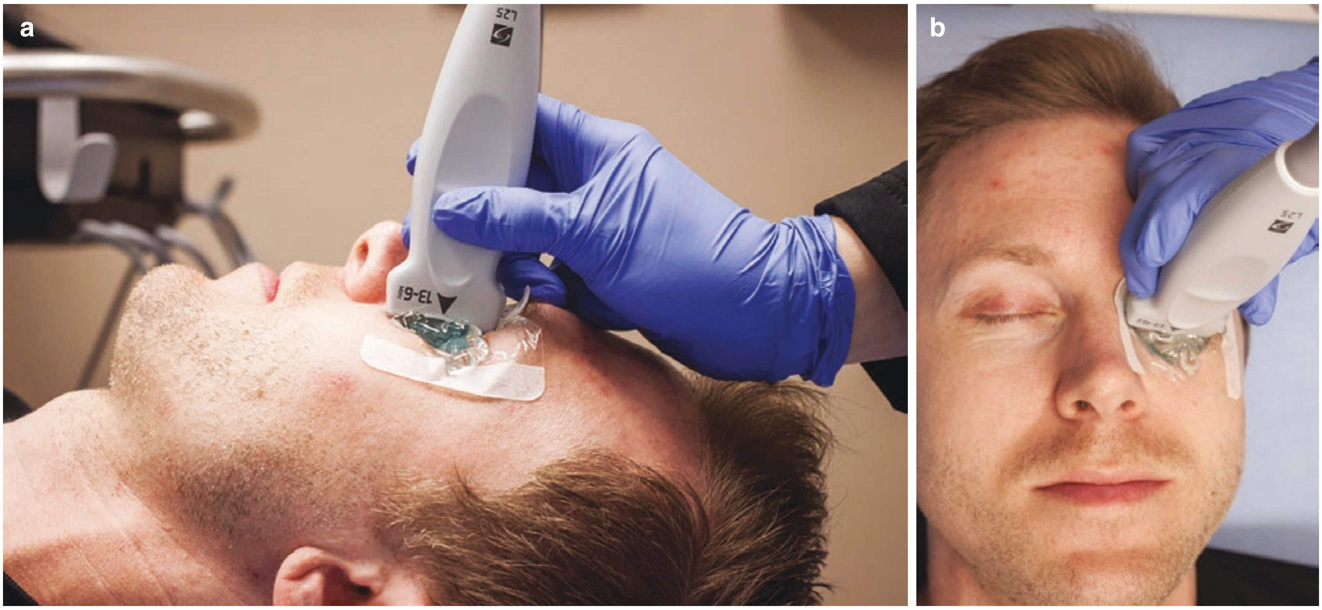

Fig. 56.2 Probe positioning with Tegaderm applied to orbit: (**a**) sagittal view and (**b**) transverse view

Fig. 56.3 Ocular ultrasound with normal anatomy findings with anatomy labeled

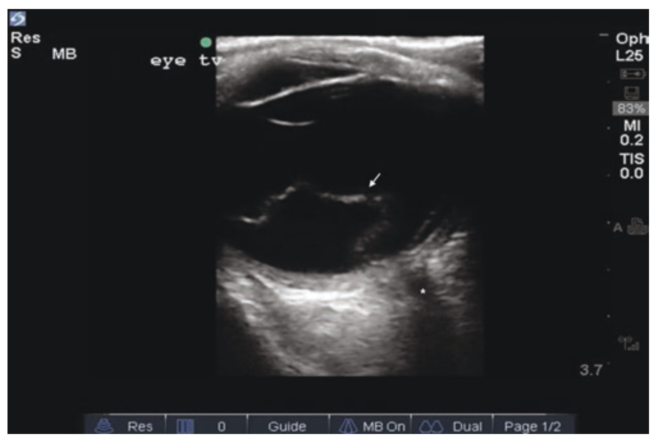

Fig. 56.4 Retinal detachment appears as a hyperechoic linear structure (*white arrow*). *White* asterisk shows the optic nerve sheath shadow

8. Continuing posteriorly, identify the anterior chamber, which is an anechoic area bordered by the cornea, iris, and lens. The iris is an echogenic linear structure, and the normal lens is anechoic.
9. Identify the vitreous chamber, the large anechoic region posterior to the lens.
10. In the retrobulbar region, the optic nerve can be identified as a hypoechoic linear structure perpendicular to the globe (Fig. 49.3). Finding the optic nerve is of most importance, as this will help you differentiate between a retinal detachment and a vitreous detachment.
11. Carefully evaluate the posterior globe. The normal retina cannot be distinguished from the other choroidal layers on ultrasound.
12. A *retinal detachment* will appear as a hyperechoic linear floating membrane in the posterior chamber and will appear to coming off the optic nerve (Fig. 56.4).
13. A *vitreous detachment* is an abnormal finding that can be seen with ultrasound. The difference will be that the vitreous detachment will *not* be associated with the

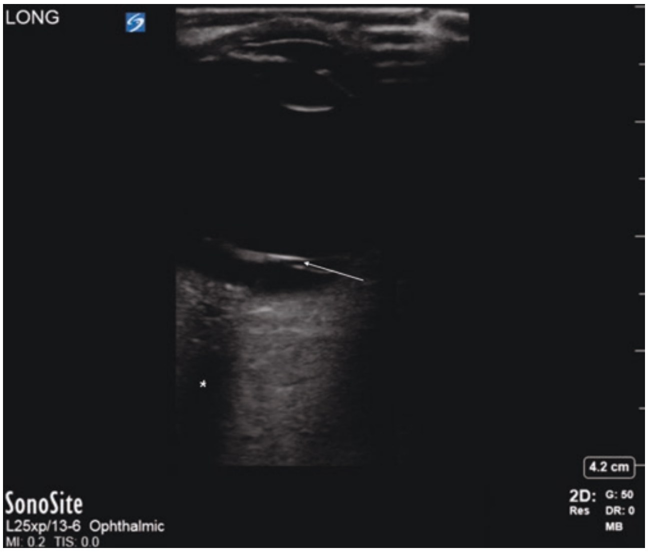

Fig. 56.5 Vitreous detachment appears as a hyperechoic linear structure (*white arrow*) unrelated to the optic nerve. *White* asterisk shows the optic nerve sheath shadow

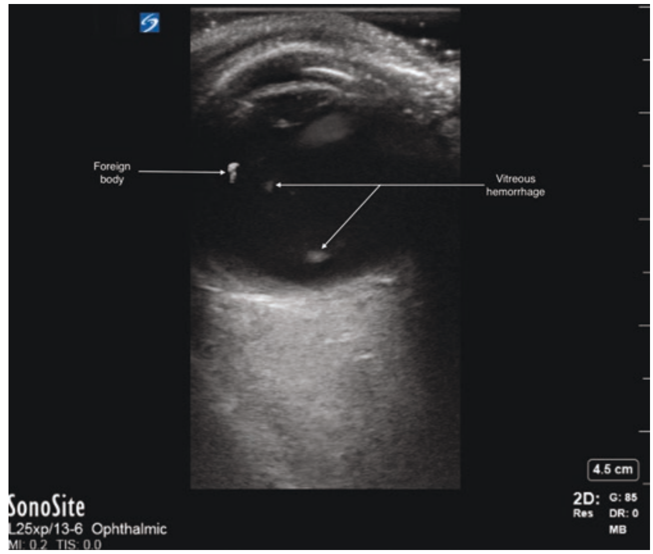

Fig. 56.6 Vitreous hemorrhages appear as multiple hyperechoic "floaters" within the posterior or vitreous chamber (double arrows). Foreign bodies tend to be hyperechoic and may cast a reverberation artifact under the structure as shown above (single arrow)

optic nerve and will likely cross from posterior wall to posterior wall with no paucity over the optic nerve (Fig. 56.5).

14. A *vitreous hemorrhage* is typically seen as multiple echogenic "floaters" inside the vitreous body. In most circumstances, the gain will need to be increased to be able to identify these. (Fig. 56.6). Identification can be further enhanced by recording a small clip as the patient looks to each side on a closed eyelid, causing a "washing machine sign."
15. *Foreign bodies* are a rare but dangerous complication to ocular trauma. Most of these can be identified using ultrasound, but the sensitivity will vary depending on the density and structural components of the foreign body. They can be seen as a single (or multiple) hyperechoic structures within the anterior or posterior chambers of the eye (Fig. 56.6).

Complications

- Conjunctival infection or irritation (adhesive film can help prevent this).
- Increased intraocular pressure (if too much pressure is applied).

Pearls and Pitfalls

- Pearls
  - Use a transparent adhesive such as Tegaderm to decrease the risk of conjunctival infection or irritation. Keep in mind bottled ultrasound transducer gel is not considered sterile. This will also make the procedure more tolerable and less irritating.
  - Use a liberal amount of gel over the protective film to obtain the best images.
  - Use minimal pressure to obtain the best images.
  - Wider linear transducers will incorporate more of the eye in the window.
  - Increasing the gain may unmask occult ocular pathology (i.e., retinal detachments, vitreous detachment, or hemorrhages).
  - False positives on ocular ultrasound may occur with disk edema or vitreous hemorrhage.
- Pitfalls
  - Subacute and small retinal detachments may be missed on ocular ultrasound.
  - While under-gained imaging may miss occult pathology, excessive over-gaining may lead to some false positives.

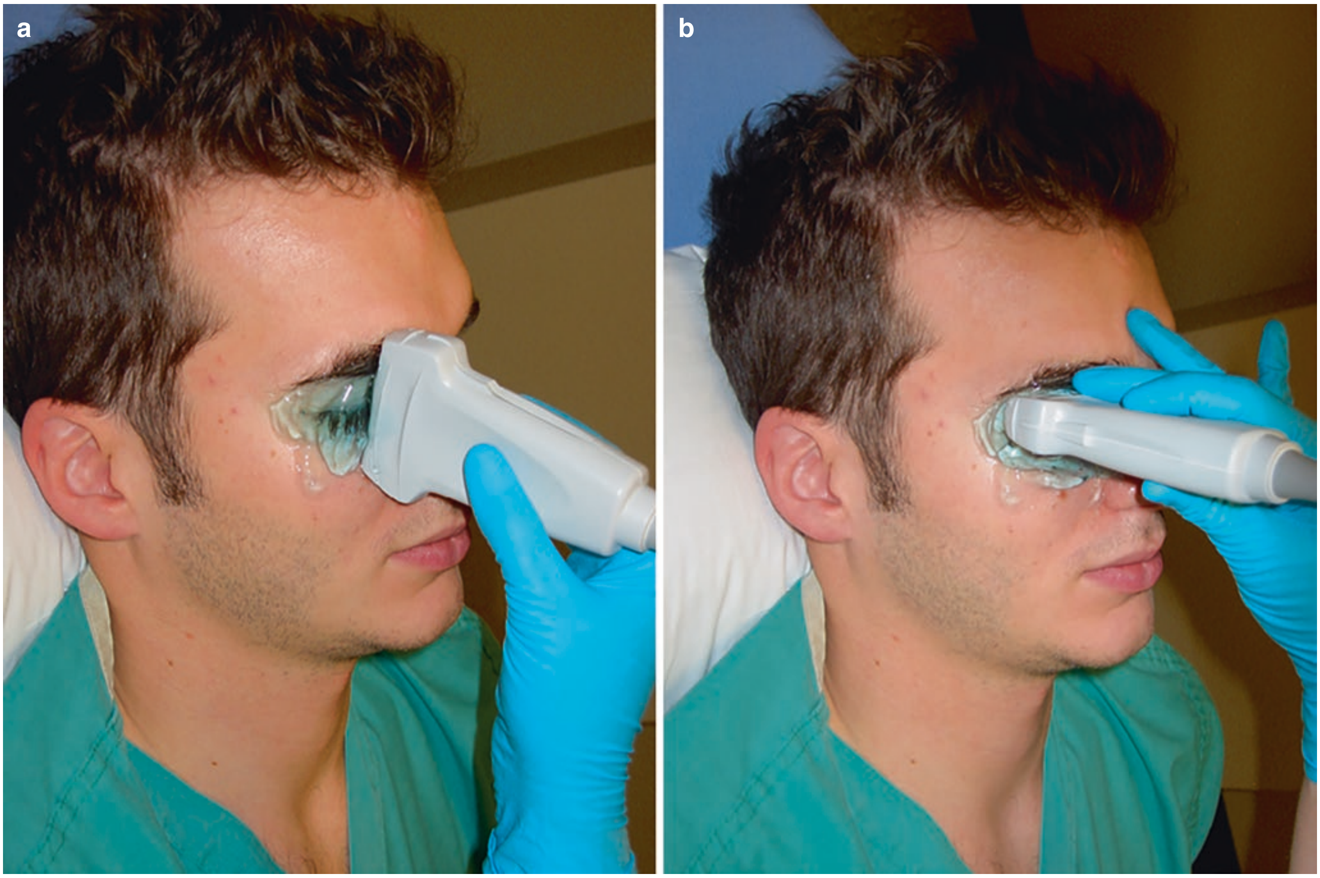

Fig. 56.7 Probe positioning with Tegaderm applied to orbit: (**a**) sagittal view, (**b**) axial view

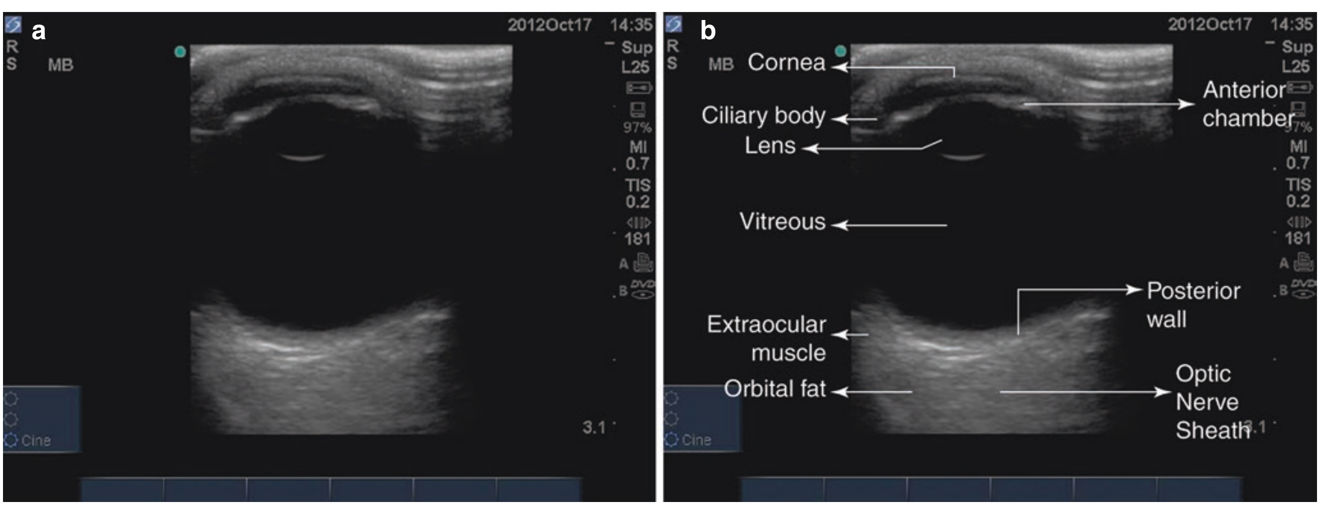

Fig. 56.8 Ocular ultrasound with normal anatomy findings ((**a**) without labels, (**b**) with anatomy labeled)

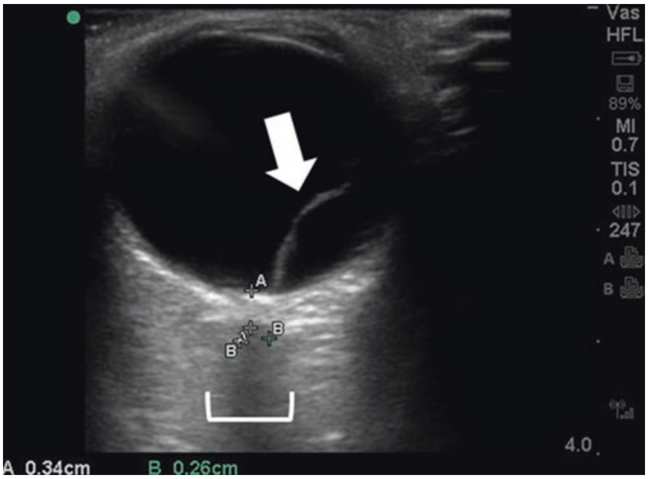

Fig. 56.9 Retinal detachment appears as a hyperechoic linear structure (*white arrow*). *White* bracket shows the optic nerve sheath shadow (see Chap. 50 for more information)

Suggested Reading

Baker N, Amini R, Situ-LaCasse EH, Acuña J, Nuño T, Stolz U, et al. Can emergency physicians accurately distinguish retinal detachment from posterior vitreous detachment with point-of-care ocular ultrasound? Am J Emerg Med. 2018;36(5):774–6. https://doi.org/10.1016/j.ajem.2017.10.010. Epub 2017 Oct 13.

Blaivas M. Bedside emergency department ultrasonography in the evaluation of ocular pathology. Acad Emerg Med. 2000;7:947–50.

Blaivas M, Theodoro D, Sierzenski PR. Elevated intracranial pressure detected by bedside emergency ultrasonography of the optic nerve sheath. Acad Emerg Med. 2003;4:376–81.

Shinar Z, Chan L, Orlinksy M. Use of ocular ultrasound for the evaluation of retinal detachment. J Emerg Med. 2011;4:53–7.

Whitcomb MB. How to diagnose ocular abnormalities with ultrasound. AAEP Proc. 2002;48:272–5.

Tonometry

57

Bobby K. Desai

Indications

- To measure intraocular pressure (IOP).

Contraindications

- A relative contraindication is the presence of an active or indolent infection about the cornea or conjunctiva, unless a one-time use device is used (e.g., a Tono-Pen XL).
- Recent trauma to the eye.
- Uncooperative patients because improper technique may cause damage to the eye.

Overview

- Tonometry is the measurement of IOP obtained by evaluating the resistance of the eye to indentation by a force applied to it.
- Can be obtained by several methods.
- Two methods are routinely used in an emergency department setting:
  - *Impression tonometry*: measures the indentation made by a plunger carrying a known amount of weight.
  - More weight can be added to the apparatus.
  - The more weight needed to indent the cornea results in a higher IOP reading.
- The Schiøtz tonometer is the most commonly used apparatus to utilize this method (Fig. 57.1).
- *Electronic indentation tonometry*: does not exert pressure on the eye (Fig. 57.2).

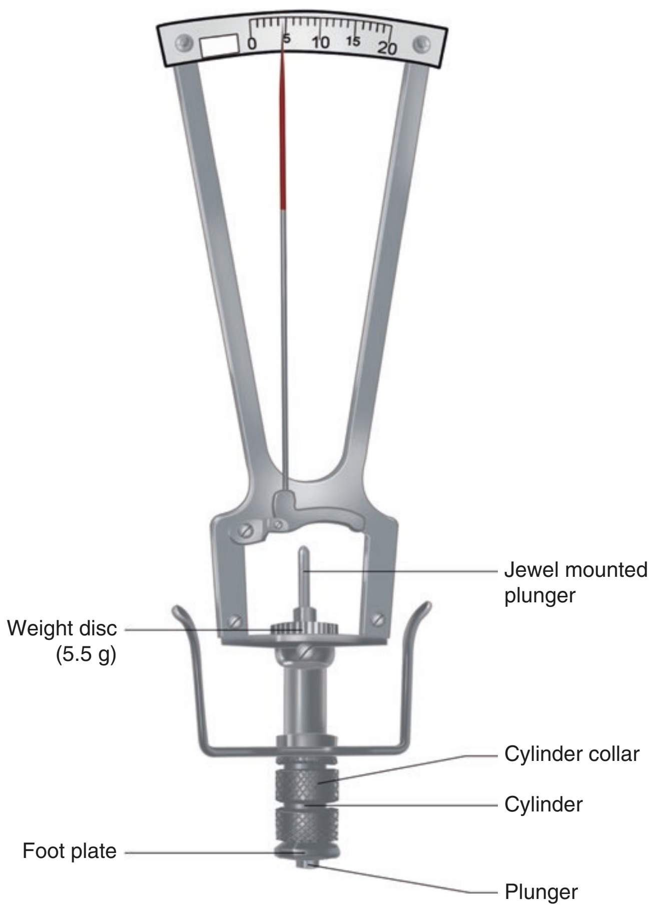

Fig. 57.1 Schiøtz tonometer

Schiøtz Tonometry

Procedure: Schiøtz Tonometry (Fig. 57.3)

1. Carefully clean the apparatus between each patient.
   - Rubbing alcohol may be used.
   - Because it is metal, it can be autoclaved.

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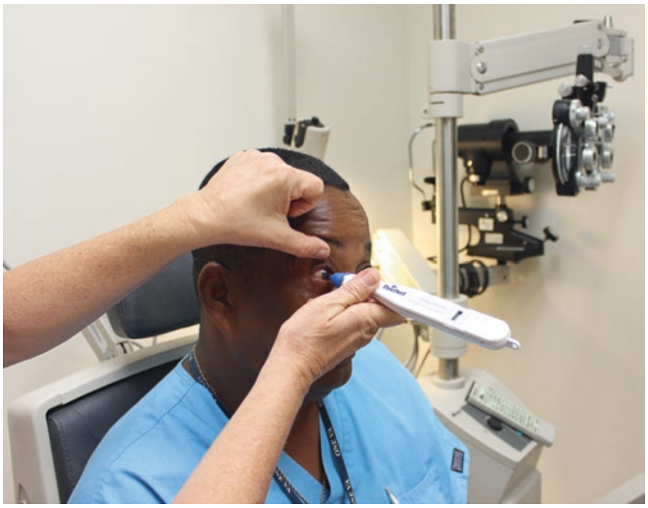

Fig. 57.2 Tono-Pen

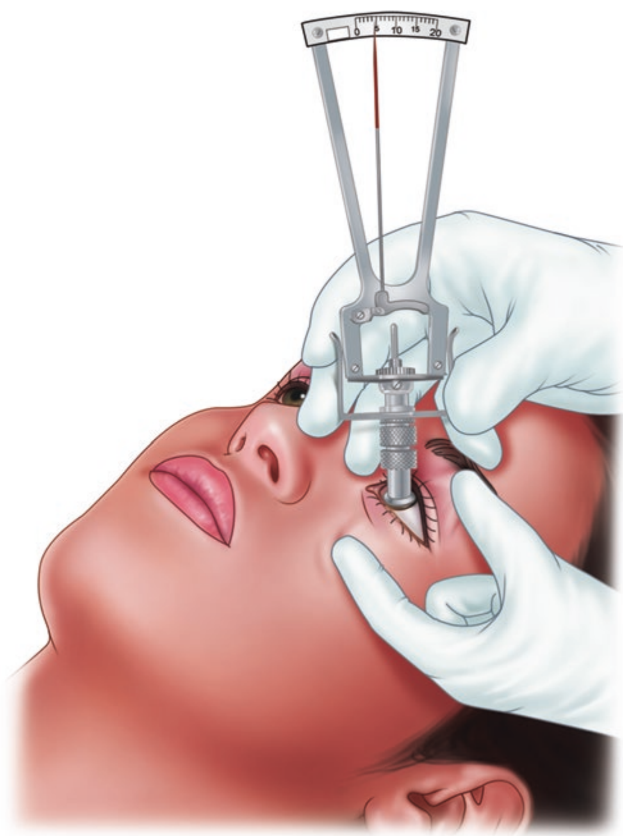

Fig. 57.3 Correct use of Schiøtz tonometer

2. Calibrate the Schiøtz tonometer with the metal test block provided.
   - Test by placing the apparatus directly on the metal block.
   - The needle should be at "0" at the far end of the scale.
     – If not, loosen the screw at the base of the needle to rezero it.
     – Ensure that the needle is completely straight because any bend will produce an erroneous reading.
3. An explanation of the procedure is helpful because patient cooperation is critical for accurate results.
4. Anesthetize the eye with topical ophthalmic anesthetic of choice.
5. The patient should be in a recumbent position.
   - Have the patient focus on an area of the ceiling.
6. Hold the instrument with the aid of the curved arms at the side of the tonometer.
   - The operator can rest her or his hand on the patient's cheek or forehead to maintain stability.
7. Gently rest the tonometer on the patient's eye such that the instrument is centered on the eye and the instrument is completely vertical; no pressure should be exerted on the eye.
8. Note the scale reading.
9. Lift the Schiøtz directly off the cornea to avoid injury.
10. Using the table provided with the Schiøtz, the operator may convert the scale reading into the IOP.
    - The scale is inversely proportional to the actual IOP.
    - If the scale is low (i.e., high IOP), the additional weights provided with the instrument may be used and the patient retested.

Pitfalls

- Ensure the plunger is clean because it can transmit infection.
- False readings may be obtained without proper calibration.
- Placing pressure on the instrument will cause false readings.

Tono-Pen Tonometry

Overview

- Electronically measures IOP.
  – Combines applanation and indentation tonometry.
- Uses pressure-sensitive electronics to average four successive readings and displays the reading and a reliability factor digitally.

Fig. 57.4 Tono-Pen calibration position

Calibration of the Tono-Pen

- Should be performed once daily.
- Hold the instrument with the tip down (Fig. 57.4).
- Press the black button twice.
  - The letters "CAL" will appear in the display.
- Press the black button again.
  - After a few seconds, the word "UP" will appear.
- Rotate the instrument so that the tip points upward.
  - If "GOOD" appears, the Tono-Pen is ready for use.
  - If "BAD" appears, repeat the process until "GOOD" appears.
- If "GOOD" does not appear, the device cannot be used.

Procedure: Tono-Pen Tonometry

1. An explanation of the procedure is helpful because patient cooperation is critical for accurate results.
2. Anesthetize the eye with the topical ophthalmic anesthetic of choice.
3. Place a probe cover on the unit.
4. The patient should be in a comfortable position because the unit can be used in any position.
   - Have the patient focus on a specific area.
5. The best way to hold the instrument is similar to that of a pen.
   - Ensure that the digital readout is visible.
6. The operator can rest his or her hand on the patient's cheek or forehead to maintain stability.
7. Hold the unit perpendicular to the patient's cornea.
8. Press the black button only once.
   - If "ICALI" is seen, followed immediately by a single row of dashes [– – – –], it indicates that the Tono-Pen requires calibration before it will measure.
   - If "====" is seen and a "beep" is heard, the unit is ready.
   - Proceed with measurement.
9. Gently touch the Tono-Pen to the cornea and withdraw (Fig. 57.5). Repeat several times.
   - Indentation is not required.
10. The unit will "chirp" and a digital reading will be displayed if a valid reading is obtained.

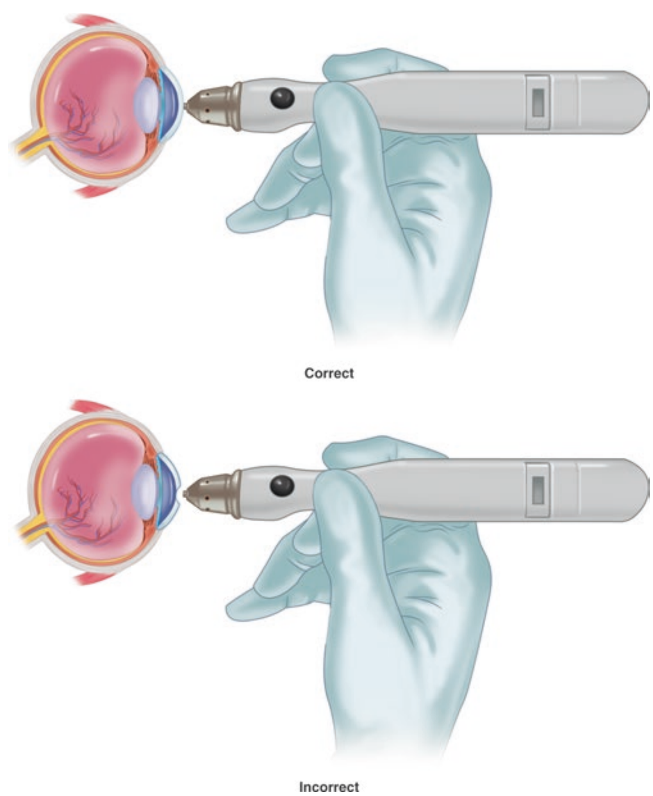

Fig. 57.5 Proper use of Tono-Pen

11. After four valid readings are obtained, the average of these measurements as well as a single bar that signifies statistical reliability will appear on the readout.
    - After the final beep if the liquid crystal display (LCD) readout shows "----, "not enough valid readings were obtained.
    - In this case, the measurement must be repeated.

Pitfalls

- Unsuccessful calibration mandates a repeat attempt at calibration.
- Loosen the Ocu-Film tip cover and repeat for multiple failed attempts.
- Press the reset button and reattempt calibration.
- Replace the battery if necessary.
- If all else fails, use another device or Schiøtz tonometer.

Complications

- Unusual if proper technique is used.
- If too much force is applied, a corneal abrasion may result.
- Infection when using an improperly sterilized Schiøtz tonometer.

Suggested Reading

Lang GK. Ophthalmology: a short textbook. Stuttgart: Thieme; 2000.
Rhee DJ, Pyfer MF, Rhee DM, editors. The Wills eye manual: office and emergency room diagnosis and treatment of eye disease. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 1999.

58 Lateral Canthotomy

Benjamin M. Mahon, Tracy Macintosh, and Bobby K. Desai

Indications

- Absolute indications: in the presence of presumed or confirmed retrobulbar hemorrhage, traumatic or atraumatic.
  - Acute visual loss.
  - Intraocular pressure (IOP) greater than 40 mmHg (normal IOP is 10–20 mmHg).
  - Proptosis not amenable to retropulsion.
- Relative indications: in the context of presumed or confirmed retrobulbar hemorrhage (Fig. 58.1).
  - Ophthalmoplegia.
  - Cherry red macula.
  - Profound eye pain.
  - Afferent pupillary defect (Marcus Gunn pupil).
- This defect is seen with the *swinging flashlight test.*
  - Shine a light into both eyes; a normal response is equal constriction of both pupils.
  - In those patients with an afferent papillary defect, when light is swung from an unaffected pupil to an affected pupil, the pupil will seem to paradoxically dilate, rather than constrict. The pupil on the nonaffected side will similarly dilate as light is shown into the affected eye. This results from injury to the afferent fibers of cranial nerve (CN) II on the affected side, while the efferent fibers, innervated by CN III, remain intact.

Fig. 58.1 Retrobulbar hemorrhage

  - This procedure is most effective if performed as soon as possible because irreversible vision loss can occur secondary to ischemia in as little as 90 min.

Contraindications

- Absolute.
  - Globe rupture.
- Relative.
  - Suspected globe rupture: heralded by a number of signs including hyphema, irregularly shaped pupil, exposed uveal tissue, Seidel sign, or profound restriction of extraocular movement.

Materials and Medications

- Straight hemostat.
- Suture or iris scissors.
- Forceps.
- 1–2% lidocaine with epinephrine
- Tetracaine.

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- Sterile gloves.
- Sterile towels/drapes.
- 4 × 4 gauze
- Face shield/mask.
- Large-bore needle to withdraw anesthetic, 25-gauge needle to infiltrate.
- 10-cc syringe
- Normal saline.
- Clean paper clip.
- Morgan Lens.

Procedure

1. Position the patient.
   - While waiting for the procedure to begin, the patient should initially be upright to produce any decrease in IOP that can be provided.
   - At the start of the procedure, lay the patient supine.
   - A cooperative patient is absolutely necessary because even slight movements can cause devastating iatrogenic injury.
   - If the patient is anxious or conscious, sedation may be required.
   - In extreme cases of altered mental status or combative trauma patients, endotracheal intubation and mechanical ventilation may be required.
2. Use a paper clip to create a hook to retract the upper eyelid (Fig. 58.2 a & b).
3. Gently irrigate the affected eye to remove any debris.
4. Apply 1 drop of tetracaine, and place the Morgan Lens to the eye to prevent iatrogenic trauma to the cornea or globe.
5. Inject approximately 1–2 mL of 1–2% lidocaine with epinephrine into the lateral canthus of the affected eye (Fig. 58.2 a & b, dotted line).
6. Using a curved hemostat, gently crimp the skin over the lateral corner of the patient's eye down to the orbital rim for 1–3 min to establish hemostasis, and set the boundaries for the incision (Fig. 58.3).
   - Using forceps, use the hemostats to pick up the skin just crushed.
   - Raise the skin with forceps, and then use scissors to make a 1- to 2-cm incision from the lateral corner of the eye extending laterally outward (Fig. 58.4 a & b).
     – This incision can often sufficiently decrease IOP.
     – It is feasible to remeasure the IOP at this point, and if it is still greater than 40 mmHg, proceed to the next step.
   - Visualize the lateral canthal tendon by retracting the inferior orbital lid inferiorly.
   - Direct the scissors along the lateral side of the orbital rim away from the globe, and cut the lateral canthal tendon inferiorly (Fig. 58.5).
   - At this point, again measure IOP, and if greater than 40 mmHg, proceed to the next step.
   - Direct the scissors along the lateral side of the orbital rim away from the globe, this time directed superiorly, and cut the superior crux of the lateral canthal tendon.

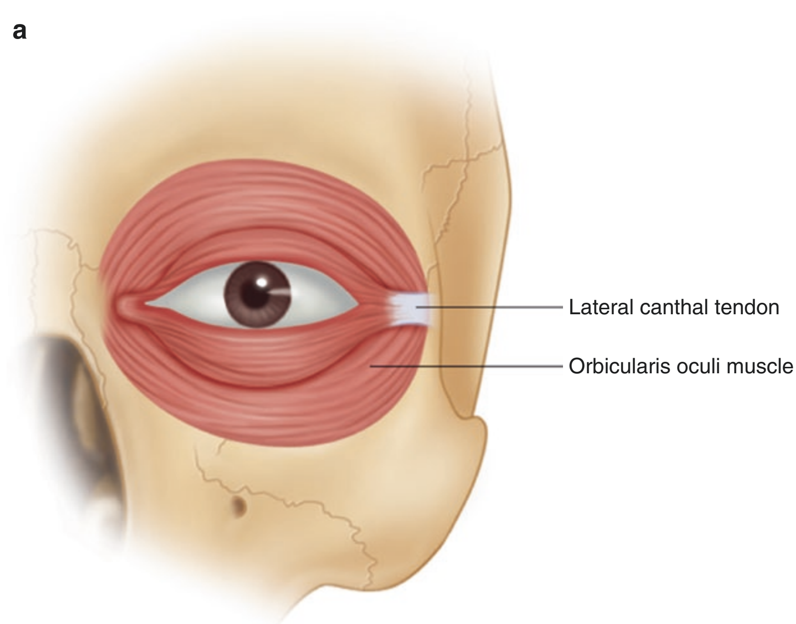

Fig. 58.2 (**a**) Lateral canthal tendon. (**b**) Eyelid retraction using a clean paper clip, inject lidocaine along dotted line

Fig. 58.3 Crimping the skin with hemostat

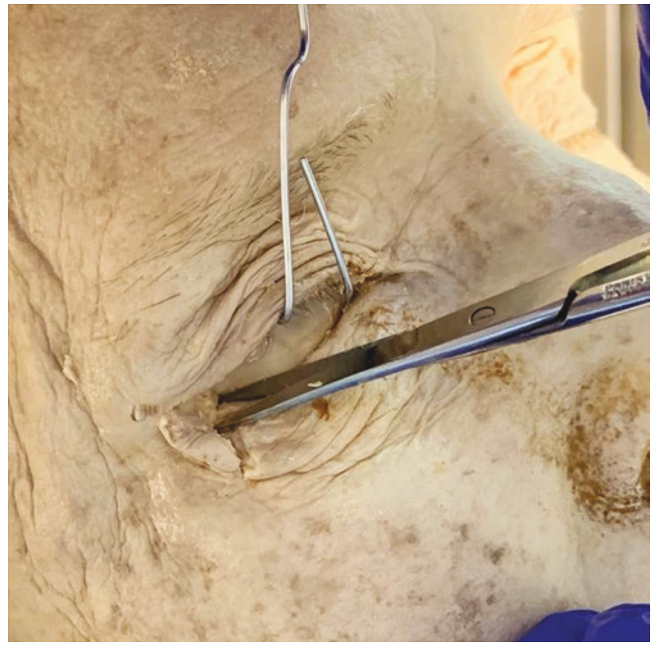

Fig. 58.5 Identifying the inferior lateral canthal tendon

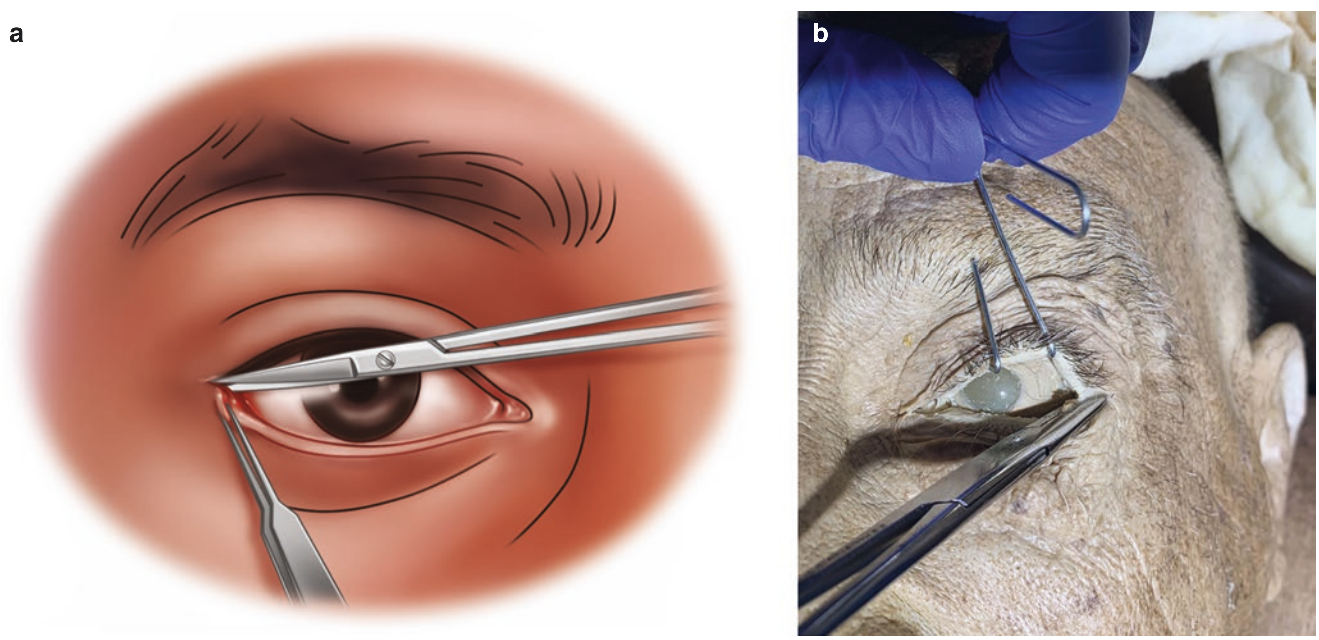

Fig. 58.4 (**a** and **b**) Initial cut through lateral canthus

Complications

- If one is making a superior incision, caution must be taken during this procedure to avoid injury to the lacrimal gland or artery.
- An additional complication of the procedure is ptosis due to iatrogenic injury to the levator aponeurosis, either partially or completely.
- The most obvious complication involves direct injury to the globe itself due to either operator error or poor patient control and immobility; placing the Morgan Lens will decrease this risk.
- Hemorrhage from inadequate hemostasis.
- Infection.

Pearls and Pitfalls

- Abrupt decrease in pain, decrease in IOP, and resolution of afferent pupillary defect will herald a successful procedure, assuming it was performed within an early enough time frame.
- Having an assistant present is beneficial.
- In this case, the role of the assistant is to provide lateral retraction of the tissues to decrease likelihood of globe rupture.
- After cantholysis of the inferior component of the lateral canthal tendon, the lower lid will become lax as its attachment to the lateral wall is separated. This signifies a successful incision.
- Incisions made during this procedure generally heal without the need for suturing.
- Emergent ophthalmological consultation should ideally be sought before beginning this procedure.
- Emergent ophthalmological consultation is mandatory subsequent to the procedure.

Suggested Reading

Goodall KL, Brahma A, Bates A, Leatherbarrow B. Lateral canthotomy and inferior cantholysis: an effective method of urgent orbital decompression for sight threatening acute retrobulbar haemorrhage. Injury. 1999;30:485–90.

McInnes G, Howes DW. Lateral canthotomy and cantholysis: a simple vision-saving procedure. CJEM. 2002;4:49–58.

Roberts JR, Hedges JR, editors. Clinical procedures in emergency medicine. 5th ed. Philadelphia: WB Saunders; 2009. Chap. 63.

Vassallo S, Hartstein M, Howard D, Stetz J. Traumatic retrobulbar hemorrhage: emergent decompression by lateral canthotomy and cantholysis. J Emerg Med. 2002;22:251–6.

Fluorescein Eye Staining

59

Cherian Plamoottil

Indications

- Fluorescein remeasure in eye staining is a diagnostic modality that allows the clinician to view the surface of the eye to evaluate for corneal injuries secondary to trauma or a foreign body. It can be used to identify corneal ulcers and abrasions. It is also useful in determining potential infectious causes such as dendritic lesions from herpes simplex. Using a slit lamp with the eye staining technique can also indicate the presence of a globe rupture.

Contraindications

- Allergies to fluorescein and tetracaine may cause hypersensitivity reactions.

Materials and Medications

- Fluorescein strip.
- Tetracaine.
- Cobalt Blue light.

Procedure

1. Position the patient in a comfortable position by having them lay supine looking upward. The provider is best situated on the side of the patient's injury.
2. Apply tetracaine solution to the affected eye in order to numb the surface of the eye.
3. Once the eye is numb, use the fluorescein strip to dye the eye. This can be done by moistening the tip of the strip and applying it to the conjunctival surface or interior fornix of the conjunctiva.
4. Have the patient blink several times to spread the dye.
5. Then, after dimming the lights in the room, use the cobalt blue light to evaluate the surface of the eye.
6. Observe for any areas of uptake where the surface of the eye turns green as it implies pathology. Note the shape, location, and size of any area that turns green (Fig. 59.1) [1].

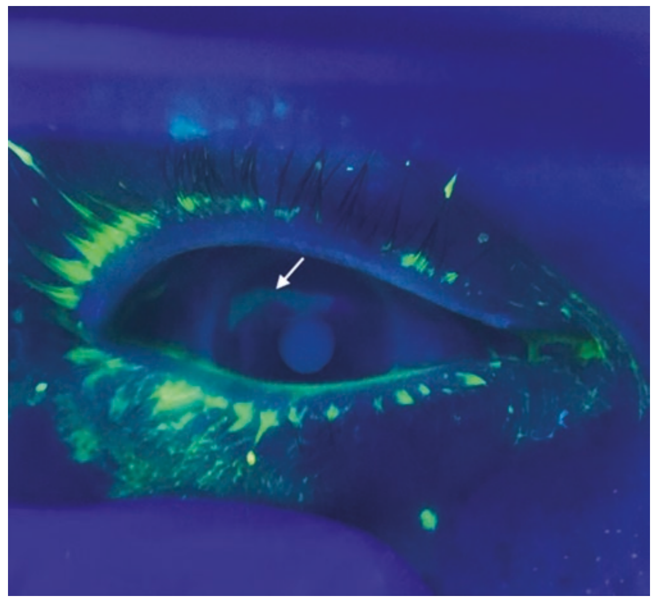

Fig. 59.1 White arrow points to the corneal abrasion in green

Complications

- Be mindful of patients with allergies.
- Inform the patient that once stained, the eye may retain the orange color for a brief period of time.

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Pearls and Pitfalls

- Pearls
  - Tetracaine has an onset of action of 30 seconds and lasts 10–20 minutes.
  - Evert the eyelids to ensure that there are no foreign bodies causing further damage.
  - Most abrasions will heal within 72 hours.
  - A positive Seidel test is used to detect the presence of an anterior chamber leakage to the cornea but typically requires the use of slit lamp.
- Pitfalls
  - Without properly anesthetizing, applying the fluorescein strip can be painful to the patient.
  - Failing to do a thorough ocular exam including evaluating visual acuity and when necessary ocular pressure may result in misdiagnosis.

Suggested Reading

Ahmed F, House RJ, Feldman BH. Corneal abrasions and corneal foreign bodies. Prim Care. 2015;42(3):363–75. https://doi.org/10.1016/j.pop.2015.05.004. Epub 2015 Jul 31

Barrientez B, Nicholas SE, Whelchel A, Sharif R, Hjortdal J, Karamichos D. Corneal injury: clinical and molecular aspects. Exp Eye Res. 2019;186:107709. https://doi.org/10.1016/j.exer.2019.107709. Epub 2019 Jun 22

Fusco N, Stead TG, Lebowitz D, Ganti L. Traumatic corneal abrasion. Cureus. 2019;11(4):e4396. https://doi.org/10.7759/cureus.4396.

Part VIII

Otorhinolaryngologic Procedures

Epistaxis Control

60

Benjamin M. Mahon, Tracy Macintosh, and Bobby K. Desai

Etiology

- Anterior source: approximately 90% of nosebleeds, usually Kiesselbach's plexus (Fig. 60.1).
  - Digital trauma (i.e., nose picking "epistaxis digitorum").
  - Trauma.
  - Infection.
  - Nasal foreign body.
  - Dry air.
  - Atmospheric pressure alterations (e.g., increased altitude, lower arterial partial pressure of oxygen [PaO_2]).
  - Allergies.
  - Blood dyscrasias.
  - Malignancy (e.g., leukemia, lymphoma).
- Posterior source: approximately 10% of nosebleeds, usually sphenopalatine artery (Fig. 60.2).
  - Iatrogenic coagulopathy (e.g., warfarin, heparin, high-dose aspirin, direct oral anticoagulant).
  - Blood dyscrasia.
  - Liver failure.
  - Renal failure.

Malignancy

- Older age.

Indications

- Acute/recurrent epistaxis.

Contraindications

- Resolution of epistaxis episode before arrival.
- Massive facial trauma.

Materials and Medications

- Headlight with focused beam.
- Gown.
- Gloves.
- Mask with visor.
- Full-body drape or sterile towels.
- Nasal packing material (any or all of the following, as needed [see later]): several cotton pledgets, 3–5 feet of ½-inch ribbon gauze (preferably enriched with petroleum jelly and bacitracin), anterior epistaxis balloon nasal pack.
- Topical vasoconstrictor (e.g., 1% pseudoephedrine or 1:1000 epinephrine).
- Topical anesthetic (e.g., 4% lidocaine solution or 2% tetracaine).
- Nasal speculum.
- Tongue depressors (2).
- Gauze.
- Tape.
- Bayonet forceps.
- Anterior epistaxis balloon (e.g., Rhino Rocket).
- Any of the following commercial products, as needed (see later): Gelfoam, Surgicel, Crosseal, and FloSeal.
- Tranexamic acid.
- Foley catheter.

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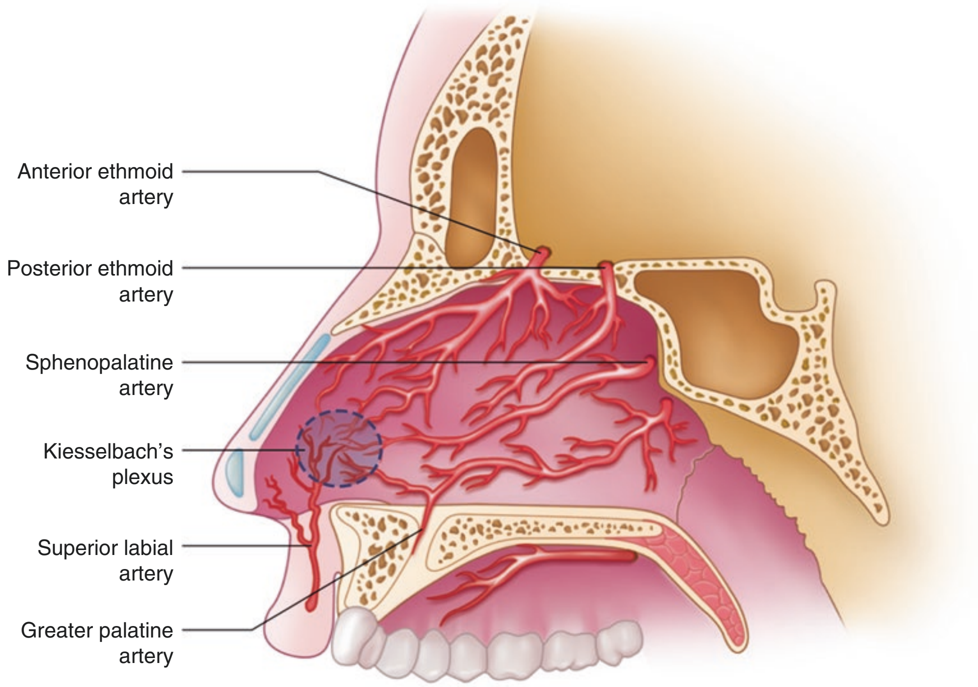

Fig. 60.1 Vascular supply to the nasal septum

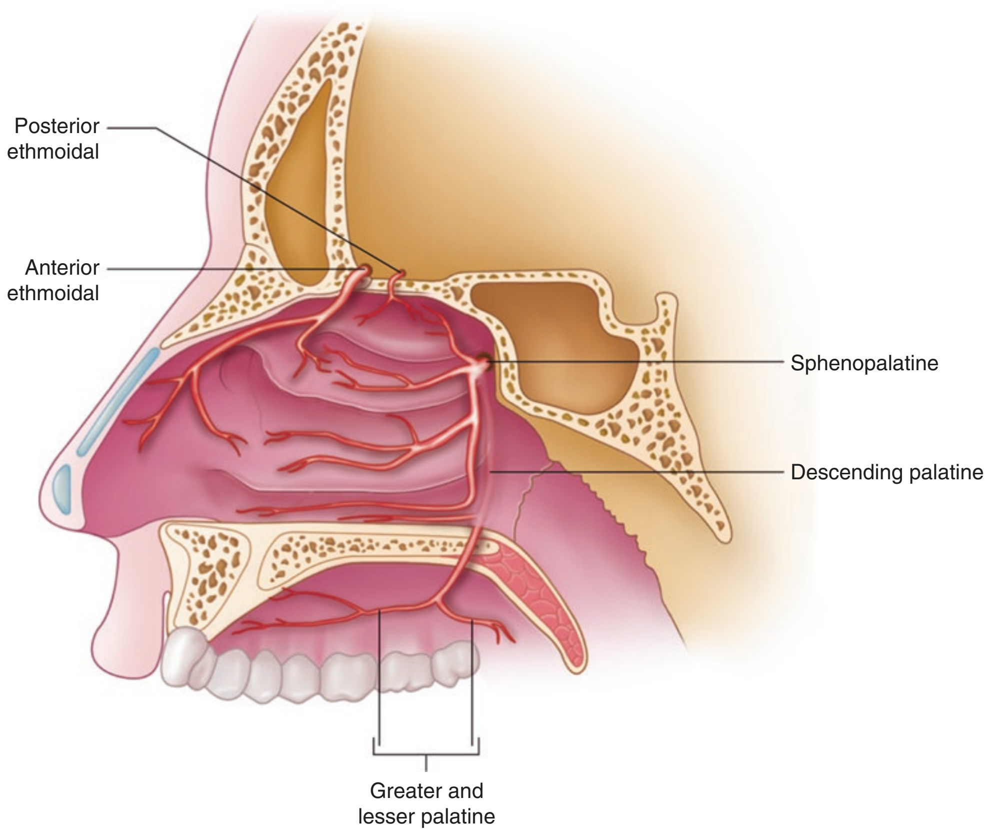

Fig. 60.2 Vascular supply of the lateral wall of the nose

Procedure: Anterior Epistaxis

- Management of epistaxis should be performed in a step-wise fashion, beginning with the least invasive technique and then, if this fails, proceeding to the next strategy.
- Initial preparation:

1. Assemble necessary equipment at the bedside.
2. Have the patient seated upright, with head and neck in the sniffing position.
3. Universal precautions are mandatory: gown, glove, and mask.
4. Drape the patient with towels or a large body drape.
5. If initial evaluation using the headlamp and nasal speculum with gentle spreading in a vertical fashion or a simple visual examination reveals the source (anterior vs posterior), proceed with the appropriate management pathway as determined later.
   - If clot obstructs visualization, it is recommended for the patient to gently blow her or his nose once to remove any easily friable clots and then proceed with immediate inspection. If anterior nose bleeds, go to the next step.

- Management of anterior epistaxis:

1. *Direct Pressure*: Initial step in the management of anterior nosebleeds involves pinching the patient's nostrils firmly for at least 10–15 min.
   - This can be done by the patient, or a simple hands-free device can be assembled at the bedside with tongue depressors, gauze, and tape (Fig. 60.3). Tape gauze around the end of two tongue depressors, and then tape the two tongue depressors together at the opposite end.
   - Simple pressure is very often enough to provide appropriate hemostasis in anterior nosebleeds.
   - If this fails, proceed to the next step.
2. *Topical Vasoconstrictor*: A topical vasoconstrictor of choice (e.g., cocaine, oxymetazoline, 1% pseudoephedrine) can be applied to the septum and lateral walls of the nose either topically with cotton-tipped applicators or by using soaked pledgets.
3. Continue to apply firm pressure to the nares for 10–15 min, and recheck the nose for evidence of bleeding.
4. *Silver Nitrate*: If the bleeding site can be easily visualized, chemical cautery may be attempted with silver nitrate (Fig. 60.4). Aim proximally; avoid cauterizing both sides of the septum to avoid perforating the septum.
   - This can be accomplished with the help of a nasal speculum and a headlight.

Fig. 60.3 Example of silver nitrate stick

Fig. 60.4 Example of commercial nasal pack

- It is advised to cauterize both the site itself and 0.5 cm around the site, by holding the silver nitrate stick to the site for at least 20 s until the bleeding stops.
- Only cauterize one side of the septum to avoid causing perforation.
- If bleeding then stops, cover the site with an absorbable gelatin foam or an oxidized cellulose such as Gelfoam or Surgicel, or simply apply topical antibiotic to the site.

5. *Cotton Pledgets*: If there is continued bleeding, the clinician may apply either two elongated cotton pledgets or a commercially available substitute (e.g., a Rhino Rocket or similar device [Fig. 60.5]) presoaked in a few milliliters or a 1:1 mixture of a topical vasoconstrictor and an anesthetic. Combinations can include the previously cited two agents, plus 2% tetracaine or 4% lidocaine.
6. Universal instructions for the insertion of a commercially available anterior nasal pack include (Fig. 60.6):

- Soak the fabric via the manufacturer's recommended solution if required.
- Insert antibiotic ointment in the nares to facilitate insertion.

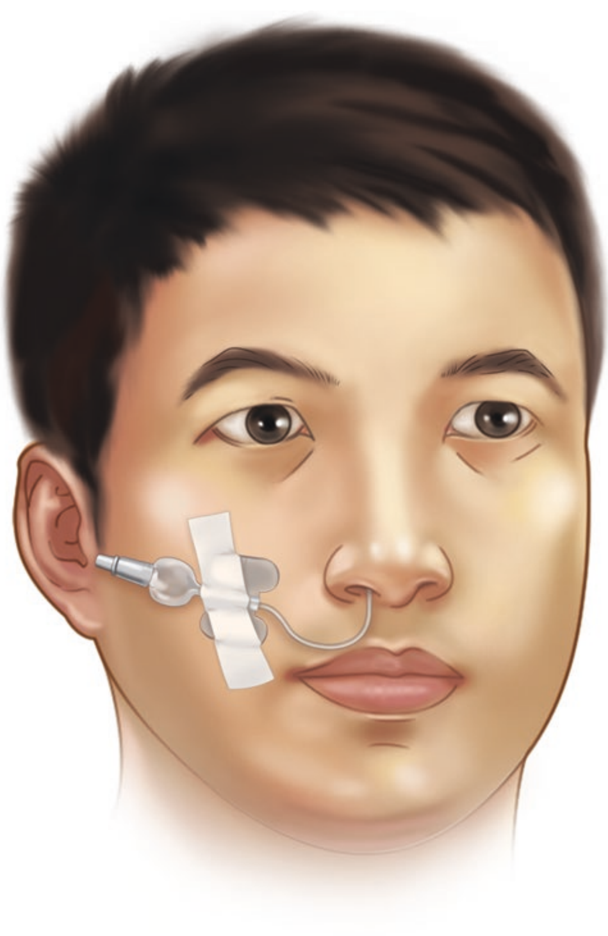

Fig. 60.5 Proper taping of a commercial anterior nasal pack

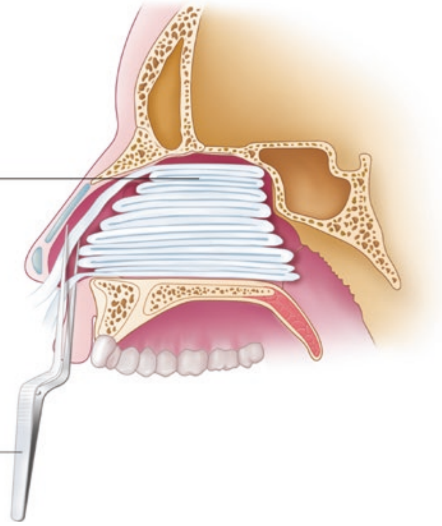

Fig. 60.6 Gauze method

- Insert the entire length of the balloon along the inferior surface of the nasal cavity directing posteriorly.
- The fluid within the nasal cavity should cause it to expand spontaneously while in the nares, after which the remaining exposed string can be taped to the cheek.
- For those devices that require air instillation, read the manufacturer's instructions on how much air to instill within the device.

7. *Gauze Packing*: Another option is to provide an anterior nasal packing in layers, using a few feet of ½-inch ribbon gauze (Fig. 60.7).
8. It is preferable if this gauze is impregnated with petroleum jelly and is enriched with bacitracin ointment.
   - If it is not, bacitracin can be applied to the strip before its insertion into the nasal cavity.
9. To facilitate the insertion, bayonet forceps can be used to gently lay each successive strip on top of the one before it.
10. Begin inferiorly, laying each strip on top of the other, about three or four layers at a time, with the end points protruding from the opening of the nasal cavity.
11. Pack the strands firmly.
12. It may take several feet to pack the entire nasal cavity.
13. This may be both uncomfortable for the patient and time-consuming for the provider, so ensure adequate time and copious topical anesthetic.
14. Parenteral analgesic or anxiolytics may be required for any of these techniques.
15. *Tranexamic Acid*: There is evidence that soaking gauze in tranexamic acid is more effective than packing alone at stopping epistaxis in patients taking antiplatelet agents.
16. Gauze or cotton pledgets can be soaked in the injectable form of 10% tranexamic acid and inserted into the

Fig. 60.7 Example of posterior balloon

affected nostril with direct pressure until bleeding has stopped, at least 15 minutes.

17. If none of the above are available, insert two cotton pledgets or gauze gently into the nostrils after vasoconstrictor/anesthetic topical solution has been sprayed into the nose either manually or with the addition of bayonet forceps. Keep in place for at least 15 min; apply firm pressure to the nares as described previously.
    - If the bleeding has then stopped, they can be removed at this time. If it does not, it is advised to repeat the previous step a second time, this time with a longer period of pressure, before proceeding to the next step.
18. If all of these techniques fail to control bleeding, the clinician may apply a sealant spray or foam enriched with thrombin to enhance clotting.
    - Commercially available options include Crosseal or FloSeal.
19. Finally, if none of these techniques manage to halt what one is sure is only an anterior, albeit persistent, nosebleed, consult the otolaryngologist for further guidance keeping direct pressure in place.
    - Another consideration at this point may be that the uncontrollable anterior nosebleed is really a posterior nosebleed from an undetermined location.
    - It may be prudent to proceed to the algorithm for treatment of posterior epistaxis, even if a posterior bleed is not specifically confirmed.

Complications

- Using an inadequate amount of packing when inserting the ribbon gauze, the entire product may serve as a plug with potential aspiration risk, rather than as a tool for hemostasis.
- Otitis, sinusitis, and toxic shock syndrome.

Pearls and Pitfalls

- Pearls
  – Be sure to perform a reevaluation of both the posterior oropharynx and the posterior nasopharynx after insertion of any of the previously discussed devices, and inspect for continued bleeding/oozing to ensure hemostasis has been accomplished.
  – For those patients with nasal packs in place, consider the use of oral antibiotics to avoid subsequent sinusitis, otitis, or toxic shock syndrome.
- Appropriate antibiotic choices include cephalexin, clindamycin, or amoxicillin-clavulanic acid.
- The use of antibiotics for short-term packing has not been proven.
  – Consider admission for elderly patients or for those patients with potential airway complications such as those patients with chronic obstructive pulmonary disease (COPD), patients at risk for aspiration.
  – Consider reversing anticoagulant agents in patients with persistent hemorrhage.
  – Patients with persistent bleeding despite the above interventions require urgent vs emergent ENT evaluation for potential ligation or embolization.
  – Have the patient follow up with otolaryngology within 2–3 days for reevaluation and packing removal.
  – Provide adequate discharge instructions warning the patient against nose blowing, sneezing with the mouth closed, or any movements or actions that cause a Valsalva maneuver.
- Pitfalls
  – Discharging a patient without an adequate period of observation.
  – Failing to ensure appropriate follow-up.
  – Providing inadequate discharge instructions.
  – Mistaking an anterior nosebleed for a posterior nosebleed.
  – Leaving silver nitrite on exposed nasal mucosa can lead to iatrogenic nasal septal perforation.
  – Not informing the patient that minimal oozing of blood from the nose can be expected.

Procedure: Posterior Epistaxis

- Preliminary steps.

1. Owing to the possibility of extreme exsanguination from a posterior source of epistaxis or airway obstruction from a large clot dislodgment or large volume of blood aspiration, the stability of the patient's airway, breathing, and circulation must be ensured first.
   - Appropriate interventions entirely depend on the presentation of the patient and therefore are not described in this chapter.
   - Patients with posterior epistaxis can lose a large volume of blood quickly, so this needs to be an initial consideration.
2. Consider establishing intravenous access and placing the patient on a cardiac monitor.
3. Because patients with posterior epistaxis tend either to be older, on various blood thinners, or to potentially have some type of coagulopathy, consider obtaining a complete blood count, prothrombin time, and partial thromboplastin time as part of the preliminary workup.
4. Consider a blood type and screen.
5. Initiate early reversal of anticoagulant agents for life-threatening bleeding.

- Management of posterior epistaxis.

1. Inspect the nares as described in the previous section on anterior nosebleeds.
2. Several of the techniques discussed may be attempted but may not be successful.
3. Assemble necessary equipment at the bedside.
4. Have the patient seated upright, with the head and neck in the sniffing position.
5. Universal precautions including a gown, glove, and mask should be employed.
6. Drape the patient with towels or a large body drape.
7. Apply a combination of a topical vasoconstrictor and anesthetic to the nose.
   - An appropriate choice (e.g., 1% pseudoephedrine or 1:1000 epinephrine in a 1:1 ratio with 4% lidocaine or 2% tetracaine).
8. Be aware, however, that there are situations in which the bleeding may be too brisk, and this step may need to be avoided owing to time constraints and the volume of bleeding.
9. Otolaryngology should be consulted as early as possible in the management of this condition, both for admission and in case the failure of the following techniques.
10. Proceed directly to insertion of a unilateral or, preferably, bilateral posterior nasal pack or balloon.

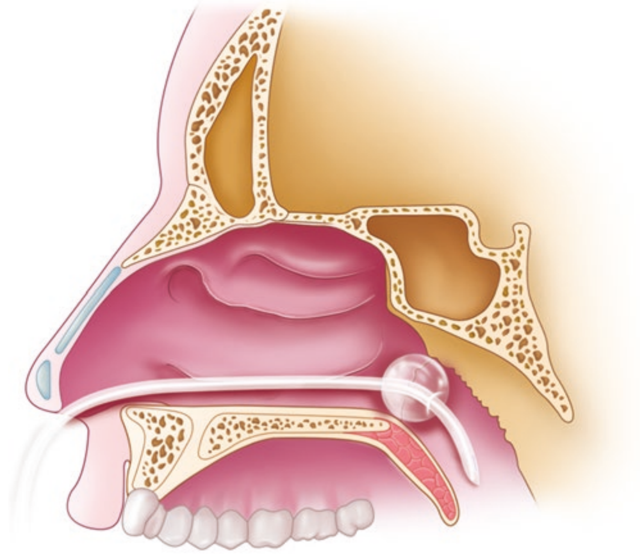

Fig. 60.8 Foley catheter in the posterior nasopharynx

   - An example of these is the elongated version of the Rhino Rocket (9 cm) as described previously.
   - Insertion and securing of the product proceed essentially the same way, except that it is inserted deeper into the posterior oropharynx.
11. Consider the use of a dedicated posterior balloon, such as a Nasostat or Epistat (Fig. 60.8).
12. Place the patient with posterior packing on continuous oxygen monitoring.
   - These devices are double-balloon systems that are lubricated preferably with bacitracin (sterile jelly is also appropriate) and inserted into the posterior nasopharynx.
   - The posterior balloon is then inflated with the product-specific quantity of air.
   - The product is then withdrawn slightly to ensure that the posterior balloon is situated firmly in its desired location of the posterior nasal cavity.
   - The anterior balloon is then inflated with the device-specific quantity of normal saline, and the device is secured.

- If the previously discussed resources are not available, a clinician can insert an adult-caliber Foley catheter into the posterior nasopharynx, with inflation of the balloon, and gentle traction anteriorly to ensure the bulb is situated similarly to the Nasostat or Epistat, firmly in the posterior nasal cavity to tamponade off the bleeding (Fig.60.9).
- If all of these techniques still fail to control bleeding, an otolaryngologist will likely need to intervene, performing techniques outside the scope of practice of the emergency

physician, including electrocautery, submucosal lidocaine/epinephrine injections, or other surgical interventions.
- The final step in the management of this patient includes admission to a monitored bed.

Pearls and Pitfalls

- Pearls
  - Consult otolaryngology early in the workup as soon as a posterior bleed is identified.
  - Patients receiving packing will still need to be placed on antibiotics, such as a first-generation cephalosporin, clindamycin, or amoxicillin-clavulanic acid.
  - Perform a good physical examination concomitantly with the management of the bleed specifically geared toward assessing the patient's volume status (orthostatics, capillary refill, heart rate), because the patient may have significant volume loss depending on the duration and quantity of the bleed.
  - Obtain a thorough history including prior history of bleeding, prior admission for epistaxis, any anticoagulant use, blood dyscrasias, and risk factors for respiratory failure.
- Pitfalls
  - Misclassifying a posterior bleed as an anterior bleed. This can be catastrophic if the patient is discharged. Refer to the "Etiology" section earlier.
  - Discharging the patient with posterior packing.
  - Consulting otolaryngology too late.
  - Underestimating the volume of blood loss. It may be helpful to think of these patients as trauma patients in their initial management and to proceed down the standard primary survey/intervention/secondary survey/intervention approach, ensuring that the volume needs are identified early.
  - Infection.
  - Pressure necrosis of the septum.
  - Hypoxia.
  - Aspiration.
  - Arrhythmias.
  - Dysphagia.
  - Dislodgment of the pack.

Suggested Reading

Buttaravoli P. Minor emergencies, splinters to fractures. 2nd ed. Philadelphia: Mosby; 2007.

Kucik CJ, Clenney T. Management of epistaxis. Am Fam Physician. 2005;71(2):305–11.

Marx JA, Hockberger RS, Walls RM, editors. Rosen's emergency medicine: concepts and clinical practice. 6th ed. Philadelphia: Mosby; 2006.

Pope LE, Hobbs CG. Epistaxis: an update on current management. Postgrad Med J. 2005;81(955):309–14.

Singer AJ, Blanda M, Cronin K, et al. Comparison of nasal tampons for the treatment of epistaxis in the emergency department: a randomized controlled trial. Ann Emerg Med. 2005;45:134–9.

Summers SM, Bey T. Chap. 239. Epistaxis, Nasal Fractures, and Rhinosinusitis. In: Tintinalli's Emergency Medicine, seventh ed. New York, NY: McGraw Hill; 2011.

Zahed R, et al. Topical tranexamic acid compared with anterior nasal packing for treatment of epistaxis in patients taking antiplatelet drugs: randomized controlled trial. Acad Emerg Med. 2017:261–6.

Treatment of Septal Hematoma

61

Bobby K. Desai

Indications

- Septal hematomas occur after force applied to the nasal cartilage results in leakage of blood from the perichondrium (Figs. 61.1 and 61.2). They may be unilateral or bilateral.
  - Untreated, this hematoma can expand and mechanically obstruct the blood vessels that supply the nasal cartilage.

Contraindications

- In the setting of massive facial trauma, airway protection and consultation with otolaryngology or oral surgery may be required.

Materials and Medications

- 5-cc syringe.
- 20-gauge needle (may use larger-gauge needle, but smaller ones may not allow for adequate suctioning).
- Topical antiseptic.
- Sterile drapes, gown, eye protection, and gloves.
- Light source—preferably a headlamp.
- If using procedural sedation, specific medications of choice are needed as well as monitoring and resuscitation equipment.
- Nasal speculum.
- 4% liquid cocaine or 4% liquid lidocaine for anesthesia.
- Topical vasoconstrictor of choice (oxymetazoline or phenylephrine).
- Scalpel (#15 blade).
- Suction setup.

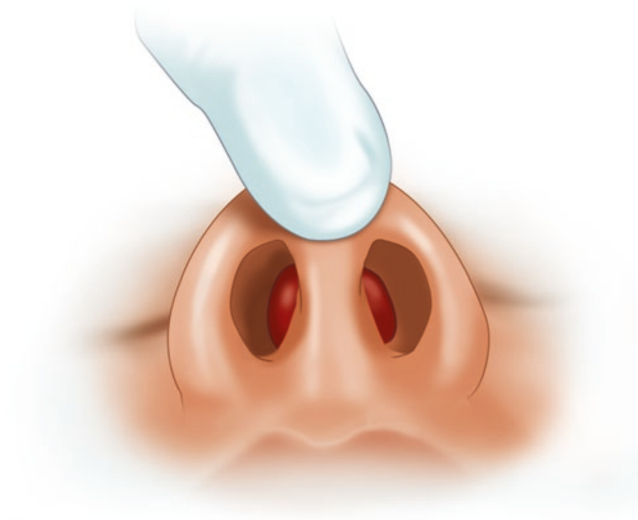

Fig. 61.1 Example of a septal hematoma

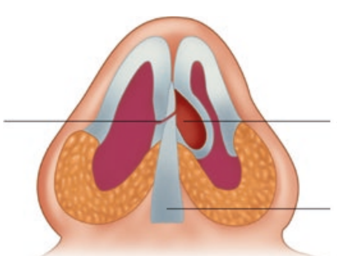

Fig. 61.2 Diagram of a septal hematoma

- Saline for irrigation.
- Sterile gauze.
- Iodoform packing or sterile rubber band.
- Anterior nasal pack (Rhino Rocket).
- Intravenous antibiotics to cover *Staphylococcus aureus*, group A β-hemolytic streptococci, *Streptococcus pneumoniae*, and *Haemophilus influenzae*.

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Procedure

- Preprocedure:
  - Explain the procedure to the patient.
  - Informed consent may be required.
- Procedure—unilateral (Fig. 61.3):

1. Place the patient in a seated position if the procedure is to be done without procedural sedation:
   - If performing the procedure under procedural sedation, the patient may be placed in the supine position with appropriate monitoring and resuscitation equipment on standby.
2. Provide local anesthesia by applying the topical anesthetic of choice to cotton pledgets, wringing out the excess before insertion:
   - Remove after 10 min.
   - If using lidocaine, a topical vasoconstrictor may be required that may be mixed with the lidocaine or applied directly on the nasal mucosa before the procedure.
3. Using a nasal speculum, open the affected nares vertically as wide as possible. Horizontal use may obscure the hematoma.
4. Using a #15 blade, make a vertical incision at the hematoma extending the incision posteriorly at its base:
   - Avoid making the incision too deep to prevent septal perforation.
5. Apply suction and gauze to control bleeding.
6. Pack the incision site with iodoform gauze or a sterile rubber band in order to keep the incision open to prevent re-accumulation of blood.
7. This packing can be held in place with an anterior nasal pack.

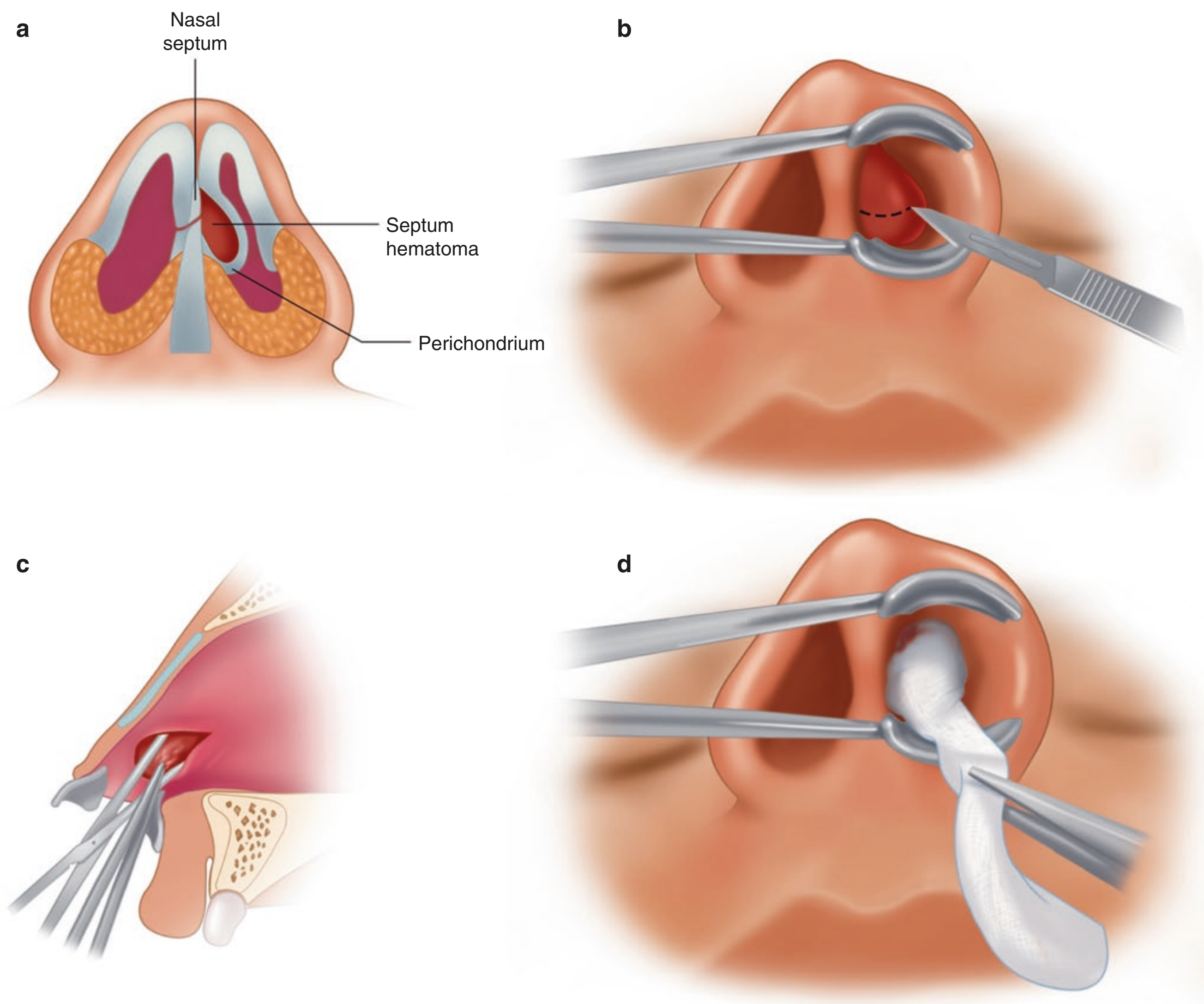

Fig. 61.3 (**a**–**d**) Technique for drainage of a unilateral septal hematoma

8. The pack should be placed in both nares to prevent deformity of the nasal septum.
9. Consider administration of a dose of intravenous antibiotics.
10. Send the patient home with a prescription for oral antibiotics.
11. Arrange follow-up for 24 h.

- Procedure—bilateral (Fig. 61.4):

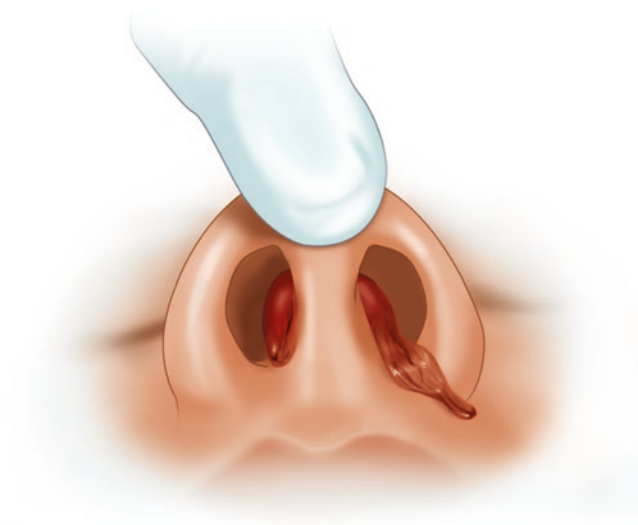

Fig. 61.4 Technique for drainage of a bilateral septal hematoma

1. If bilateral hematomas are present, otolaryngology consultation should be sought.
2. One method involves the incision of one side only through the nasal septum so that both may drain through one side:
   - Care must be taken *NOT* to penetrate the overlying mucosa of the other side.
3. The second option is to repeat the unilateral drainage procedure on the contralateral side.
4. Must avoid aligning incisions on either side of the septum due to the risk of communication and permanent septal perforation.

Pitfalls and Complications

- Bleeding.
- Infection: toxic shock syndrome.
- Deformity of the nose.
- Permanent septal perforation.
- Inadequate drainage.
- Re-accumulation of blood.
- Development of septal abscess.

Suggested Reading

Ginsburg CG. Consultation with the specialist: nasal septal hematoma. Pediatr Rev. 1998;19:142–3.
Savage RR, Valvich C. Hematoma of the nasal septum. Pediatr Rev. 2006;27:478–9.

62 Nasal Foreign Body Removal

Bobby K. Desai and Tracy Macintosh

Indications

- Visualized foreign body (FB) on inspection.
- Continued unilateral nasal discharge of unknown etiology.
- Recurrent epistaxis.

Contraindications: Need Urgent Referral

- Those cases in which the emergency physician is not confident of success.
- Combative patients who are not candidates for conscious sedation.
- Embedded FBs.
- Penetrating injuries with an FB.
- Button batteries that cannot be removed.
- Patients with bleeding diathesis.
- Respiratory distress.
- FBs superior and medial to the middle turbinate owing to risk of puncture to the cribriform plate.
- Chronic FBs may be difficult to visualize and these should be referred.

Materials and Medications

- 1% lidocaine without epinephrine (solution) for anesthesia
- 2% lidocaine jelly
- 0.5% phenylephrine to vasoconstrict the vessels
- Nasal speculum (Fig. 62.1).
- Headlamp or other direct lighting instrument.
- Ambu bag (Fig. 62.2).
- Alligator forceps (Fig. 62.3).
- Curved hook (Fig. 62.4).
- Foley catheter.
- Suction: Schuknecht catheter (Fig. 62.5).
- Eye and biohazard protection for the clinician.

Procedures (Based on the Method Chosen, Tailor to FB Size, Location, Patient Age)

Alligator Forceps

- Perhaps the easiest method to use for easily visualized FBs.
- Care must be taken for those FBs that are easily broken apart (e.g., peas) to ensure that all of the matter has been removed.
- Using a nasal speculum, spread the nares as much as possible to maximize visualization.
- Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
- Grasp the FB with the forceps.
- After removal, ensure the complete removal of the object and ensure that no other FBs are present.

Pitfalls and Complications

- Pushing the object deeper into the nares.
- Inability to totally remove the FB.
- Attempted removal of an embedded FB may cause significant bleeding.

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Fig. 62.1 (**a**–**c**) Example of nasal speculum

Curved Hook

- Used for nongraspable objects especially in the anterior nares.
- Using a nasal speculum, spread the nares as much as possible to maximize visualization.
- Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
- Pass the hook behind the object, or if the object has holes, the hook may be placed inside the hole to facilitate removal.
- Slowly withdraw the hook, thereby removing the FB.
- After removal, ensure the complete removal of the object and ensure that no other FBs are present.

Pitfalls and Complications

- This technique cannot be used if the object cannot be directly visualized because of risk of significant trauma from blind insertion of the hook.
- Attempted removal of an embedded FB may cause significant bleeding.

Fig. 62.2 Example of Ambu bags

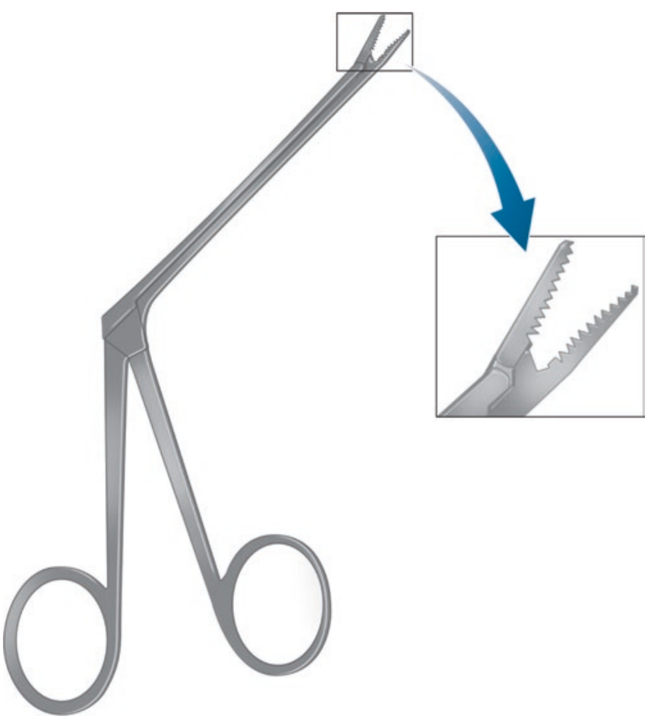

Fig. 62.3 Example of alligator forceps

Fig. 62.4 Example of a curved hook

Fig. 62.5 Example of a Schuknecht suction tube

Foley Catheter Removal

- Use a 5 or 6 French catheter.
- Anesthetize the nares with lidocaine with or without epinephrine and vasoconstrict the nasal vessels with phenylephrine.
- Ensure that the Foley balloon has no leaks.
- Place the patient in a supine position:
- Consider procedural sedation for children and/or a papoose board.
- Lubricate the Foley tip and balloon with lidocaine jelly.
- Advance the tip past the object.

- Blow up the balloon with 2–3 mL of air and gently withdraw the catheter:
- The amount of air may need to be adjusted depending on the size of the object to be withdrawn.
- Pulling too quickly may cause a soft FB to break apart.

Pitfalls and Complications

- This technique may be used if the FB is not visible.
- In order for this technique to work, the catheter must be able to slide posterior to the object in order for the balloon to pull out the object.

Suction

- A small metal suction catheter—the Schuknecht catheter—may be used.
- The suction is placed against the FB and slowly withdrawn.
- This technique works best for round smooth objects visualized in the anterior nares.

Pitfalls and Complications

- May not work for posteriorly displaced FBs.
- May not work for objects too tightly entrenched in the nares.

Nasal Positive Pressure

- This technique works best for round FBs occluding the nare(s).
- Place the patient in a supine or seated position:
  - Consider a papoose board to secure the patient.
- Apply pressure to the contralateral nare to occlude it.
- Connect an Ambu bag to high-flow oxygen:
  - Use a facemask that covers only the mouth.
- Place the mask on the patient's mouth and allow it to expand by covering the thumbhole.
- If this pressure is insufficient to expel the object, the Ambu bag may be compressed to add pressure to the attempt.
- This may allow the object to be seen and grasped in the anterior nares.
- This technique may be adapted by having a trusted adult occlude the unaffected nostril and blow into the child's mouth to expel the foreign body, also known as "mother's kiss."

Pitfalls and Complications

- Too much pressure could theoretically rupture the tympanic membranes.

Suggested Reading

Backlin SA. Positive-pressure technique for nasal foreign body removal in children. Ann Emerg Med. 1995;25:624–5.

Chan TC, Ufberg J, Harrigan RA, et al. Nasal foreign body removal. J Emerg Med. 2004;26:441–5.

Kadish H. Ear and nose foreign bodies: it is all about the tools. Clin Pediatr. 2005;44:665–70.

63 Cerumen Removal

Bobby K. Desai

Indications

- Hearing loss.
- Profound dizziness.
- Pain.

Contraindications

- Uncooperative patient.
- Potential for foreign bodies.
- Prior surgery to the ear or mastoid.
- History of middle or outer ear disease.

Materials and Medications

- Ear speculum (Fig. 63.1).
- Eye and biohazard protection for the clinician.
- Headlamp or other direct lighting instrument.
- Cerumen-softening solutions:
  - Carbamide peroxide.
  - Mineral oil- or other oil-based agents including almond or olive oil.
  - Liquid docusate sodium.
  - Acetic acid.
  - Sodium bicarbonate.
- Alligator forceps (Fig. 63.2).
- Curved hook or cerumen spoon (Figs. 63.3 and 63.4).
- Suction—Schuknecht catheter.
- Irrigation setup:
  - Ear syringe (Figs. 63.5 and 63.6).
  - 20- to 60-mL syringe with an 18-gauge angiocath attached
  - Commercial ear irrigation setup.

Fig. 63.1 Example of an ear speculum

  - Warm water (tap water may be used).
  - Kidney-shaped basin or other collection device.
  - Towels.

Procedure

1. Explain the procedure to the patient to facilitate cooperation:
   - Some discomfort may be involved, including a sensation of pressure and the wet feeling from the water used for irrigation.
   - Nausea, vomiting, or a sensation of vertigo may also be experienced:
     – Consider pretreatment of vertigo with agent of choice.

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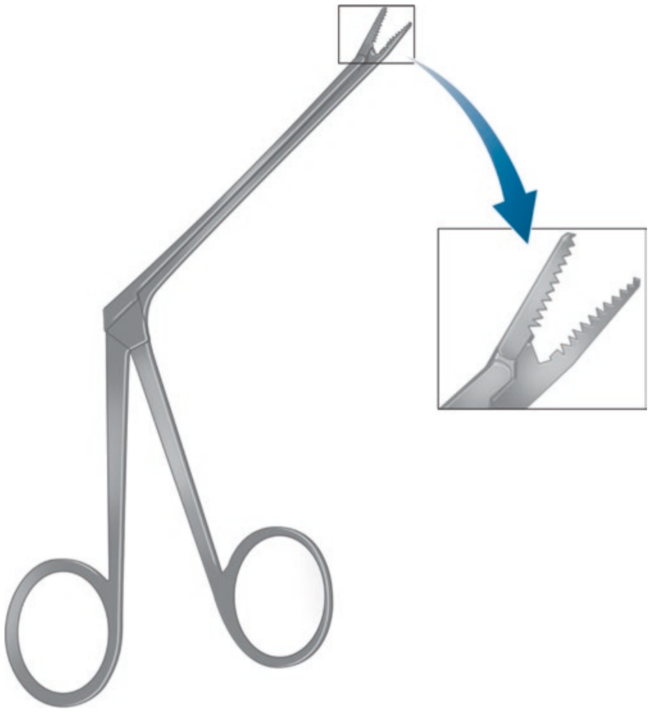

Fig. 63.2 Example of alligator forceps

2. The patient may be seated or supine with the head slightly turned to the affected side to facilitate the collection of fluid.
3. Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
4. Pull the ear up and out to straighten the ear canal.
5. Before irrigation, if the cerumen is hard, alligator forceps or a cerumen spoon may be used under direct visualization to remove as much cerumen as possible.
6. Use a cerumen-softening agent before irrigation by instilling and leaving in for 30 min to maximize softening.
7. Place a collection device next to the patient's ear, or alternatively, have the patient hold a kidney-shaped basin near the ear to collect any liquid.
8. Attach an angiocath to a 20- or 60-mL syringe, place the tip of the catheter within the ear canal, and aim toward the tympanic membrane.
9. Slowly inject the solution into the ear canal:
   - Care must be taken to limit the force used owing to the potential for tympanic membrane rupture.
   - The fluid can be injected in short bursts or all at once.
10. Direct the stream as much as possible toward the rear of the cerumen to be removed.
11. Continually reassess the ear canal to ensure that all cerumen has been removed:
    - If one large piece remains, use a cerumen hook to facilitate removal.

Fig. 63.3 Examples of cerumen spoons

Fig. 63.4 Examples of ear curettes

12. If the patient complains of severe sharp pain, stop the procedure and assess the tympanic membrane for rupture:
    - Consider referral or otolaryngological consultation at this point.
13. After successful removal, dry the ear canal with cotton-tipped applicators to prevent otitis externa.

Fig. 63.5 Example of a typical bulb syringe used in irrigation

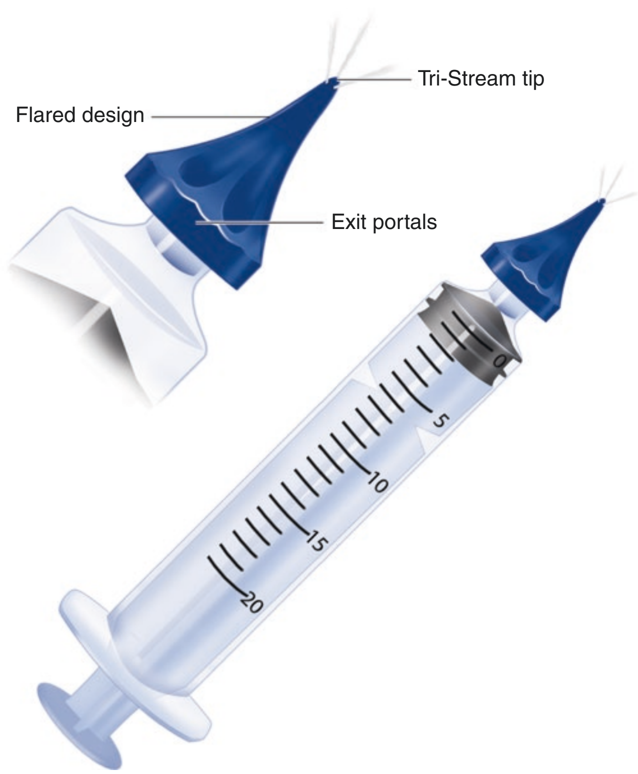

Fig. 63.6 Example of a specialized ear syringe

Pearls, Pitfalls, and Complications

- Using warm water will help prevent a caloric response including vertigo, nausea, and vomiting.
- Rupture of the tympanic membrane.
- Unsuccessful irrigation secondary to inadequate time given to softening agents before attempting removal.
- Bleeding of the external auditory canal.
- Otitis externa.
- Hearing loss.

Suggested Reading

Blake P, Matthews R, Hornibrook J. When not to syringe an ear. N Z Med J. 1998;111:422.

McCarter D, Courtney AU, Pollart SM. Cerumen impaction. Am Fam Physician. 2007;75:1523–8.

Roland PS, Smith TL, Schwartz SR, et al. Clinical practice guideline: cerumen impaction. Otolaryngol Head Neck Surg. 2008;139:S1–21.

Ear Foreign Body Removal

64

Bobby K. Desai

Indications

- Visualized foreign body (FB) on inspection.
- Continued unilateral otorrhea of unknown etiology mandates a search.
- Recurrent bleeding.
- History of FB placement by patient.

Contraindications: Need Urgent Referral

- Those cases in which the emergency physician is not confident of success.
- Combative patients are not candidates for conscious sedation.
- Embedded FBs.
- Penetrating injuries with an FB.
- FBs close to the tympanic membrane.
- Consider referral of spherical FBs because these may be difficult to grasp.
- Chronic FBs may be difficult to visualize; these should be referred.
- Consider referral for those patients who have attempts made at other institutions.

Materials and Medications

- Ear speculum (Fig. 64.1)
- Eye and biohazard protection for the clinician
- Headlamp or other direct lighting instrument
- Alligator forceps (Fig. 64.2)
- Curved hook (Fig. 64.1) or cerumen spoon (Fig. 64.3)
- Suction—Schuknecht catheter (Fig. 64.2)
- Irrigation setup:

Fig. 64.1 Example of a curved hook

- Ear syringe (Fig. 64.3)
- 20- to 60-mL syringe with an 18-gauge angiocath attached
- Water (tap water may be used)
- Basin or other collection device
- Towels
- Cyanoacrylate (Fig. 64.4)

Procedures (Based on the Method Chosen)

Alligator Forceps

- Ideal for easily visualized FBs, especially graspable FBs in the lateral third of the ear canal:
  - May have limited success with rounded objects
- Care must be taken for those FBs that are easily broken apart (e.g., peas) to ensure that all of the matter has been removed:
  - May need irrigation subsequent to the attempt.
- Explain the procedure to the patient to facilitate cooperation.
- Pull the ear up and out to straighten the ear canal.
- Consider using a specialized otoscope with magnification (an operating otoscope) to maximize visualization.
- The patient may be seated or supine with the unaffected side turned to the gurney or examining chair.
- Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
- Attempt to grasp the FB with the forceps:
  - If using an ear speculum, attempt to bring the object as close as possible to the speculum in order to stabilize it and slowly remove both.
- After removal, ensure the complete removal of the object and ensure that no other FBs are present.

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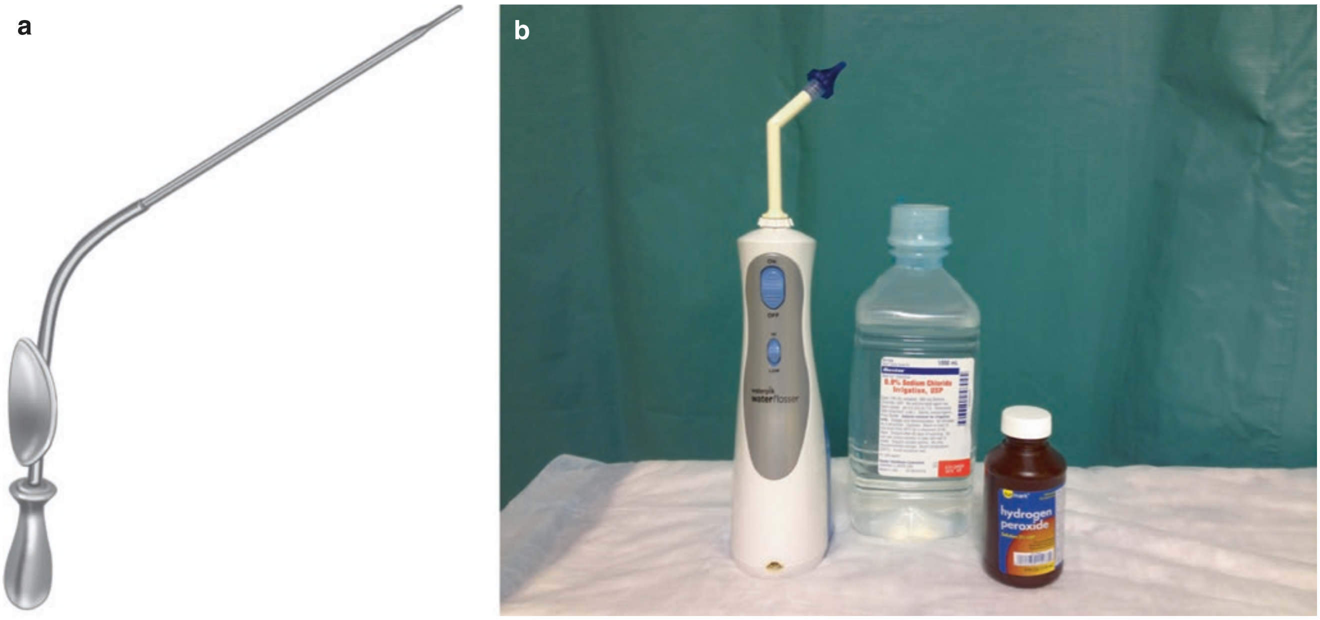

Fig. 64.2 (**a**) Example of a Schuknecht suction tube, (**b**) example of ear irrigation setup using a Waterpik system

Fig. 64.3 Example of a typical syringe used in irrigation

Fig. 64.4 Example of cyanoacrylate

Pitfalls and Complications

- Pushing the object deeper into the auditory canal.
- Inability to totally remove the FB.
- Attempted removal of an embedded FB may cause significant bleeding.

Curved Hook

- Ideal for spherical objects in the lateral third of the auditory canal.
- Can be used for non-graspable objects especially in the lateral third of the auditory canal.
- Direct visualization is necessary to avoid trauma to the ear canal.
- Consider using a specialized otoscope with magnification (an operating otoscope) to maximize visualization.
- Explain the procedure to the patient to facilitate cooperation.
- The patient may be seated or supine with the unaffected side turned to the gurney or examining chair.
- Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
- Pull the ear up and out to straighten the ear canal.
- Pass the hook behind the object, or if the object has holes, place the hook inside the hole to facilitate removal:
- In order for this technique to succeed, there must be sufficient area near the object to facilitate the hook going behind it.

- Slowly withdraw the hook, thereby removing the FB.
- After removal, ensure the complete removal of the object and ensure that no other FBs are present.

Pitfalls and Complications

- Pushing the object deeper into the auditory canal.
- This technique cannot be used if the object cannot be directly visualized because significant trauma may arise owing to the misplacement of the hook.
- Attempted removal of an embedded FB may cause significant bleeding.
- Do not use this technique if the object is close to the tympanic membrane owing to risk of rupture.

Suction

- A small metal suction catheter—the Schuknecht catheter—may be used.
- Ideal for hard rounded objects in the lateral third of the ear canal:
  – Does not work as well for those objects closer to the tympanic membrane owing to lack of suction and the narrow ear canal
- Direct visualization of the object is mandatory:
  – The catheter must be placed directly on the object for this technique to succeed.
- Explain the procedure to the patient to facilitate cooperation.
- The patient may be seated or supine with the unaffected side turned to the gurney or examining chair.
- Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
- Pull the ear up and out to straighten the ear canal.
- Place the suction against the FB and slowly withdraw.

Pitfalls and Complications

- Pushing the object deeper into the auditory canal
- May not work for objects too tightly entrenched in the ear canal

Irrigation

- Useful for small particulate matter unable to be grasped by forceps or too small for a hook to pull out:
  – Cannot be used for button batteries or vegetable matter:
- Irrigation may cause an alkaline necrosis with the button battery.
- Vegetable matter may expand, increasing the difficulty of removal.
- Explain the procedure to the patient to facilitate cooperation:
  – Some discomfort may be involved, including a sensation of pressure and a feeling cold wetness from the water used.
- The patient may be seated or supine with the head slightly turned to the affected side to facilitate collection of fluid.
- Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
- Pull the ear up and out to straighten the ear canal.
- Place a collection device next to the patient's ear, or alternatively, have the patient hold a basin.
- Attach an angiocath to a 20- or 60-mL syringe and place the tip of the catheter within the ear canal, or use a Waterpik system.
- Slowly inject the solution into the ear canal:
  – Care must be taken to limit the force used owing to the potential for tympanic membrane rupture.
- Direct the stream as much as possible toward the rear of the object(s) to be removed.
- Continually assess the ear canal to ensure that all foreign matter has been removed.
- If the patient complains of severe sharp pain, stop the procedure and assess the tympanic membrane for rupture:
  – Consider referral or otolaryngological consultation at this point.

Pitfalls and Complications

- Owing to instillation of room temperature water, a caloric response may occur including vertigo, nausea, and vomiting.
- Rupture of the tympanic membrane.

Cyanoacrylate

- Useful for objects that can be directly visualized.
- Ideal for hard rounded objects in the lateral third of the ear canal:
  – Does not work as well for those objects closer to the tympanic membrane owing to lack of visualization
- Direct visualization of the object is mandatory:
  – The stick with the cyanoacrylate must be placed directly on the object for this technique to succeed.
- Consider using a specialized otoscope with magnification (an operating otoscope) to maximize visualization.
- Explain the procedure to the patient to facilitate cooperation.

- The patient may be seated or supine with the unaffected side turned to the gurney or examining chair.
- Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient.
- Pull the ear up and out to straighten the ear canal.
- Place a small amount of cyanoacrylate on the end of a cerumen spoon or wooden end of a cotton-tipped swab.
- Using direct visualization, place the stick in the ear canal and touch the FB.
- Leave the stick on the object for approximately 30–60 s to facilitate drying of the glue.
- Remove the stick and the FB (Fig. 64.5).

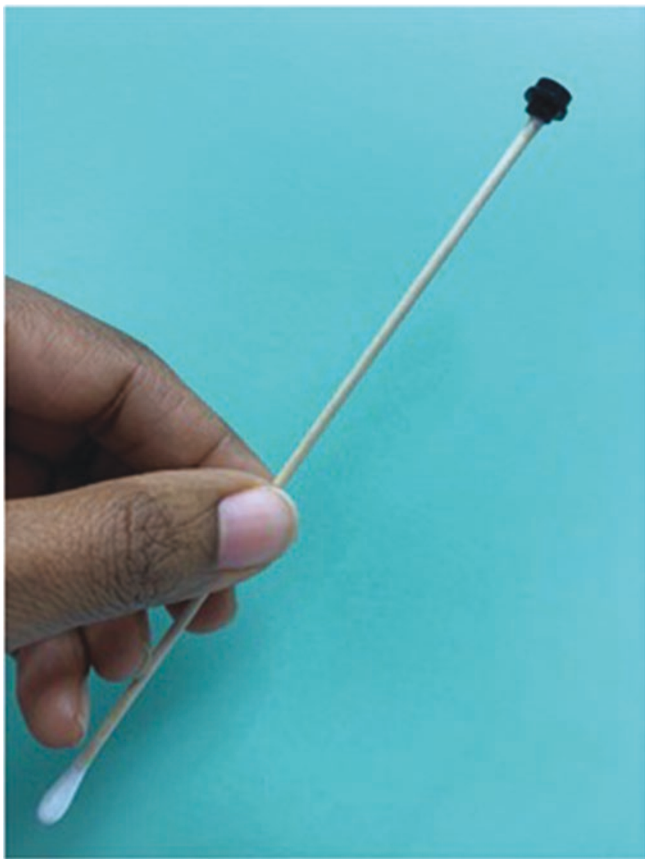

Fig. 64.5 Remove the stick and the foreign body

Pitfalls and Complications

- This technique cannot be used if the object cannot be seen.
- The object must be relatively smooth to facilitate placement of the glue.

Suggested Reading

Hanson RM, Stephens M. Cyanoacrylate-assisted foreign body removal from the ear and nose in children. J Paediatr Child Health. 1994;30:77–8.

Kadish H. Ear and nose foreign bodies: it is all about the tools. Clin Pediatr. 2005;44:665–70.

65 Treatment of Auricular Hematoma

Bobby K. Desai

Indications

- Presence of auricular hematoma:
  - These occur after significant force is applied to the ear.
  - This type of hematoma will separate the perichondrium from the cartilage:
    - Untreated, this hematoma prevents the development of new cartilage, subsequently deforming the auricle, causing *cauliflower ear* (Figs. 65.1 and 65.2).

Contraindications

- Uncooperative patient.
- Evidence of infection mandates plastic surgery or otolaryngology consultation.
- Significant trauma to area around the ear.

Materials and Medications

- 5-cc syringe
- 20-gauge needle (may use larger-gauge needle, but smaller ones may not allow for adequate suctioning)
- Topical antiseptic
- Sterile drapes, gown, eye protection, and gloves
- 1% lidocaine for anesthesia
- Scalpel (#11 or #15 blade)
- Suction setup
- Saline for irrigation
- Hemostat and forceps
- Penrose drain or plain gauze packing
- Xeroform gauze
- Laceration tray setup:
  - Needle driver
  - 4–0 nonabsorbable suture
- Antibiotic ointment
- Gauze bandages

Fig. 65.1 Example of a cauliflower ear

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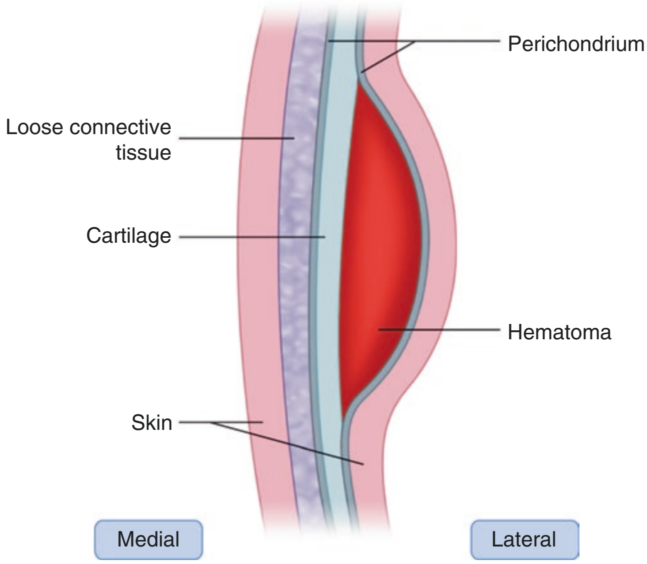

Fig. 65.2 Schematic of auricular hematoma

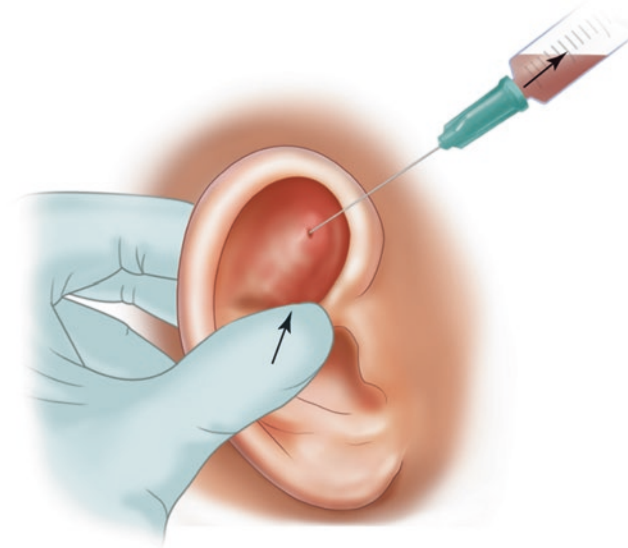

Fig. 65.3 Aspiration of a hematoma

Procedure (Needle Aspiration)

1. Explain the procedure to the patient.
2. Informed consent may be required.
3. The patient may be seated or supine with the unaffected side turned to the gurney or examining chair.
4. Stabilize the head with the nondominant hand, or for children, consider a papoose board to secure the patient:
   - Consider procedural sedation for children.
5. Carefully clean the area with an antiseptic solution of choice (povidone-iodine [Betadine] or chlorhexidine solution) and allow to dry.
6. Anesthetize the area where the hematoma is of greatest diameter with 1% lidocaine.
7. Inject the hematoma itself to promote increased anesthesia.
8. The clinician should prepare for the procedure by practicing universal precautions.
9. Drape the patient's ear.
10. Attach a 20-gauge needle to a syringe:
    - A 5-cc syringe should be sufficient.
11. Attempt to aspirate the hematoma contents with the prepared syringe (Fig. 65.3).
12. "Milking" the hematoma may be required to fully remove the clot:
    - If the hematoma has been present for sufficient time for the blood to completely clot, needle aspiration will fail, and an alternative technique, described later, may be necessary to completely evacuate the hematoma.
13. Place antibiotic ointment around the injection site.
14. Loosely dress the area.
15. Refer to an otolaryngologist or a plastic surgeon for follow-up care:

If needle aspiration fails, a larger incision may be required using the following procedure:

1. Perform the previously discussed steps.
2. Consider a local field block of the greater auricular nerve.
3. Make an incision over the hematoma, following the anatomy of the helix (Fig. 65.4):
   - The incision should be 5–6 mm in length and curvilinear, following the concavity of the helix.
   - More than one incision may be required.
4. Remove the hematoma with hemostats or forceps:
   - Suctioning may be used as well.
5. Copiously irrigate the cavity with saline to make certain of complete removal of the hematoma.
6. Insert the Penrose drain or plain packing into the incision.
7. Antibiotic ointment may be applied to the incision site.
8. Place the Xeroform gauze over the incision site.
9. Apply a compression dressing to the ear (Fig. 65.5):
   - Place dry cotton into the ear canal to protect from possible drainage and subsequent infection (Fig. 65.6).
   - Mold Xeroform gauze in and around the contours of the helix (Fig. 65.7).
   - With the aid of an assistant, place the gauze behind the pinna and over the Xeroform gauze already molded to the anterior portion of the ear (Fig. 65.8).

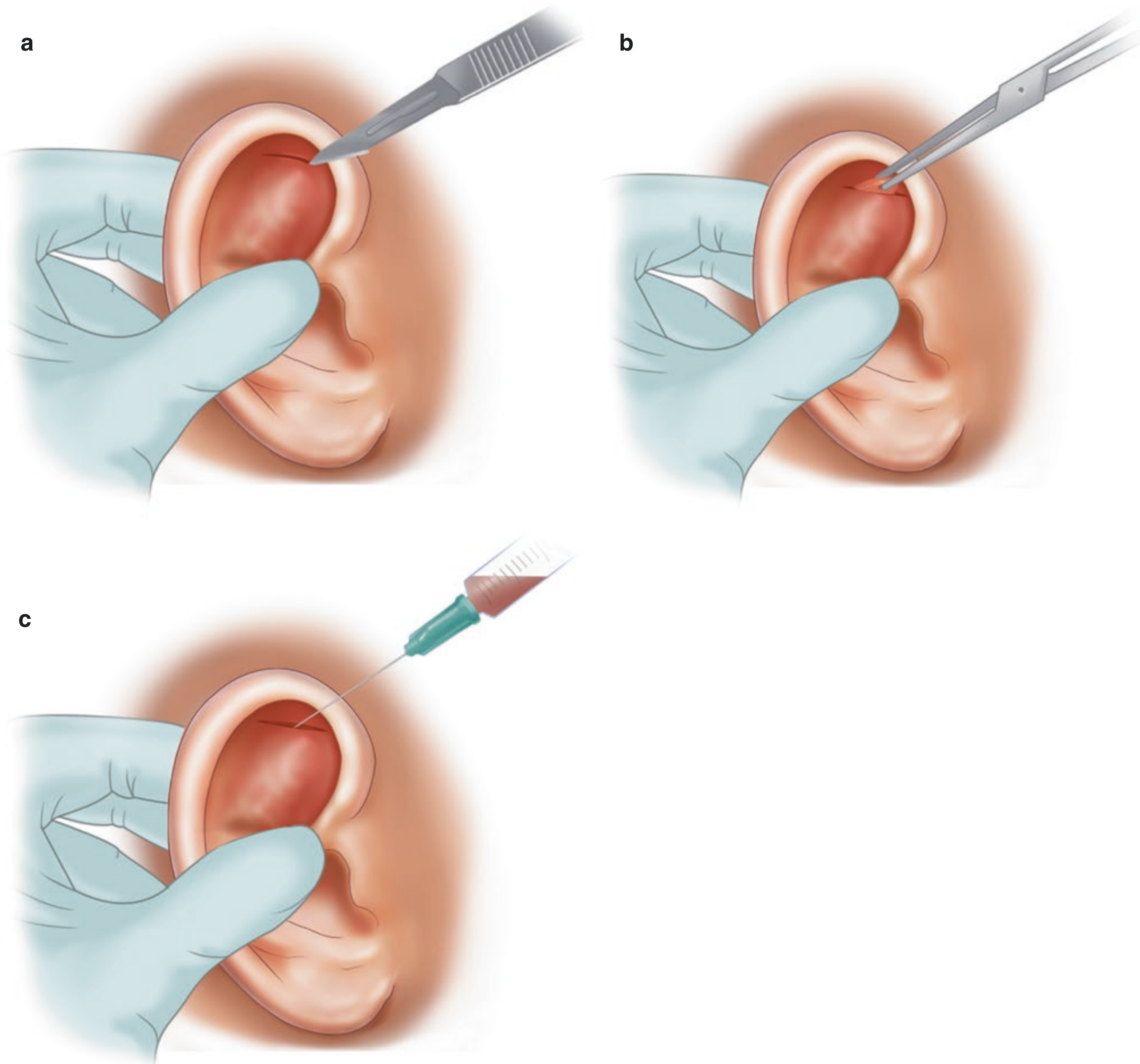

Fig. 65.4 Incision of an auricular hematoma. (**a**) Incision; (**b**) removal of clot with forceps; (**c**) aspiration of blood with syringe

- Place more fluffed gauze over the ear (Fig. 65.9).
- While the assistant holds the anterior and posterior gauze in place, use a web roll (Kerlix) around the head to keep the gauze in place. Then, wrap the head with an ACE wrap or stretchy bandage (Figs. 65.10 and 65.11).
- These steps are critical to maintain equal compression of the ear, which will help prevent future deformity.
- Alternatively, dental rolls can be secured with suture to the anterior and posterior site of the drained hematoma (Fig. 65.12).

10. Place the patient on prophylactic antibiotics.
11. Refer to an otolaryngologist or a plastic surgeon for follow-up care.

Fig. 65.5 Materials needed for compression dressing

Fig. 65.6 Place cotton in the ear to prevent drainage into the ear

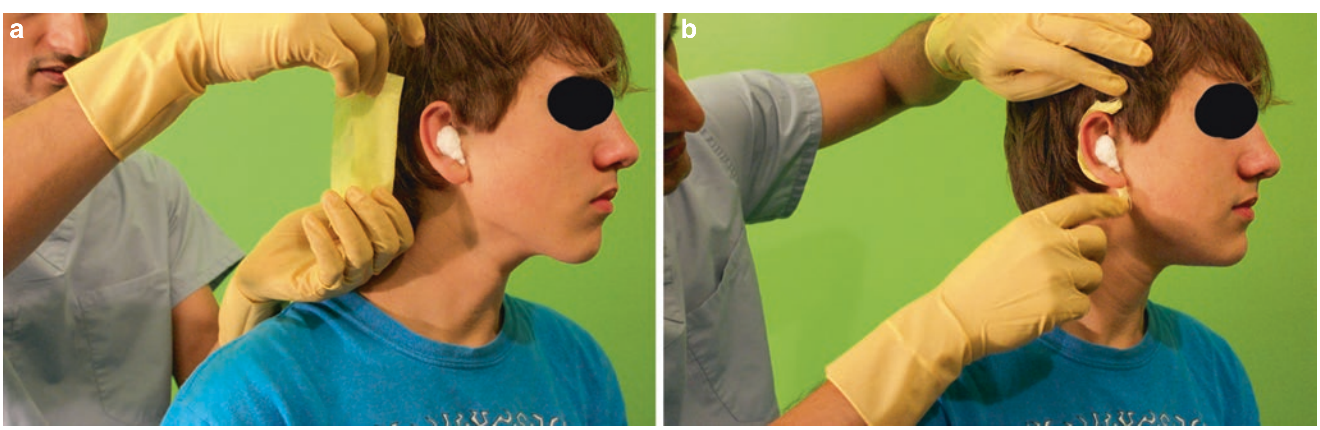

Fig. 65.7 (**a**, **b**) Mold Xeroform gauze around ear helix

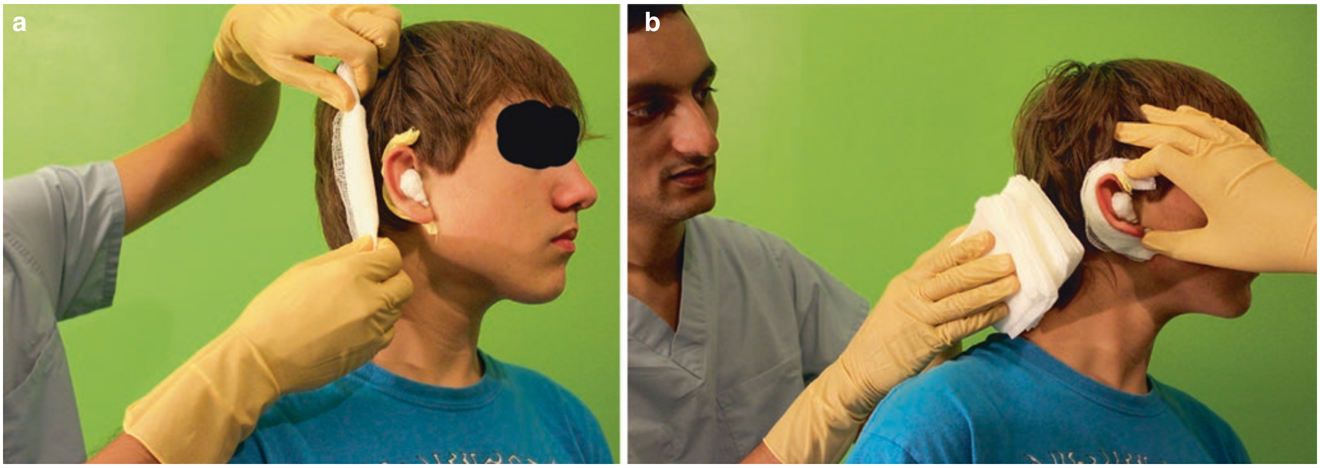

Fig. 65.8 (**a**, **b**) Mold sterile gauze on top of Xeroform gauze around ear helix

Fig. 65.9 Pad outside of the ear with 4×4 gauze pads

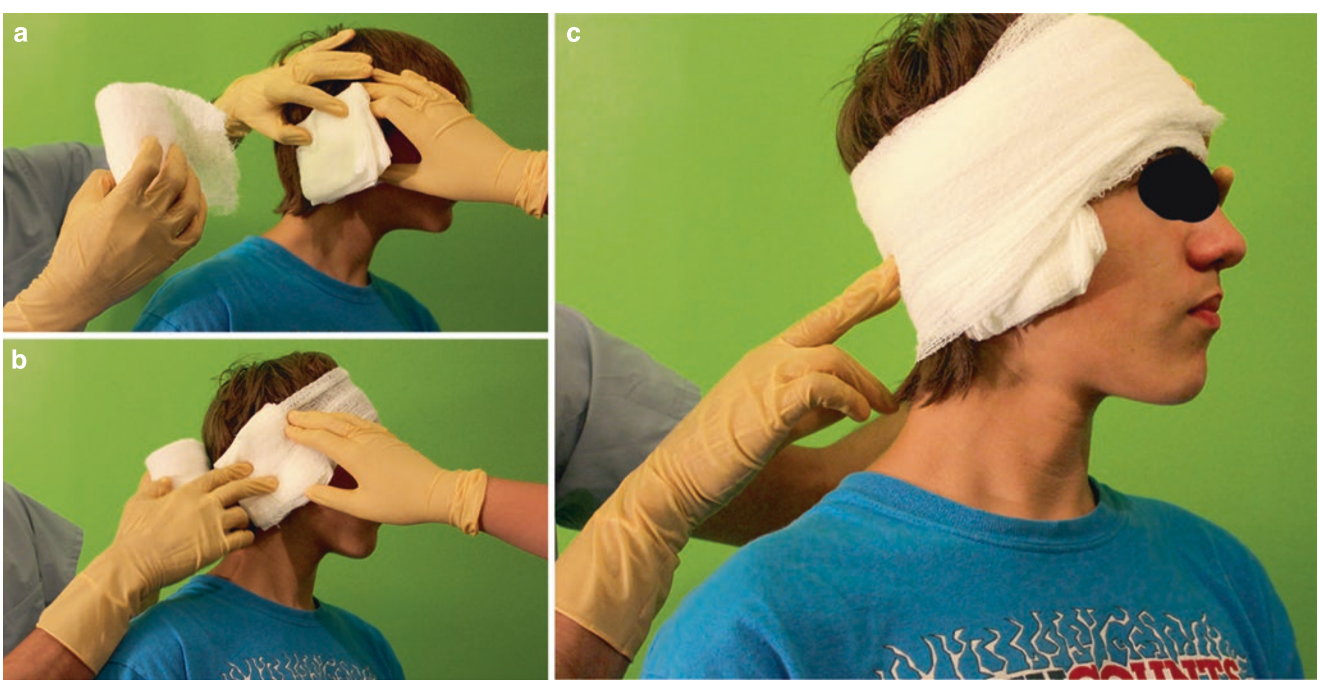

Fig. 65.10 (**a**–**c**) Wrap the head with Kerlix (sterile gauze roll)

Fig. 65.11 (**a–d**) Wrap the head with elastic bandage

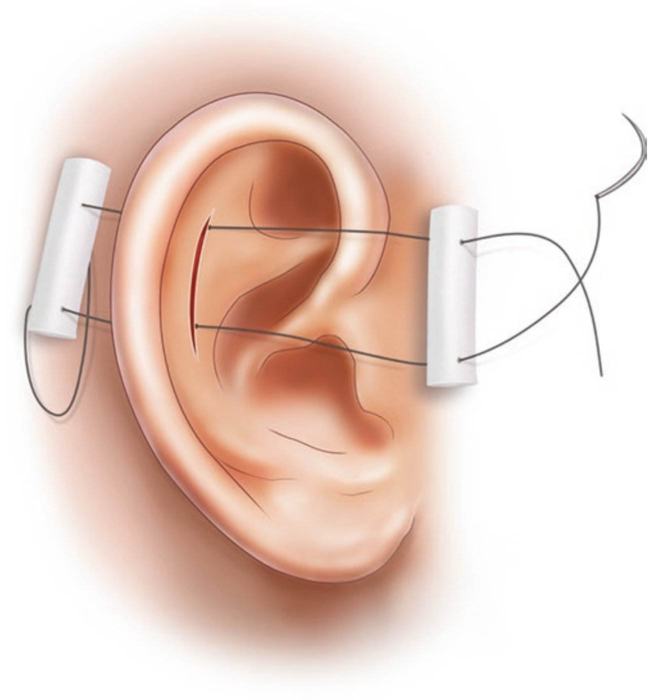

Fig. 65.12 Dental rolls secured to the ear

Pitfalls and Complications

- Bleeding.
- Infection—perichondritis.
- Deformity of the auricle
- Inadequate clot removal.
- Hematomas present for several days warrant a plastic surgery or an otolaryngology consultation.

Acknowledgement The authors would like to thank Thor Shiva Stead for serving as the subject in many of the photographs in this chapter.

Suggested Reading

O'Donnell BP, Eliezri YD. The surgical treatment of traumatic hematoma of the auricle. Dermatol Surg. 1999;25:803–5.
Starck WJ, Kaltman AI. Current concepts in the surgical management of traumatic auricular hematoma. J Oral Maxillofac Surg. 1992;50:800–2.

Incision and Drainage of Peritonsillar Abscess

66

Melinda W. Fernandez and Bobby K. Desai

Indication

- Peritonsillar abscess

Contraindications

- Absolute
  - Malignancy
  - Vascular malformations
- Relative
  - Pediatric patient
  - Severe trismus
  - Uncooperative patient

Materials and Medications

- #11 or #15 scalpel
- 27-gauge 1.5-inch needle, 18- to 20-gauge 1.5-inch or longer needle
- 5-mL syringe, 10- to 20-mL syringe
- Tape
- Trauma shears
- Viscous lidocaine
- Lidocaine 1% with epinephrine
- Laryngoscope with MAC 3 or 4 or tongue blade(s) and headlamp or other light source
- Suction setup with Frazier or tonsil suction tip

Procedure: Aspiration

1. Informed consent may be required.
2. Raise the head of bed to at least 60°, and place a pillow or other support behind the patient's head.
3. Prepare an 18- to 20-gauge 1.5-inch needle on a 10- to 20-mL syringe with a needle guard:
   - This can be accomplished by using trauma shears to cut 1–1.5 cm off the distal plastic needle cover and replacing the cover over the needle.
   - This now creates a guard to prevent deep penetration into vascular structures (Fig. 66.1).
4. Topically anesthetize area with viscous lidocaine (alternatively, can use Cetacaine [benzocaine, tetracaine hydrochloride, and butamben] spray).
5. Using lidocaine 1% with epinephrine and a 27-gauge 1.5-inch needle on a 5-mL syringe, infiltrate 1–2 mL into the area. Blanching should be apparent.
6. Palpate the oropharynx with the gloved finger to evaluate for fluctuance.
7. Assemble a MAC 3 or 4 intubation blade on a laryngoscope handle, and open into the light-on position.

Fig. 66.1 Guard to prevent deep penetration of vascular structures

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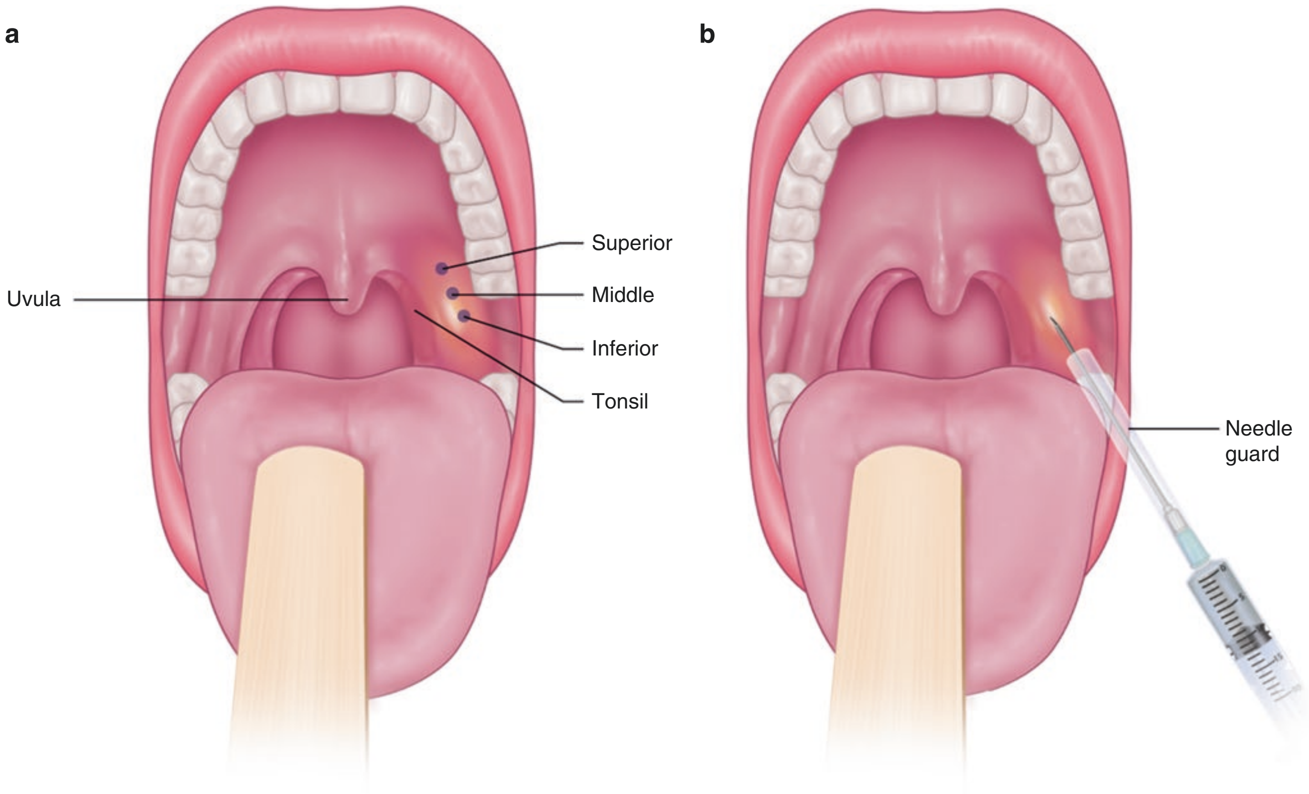

Fig. 66.2 Aspiration of a peritonsillar abscess: (**a**) Aspirate the superior pole first. If no pus aspirated, move 1 cm inferior to the middle pole. If still no pus, make final attempt by moving 1 more cm inferiorly to the inferior pole. (**b**) Demonstrates use of needle guard

Insert the blade into the patient's mouth, and advance the blade as far posteriorly as possible without inducing gagging. Have the patient hold the laryngoscope handle. Alternatively, use a tongue blade and headlamp or other light source, but the laryngoscope technique allows for an unobstructed view of the area, and the weight of the handle helps hold the patient's mouth open.

8. Using the previously prepared needle guard on the long 18- to 20-gauge needle on a 12-mL syringe, insert the needle into the most fluctuant area (as determined from the previous examination), aspirating as the needle advances (Fig. 66.2). The most fluctuant area will usually be located in the superior pole of the tonsil:
   - It is very important to be careful not to angle the needle laterally toward the carotid artery. Also remember, this is a peritonsillar abscess, so do not aspirate the tonsil itself.
9. After aspiration, if there is a pus return, remove as much purulent drainage as possible. Typical drainage is between 2 and 6 mL. If a large amount of pus is obtained (>6 mL), incision and drainage (I&D) may be indicated. (See later for details on I&D.)
10. If the aspirate did not return pus, attempt aspiration again by moving the insertion site 1 cm inferiorly to the middle pole of the peritonsillar space. If there is still no pus aspirated, make a final attempt by moving again 1 cm inferiorly to the lower pole of the peritonsillar space.
11. Suction should be set up, readily available, and turned on. Use suction to prevent the patient from aspirating or swallowing any purulent drainage.
12. Expect a small amount of bleeding when the procedure is complete and the needle is removed.

Procedure: Incision and Drainage

1. Raise the head of the bed and anesthetize the area as described previously.
2. Have suction set up with a Fraser or tonsil tip, available, and turned on.
3. Have the patient hold the laryngoscope handle after the blade has been inserted orally as described previously.
4. Fashion a blade guard on a #11 or #15 blade scalpel by taping over the blade with only 0.5 cm of the blade exposed at the tip. Incise the area that was previously aspirated with a small stab incision. Suction the area.

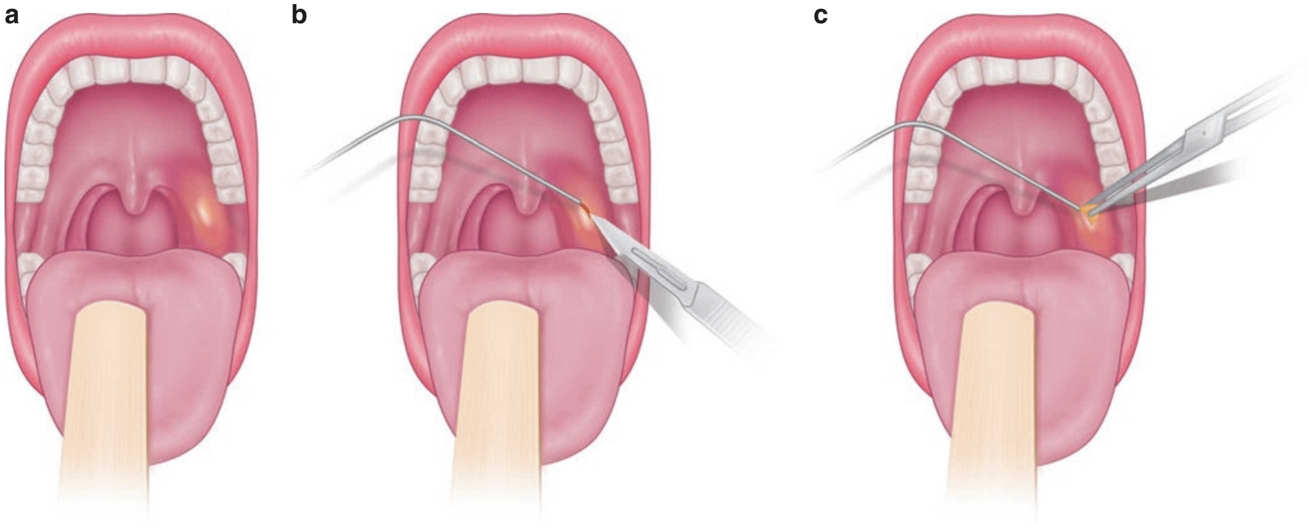

Fig. 66.3 Incision and drainage of peritonsillar abscess: (**a**) Gain access with appropriate lighting. (**b**) Fashion a blade guard on a #11 or #15 blade scalpel by taping over the blade with only 0.5 cm of the blade exposed at the tip. Incise the area that was previously aspirated with a small stab incision. (**c**) Insert a curved Kelly clamp into the incision, and open gently to enter the abscess cavity and break up loculations. Do not pack!

5. Insert a curved Kelly clamp into the incision, and open gently to enter the abscess cavity and break up loculations (Fig. 66.3). Suction as necessary.
6. Have the patient gargle with a saline solution and expectorate.
7. Do not pack the abscess cavity.
8. Observe for 2–4 h for bleeding.

Complications

- Aspiration or incision of the carotid artery
- Excessive bleeding
- Aspiration of purulent material
- Pain

Pearls and Pitfalls

- Pearls
  - Airway protection should always be considered. Intubation may be necessary for very large abscesses with airway compromise.
  - Bedside ultrasound is a valuable tool in confirming the diagnosis of peritonsillar abscess. Perform using the intracavitary probe covered with a sterile glove or other appropriate probe cover, and insert into the oropharynx. The abscess will appear as any other abscess: an encapsulated, hypoechoic structure. Doppler flow can also be used to locate the carotid artery relative to the abscess.
  - Empirical oral antibiotics after aspiration or I&D are considered usual care and should cover for group A streptococcus and oral anaerobes:

    Amoxicillin/clavulanate or clindamycin is the most commonly used.
  - A single dose of high-dose steroids may be helpful in relieving symptoms.
  - Patients who cannot tolerate oral fluids, cannot take oral antibiotics, or appear to have a toxic response should be admitted. Others may be discharged with 24-h follow-up.
- Pitfalls
  - The carotid artery is located approximately 2.5 cm posterolaterally to the tonsils. Take care that the needle is not inserted too far laterally or the risk of aspirating the carotid artery is increased.
  - Incision into the tonsil itself may cause excessive bleeding. Aspiration or incision into the tonsil will likely miss the abscess altogether and may result in misdiagnosis.
  - There is a 1–15% failure and recurrence rate.

Suggested Reading

Afarian H, Lin M. Tricks of the trade—say "ah!"—needle aspiration of peritonsillar abscess. ACEP News. 2008;27(5):38.

Braude DA, Shalit M. A novel approach to enhance visualization during drainage of peritonsillar abscess. J Emerg Med. 2008;35:297–8.

Galioto NJ. Peritonsillar abscess. Am Fam Physician. 2008;77:199–202.

Ozbek C, Aygenc E, Tuna EU, Selcuk A, Ozdem C. Use of steroids in the treatment of peritonsillar abscess. J Laryngol Otol. 2004;118:439–42.

Roberts J, Hedges J, editors. Clinical procedures in emergency medicine. 5th ed. Philadelphia: Saunders; 2009. p. 1184–9.

Vieira F, Allen SM, Stocks RM, Thompson JW. Deep neck infection. Otolaryngol Clin North Am. 2008;41:459–83.

Incision and Drainage of Sublingual Abscess

67

Melinda W. Fernandez and Bobby K. Desai

Indication

- Sublingual abscess (Fig. 67.1)

Contraindications

- Relative
  - Pediatric patient
  - Severe trismus—may need sedation or drainage in the operating room
  - Uncooperative patient—may need sedation or drainage in the operating room
  - Coagulopathy, patients taking anticoagulants, or patients with a known bleeding disorder

Materials and Medications (Fig. 67.2)

- #11 scalpel
- Hemostats
- Penrose drain
- 4–0 silk suture
- 25- to 27-gauge 1.5-inch needle for injecting anesthetic
- 18- to 20-gauge needle for drawing up anesthetic
- 5- to 10-mL syringe or control syringe
- Viscous lidocaine (or other topical anesthetic)
- Lidocaine 1% with epinephrine
- Light source
- Suction setup with tonsil suction tip
- Culture swab

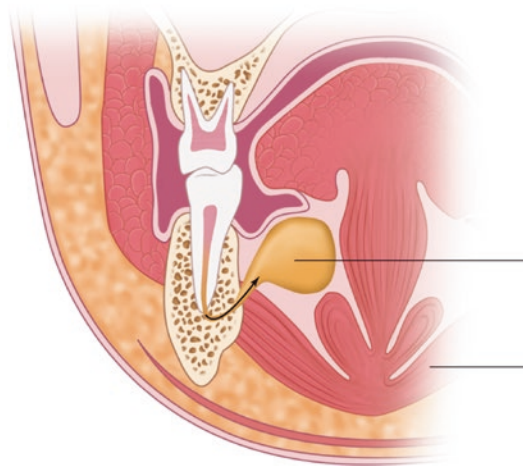

Fig. 67.1 Sublingual abscess

Procedure: Incision and Drainage

1. After explaining the procedure, risks, and benefits to the patient, put the head of the bed in the most comfortable working position for the clinician and the patient. Alternatively, the clinician may also elect to position the patient in an upright procedure chair that has multiple positions.
2. Apply viscous lidocaine topically with a cotton-tipped swab to the area to be injected with anesthetic. Leave in place for a minute or 2. Alternatively, spray the area with a topical anesthetic spray.
3. Have suction set up with a tonsil tip, available, and turned on.
4. Draw up the appropriate amount of lidocaine with epinephrine into a 5-mL syringe (control syringe if available).
5. Direct light source to the area to be worked on. *Adequate lighting is essential.* Options include a headlamp or an overhead adjustable light.

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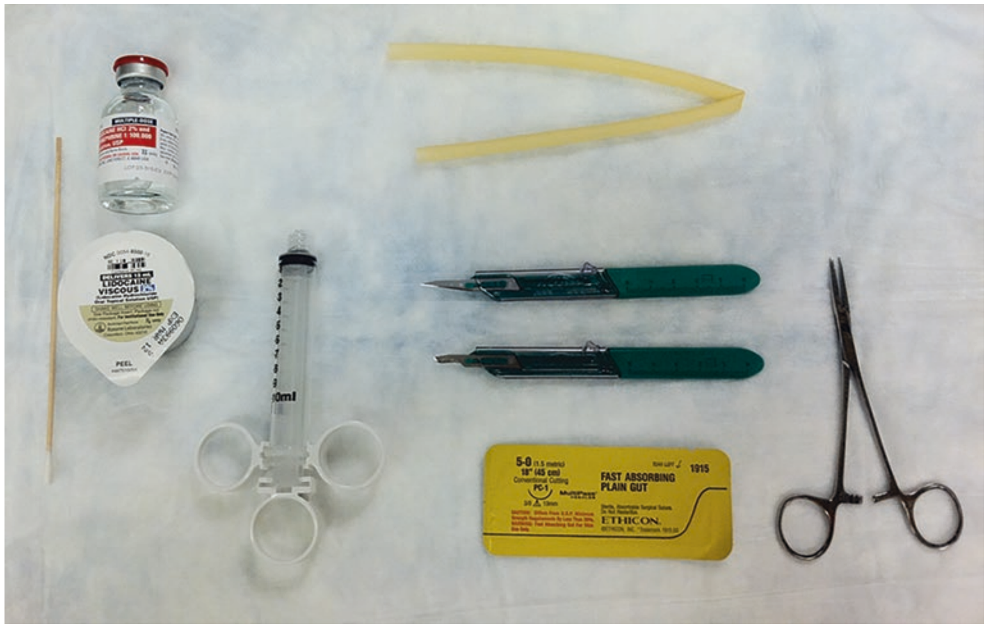

Fig. 67.2 Materials needed: #11 scalpel, hemostats, Penrose drain, 4–0 silk suture, 25–27-gauge 1.5-inch needle for injecting anesthetic, 18- to 20-gauge needle for drawing up anesthetic, 5- to 10-mL syringe or control syringe, viscous lidocaine (or other topical anesthetic), lidocaine 1% with epinephrine, light source, suction setup with tonsil suction tip, culture swab (optional)

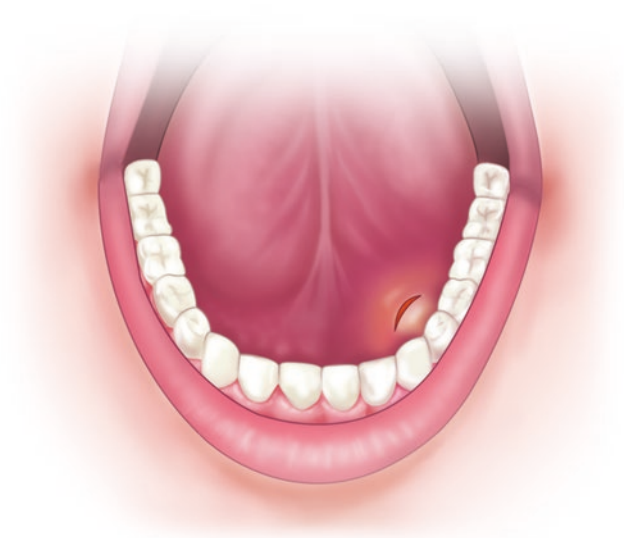

Fig. 67.3 Incise the lowest portion of the abscess

6. Change needle to the 27-gauge needle, and inject 1–2 mL of lidocaine with epinephrine using an inferior alveolar block. Alternatively, anesthetize the floor of the mouth around the most fluctuant area. Avoid injecting through the infected tissue to avoid possible spread into deeper spaces.
7. Using the scalpel, make an intraoral stab incision superficially at the lowest point of the pus accumulation (Fig. 67.3). This will facilitate evacuation of pus under gravity. Have the suction catheter in the mouth and allow the purulent material to drain into the suction.
8. Obtain a specimen of the purulent fluid for culture and sensitivity.
9. Insert a hemostat into the incision to facilitate drainage, but do not open it up to avoid injury to neurovascular structures. Gently massage the soft tissue surrounding the abscess to assist drainage. Suction as necessary to avoid swallowing or aspirating the pus.
10. Once adequate drainage has been achieved, place a small Penrose drain (or other rubber-type drain) into the cavity, and stabilize on one side with a silk suture that goes through the drain and the mucosa (Fig. 67.4).
11. Have the patient rinse and spit with a half-strength peroxide solution followed by either water or saline.
12. Watch for signs of bleeding or upper airway symptoms.
13. Ensure that the patient can tolerate oral fluids before discharge.

Complications (Generally Minimal)

- Excessive bleeding (apply pressure—to avoid potential nerve injury, do not cauterize or ligate unless absolutely necessary)
- Aspiration of purulent material (have the patient sit upright and use suction as the abscess is incised)
- Pain

Pearls and Pitfalls

- Pearls
  – Airway protection is paramount. Infections in this space can quickly spread to the submandibular region and can compromise the airway owing to swelling (Ludwig's angina):

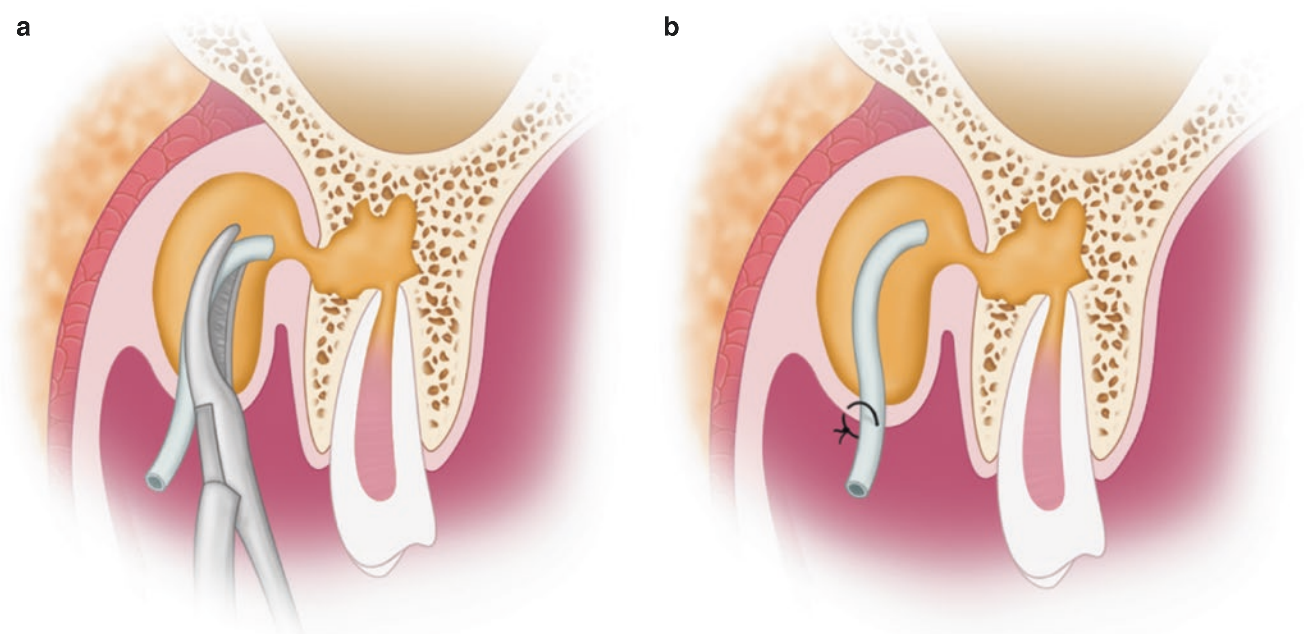

Fig. 67.4 (**a**) Using hemostats, place small Penrose drain into the abscess cavity. (**b**) Suture Penrose in place with a silk suture that goes through the drain and the mucosa

Assess for elevation of the floor of the mouth and tongue, ability to lie supine, drooling, stridor, and restlessness.

If these signs are present, emergent surgical airway will be necessary before incision and drainage (I&D).

– The sublingual space is bounded superiorly by the oral mucosa and inferiorly by the mylohyoid muscle.
– Infected premolars and first molars drain into this space because the apices of their roots are located superior to the mylohyoid muscle.
– The source molar should be extracted as soon as possible after I&D.
– Empirical oral antibiotics after I&D should cover for group A streptococcus and oral anaerobes. Penicillin remains the drug of choice, but clindamycin or amoxicillin–clavulanic acid can be substituted.

• Pitfalls
  – The lingual artery, vein, and nerve are contained in the posterolateral area of the floor of the mouth, and the hypoglossal nerve is nearby. These must be avoided when performing I&D for sublingual abscesses.

Suggested Reading

Flynn TR, Shanti RM, Levi MH, Adamo AK, Kraut RA, Trieger N. Severe odontogenic infections, part 1: prospective report. J Oral Maxillofac Surg. 2006;64:1093–103.

Reichman E, Simon R, editors. Emergency medicine procedures. New York: McGraw-Hill Education; 2003. p. 1342–5.

Roberts J, Hedges J, editors. Clinical procedures in emergency medicine. 5th ed. Philadelphia: Saunders; 2009. p. 1184–9.

Vieira F, Allen SM, Stocks RM, Thompson JW. Deep neck infection. Otolaryngol Clin N Am. 2008;41:459–83.

Incision and Drainage of Parotid Duct Abscess

68

Melinda W. Fernandez and Bobby K. Desai

Indication

- Parotid duct abscess

Contraindications

- Absolute
  - None
- Relative
  - Pediatric patient
  - Severe trismus—may need sedation or drainage in the operating room
  - Uncooperative patient—may need sedation or drainage in the operating room
  - Coagulopathy, patients taking anticoagulants, or patients with a known bleeding disorder

Materials and Medications (Fig. 68.1)

- #11 scalpel
- 4 × 4 gauze
- Hemostat
- Penrose drain or ¼-inch packing gauze
- Light source (headlamp or overhead light)
- Culture swab
- 4-0 silk suture
- 25- to 27-gauge needle, 1.5–2 inches long
- 18-gauge needle to withdraw anesthetic from vial
- 5-mL syringe
- Viscous lidocaine or other topical anesthetic
- Lidocaine with epinephrine
- Suction setup with Frazier or tonsil suction tip

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Procedure (Figs. 68.2 and 68.3)

1. After explaining the procedure, risks, and benefits to the patient, put the head of the bed in the most comfortable working position for the operator and the patient. Alternatively, position the patient in an upright procedure chair that has multiple positions.
2. Find the most fluctuant area. Apply viscous lidocaine topically with a cotton-tipped swab to the area to be injected with anesthetic. Leave in place for a minute or 2. Alternatively, spray the area with a topical anesthetic spray.
3. Have suction setup with a tonsil tip, available, and turned on.
4. Draw up the appropriate amount of lidocaine with epinephrine into a 5-mL syringe (control syringe if available).
5. Direct light source to the area to be worked on. *Adequate lighting is essential.* Options include a headlamp or an overhead adjustable light.
6. Change needle to a 25- or 27-gauge needle. Inject 1–2 mL of lidocaine with epinephrine just beneath the mucosal surface. Avoid injecting through the infected tissue to avoid possible spread into deeper spaces.
7. Using the scalpel, make an intraoral stab incision superficially into the area of greatest fluctuance (Fig. 68.4). Have the suction catheter in the patient's mouth and allow the purulent material to drain into the suction.
8. Obtain a specimen of the purulent fluid for culture and sensitivity.
9. Insert a hemostat into the incision to facilitate drainage, but do not open it up in order to avoid injury to neurovascular structures. Gently massage the soft tissue surrounding the abscess to assist drainage. Suction as necessary to avoid swallowing or aspirating the pus.

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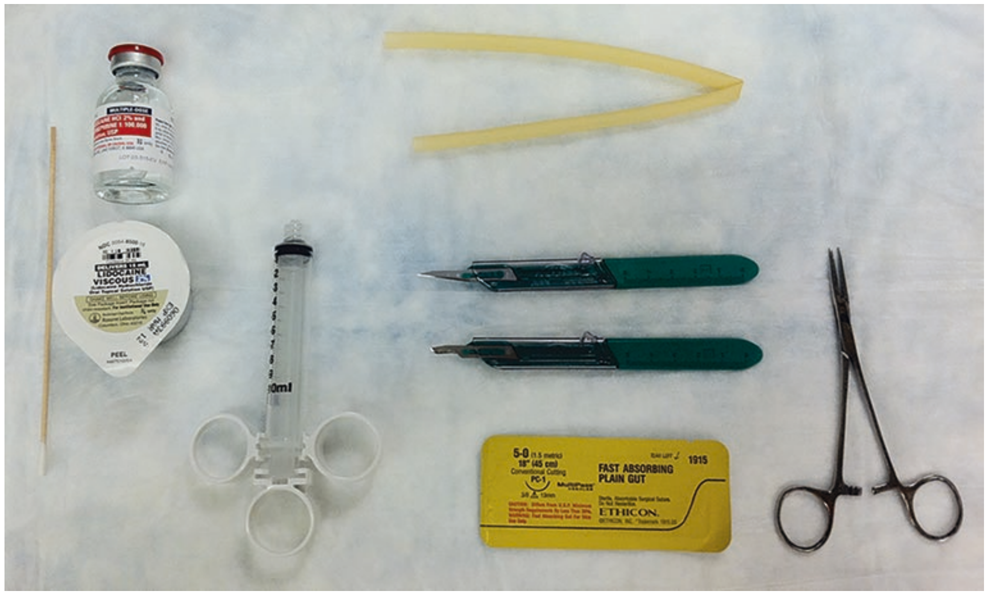

Fig. 68.1 Materials needed: #11 scalpel, hemostats, Penrose drain, 4-0 silk suture, 25- to 27-gauge 1.5-inch needle for injecting anesthetic, 18- to 20-gauge needle for drawing up anesthetic, 5- to 10-mL syringe or control syringe, viscous lidocaine (or other topical anesthetic), lidocaine 1% with epinephrine, light source, suction setup with tonsil suction tip, culture swab (optional)

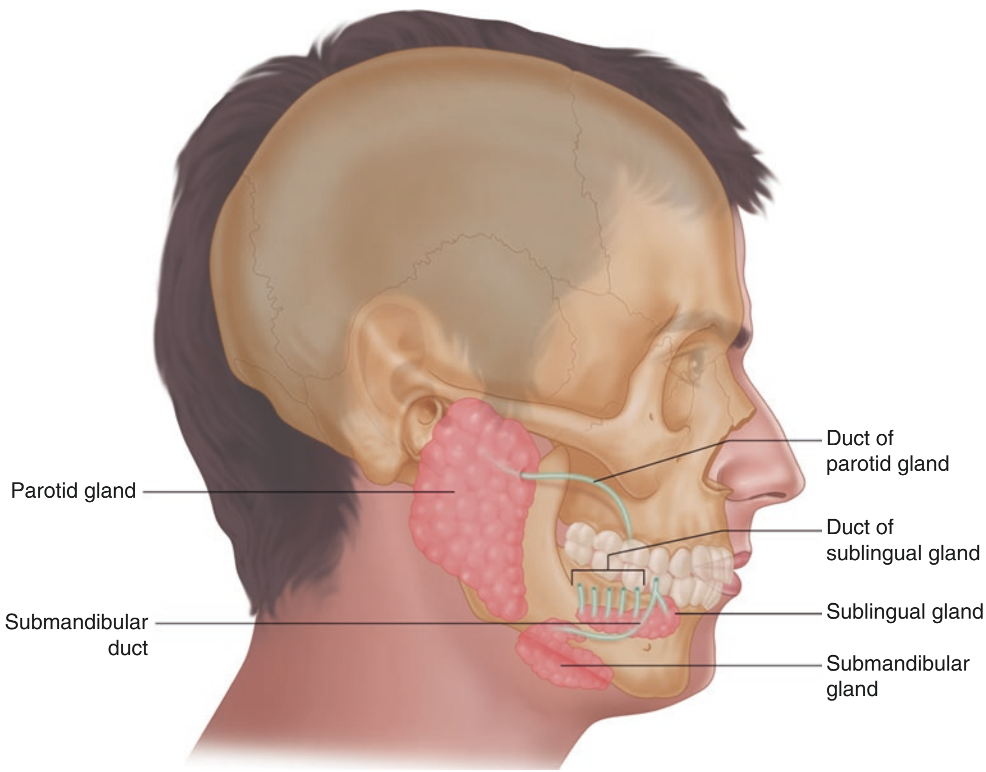

Fig. 68.2 Anatomy of the salivary glands

10. Have the patient rinse and spit with a half-strength peroxide solution.
11. Place a small Penrose drain (or other rubber-type drain) into the cavity, and stabilize on one side with a silk suture that goes through the drain and the mucosa. Alternatively, cut a strip of ¼-inch packing gauze and insert into the abscess cavity.
12. Have the patient rinse and spit with a half-strength peroxide solution followed by either water or saline.
13. Watch for signs of bleeding or upper airway symptoms.
14. Ensure that the patient can tolerate oral fluids before discharge.

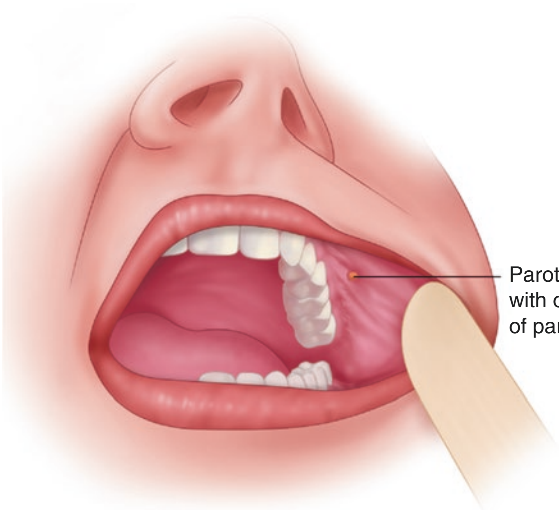

Fig. 68.3 Parotid papilla: opening of the parotid gland located adjacent to third upper molar

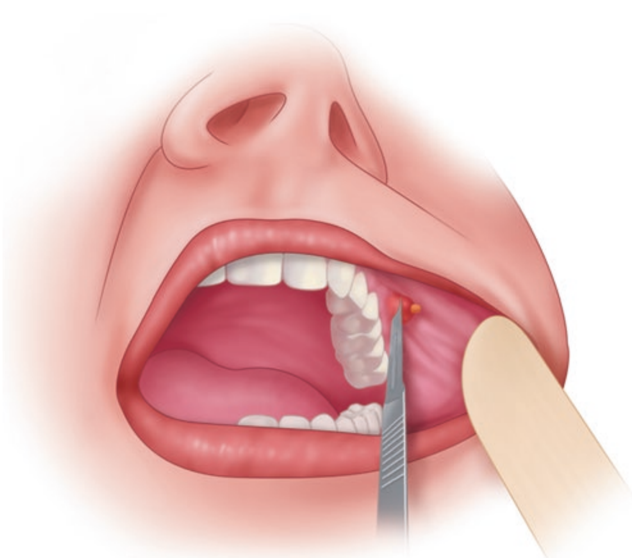

Fig. 68.4 Parotid abscess; make a superficial stab into the most fluctuant area

Complications

- Complications are generally minimal but may include:
  - Excessive bleeding (apply pressure; to avoid potential nerve injury, do not cauterize or ligate unless absolutely necessary)
  - Aspiration of purulent material (have the patient sit upright and use suction as the abscess is incised)
  - Pain

Pearls and Pitfalls

- Airway protection should always be considered.
- Empirical oral antibiotics after incision and drainage are considered usual care and should cover for group A streptococcal and oral anaerobes. Penicillin remains the drug of choice, but clindamycin or amoxicillin–clavulanic acid can be substituted.
- Patients who cannot tolerate oral medications, cannot take oral antibiotics, or appear to have a toxic response should be admitted. Pediatric patients should be admitted. Others may be discharged with 24-h follow-up.

Suggested Reading

Reichman E, Simon R, editors. Emergency medicine procedures. New York: McGraw-Hill Education; 2003. p. 1346–9.

Roberts J, Hedges J, editors. Clinical procedures in emergency medicine. 5th ed. Philadelphia: Saunders; 2009. p. 1184–9.

Part IX

Dental Procedures

Techniques of Mandibular Anesthesia

69

Susana Perry, Joshua Perry, and Rosalia Rey

Inferior Alveolar Nerve Block

Nerves Anesthetized

- Inferior alveolar, branch of the posterior division of the mandibular nerve (V3, branch of the trigeminal nerve)
- Incisive
- Mental
- Lingual (usually)

Areas Anesthetized (Fig. 69.1)

- Mandibular teeth to midline
- Body of the mandible
- Buccal mucoperiosteum, mucous membrane anterior to the mandibular first molar
- Anterior two thirds of the tongue and floor of the mouth (via the lingual nerve)
- Lingual soft tissues and periosteum (via the lingual nerve)

Indications

- When buccal soft tissue anesthesia is necessary
- When lingual soft tissue anesthesia is needed
- When performing procedures on multiple mandibular teeth in one quadrant

Contraindications

- Infection or acute inflammation in the area of injection
- Patients who might bite their lip or tongue (e.g., very young child or physically or mentally handicapped adult or child)
- In relation to local anesthetic use

Absolute
- Local anesthetic allergy
- Avoid all local anesthetics in the same chemical class (e.g., esters).
- Bisulfite allergy
  – Avoid vasoconstrictor-containing local anesthetics.

Relative
- Atypical plasma cholinesterase
- Methemoglobinemia (idiopathic or congenital)
- Significant liver dysfunction (American Society of Anesthesiologists [ASA] III–IV)
- Significant kidney dysfunction (ASA III–IV)
- Significant cardiovascular disease (ASA III–IV):
  – Avoid high concentrations of vasoconstrictors.
  – Use local anesthetics with epinephrine concentrations of 1:200,000 or 1:100,000 or 3% mepivacaine or 4% prilocaine.
- Clinical hyperthyroidism (ASA III–IV):
  – Avoid high concentrations of vasoconstrictors.
  – Use local anesthetics with epinephrine concentrations of 1:200,000 or 1:100,000 or 3% mepivacaine or 4% prilocaine.

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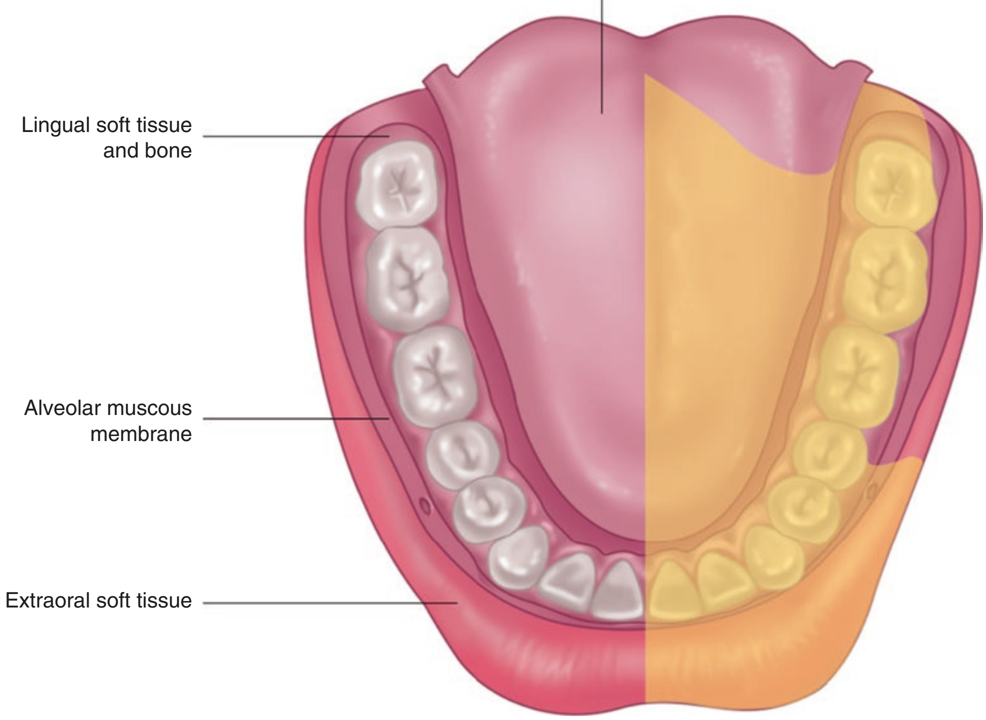

Fig. 69.1 Areas anesthetized with inferior mandibular nerve block

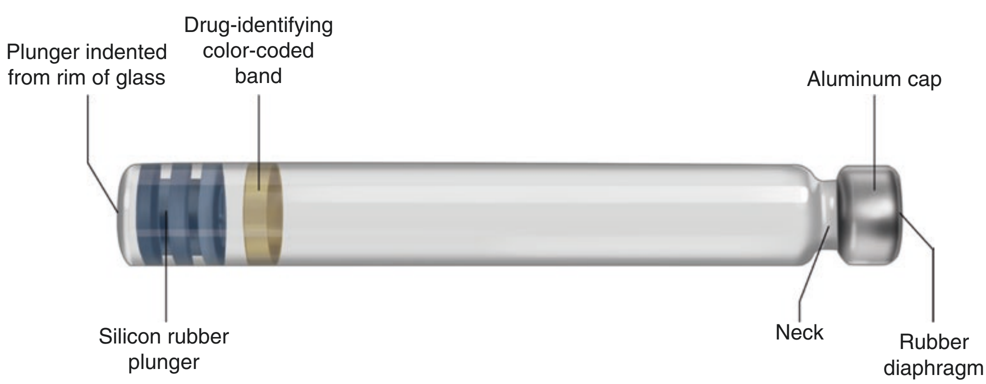

Fig. 69.2 Local anesthetic carpule (1.7–1.8 mL)

Materials and Medications

- Local anesthetic carpule (1.7–1.8 mL):
  - Mepivacaine 3% (+epinephrine 1:100,000)
  - Articaine HCI 4% (+epinephrine 1:100,000 or 1:200,000)
  - Lidocaine HCI 2% (+ epinephrine 1:50,000 or 1:100,000) (Fig. 69.2)
  - Bupivacaine HCI 0.5% + epinephrine 1:200,000
- Aspirating syringe (Fig. 69.3)
- Needle (Fig. 69.4):
  - Gauge refers to the lumen of the needle: The smaller the number, the greater the diameter of the lumen.

Fig. 69.3 Aspirating syringe

  - Needles are color-coded by gauge: red = 25 gauge, yellow = 27 gauge, and blue = 30 gauge.
  - *Recommendations: For inferior alveolar nerve (IAN) block, it is best to use a 25-gauge-long needle.*
- Mouth props
- Retractors

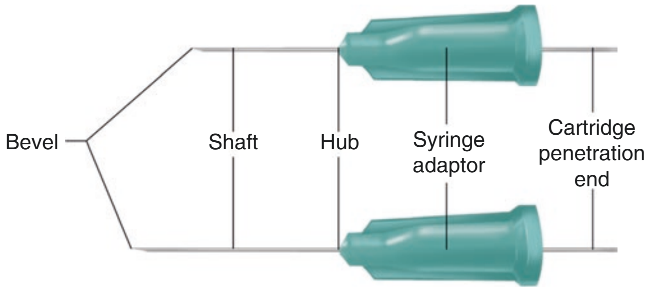

Fig. 69.4 Needle

Procedure

1. Target area: IAN as it passes downward toward the mandibular foramen.
2. Landmarks:
   (a) Coronoid notch
   (b) Pterygomandibular raphe
   (c) Occlusal plane of mandibular posterior teeth
3. Procedure:
   (a) Correct position for operator:
      (i) For a right IAN block, a right-handed administrator should sit at the 8 o'clock position facing the patient.
      (ii) For a left IAN block, a right-handed administrator should sit at the 10 o'clock position facing in the same direction as the patient.
   (b) Recommended to position the patient supine and with the mouth wide open.
   (c) Place the thumb on the coronoid notch and index finger extraorally on the posterior border of the ramus in order to estimate the distance between these two points (Fig. 69.5):
      (i) The needle insertion should be three fourths of the anteroposterior distance from the coronoid notch to the deepest part of the pterygomandibular raphe.
   (d) Place the barrel of the syringe in the corner of the mouth on the contralateral side, usually corresponding to the premolars.
   (e) Slowly advance the needle until bony resistance is met:
      (i) For anxious or sensitive patients, a small volume of anesthetic may be deposited as the soft tissue is penetrated.
      (ii) Average depth of penetration to bony contact will be 20–25 mm, approximately two thirds to three fourths the length of a long needle.
      (iii) If the bone is contacted too soon (less than half the length of a long needle), the needle tip is usually located too far anteriorly (laterally) on the ramus. To correct:
         - Withdraw it slightly from the tissues and bring the syringe barrel anteriorly toward the lateral incisor or canine; reinsert to the proper depth.
      (iv) If the bone is not contacted, the needle tip is usually located too far posterior (medial). To correct:
         - Withdraw it slightly in tissue (leaving approximately one fourth its length in tissue), and reposition the syringe barrel more posteriorly (over the mandibular molars).
         - Continue the insertion until contact with the bone is made at an appropriate depth (20–25 mm).
   (f) Aspirate. If negative, slowly deposit 1.5 mL of anesthesia over 60 s.
   (g) Wait 3–5 min before commencing the dental procedure.
4. Precaution: *Do not deposit anesthesia if the bone is not contacted*. The needle tip may be resting within the parotid gland near the facial nerve (cranial nerve VII), and a transient paralysis of the facial never may occur if solution is deposited.

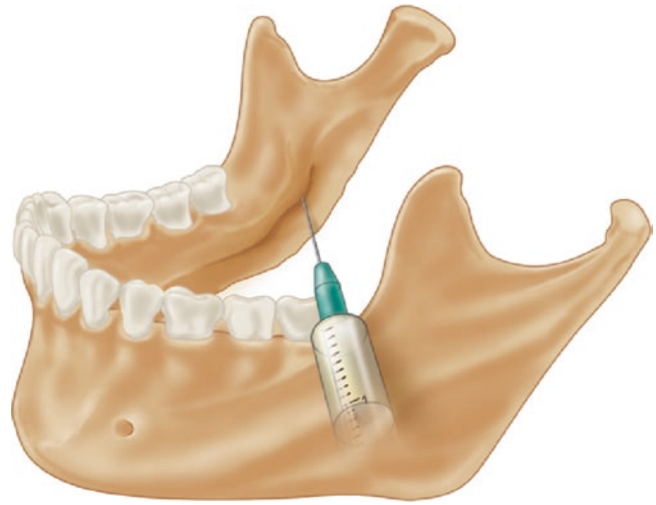

Fig. 69.5 Needle orientation for inferior alveolar nerve block

Buccal Nerve Block

Nerve Anesthetized

- Buccal nerve, a branch of the anterior division of the mandibular nerve

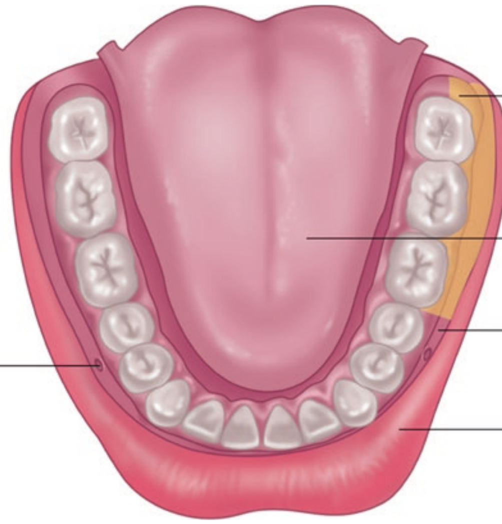

Fig. 69.6 Areas anesthetized with buccal nerve block

Area Anesthetized (Fig. 69.6)

- Soft tissues and periosteum buccal to the mandibular molars

Procedure

1. A 25-gauge-long needle is recommended.
2. Landmarks: mandibular molars and mucobuccal fold.
3. Orient the bevel of the needle *toward* the bone during injection.
4. Correct positioning:
   (a) For a right buccal nerve block, a right-handed administrator should sit at the 8 o'clock position directly facing the patient.
   (b) For a left buccal nerve block, a right-handed administrator should sit at the 10 o'clock facing in the same direction as the patient.
5. Procedure:
   (a) With the index finger, pull the buccal soft tissues in the area of injection laterally to allow for better visualization.
   (b) Align the syringe parallel to the occlusal plane of the teeth.
   (c) Penetrate the mucous membrane at the injection site, distal and buccal to the last molar (Fig. 69.7).
6. If tissue at the injection site becomes swollen, stop depositing solution.

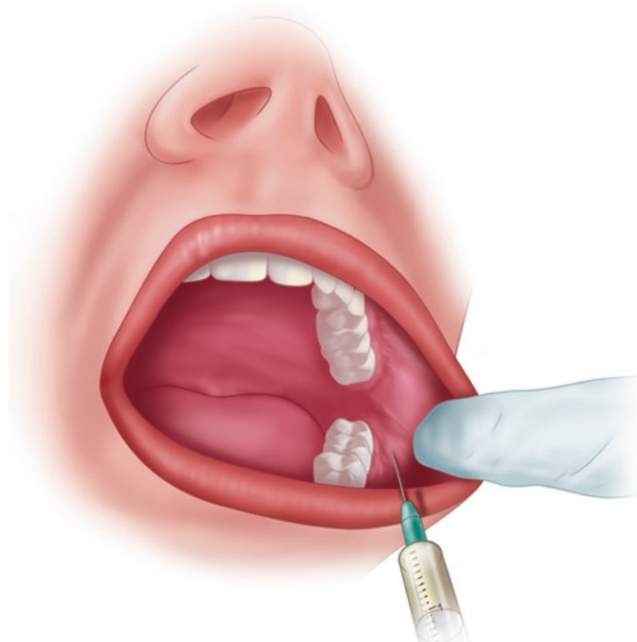

Fig. 69.7 Needle orientation for buccal nerve block

Mental Nerve Block

Nerve Anesthetized

- Mental nerve, a terminal branch of the inferior alveolar nerve

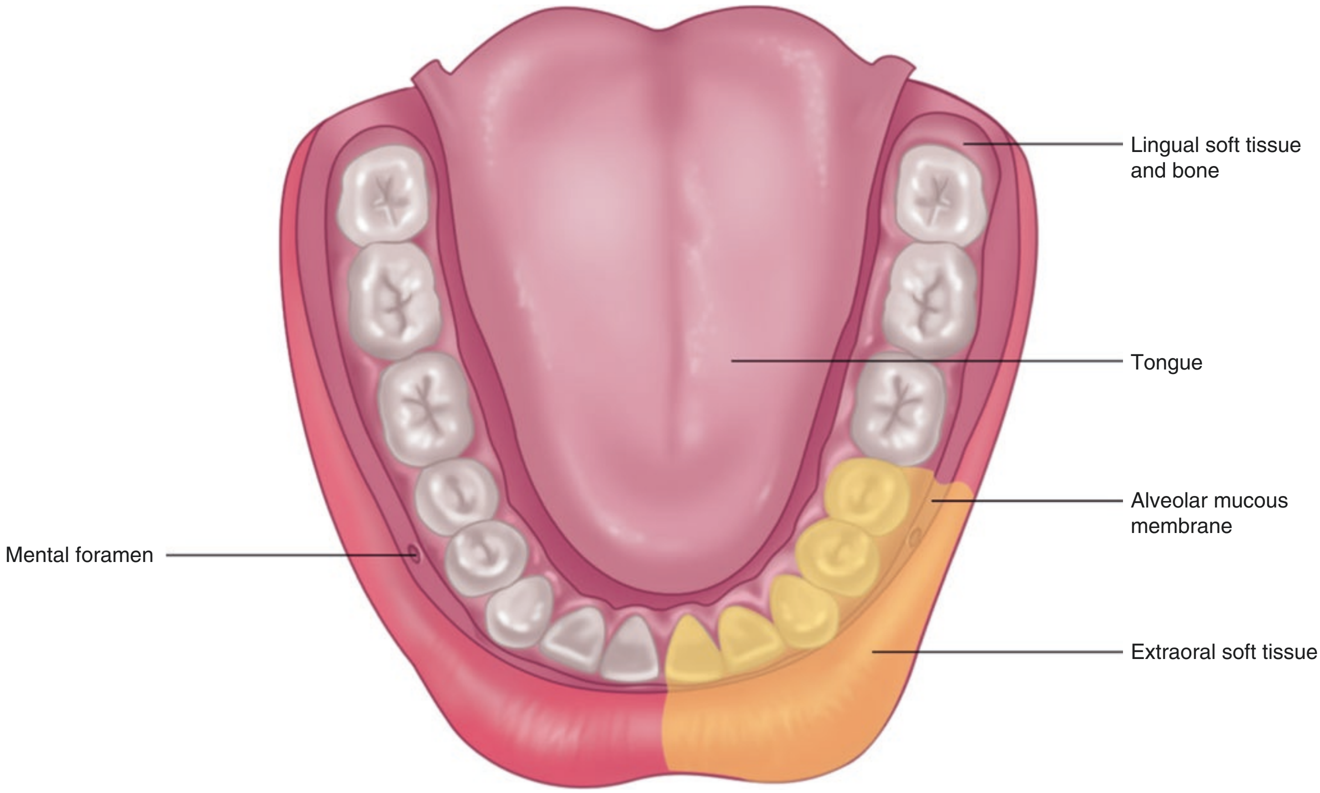

Fig. 69.8 Areas anesthetized with mental nerve block

Area Anesthetized (Fig. 69.8)

- Buccal mucous membranes anterior to the foramen (around the second premolar) to the midline and skin of the lower lip

Indications

- For buccal soft tissue anesthesia in procedures such as:
  - Soft tissue biopsies
  - Suturing of soft tissues

Procedure

1. Area of insertion: mucobuccal fold at or just anterior to the mental foramen.
2. Orientation of bevel should be *toward* the bone during injection.
3. Operator should sit in front of the patient so that the syringe is below the patient's line of sight.
4. Locate the mental foramen:
   (a) Place the index finger in the mucobuccal fold, and press against the body of the mandible in the area of the first molar.
   (b) Move the finger anteriorly until the bone beneath the finger feels somewhat concave.
   (c) The mental foramen is usually found around the apex of the second premolar.
   (d) Orient the needle with the bevel directed toward the bone.
   (e) Penetrate the mucous membrane and advance needle slowly; penetration depth is usually 5–6 mm.
   (f) If aspiration is negative, deposit approximately one third of the cartridge over 20 s.
   (i) If the site balloons, stop the deposition of anesthetic and remove the syringe.

Suggested Reading

Bennett CR. Monheim's local anesthesia and pain control in dental practice. 6th ed. St. Louis: Mosby; 1978.
Gow-Gates GAE. Mandibular conduction anesthesia: a new technique using extraoral landmarks. Oral Surg. 1973;36:321–8.
Jastak JT, Yagiela JA, Donaldson D. Local anesthesia of the oral cavity. Philadelphia: WB Saunders; 1995.
Malamed SF. The Gow-Gates mandibular block: evaluation after 4275 cases. Oral Surg. 1981;51:463.
Malamed SF. Handbook of local anesthesia. 5th ed. St. Louis: Mosby; 2004.

70 Reduction of Dislocated Temporomandibular Joint

Christopher J. Spencer and Geraldine Weinstein

Indications

- Open lock: associated with yawning, vomiting, or opening the mouth wide
- Open lock: associated with a dental procedure
- Open lock: associated with endoscopy
- Open lock: associated with oral intubation
- Time duration: acute to 3 weeks or less duration

Contraindications for Closed Reduction

- Absolute
  – Head trauma with fracture of the skull, maxilla, mandible, or mandibular condyles
- Relative
  – Dislocation of 30 days or longer (will likely be unable to accomplish reduction without general anesthesia and/or open surgical approach)

Materials and Medications

- Local anesthetic syringe.
- Lidocaine 2% 1–2 mL.
- 25- to 27-gauge needle (long or approximately 2 inches long).
- Betadine (povidone-iodine) or other skin antiseptic preparation.
- Gauze padding for thumbs.
- Consider a muscle relaxant.
- Consider conscious sedation.

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Procedure

Manual Closed Reduction Without Local Anesthesia (Fig. 70.1)

1. Position the patient in an upright posture with the mandible at the physician's flexed elbow height (physician's comfortable position).
2. Place the thumbs on the mandibular molars with wrapping around the thumbs to protect from possible biting force once the mandible reduces.
3. Apply bilateral firm force in an inferior direction.
4. The mandible will move rapidly in an inferior and then a posterior direction as the condyles slide back over the height of their respective articular eminences.

Manual Closed Reduction with Local Anesthesia

- If the mandible will not respond to closed reduction with just thumb pressure, likely the masticatory muscles are contracting with sufficient force to prohibit the condyles from being sufficiently distracted owing to pain:
  1. Reduction of pain in the temporomandibular joint (TMJ) with local anesthesia.
  2. *Auriculotemporal block of V3:*
     - The auriculotemporal nerve that innervates the TMJ may be anesthetized inferior to the TMJ capsule. It can be accessed through the skin just anterior to the tragus.
     - With the patient's mouth wide open (it already is in this case), a triangular-shaped hollow will be evident inferior and posterior to the mandibular condyle. Insert the needle at a 20-degree anterior inclination, in the horizontal plane, at the level of the inferior border of the tragus of the ear (Fig. 70.2). The bevel of the needle should be anterior.

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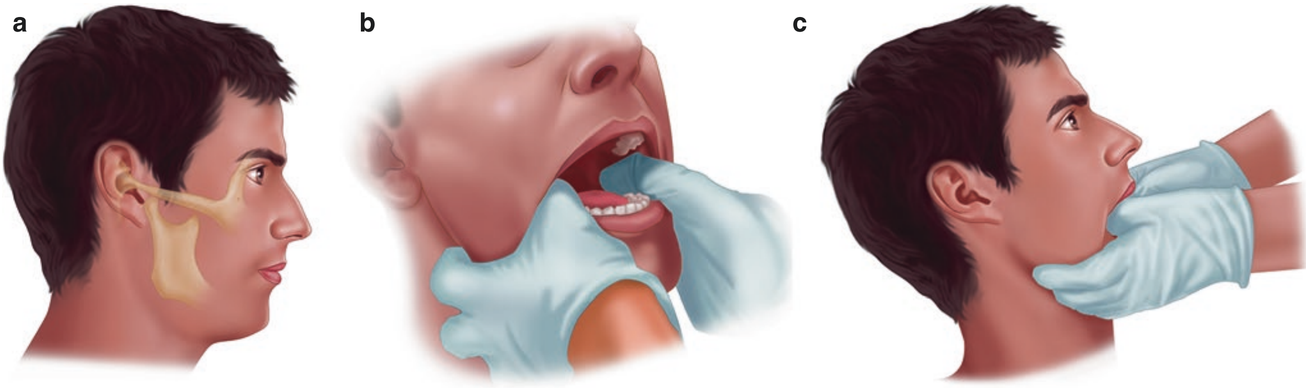

Fig. 70.1 Reduction in progress: (**a**) In a mandibular dislocation, the condyle will be anterior and superior to the articular eminence. (**b**) Position the thumbs on mandibular molars, and apply firm pressure in an inferior direction to distract the TM joint condyles so that they can reposition themselves into the glenoid fossa so that the TM joint can be reduced. (**c**) Lateral view of the distraction force with direction in an inferior direction to distract the condyle of the TM joint

Fig. 70.2 Infiltration of cranial nerve V, the auriculotemporal branch (V3)

- The needle should be inserted behind the (posterior) ramus and approximately 2 cm deep (aiming for the medial aspect of the posterior border of the ramus). If the posterior border of the ramus is contacted, the needle will need to be directed in a more posterior direction. Then, deposit 1–2 mL of lidocaine 2%.

3. Then, as before, place the thumbs in a bilateral position on the patient's mandibular molars, and depress the mandible to distract the condyles in an inferior direction.
4. Conscious sedation may be utilized if the reduction procedure has been arduous and stressful for the patient.

Complications

- Inability to reduce the condyles manually which may lead to more invasive procedures.
- If the condition is acute (≤24 h) and not associated with trauma, there are few if any significant complications or risks for this procedure.

Pearls

- The manual pressure required on the mandibular molars needs to be sustained and very firm.
- If both condyles are dislocated, it is likely beneficial to attempt one side at a time.
- The clinician needs to protect the thumbs from the impact of the patient's molars during the sudden successful reduction because the biting forces are significant in the molar region.

Suggested Reading

Chan TC, Harrigan RA, Ufberg J, Vilke GM. Mandibular reduction. J Emerg Med. 2008;34:435.

Donlon WC, Truta MP, Eversole LR. A modified auriculotemporal nerve block for regional anesthesia of the temporomandibular joint. J Oral Maxillofac Surg. 1984;42:544.

Huang IY, Chen CM, Kao YH, Chen CM, Wu CW. Management of long-standing mandibular dislocation. Int J Oral Maxillofac Surg. 2011;40:810–4.

Prabhakar V, Singla S. Bilateral anterosuperior dislocation of the intact mandibular condyles in the temporal fossa. Int J Oral Maxillofac Surg. 2011;40:640–3.

Thagarajah T, Mcculloch N, Thangarajah S, Stocker J. Bilateral temporomandibular joint dislocation in a 29-year-old man: a case report. J Med Case Rep. 2010;4:270.

Dry Socket (Alveolar Osteitis, Fibrinolytic Osteitis)

71

Michael A. Abraham, Amir Azari, Jennifer Westcott, and Franci Stavropoulos

Indications (Fig. 71.1)

- Definition: severe pain occurring 2–3 days after tooth extraction
- Recent tooth extraction, especially of a mandibular tooth or an impacted third molar
- Partially or completely visible bone socket
- Intense radiating pain (often to the ear)
- Fetid odor without suppuration
- Absence of swelling, lymphadenitis, or bacteremia
- Foreign bodies present in the extraction socket

Contraindications

- Absolute
  - Osteomyelitis
  - Jaw fracture
- Relative
  - Retained roots
  - Infection

Materials and Medications

- Warm saline or 0.12% aqueous chlorhexidine solution
- 12-mL syringe with curved tip (Monoject syringe)
- 25-gauge needle, syringe

Fig. 71.1 Clinical photograph suggestive of a dry socket. Clinical correlation is necessary

- Local anesthetic, 2% lidocaine 1:100,000 epinephrine
- Suction with small tip or gauze
- Socket dressing:
  - Gelfoam or small gauze strips
- Socket medicament:
  - Sultan dry socket paste (guaiacol, balsam of Peru, eugenol, 1.6% chlorobutanol), iodoform, or eugenol (zinc oxide eugenol dental cement)
- Curved forceps

Procedure

1. Administer local anesthesia as necessary.
2. Remove any sutures closing the extraction site.
3. Irrigate the wound gently with warm saline or 0.12% aqueous chlorhexidine.

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4. Carefully suction or gently dry any excess saline; the socket area should be isolated from saliva by using gauze or cotton rolls.
5. Gently place iodoform-soaked gauze, Gelfoam soaked in eugenol, or Sultan dry socket paste in the extraction socket with forceps/Monoject syringe.
6. Rinse with saline and replace the dressing as needed for the first 2–3 days and every 2–3 days thereafter.
7. Remove the dressing, if it does not dissolve, without replacement once the pain has resolved.
8. Pain medication (nonsteroidal anti-inflammatory drugs [NSAIDs] or narcotics) should be prescribed if necessary.
9. Follow up with dentist.

Complications

- Delayed healing
- Wound dehiscence

Pearls and Pitfalls

- *Pearls*
  – Wound irrigation may be so painful at the first visit that administration of a local anesthetic without a vasoconstrictor should be considered.
  – The patient should experience profound pain relief within minutes of placement of the soaked medicated dressing.
  – If a medicated dressing is necessary for more than 2 weeks, reevaluate for development of osteomyelitis.
  – "Dry socket" is not a progressive disease but may persist for 10–14 days whether treated or not; therapy is palliative.
  – Instruct the patient to avoid the following, which can cause changes of pressure in the mouth:
    Smoking
    Using a straw
    Spitting
    Drinking carbonated beverages (e.g., soda, seltzer water, beer)
- *Pitfalls*
  – Avoid overmanipulating the socket because this will increase the amount of exposed bone and pain.

Suggested Reading

Bloomquist D, Hooley J, Whitacre R. A self-instructional guide: surgical complications. 3rd ed. Stroma: Seattle; 1983.
Matocha DL. Postsurgical complications. Emerg Med Clin North Am. 2000;18:549–71.
Roberts G, Scully C, Shotts R. Dental emergencies. West J Med. 2001;175:51.

72 Postextraction Hemorrhage

Michael A. Abraham, Amir Azari, Jennifer Westcott, and Franci Stavropoulos

Indications

- Recent tooth extraction site, presenting with more than a slight oozing of blood
- Full evaluation indicating amount of blood loss, present physical condition, and reason for hemorrhage including coagulopathy or medication use

Contraindications

- Absolute
  - None
- Relative
  - None

Materials and Medications

- 2 × 2 gauze pad
- Saline
- 25-gauge needle, syringe
- Local anesthetic without vasoconstrictor—2% lidocaine plain
- Gelfoam (absorbable gelatin-compressed sponge) or oxidized cellulose
- Topical thrombin
- Suture kit with 3-0 chromic gut suture or 3-0 Vicryl® suture (synthetic absorbable sterile surgical suture composed of a copolymer made from 90% glycolide and 10% l-lactide)
- Hemostat

Procedure

1. Use suction and saline irrigation to gently rinse the affected area. If a "liver" clot is present, irrigate and remove it with suction.
2. Determine the source of hemorrhage without local anesthesia, if possible, because the use of local anesthetic with an added vasoconstrictor may obscure bleeding sites.
3. Moisten a folded 2 × 2 gauze pad with saline, and place it directly onto the extraction site.
4. Instruct the patient to apply firm biting pressure, and observe for 1 h, changing gauze as necessary.
5. If bleeding persists, an intraoral nerve block should be performed:
   - Blocks are preferred to infiltrations; anesthetic with epinephrine infiltrated near the bleeding site will produce only temporary local hemostasis from vasoconstriction.
6. Gently curette the tooth extraction socket and remove areas of old blood clot or granulation tissue.
7. Check soft tissue for associated arterial bleeding:
   - If hemorrhage is localized to soft tissue, use pressure or tie off vessels.
8. Fold Gelfoam into a small cylinder to fit into the extraction socket.
9. Place Gelfoam with topical thrombin or Surgicel (absorbable hemostat) into the socket, and hold in position with a figure-of-eight stitch using 3-0 chromic gut suture or 3-0 Vicryl suture (Figs. 72.1 and 72.2).
10. Fold 2 × 2 gauze, moisten it with saline, and place it over the suture.
11. Instruct the patient to bite down with firm pressure for 30 min; repeat as necessary.
12. Follow up with dentist.

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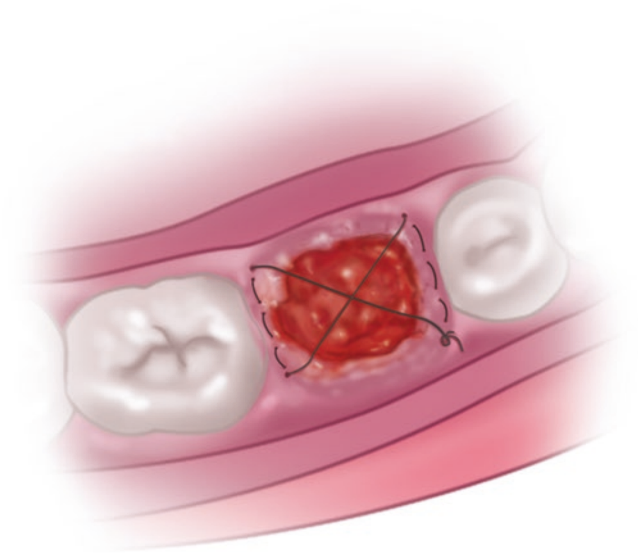

Fig. 72.1 A resorbable figure-of-eight suture placed over an extraction socket

Fig. 72.2 Gelfoam (absorbable gelatin-compressed sponge) being placed into the extraction socket. (Photograph courtesy of Dr. Michael Abraham)

Complications

- Continued bleeding due to lack of patient compliance.
- Continued bleeding due to coagulopathy or medication use.
- If bleeding persists and coagulopathy is identified, the administration of intravenous blood replacement products may be necessary.

Pearls and Pitfalls

- Pearls
  - Minor bleeding concerns may be addressed at home by instructing the patient to bite on the affected area with a tea bag for 30 min (tannic acid in tea is a vasoconstrictor).
  - It is normal for an extraction socket to ooze slight amounts of blood for 12–24 h; it is normal for patients to see some blood on their pillow after waking.
  - The patient should be instructed to avoid the following, which can cause changes of pressure in the mouth:
    - Smoking
    - Using a straw
    - Spitting
    - Drinking carbonated beverages (e.g., soda, seltzer water, beer)
- Pitfalls
  - Small amounts of blood mixed with saliva may deceptively appear as large amounts of blood.

Suggested Reading

Bloomquist D, Hooley J, Whitacre R. A self-instructional guide: surgical complications. Seattle: Stroma; 1983. p. 50–5.
Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th ed. St. Louis: Mosby Elsevier; 2008. p. 195–7.

Fractured Tooth

73

Varun Solanki and Geraldine Weinstein

Indication (Fig. 73.1)

- Temporary repair of an acute dental fracture until follow-up by a dentist can be secured.

Methods of Sustaining Dental Fracture

- Traumatic injury to the head/facial area
- Falling down
- Extensive tooth decay that has undermined the integrity of the tooth structure
- Biting down on something hard

Four Types of Fractured Tooth (Fig. 73.2)

- *Type 1*: contained to the enamel of the tooth, asymptomatic, and can be treated easily with a composite filling by a dentist.
- *Type 2*: involves a fracture through the dentin layer of the tooth. The patient may experience some sensitivity to temperature changes and chewing. Depending on the severity, treatment may include a root canal and a restoration by a dentist.
- *Type 3*: involves the pulp of the tooth and will require endodontic treatment by a dentist.
- *Type 4*: a root fracture in the tooth that makes it nonrestorable and requiring extraction. It is diagnosed by means of a periapical radiograph taken in a dental office.

Fig. 73.1 Examples of fractured teeth

Contraindication

- *Relative*
  – Patients at high risk of aspiration owing to intoxication and altered mental status

Materials and Medications

- Warm saline or 0.12% aqueous chlorhexidine solution for irrigation of tissues and tooth
- Irrigating syringe
- Suction with a small tip
- Gauze to control hemorrhage
- Resorbable sutures and local anesthetic as needed for soft tissue lacerations
- Temporary tooth restoration material like intermediate restorative material (IRM) and glass ionomer (like Fuji). Composite bonding material and orthodontic wire

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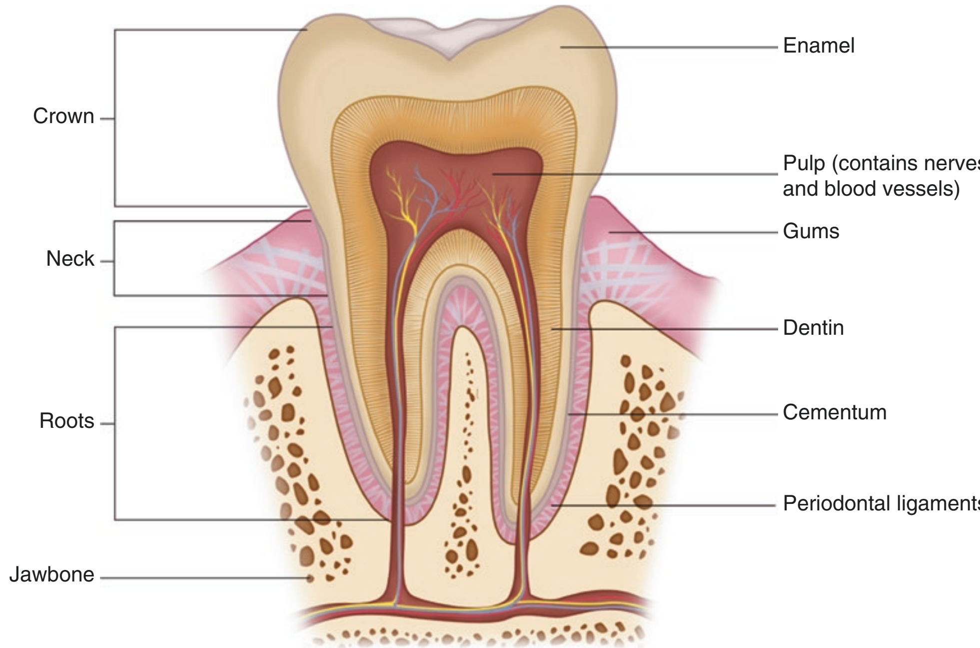
Fig. 73.2 Anatomy of a tooth



Procedure

1. Have the patient rinse the mouth out with warm water to clean out any debris. Apply an ice pack to the affected cheek to reduce swelling.
2. Anesthetize the area, either locally at the tooth apex or with a nerve block (mental or inferior alveolar).
3. Irrigate the area; assess the fracture intraorally and check for soft tissue lacerations. Use the gauze with finger pressure to control bleeding in the soft tissue or the tooth.
4. Check if the tooth or bony segment is mobile. If so, a referral to a dentist or oral surgeon is necessary as soon as possible for proper assessment.
5. Type II fractures (fracture limited to dentin layer): cover the exposed surface with a temporary dental cement. In a pinch, 2-octyl cyanoacrylate (Dermabond) is an acceptable secondary alternative (Fig. 73.3).
6. Type III (pulp involved):
   – Provide immediate dental follow-up and analgesics.
   – Initiate antibiotic coverage with penicillin or clindamycin. Splinting and Immobilization: Current evidence supports short-term, passive, and flexible splints for splinting of luxated, avulsed, and root-fractured teeth. In the case of alveolar bone fractures, splinting of the teeth may be used for bone segment immobilization. When using wire-composite splints, physiological stabilization can be obtained with stainless steel wire up to 0.4 mm in diameter. (4) Splinting is considered best practice in order to maintain the repositioned tooth in its correct position and to favour initial healing while providing comfort and controlled function.

Complications

- Loss of a tooth
- Infection or abscess
- Aspiration of a segment or a whole tooth
- Cosmetic deformity

Pearls

- Be certain to perform a thorough intraoral examination, looking for tooth fragments or lacerations that may be hiding fragments.
- Dental blocks are very useful for pain control.
- If a tooth is not mobile and the *pulp is exposed*, immediate referral (within a few hours) to a dentist is necessary for

Fig. 73.3 Example of temporary dental cement. (Reproduced with permission from DenTek Oral Care, Inc.)

extraction or endodontic (root canal) treatment of the tooth. Placement of a temporary-type restoration on this tooth is *not* recommended at this time because it may exacerbate symptoms. Prescribe pain medication and possibly antibiotics when the tooth's pulp is exposed and the patient is unable to see the dentist within 24 h.

- If the tooth is not mobile and *the pulp is not exposed*, a temporary restoration can be placed on the tooth and the patient referred to a dentist for treatment. The fractured part of the tooth should be saved in the event that it can be used. If temporary tooth restoration is unavailable in the emergency department, advise the patient that it is readily available at local pharmacies.
- *All dental fractures, except type i, require dental follow-up within 24 h*: Patient Instructions: Patient compliance with follow-up visits and home care contribute to better healing following a TDI. Both patients and parents or guardians should be advised regarding care of the injured tooth/teeth and tissues for optimal healing, prevention of further injury by avoidance of participation in contact sports, meticulous oral hygiene, and rinsing with an antibacterial agent such as chlorhexidine gluconate 0.12%.

Suggested Reading

1. Levin L, Day PF, Hicks L, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: General introduction. Dent Traumatol 2020;36:309–313. https://doi.org/10.1111/edt.12574.
2. Bourguignon C, Cohenca N, Lauridsen E, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 1. Fractures and luxations. Dent Traumatol 2020;36:314-330. https://doi.org/10.1111/edt.12578.
3. Kenny KP, Day PF, Sharif MO, Parashos P, Lauridsen E, Feldens CA, et al. What are the important outcomes in traumatic dental injuries? An international approach to the development of a core outcome set. Dent Traumatol. 2018;34:4–11.
4. Kwan SC, Johnson JD, Cohenca N. The effect of splint material and thickness on tooth mobility after extraction and replantation using a human cadaveric model. Dental Traumatol. 2012;28:277–81.
5. Kahler B, Heithersay GS. An evidence-based appraisal of splinting luxated, avulsed and root-fractured teeth. Dent Traumatol. 2008;24:2–10.
6. Oikarinen K, Andreasen JO, Andreasen FM. Rigidity of various fixation methods used as dental splints. Endod Dent Traumatol. 1992;8:113–9.
7. Andreasen JO, Andreasen FM, Mejare I, Cvek M. Healing of 400 intraalveolar root fractures. 2. Effect of treatment factors such as treatment delay, repositioning, splinting type and period and antibiotics. Dental Traumatol. 2004;20:203–11.

74 Dental Avulsion Management

Laura Tucker and Abimbola O. Adewumi

Indications

- The tooth is completely displaced *out* of its socket, leading to severance of the neurovascular pulp supply and separation of the periodontal ligament (Fig. 74.1).
- Diagnosis:
  - Clinically, the socket is found empty or filled with coagulum.
  - Imaging (occlusal, periapical, and lateral views of the affected tooth and surrounding area) (Fig. 74.2).
- Confirm vacuous socket.
- Ensure that the missing tooth is not intruded.
- Diagnose root fracture or alveolar fracture.

Contraindications

- Absolute
  - Avulsed tooth is a primary tooth:

    DO NOT REPLANT OR REPOSITION AVULSED PRIMARY TEETH.

    Replantation of primary teeth increases the potential for damage to the developing permanent tooth owing to the increased frequency of pulpal necrosis.
- Relative
  - Fractured root (further intervention required before replantation)
  - Alveolar fracture (further intervention required before replantation)
  - Prolonged extraoral dry time and out of compatible solution (>1 h)
  - Immunocompromised host or congenital heart disease
  - Severe seizure disorder that may put tooth at risk for coming out while the airway is compromised
  - Patient with potential to lose airway reflexes

Materials and Medications

- Hank's Balanced Salt (Save-A-Tooth) solution or milk in which to preserve tooth until it can be replanted:
  - Normal saline if neither of those is available
- Normal saline rinse
- 20- or 18-gauge cannula for gentle irrigation of the socket
- Absorbable suture for gingival lacerations, if present
- Flexible splint materials:
  - Round dental wire
  - A flat pliable metal long enough to cover the affected tooth and the two teeth on the other side (e.g., the metal nasal bridge from a respirator mask)
- Fixative
  - Dental adhesive
  - Dermabond or some other brand of cyanoacrylate for adhesive skin closures

Procedure

1. Be certain the tooth is a permanent one and not a primary tooth.
2. If not done by the patient, gently wash the tooth under water for approximately 10 s:
   - Be certain to hold the tooth by the crown, not the root (Fig. 74.3).
3. If the tooth cannot be replanted immediately, place the tooth in Hank's solution or milk.
4. If no such medium is available, instruct the patient to hold the tooth inside his or her mouth between the cheek and the gums.
5. Gently replant the tooth, using digital pressure only into as anatomical a position as possible (Fig. 74.4):
   - Assess clinically for alignment.
   - Radiograph for confirmation.

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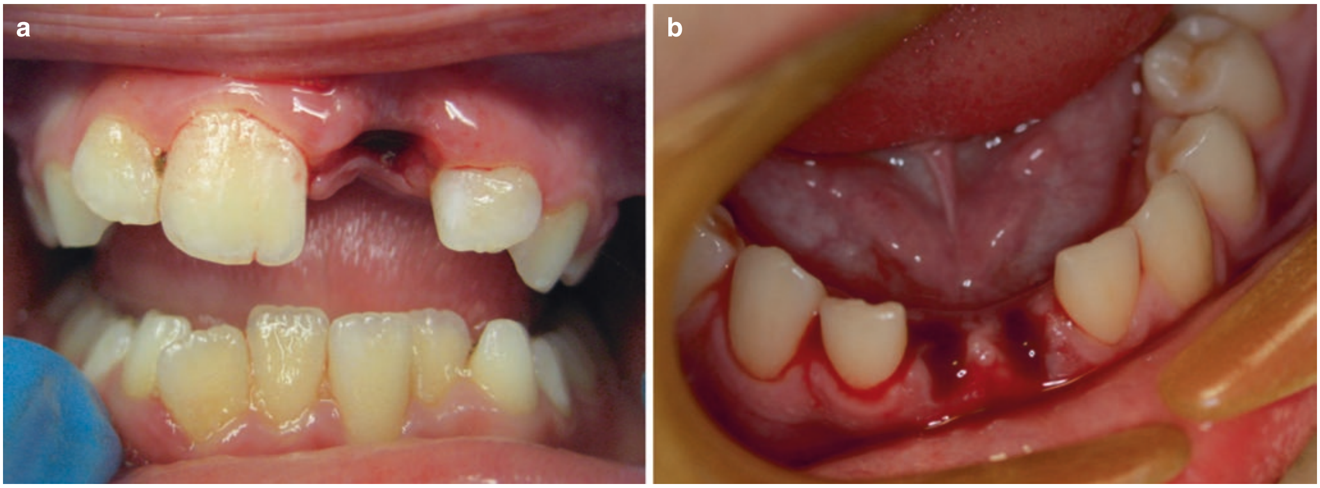

Fig. 74.1 (**a**, **b**) Empty socket following traumatic dental avulsion

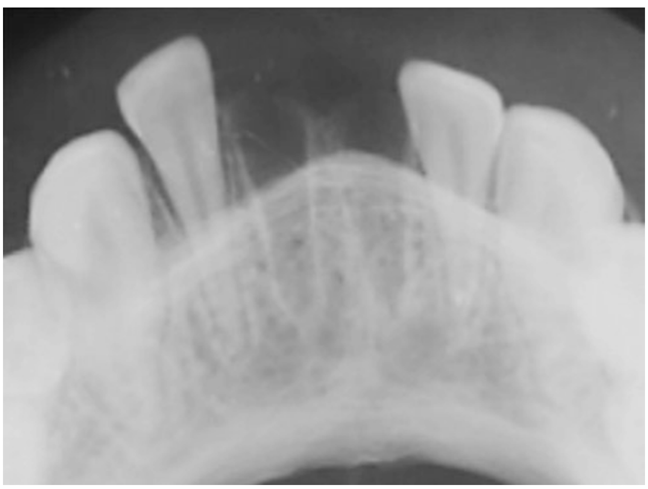

Fig. 74.2 Lower occlusal radiograph shows a complete avulsion of the mandibular right and left central incisors

Fig. 74.3 Proper way to hold an avulsed tooth

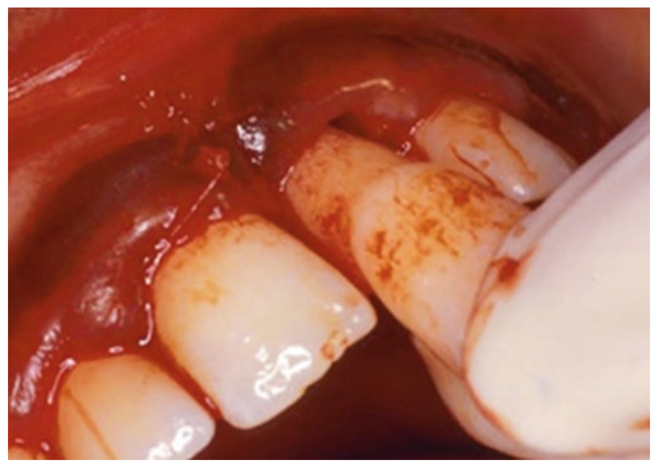

Fig. 74.4 Gentle replantation using digital pressure

6. Suture any gingival lacerations if present.
7. Apply a flexible splint, securing the affected tooth to the teeth on either side:
   - Consider using skin adhesive both to secure the tooth to its neighbors and, perhaps, to apply a makeshift splint until the patient can be seen by her or his dentist:
     – Towel dry the teeth as best as possible.
     – Apply skin adhesive (using the standard applicator) to the lateral edges of the avulsed tooth where it will make contact with its adjacent teeth.
     – If dental wire is available, apply adhesive to the buccal surfaces of the three teeth (the avulsed tooth central to the other two), and apply length of metal to the Fixodent (Fig. 74.5).
8. Systemic antibiotics with anaerobic coverage are empirical.

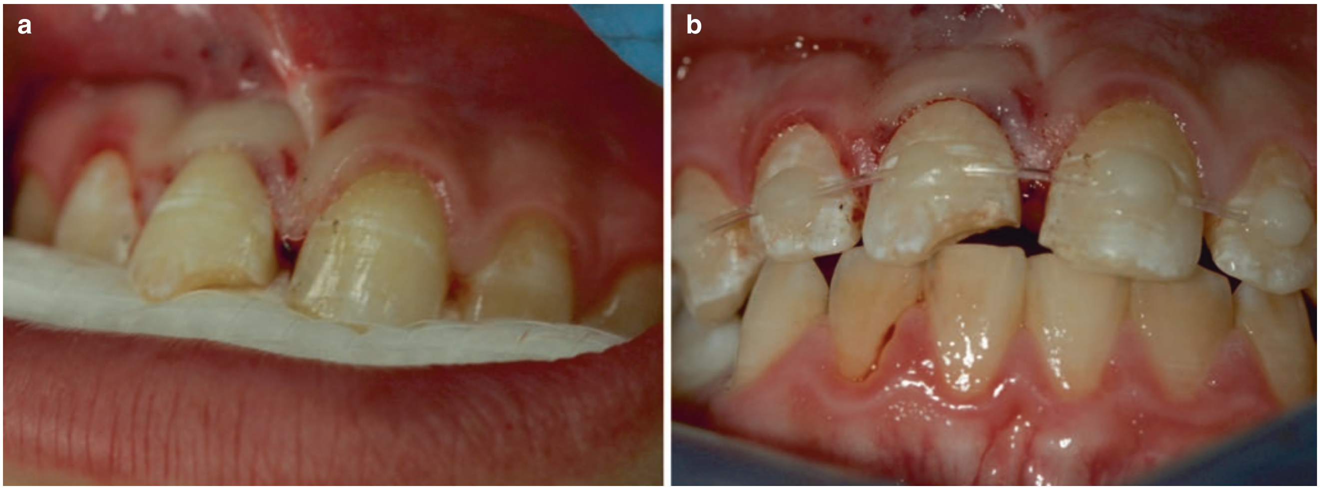

Fig. 74.5 (**a**, **b**) Splint stabilization

9. Ascertain tetanus status for the patient; update if uncertain.

Complications

- Primary teeth
  - Dilaceration (bend) in the permanent tooth crown
  - Enamel defect of the lower permanent incisors as a result of avulsion of the preceding primary tooth
- Permanent teeth
  - Discoloration as a result of loss of vitality of the avulsed tooth.
  - Ankylosis of the alveolar ridge, leading to functional and aesthetic changes.
  - Replacement resorption occurs when the replanted tooth is slowly replaced with bone.
  - External inflammatory resorption is a progressive loss of tooth associated with destruction of adjacent alveolar bone.
  - Infection.
  - Aspiration of an inadequately secured replanted tooth.

Pearls and Pitfalls

- Pearls
  - At the initial examination, make sure that all avulsed teeth are accounted for.

    If not, a radiographic examination is necessary to ensure that the missing tooth is not completely intruded (pushed into the gum) or has sustained a root fracture with loss of the coronal fragment.
  - In children, always consider the likelihood of nonaccidental trauma (abuse).
  - Short-term and long-term dental follow-up cannot be emphasized enough.
- Pitfalls
  - If the avulsed tooth cannot be accounted for, aspiration is a possibility.
- Prognosis
  - Depends on extraoral dry time (length of time the tooth has been out of the mouth and not stored in an appropriate medium):

    Ideally, the tooth should be implanted within 5 min.

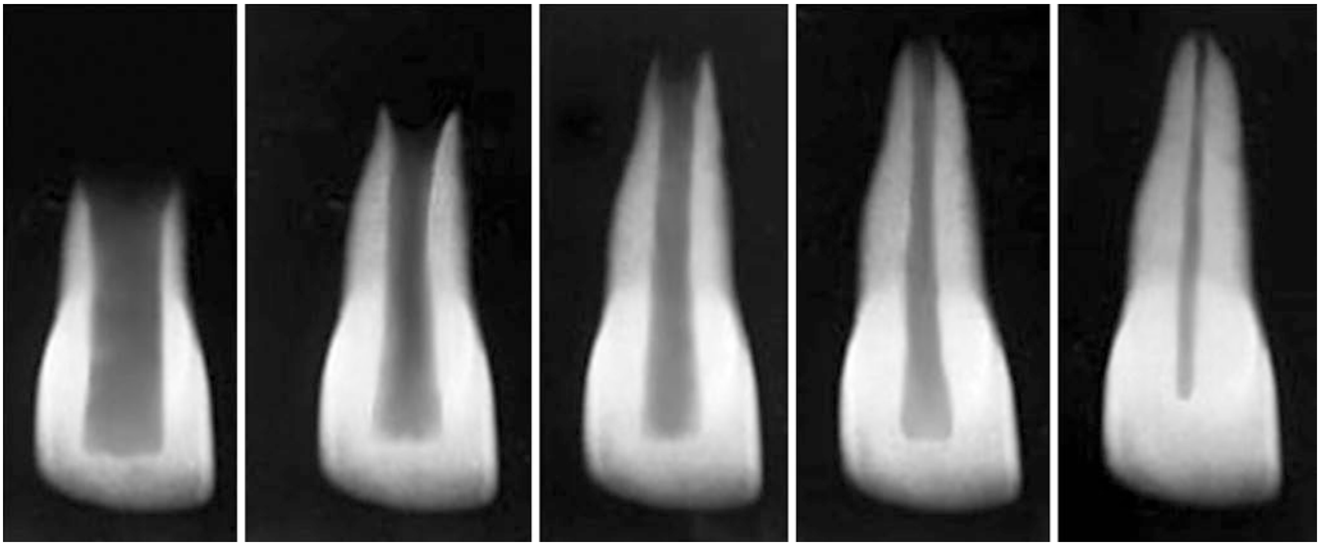

Fig. 74.6 The various stages of root development, from the less advanced (*open apex, left*) to the more advanced (*closed apex, right*)

Extraoral dry time greater than 60 min has a poor prognosis for periodontal healing.

– Depends on the stage of root development of the avulsed tooth (Fig. 74.6):
– The more advanced the root development, the lower the probability of pulp healing and survival.

Suggested Reading

AAPD Council on Clinical Affairs. Guideline on management of acute dental trauma. AAPD reference manual. Chicago: American Academy of Pediatric Dentistry; 2010–2011. p. 202–12.

Andreasen FM, Andreasen JO. Avulsions. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth. 4th ed. Oxford: Blackwell; 2007. p. 444–88.

Andreasen JO, Jensen SS, Sae-Lim V. The role of antibiotics in preventing healing complications after traumatic dental injuries: a literature review. Endod Topic. 2006;14:80–92.

Finucane D, Kinirons MJ. External inflammatory and replacement resorption of luxated, and avulsed replanted permanent incisors: a review and case presentation. Dent Traumatol. 2003;19:170–4.

Flores MT, Andersson L, Andreasen JO, et al. Guidelines for the management of traumatic dental injuries. II. Avulsion of permanent teeth. Dent Traumatol. 2007;23:130–6.

Hile LM, Linklater DR. Use of 2-octyl cyanoacrylate for the repair of a fractured tooth. Ann Emerg Med. 2006;47:424–6.

The dental trauma guide. Available at: www.dentaltraumaguide.org

Part X

Gastrointestinal Procedures

75 Excision of Thrombosed External Hemorrhoid

Latha Ganti

Indications

- Acute onset of pain within 72 h of hemorrhoid development.
- Thrombosis will be visible as a bluish-purplish painful mass in perianal area (Fig. 75.1).

Contraindications

- Absolute
  - Severe coagulopathy
  - Hemodynamic instability
  - Concurrent internal hemorrhoid with rectal prolapse
  - Painless rectal mass (Remember: external hemorrhoids are almost always painful. A painless mass is not consistent with a thrombosed external hemorrhoid.)
- Relative
  - Allergy to local anesthetics
  - Concurrent perianal infection
  - Inflammatory bowel disease
  - Serious systemic illness or comorbidity that could increase risk of procedure

Materials and Medications

- Sterile gloves
- Drapes
- Alcohol swabs or pads
- 10% povidone-iodine or chlorhexidine prep
- 2% lidocaine with epinephrine
- 5 or 10 ml syringe
- 25 or 27 gauge and 18 gauge needles

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Fig. 75.1 Bluish-purplish appearance of an external thrombosed hemorrhoid. The *ellipse* denotes the area of the elliptical incision to be made. (Reproduced with permission from Fargo and Latimer [3])

- #11 or #15 scalpel blade and handle
- Direct light source
- Forceps
- Iris scissors
- 4 × 4 gauze pads
- Adhesive tape
- 3–0 absorbable suture
- 1/4 inch iodoform packing
- Silver nitrate sticks
- Sterile dressing

Procedure

1. Patient should be in either prone, left lateral decubitus, or jackknife position (Fig. 75.2).
2. Place two vertically oriented pieces of tape down each buttock from lower back to upper thigh. Next, place a perpendicular (horizontal) strip spreading buttocks to either side, securing the gurney (Fig. 75.3).

L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0_75

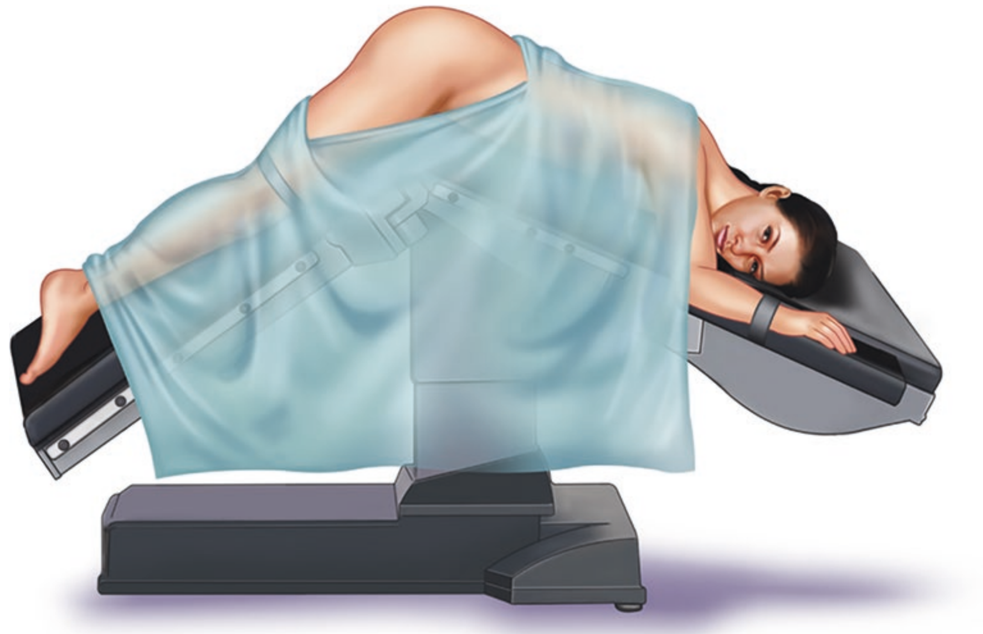

Fig. 75.2 Jackknife position

Fig. 75.3 Taping of buttocks to maximize visualization of hemorrhoid

Fig. 75.4 Direct lighting over the field

3. Place sterile drape (or surgical towels) over the field, and center direct lighting over the field (Fig. 75.4).
4. Wipe the area with alcohol.
5. Inject 1–2 cc of anesthetic into the base of hemorrhoid.
6. Clean the area with povidone-iodine or chlorhexidine prep.
7. Make an elliptical incision in the roof of the hemorrhoid, being careful to avoid the anal sphincter muscle.
8. Remove blood clot(s); multiple clots are often present.
9. If profuse bleeding is a problem, consider cauterization with silver nitrate sticks (figure-of-eight stitch may be applied as well).

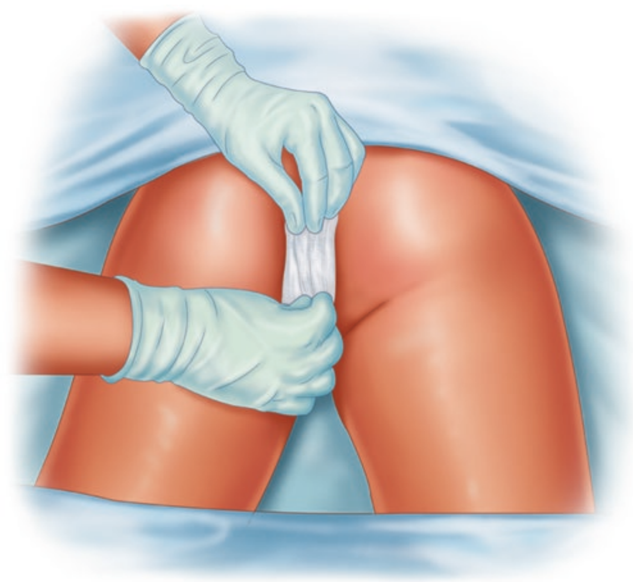

Fig. 75.5 Dress wound with sterile gauze

10. Wound can be closed with figure-of-eight absorbable suture OR can be loosely packed with 1/4 inch iodoform gauze. Do not suture if iodoform gauze was utilized.
11. Cover the wound with 4 × 4 gauze folded in half and tape into place (Fig. 75.5).
    - Discharge medications:
      – Ibuprofen and/or acetaminophen for analgesia. Avoid opiates as these may lead to constipation.
      – Stool softeners, to be taken two to three times daily.
      – Antibiotics are not necessary.
    - Discharge instructions to patient:
      – Sitz baths 3–4 times daily, for 20 min, with warm not hot water.
      – Packing should fall out spontaneously in 2 days.
      – Keep well hydrated.
      – Use gauze to protect underclothing from soilage/blood stains.
      – Return to ED if pain persists beyond 48 h.

Complications

- Common
  – Bleeding: usually self-limited. May utilize cautery or figure-of-eight suture for hemostasis
  – Pain: usually controlled with ibuprofen or acetaminophen
  – Perianal skin tag: benign
- Rare
  – Infection rate is 5% [1].
  – Recurrence rate is 5–19%, vs. 30% for simple lancing [2].
  – Stricture and/or incontinence: prevented by avoiding underlying external anal sphincter muscle,

Pearls and Pitfalls

- Pearls
  – Elliptical excision of the hemorrhoid results in much lower recurrence rate than simple lancing.
  – Risk factors for thrombosed external hemorrhoids include constipation, straining, pregnancy, and traumatic vaginal delivery.
- Pitfalls
  – Excision of multiple hemorrhoids in a circumferential fashion on all sides of the anal canal can cause anal stenosis.
  – Excision of a painless mass: if it is *painless*, it is *not* a thrombosed external hemorrhoid.

References

1. Lorber BW. Thrombosed external hemorrhoid excision. Medscape.com. www.emedicine.medscape.com/article/81039. Accessed 27 July 2014.
2. Rivadeneira DE. Outpatient and surgical procedures for hemorrhoids. UpToDate.com. http://www.uptodate.com/contents/outpatient-and-surgical-procedures-for-hemorrhoids. Accessed 27 July 2014.
3. Fargo MV, Latimer KM. Evaluation and management of common anorectal conditions. Am Fam Physician. 2012;85(6):624–30.

Selected Reading

Fargo MV, Latimer KM. Evaluation and management of common anorectal conditions. Am Fam Physician. 2012;85(6):624–30.

Jongen J, Bach S, Stübinger SH, Bock JU. Excision of thrombosed external hemorrhoid under local anesthesia: a retrospective evaluation of 340 patients. Dis Colon Rectum. 2003;46(9):1226–31.

Diagnostic Peritoneal Lavage

76

Latha Ganti and Larissa O. Dub

Indications (Table 76.1)

- Inability to perform FAST exam due to lack of equipment or operator
- Hemodynamically unstable patient in whom FAST exam is negative or equivocal

Contraindications

- Absolute
  – Indication for laparotomy already exists.
- Relative
  – Second or third trimester pregnancy
  – Previous lower abdominal surgery
  – Inexperienced operator
  – Abdominal wall infection
  – Coagulopathy
  – Cirrhosis
  – Morbid obesity

Materials and Medications

- 10% povidone-iodine prep
- 1% lidocaine with epinephrine
- Fenestrated drape
- #10 scalpel blade and scalpel holder
- Skin retractors
- Hemostats
- Diagnostic peritoneal lavage (DPL) catheter (standard peritoneal dialysis catheter)
- 10 cc syringe

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Table 76.1 Comparison parameters for DPL, FAST, and CT [1]

	DPL	FAST	CT
Speed	10–15 min	Fastest: <5 min	Variable
Repeatable	Yes, but rarely done	Yes, and frequently done	Yes, but not done often
Cost	$	$$	$$$
Invasive	Yes	No	No
Mobile	Yes	Yes	No
Advantages	Most sensitive for mesenteric and hollow viscus injuries	Highest specificity	Highly accurate but can be hampered by patient movement
Disadvantages	Misses retroperitoneal and diaphragm injuries	Hampered by subcutaneous or intra-abdominal air, obesity, and pelvic fractures Significant false-negative rate	Misses diaphragm, small bowel, and pancreatic injuries Small but significant risk of radiation-associated malignancy Cannot be done at bedside

- Warmed lactated Ringer's or normal saline solution
- Skin stapler
- Simple suture tray with suture material

Procedure

Patient Preparation

- Place patient in supine position.
- Ensure nasogastric and urethral catheters (Foley) are in place.
- Prep and drape the area from the umbilicus to the symphysis pubis.

L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0_76

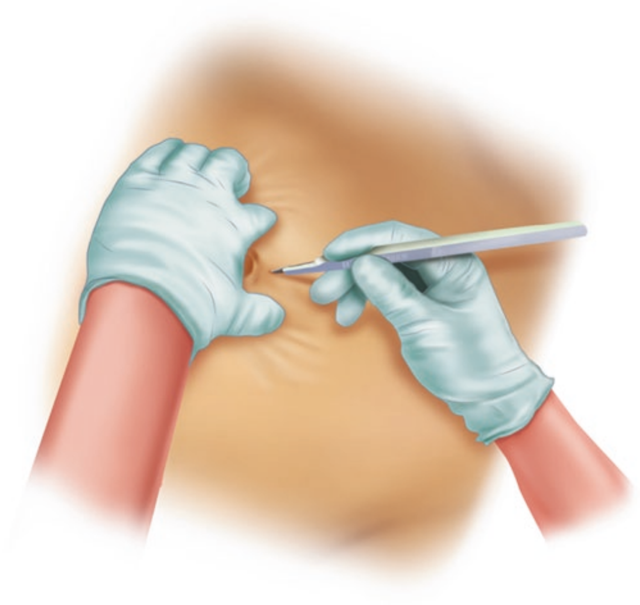

Fig. 76.1 Anesthetize the skin where incision will be made (supraumbilical incision shown here, can also make infraumbilical incision)

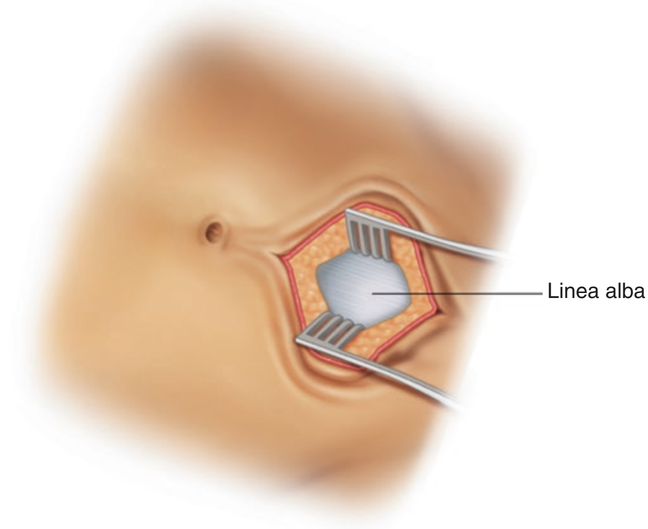

Fig. 76.2 Hold incision open with skin retractors

- Anesthetize the skin using 1% lidocaine with epinephrine where the incision will be made (Fig. 76.1).

Three DPL Techniques

- Semiopen (Seldinger) technique:
  1. Using a #10 scalpel blade, make a 2 cm incision either superior or inferior to the umbilicus.
  2. Dissect subcutaneous fat until linea alba is exposed.
  3. Hold incision open with skin retractors (Fig. 76.2).
  4. Grasp fascia with hemostats on either side of midline.
  5. Insert 18 gauge needle at 45° angle toward the pelvis (Fig. 76.3).
  6. First "pop" will be heard once fascia is penetrated.
  7. Second "pop" will be heard once peritoneum is traversed.
  8. Pass guidewire through the needle into the pelvis (should pass easily without resistance).
  9. Remove needle while keeping the wire stable.
  10. Pass the dilator over the wire through fascia, and remove (Fig. 76.4).
  11. Slip DPL catheter over guidewire aiming toward the pelvis.
  12. Aspirate peritoneal contents with syringe; aspiration of blood is a positive DPL and means immediate laparotomy (can stop DPL procedure here).
  13. If no blood is immediately seen, then connect the DPL catheter to a liter of warmed lactated Ringer's (LR) or normal saline (NS) solution for lavage (ensure setup has no one-way valves as solution and peritoneal fluid need to be able to freely mix).
  14. Place LR or NS bag on the floor once it is almost empty (minimum 300–350 ml for adults or 10–15 ml/kg for children), and allow intra-abdominal fluid to return (Fig. 76.5).
  15. Send fluid for analysis (Table 76.2).
  16. Irrigate wound, and close the skin only with staples or sutures.

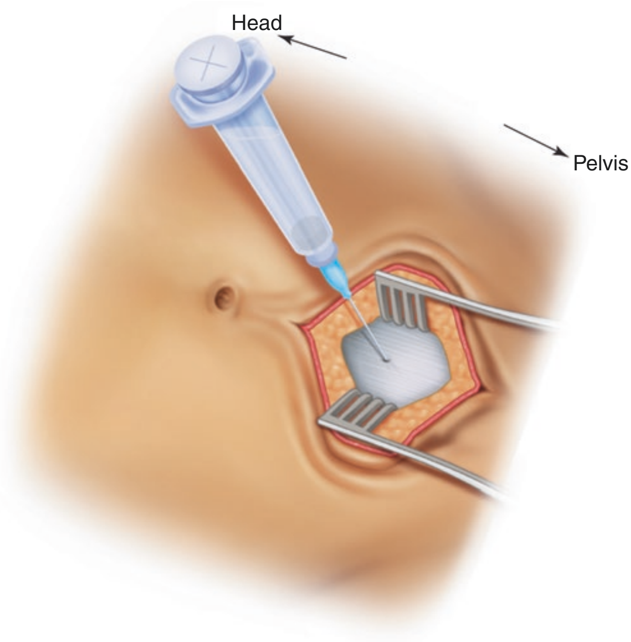

Fig. 76.3 Insert 18 gauge needle at 45° angle toward the pelvis

- Open technique:

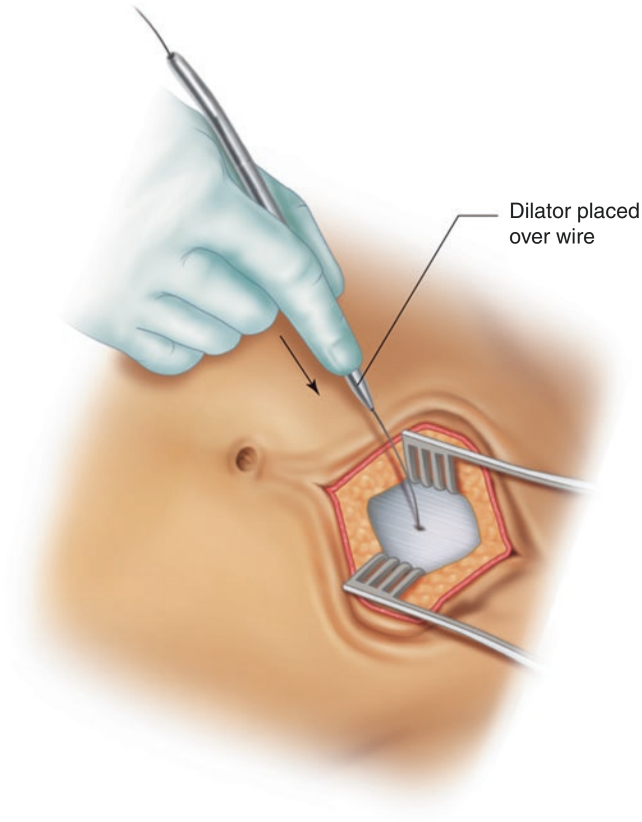

Fig. 76.4 Pass the dilator over the wire through fascia and remove

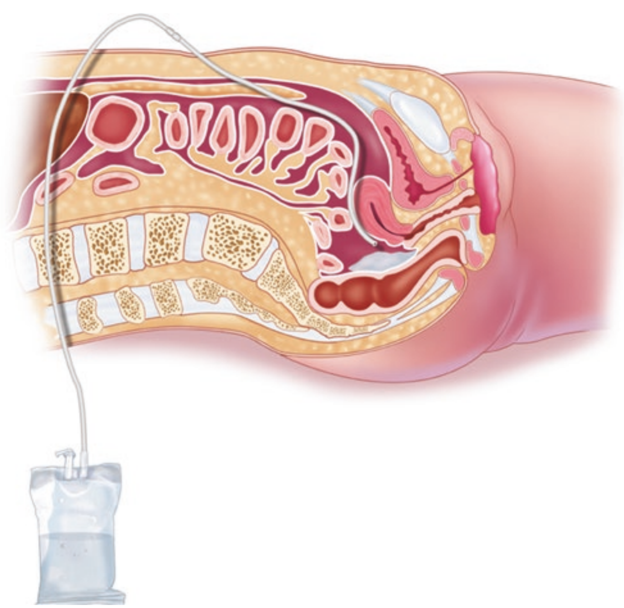

Fig. 76.5 Lavage

Table 76.2 Diagnostic peritoneal lavage red blood cell criteria (per mm^3) [2]

	Positive	Indeterminate
Immediate gross return of blood via catheter	Any amount	
Immediate return of food particles/ intestinal contents	Any amount	
Aspiration of blood	10 cc	
RBC in blunt trauma	100,000	20,000–100,000
RBC in penetrating trauma	10,000	5000–10,000
RBC in gunshot wound	5000	1000–5000
Amylase level (IU/L)	≥175	
Alkaline phosphatase level (IU/L)	≥3	
WBCs (per mm^3)	>500	250–500

1. Make a 5 cm incision inferior to the umbilicus over linea alba, and directly visualize the peritoneal cavity.
2. Both fascia (absorbable suture) and skin (nonabsorbable suture) need to be closed.

- Closed technique:
  1. Access the peritoneal cavity via percutaneous needle access.
  2. No surgical closure required.

76.5. Complications

- Wound infection or dehiscence
- Intraperitoneal injury to organs or vessels (iatrogenic hemoperitoneum)
- Unnecessary laparotomy due to false-positive result from bleeding within rectus sheath or from site of incision
- Potential failure to recover lavage fluid due to:
  – Inadvertent placement of the catheter into the preperitoneal space
  – Compartmentalization of fluid by adhesions
  – Obstruction of fluid outflow (e.g., by omentum)
  – Fluid pooling in the intrathoracic cavity due to diaphragmatic injury
- Incisional hernia

Pearls and Pitfalls

- Pearls
  – When properly done, complication rate for DPL is low.
  – Prophylactic antibiotics are generally not indicated.

- Pitfalls
  - Inadequate decompression of the stomach and urinary bladder increases the chance of injury to these organs; thus, nasogastric and Foley decompression is an important step in patient preparation.

References

1. Jagminas L. Diagnostic peritoneal lavage. Medscape.com. http://emedicine.medscape.com/article/82888-overview#a17. Accessed 28 Aug 2014.
2. Marx JA. Diagnostic peritoneal lavage. In: Ivatury RR, Cayten CG, editors. The textbook of penetrating trauma. Baltimore: Williams & Wilkins; 1996. p. 337.

Selected Reading

Whitehouse JS, Weigelt JA. Diagnostic peritoneal lavage: a review of indications, technique, and interpretation. Scand J Trauma Resusc Emerg Med. 2009;17:13.

Manual Reduction of Abdominal Hernia

77

Latha Ganti

An abdominal wall hernia is a protrusion of the intestine through an opening or area of weakness in the abdominal wall. See Table 77.1 for types of abdominal hernias and Fig. 77.1 for locations along the abdominal anatomy.

Indication

- Incarcerated hernia

Contraindications

- Absolute
  - Strangulated hernia (could result in placing dead bowel into abdominal cavity)
- Relative
  - Inability to get patient relaxed enough
  - Previous unsuccessful attempts

Materials and Medications

- Ice or cold compress
- Stretcher or gurney that can tilt to provide Trendelenburg position
- Moderate sedation drugs if providing moderate sedation
- Truss for post-procedure

Procedure

1. Patient positioning:
   - For abdominal hernia: place patient supine.
   - For groin hernia in adult: place in 20° of Trendelenburg.
   - For groin hernias in children: place in unilateral frog leg position (Fig. 77.2).
2. Apply ice or cold compress directly over hernia site to reduce swelling.
3. Administer opiate analgesia or moderate/procedural sedation.
4. Wait up to 30 min as hernia may reduce spontaneously after swelling has gone down and patient is relaxed.
5. Gently apply steady pressure distally on the tissue at the neck of the hernia with one hand, and with other hand, guide hernia proximally through fascial defect. Too much pressure distally can cause hernia to balloon further, mak-

Table 77.1 Types of abdominal hernias

Type	Defect	Most commonly seen in	Notes
Inguinal	Intestine or bladder protrudes through abdominal wall or into inguinal canal in the groin	Men because of a natural weakness in this area	96% of all groin hernias are inguinal; 4% are femoral
Femoral	Intestine enters canal carrying femoral artery into the upper thigh	Women, especially those who are pregnant or obese	
Incisional	Intestine pushes through abdominal wall at the site of previous abdominal surgery	Elderly or overweight people who are inactive after abdominal surgery	
Umbilical	Part of the small intestine passes through abdominal wall near the navel	Newborns and obese women or those who have had many children	In children, not repaired until age five because it often resolves on their own
Hiatal	Upper stomach squeezes through hiatus, an opening in the diaphragm through which the esophagus passes		

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Fig. 77.1 Types of abdominal wall hernias

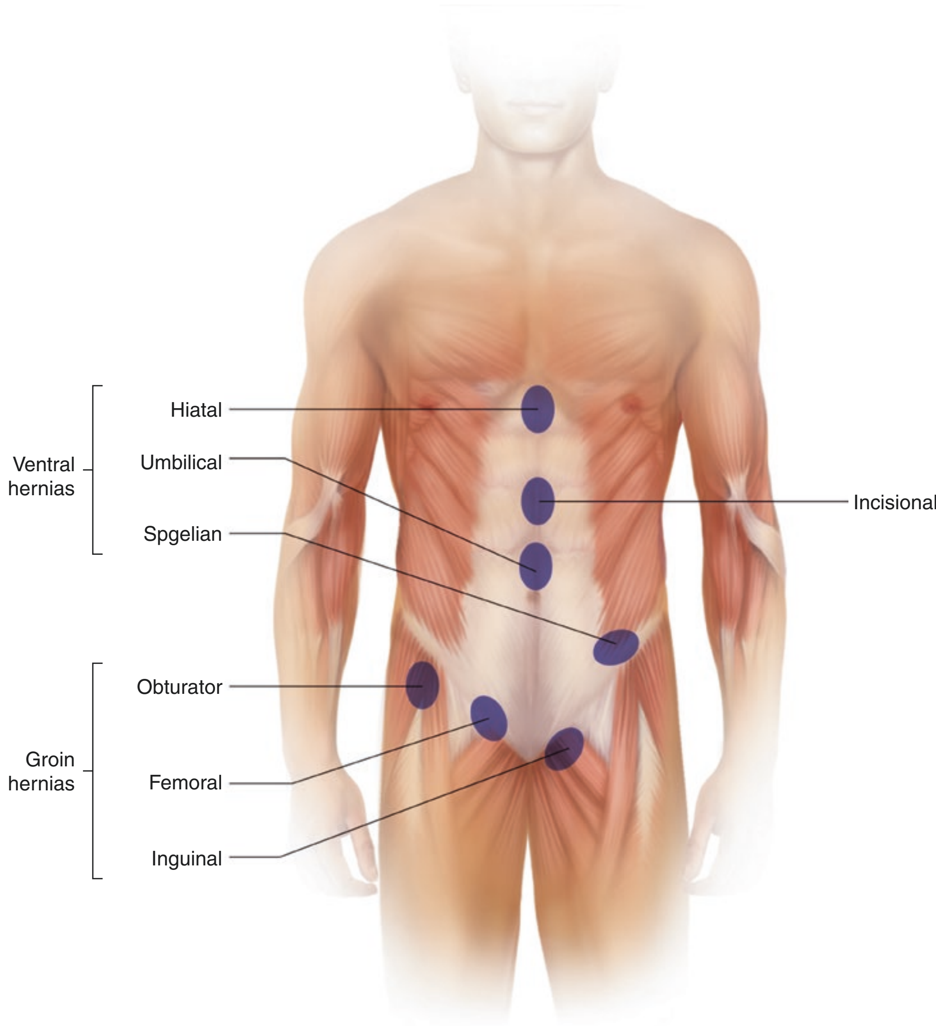

Fig. 77.2 Frog leg position in children

ing manual reduction difficult. It takes up to 15–20 min. Do not rush procedure.

6. Once hernia is reduced, pain will improve.
7. An external support garment or truss (Fig. 77.3) can be helpful to hold reduced hernia in place and serve as a temporizing measure until surgical repair can be done.
8. Advise patient to schedule elective surgical repair.
9. If unable to reduce the hernia, obtain surgical consultation. Do not force repeated attempts.

Complications

- Pain.
- Inability to achieve manual reduction, leading to strangulation of the hernia.
- Strangulation can result in peritonitis and sepsis.
- Recurrence.
- Hydrocele.

Fig. 77.3 An example of a truss, or external support, which can be useful as a temporizing measure until definitive hernia repair can be done

Pearls and Pitfalls

- Pearls
  - Definitive treatment for a hernia is surgery (herniorrhaphy). Without surgery, hernias grow larger over time; they do not disappear. Small hernias are easier to fix and result in fewer complications.
  - The only hernia that can resolve on its own is an umbilical hernia in a child.
  - Trusses, bandages, and tape may provide some comfort but do not reduce risk of incarceration or strangulation.
  - Note that if a truss is worn, it should be in place after reduction of the hernia. Also, it can be impractical in hot climates.
- Pitfalls
  - When the constricting neck and the protrusion are both reduced into the abdomen together (known as a reduction en masse), without actually reducing the hernia itself, strangulation ensues even though it appears one has reduced the hernia.
  - If there is still considerable pain after the reduction, it is likely that the reduction was not successful or that dead bowel has been reduced into the abdominal cavity.
  - Not recognizing strangulation leads to gangrenous bowel, peritonitis, and sepsis.

Suggested Reading

Campanelli G, Canziani M, Frattini F, et al. Inguinal hernia: state of the art. Int J Surg. 2008;6 Suppl 1:S26–8.

Jenkins JT, O'Dwyer PJ. Inguinal hernias. BMJ. 2008;336(7638):269–72.

Moses S. Hernia reduction. 2014. http://www.fpnotebook.com/mobile/Surgery/GI/HrnRdctn.htm . Accessed 15 Sept 2014.

Extended Focused Assessment with Sonography for Trauma

78

Javier Rosario, Coben Thorn, and L. Connor Nickels

Indications

- Blunt abdominal or chest trauma.
- Penetrating abdominal or chest trauma.
- Undifferentiated hypotension.
- The "E" in EFAST refers to the "extended" ability to detect lung pathology such as a pneumothorax or hemothorax during the otherwise standard trauma FAST exam using the same equipment with or without an additional transducer probe.
- Specific findings that can be detected on extended focused assessment with sonography for trauma (EFAST):
  - Pericardial fluid
  - Pleural fluid
  - Free intraperitoneal fluid
  - Pneumothorax

Contraindication

- Need for immediate operative intervention

Materials and Medications

- Ultrasound machine
- Probe(s): Curved array probe (−2 MHz) is preferred, but phased array probe (5–1 MHz) can also be used if needed:
  - Phased array has a smaller footprint, allowing easier access between intercostal spaces (Fig. 78.1); however, curved array provides better resolution of images (Fig. 78.2). The linear array transducer (13–6 MHz) is good for lung images.
- Gel
- Skilled ultrasound operator

Fig. 78.1 Phased array transducer with a small footprint that is helpful to fit between the ribs and can be used for focused assessment with sonography for trauma (FAST) examination

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- ± Laboratory work, cardiac monitor, and two large-bore intravenous (IV) needles:
  - All trauma alerts and unstable patients must have all of these.

Procedure

1. Ultrasound machine in the abdominal preset.
2. Patient in the supine position.
3. Phased array or curved array probe for focused assessment with sonography for trauma (FAST) and linear array for the lung.
4. Begin scanning the patient in a systematic fashion:
   - All the views should be scanned by thoroughly sweeping through the area in question in order to maximize the information obtained.
   - All views should be obtained in the same order every time.
   - Obtain all four views, five views if pneumothorax is included.
5. Free fluid appears as anechoic or black.

Fig. 78.2 Curved array transducer with a larger footprint and better resolution for deeper imaging that can be used for FAST examination as well as lung examination

Subxiphoid Four-Chamber View (Fig. 78.3)

1. Examine for free pericardial fluid:
   - Anechoic (black) stripe seen between the myocardium and the pericardium
2. Probe is placed in the subxiphoid area.
3. Indicator is to the patient's right.
4. Probe is directed toward the patient's left shoulder.
5. Use a shallow angle in the head to feet direction.
6. Should adequately visualize the following:
   - Liver edge superficially
   - Right ventricle
   - Left ventricle
   - Right atrium
   - Left atrium
7. If unable to obtain this view, proceed to *parasternal long-axis view*:
   - Probe is placed perpendicular at the left parasternal border.
   - Third to fourth intercostal space.
   - Indicator is to the patient's right shoulder.
   - Coronal section through the heart's long axis should adequately visualize the following:
     - Right ventricle most superficially
     - Left ventricle
     - Mitral valve
     - Left atrium
     - Aortic valve
     - Aortic outflow tract

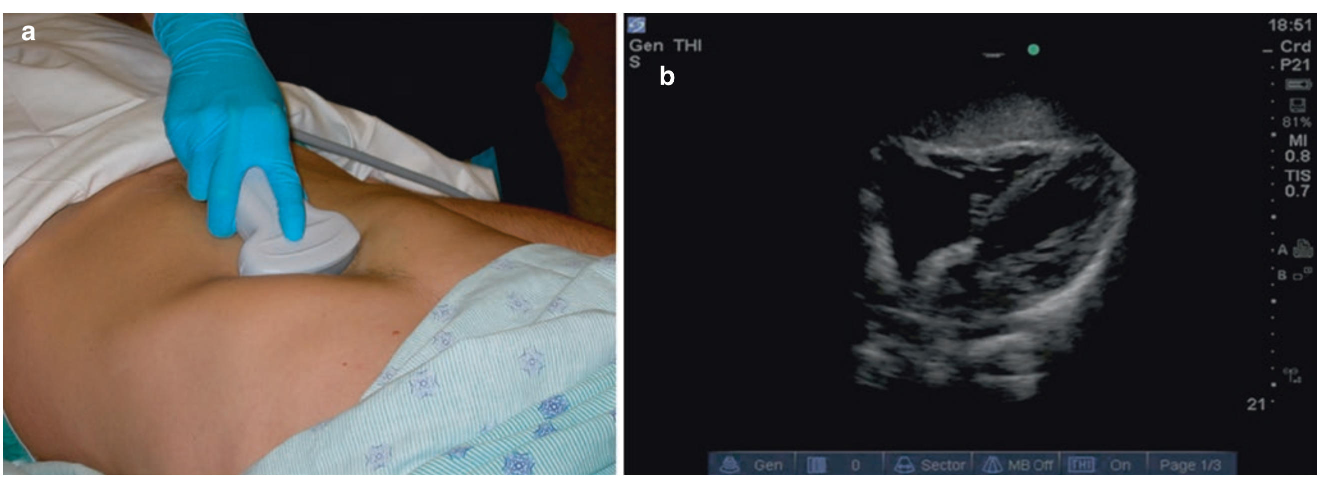

Fig. 78.3 (**a**) Image shows how to obtain the subxiphoid four-chamber view of the heart using the curved array transducer. (Photograph courtesy of F. Eike Flach, MD). (**b**) Ultrasound image of four-chamber view of the heart. (Used with permission from First aid for the emergency medicine clerkship 3rd Ed, McGraw Hill, 2011.) *RV* right ventricle, *LV* left ventricle, *RA* right atrium, *LA* left atrium

Right Upper Quadrant View (Fig. 78.4)

1. Examine for free fluid in all of the following areas:
   - Right intrathoracic space:
     – Anechoic area above the diaphragm
   - Morison's pouch: hepatorenal space
     – Anechoic stripe between the liver and the kidney
   - Right paracolic gutter:
     – Anechoic collection surrounding the inferior tip of the kidney
2. Probe is placed in the midaxillary line on the right.
3. Indicator is directed toward the patient's head.
4. Probe is in the coronal plane; angle can be aimed obliquely while scanning anterior to posterior.

Left Upper Quadrant View (Fig. 78.5)

1. Examine for free fluid in all of the following areas:
   - Left intrathoracic space:
     – Anechoic area above the diaphragm
   - Subphrenic space:
     – Anechoic stripe below the diaphragm and above the spleen
   - Splenorenal space:
     – Anechoic stripe between the spleen and kidney
   - Left paracolic gutter:
     – Anechoic collection surrounding the inferior tip of the kidney
2. Probe is placed in the midaxillary line on the left.

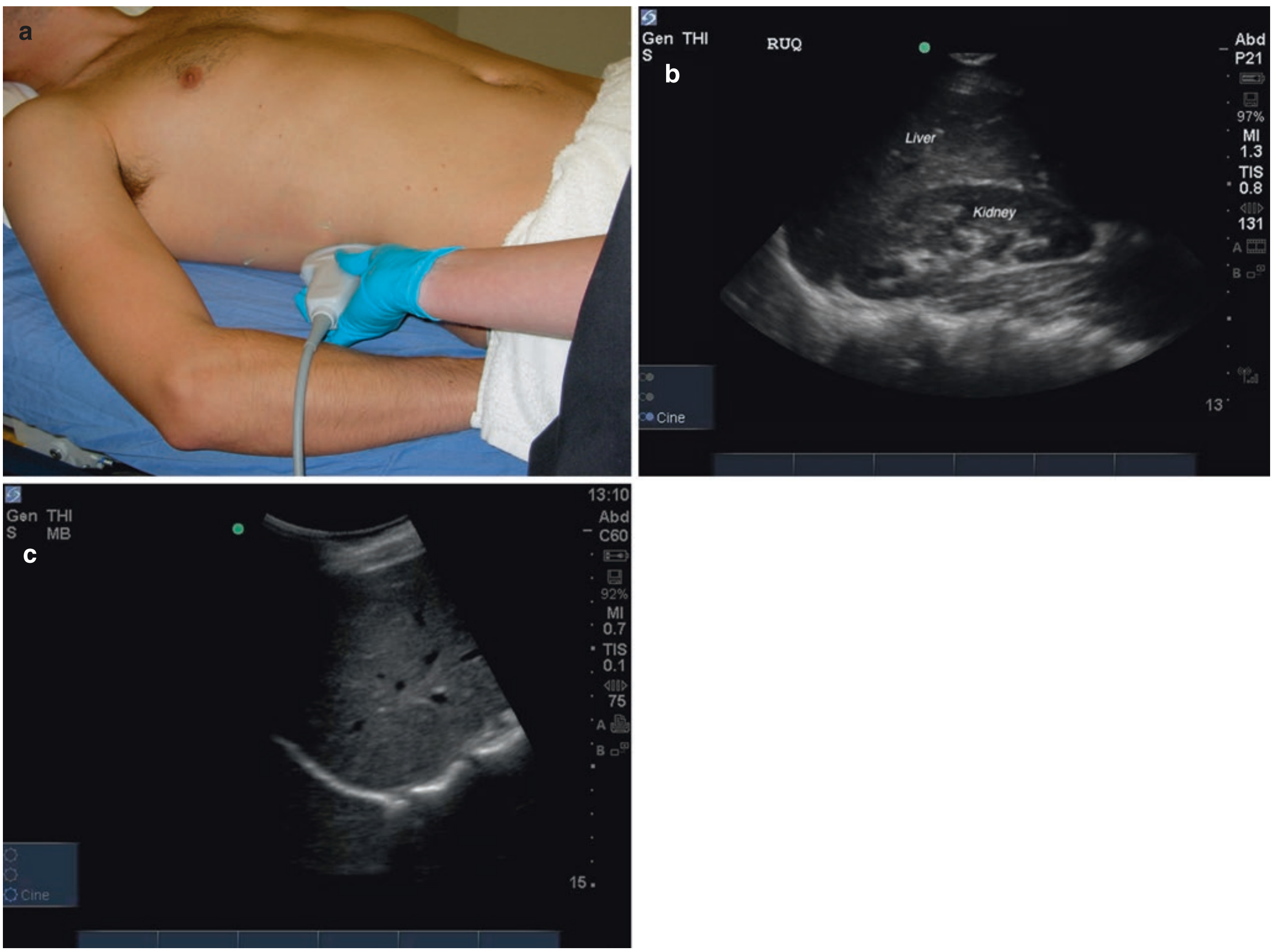

Fig. 78.4 (**a**) Image shows how to obtain the right upper quadrant view of the FAST exam using the curved array transducer. The probe is aimed slightly obliquely in the coronal plane to get a better view between the ribs. (Photograph courtesy of F. Eike Flach, MD). (**b**) Ultrasonographic view of the liver. (**c**) Ultrasonographic view of the liver–kidney interface (Morison's pouch)

3. Indicator is directed toward the patient's head.
4. Probe in the coronal plane; angle can be aimed obliquely while scanning anterior to posterior.

Pelvic View (Figs. 78.6 and 78.7)

1. Examine for intraperitoneal free fluid in the pelvis:
   - Anterior pelvis, above the bladder:
     – Anechoic fluid above the bladder
   - Posterior cul-de-sac (pouch of Douglas):
     – Anechoic fluid posterior to the bladder or uterus
2. Probe is placed above the pubic symphysis over the bladder.
3. Scan through in both planes:
   - Transverse plane (Fig. 78.6):
     – Indicator is to the patient's right.
     – Scan through the bladder in the head to feet direction.
   - Sagittal plane (Fig. 78.7):
     – Indicator is aimed to the patient's head.
     – Scan through the bladder in a right to left direction.

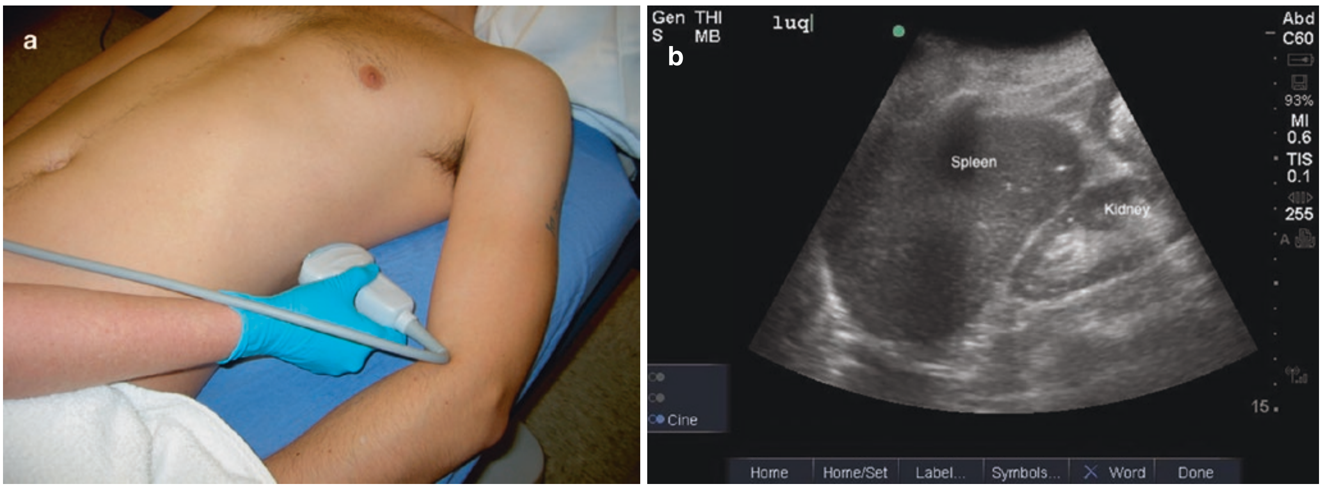

Fig. 78.5 (**a**) Image shows how to obtain the left upper quadrant view of the FAST examination using the curved array transducer. Again, the probe is aimed slightly obliquely and is placed more superiorly in the midaxillary line. (Photograph courtesy of F. Eike Flach, MD). (**b**) Ultrasonographic view of spleen–kidney interface

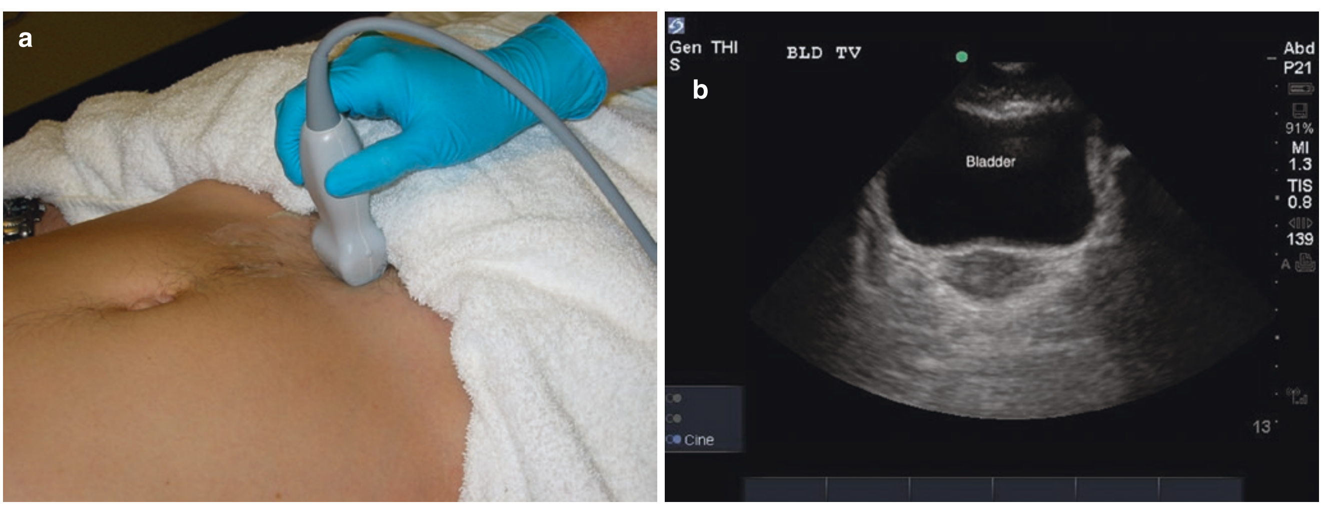

Fig. 78.6 (**a**) Transverse pelvic view of the FAST examination using the phased array transducer. With gentle force, the probe is pressed downward in order to look back behind the pubic symphysis and view the bladder. (Photograph courtesy of F. Eike Flach, MD). (**b**) Ultrasonographic view of the bladder in transverse plane

EFAST with Lung Views (Figs. 78.8 and 78.9)

1. Examine for pneumothorax:
   - Lung sliding:
     – Absence: pneumothorax
     – Presence: normal lung
   - M-mode tracing (Fig. 78.9):
     – Seashore sign: normal lung
     – Barcode or stratosphere sign: pneumothorax
2. Probe is placed on the anterior chest in the midaxillary line.
3. Level of the second to fourth intercostal spaces.
4. Sagittal position.
5. Center the probe over the pleural line between the ribs:
   - Find the rib and then slide the probe toward the head or feet to center the pleural line.
6. Observe for lung sliding.
7. Press M-mode and move the line over the pleural line and press M-mode again to get the tracing.
8. Examine multiple other areas anteriorly, moving distally, and in midaxillary line laterally, moving from superior to inferior.

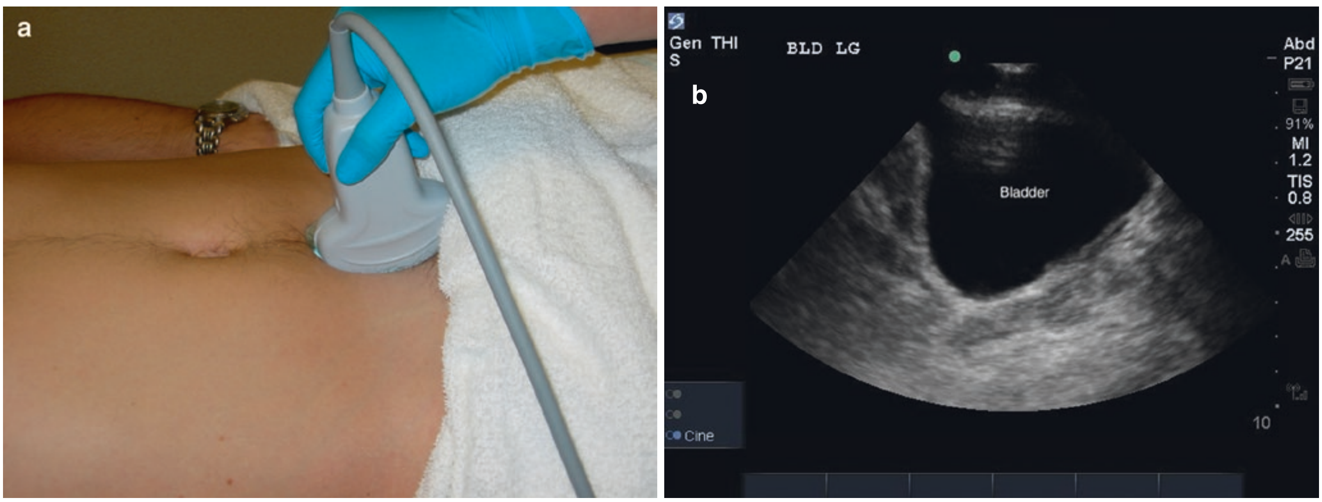

Fig. 78.7 (**a**) Sagittal pelvic view of the FAST exam using the curved array transducer (C60). With gentle force, the probe is pressed downward in order to look back behind the pubic symphysis and view the bladder. (Photograph courtesy of F. Eike Flach, MD). (**b**) Ultrasonographic view of the bladder in sagittal plane

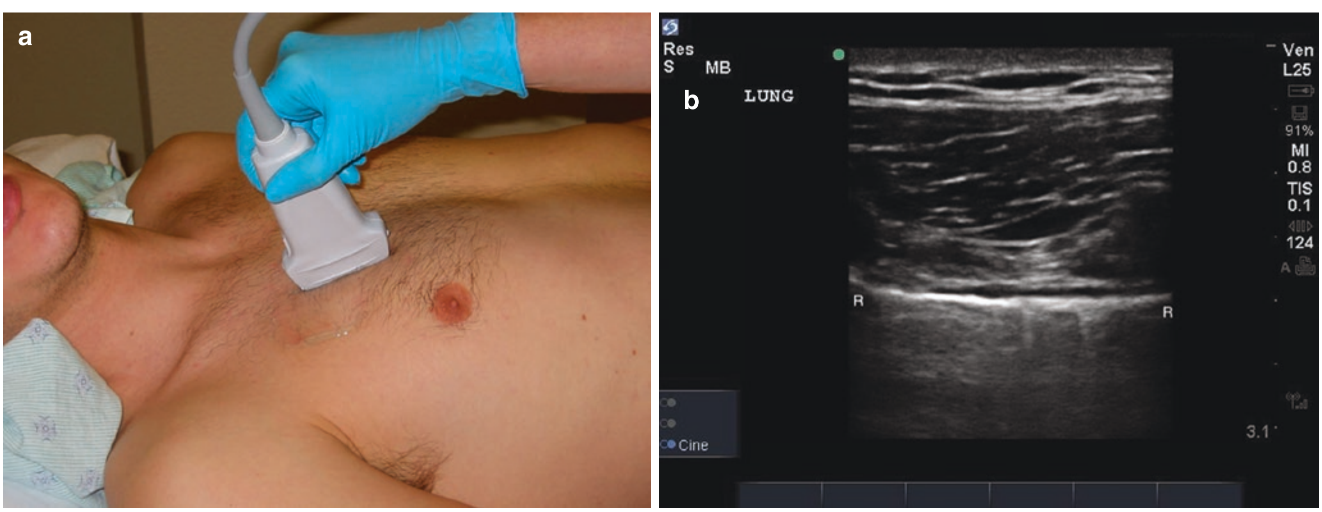

Fig. 78.8 (**a**) Right lung view of the extended focused assessment with sonography for trauma (EFAST) examination using the linear array transducer. The probe is placed in the sagittal plane on the anterior chest in the midaxillary line approximately at the second intercostal space and centered over the pleural line. (Photograph courtesy of F. Eike Flach, MD). (**b**) Ultrasonographic view of the lung. *R* = rib space shadow

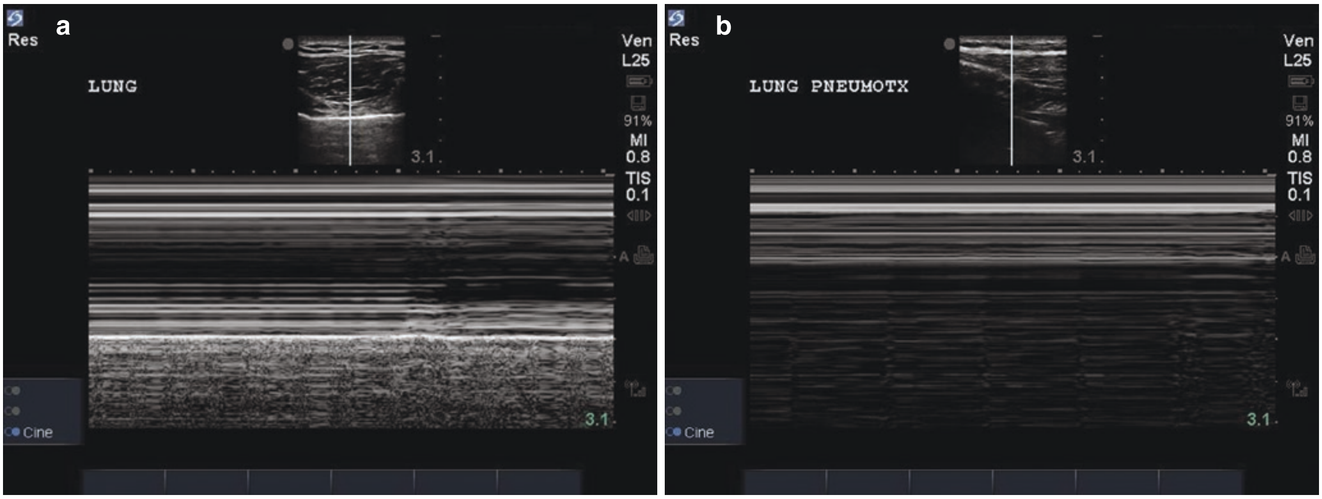

Fig. 78.9 Lung views with selection of M-mode showing (**a**) normal sliding appearance and (**b**) absence of sliding in presence of pneumothorax

Complications

- Overreliance on ultrasound to rule out abdominal injury:
  - FAST examinations do not detect retroperitoneal bleeding, solid organ injury, contained subcapsular hematomas, and bowel injuries.
- Not scanning through the object in question could lead to false-negative results.

Pearls and Pitfalls

- Always follow the ABCs (airway, breathing, circulation) first in any unstable patient.
- Always make sure the depth is set adequately:
  - Recommend starting deeper to make sure positive findings are not missed and then adjustments can be made from there.
- The curved array probe may be used throughout the entire EFAST for convenience if necessary.

Subxiphoid Four-Chamber View

- For larger body habitus, need to parallel the probe with the body in the subxiphoid area and use firm pressure to press the entire probe downward so as to look up under the xiphoid process at the heart.
- Moving the entire probe more to the patient's right in the subxiphoid area while still looking toward the left shoulder may improve visualization by using the liver as a window.
- Fat pad:
  - May be mistaken for pericardial fluid.
  - Contains echoes and, therefore, is hypoechoic rather than anechoic.
  - Should only be present anteriorly.
  - Fluid should be gravity dependent, completely encircling the heart, and seen in multiple views.

Right Upper Quadrant View

- Normal artifacts of mirroring and loss of the spine are obscured when pleural fluid is present, and, instead, the anechoic fluid is seen and there is loss of mirroring and continuation of the spine.

Left Upper Quadrant View

- Same as right upper quadrant view
- May be more difficult view to find than in right upper quadrant view for all of the following:
  - The spleen and kidney are more posterior and superior than in right upper quadrant view.
  - The spleen is smaller and less of a window for viewing.

Pelvic View

- The bowel can be mistaken for free fluid or vice versa, but holding the probe still and observing can sometimes help distinguish the two:
  - Peristalsis will occur with the bowel.
  - Internal echoes may be present in the bowel.

Lung Views

- Ultrasound is more sensitive than a supine portable chest X-ray.
  – Apex anteriorly in midaxillary line
- Rib
  – Hyperechoic horizontal line with a dense shadow posteriorly
  – Evenly spaced along the chest
- Pleural line
  – First hyperechoic line deep to the rib.
  – Actually includes the visceral and parietal pleura, but appears as one line.
  – Lung sliding is present in normal lung.
  – Comet tail artifact.
  – M-mode tracing will be the same in normal lung and pneumothorax above the pleural line and different below the pleural line.

Seashore sign:

- Appears as waves washing up on the shore.
- Granular appearance represents movement.

Stratosphere sign:

- Appears as straight lines
- Barcode appearance

Suggested Reading

Brunett P, Cameron P. Trauma in adults. In: Tintinalli J, Stapczynski J, Ma OJ, Cline D, Cydulka R, Meckler G, editors. Emergency medicine: a comprehensive study guide. 7th ed. New York: McGraw Hill; 2012. p. 1678–5.

Ma JO, Mateer JR, Blaivas M. Trauma. In: Emergency ultrasound. Course materials. New York: McGraw Hill; 2008. p. 7–109.

Saul T, Rivera M, Lewiss R. Ultrasound image quality. ACEP News. 2011;4:24–5.

Nasogastric Tube Placement

79

David P. Nguyen, L. Connor Nickels,
and Giuliano De Portu

Indications

- Evaluation of upper gastrointestinal (GI) bleeding (history of melena, bright red blood per rectum, or coffee-ground emesis):
  - Only in the cases in which frank blood is obtained, the sensitivity/specificity in detecting upper GI bleeding is poor.
  - It should not be used for diagnostic purposes. Nasogastric tubes are primarily used to remove blood from the stomach which causes irritation and vomiting. It also helps determine if the bleeding is still active (lavage does not clear).
- Commonly used in decompression of the GI tract (partial/complete small bowel obstruction).
- Prevents aspiration and gastric dilation in intubated patients.
- Used during gastric lavage and/or removal of toxins (activated charcoal) for acute overdose or poisonings.

Contraindications

- Absolute
  - Facial trauma with possible cribriform plate fracture
- Relative
  - Severe coagulopathy (consider orogastric tube placement)
  - Esophageal strictures and alkali ingestions (possible esophageal perforation)
  - Esophageal varices (studies show that it is actually safe)

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Materials and Medications

- For awake patients, consider pretreatment: lidocaine gel (2% viscous)/nebulized lidocaine (4 or 10%), vasoconstrictors (e.g., phenylephrine 0.5%), and antiemetic (e.g., ondansetron 4 mg).
- 16- or 18-French sump tube lubricating jelly
- 50- or 60-mL syringe stethoscope

Procedure

- Preparation
  1. Awake patients should receive antiemetics 15 min before procedure.
  2. Anesthetize both nares at least 5 min before placement:
     - Spray vasoconstrictor into both nares.
     - Inject about 5 mL of lidocaine gel along the floor of the nose.
     - Nebulized lidocaine via facemask also reduces both nasal and pharyngeal discomfort.
  3. Elevate the head of the bed to an upright position (when possible).
  4. Estimate tube insertion distance by measuring the tube from the xiphoid to the earlobe and then to the tip of the nose. Add 6 inches to this calculation to determine the total distance. This helps with placement in the stomach and prevents esophageal placement or coiling in the stomach. Mark the tube with a marker or tape at the desired length.
  5. Lubricate the nasogastric (NG) tube.
- Insertion (Fig. 79.1):
  1. Always insert the tube gently into the nares along the floor of the nose under direct visualization. Always point inferiorly (do not point upward).
  2. If resistance is encountered, try to apply a small amount of pressure. STOP if unable to advance. Try

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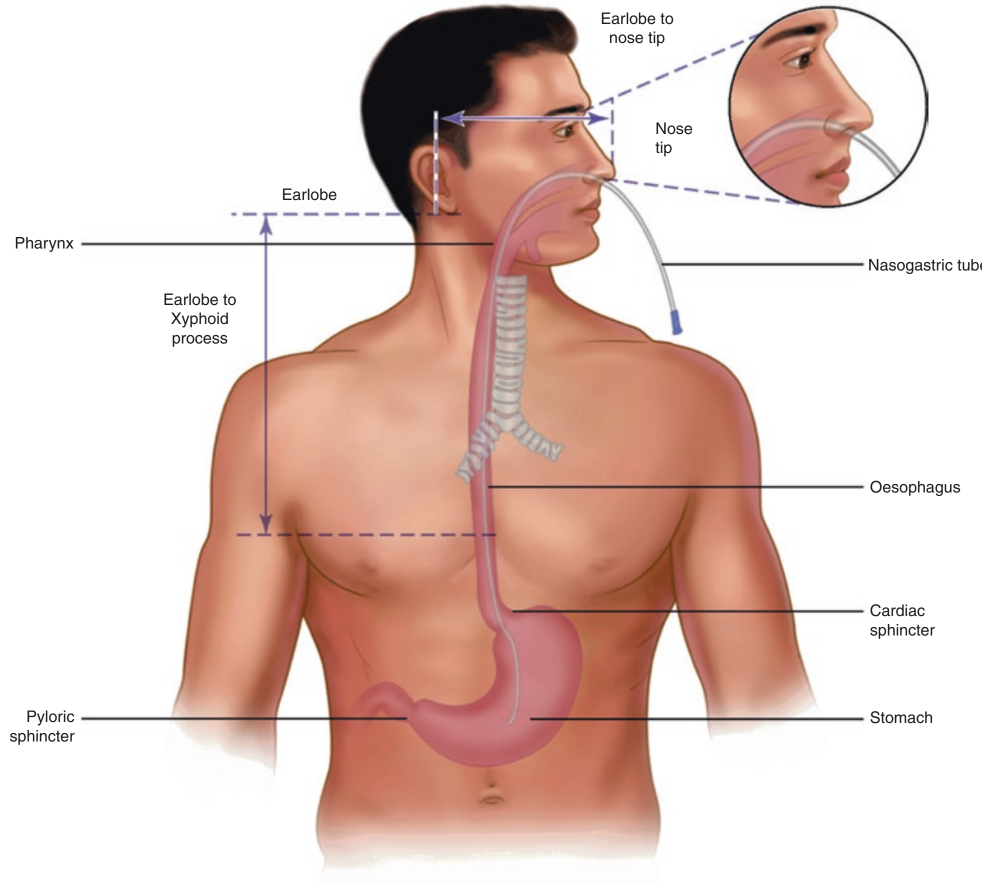

Fig. 79.1 NG tube placement

the other side. It is necessary to prevent bleeding or dissecting the tissues.

3. Have the patient flex his or her head forward when the tube is in the nasopharynx. This helps direct the tube toward the correct placement in the esophagus and not the trachea. Have the awake and cooperative patient sip water from a straw and swallow as the tube enters the oropharynx.
4. Making the tube more rigid by placing it in cold water will help advance it because the "warmer" tube will tend to coil.
5. Once the tube is in the esophagus, rapidly advance the tube into the stomach, taking into consideration the previously marked depth.

- Confirmation of tube placement:
  1. Insufflate air into the end of the NG tube, via a 50- or 60-mL syringe while auscultating for a rush of air (borborygmi) over the stomach.
  2. Aspiration of gastric contents (pH <4; there is >90% gastric placement).
  3. The awake and cooperative patient should be able to talk, and if coughing or severe discomfort occurs, consider that esophageal or bronchial placement might have occurred.
  4. Radiographic evaluation:
     - "Gold standard" is to evaluate simple radiograph for position.
     - Consider in comatose patients.
- Secure the tube:
  1. Tape the NG tube in place by taping both the tube and the nose. A butterfly bandage is typically used. Some companies produce a specific fixation for the tube.
  2. Secure the tube to where it does not press on the medial or lateral nostril (can lead to bleeding/necrosis).

Complications

- Inability to pass the tube
- Bleeding
- Curling of the NG tube in the patient's mouth
- Pulmonary/esophageal placement
- Nasal necrosis

Pearls

- Pearls
  - NG tube placement was ranked #1 as the most painful procedure in the emergency department, so it is imperative to maintain patient's comfort by using anesthetics and even maybe intravenous anxiolytics.
  - Estimate the proper length of the tube before passage to avoid placing the tip of the tube in the esophagus or excessively coiling it in the stomach.
  - If leaving the tube for a prolonged period of time, make sure that the suction is set "intermittent" or "off" to prevent irritation to the gastric mucosa owing to direct pressure.

Suggested Reading

Chun DH, Kim NY, Shin YS, Kim SH. A randomized, clinical trial of frozen versus standard nasogastric tube placement. World J Surg. 2009;33:1789–92.

Goff JS. Gastroesophageal varices: pathogenesis and therapy of acute bleeding. Gastroenterol Clin N Am. 1993;22:779.

Henneman PL. Gastrointestinal bleeding. In: Marx J, Hockberger R, Walls R, editors. Rosen's emergency medicine: concepts and clinical practice. 7th ed. Philadelphia: Mosby; 2010.

Tho PC, Mordiffi S, Ang E, Chen H. Implementation of the evidence review on best practice for confirming correct placement of nasogastric tube in patients in an acute care hospital. Int J Evid Based Healthc. 2011;9:51–60.

Esophageal Foreign Body Removal

80

David P. Nguyen, L. Connor Nickels,
and Rohit Pravin Patel

Indications

- Patient presenting with any one or combination of the following:
  - Foreign body (FB) sensation
  - Throat or lower neck
  - Substernal/epigastric area
  - Clear history of ingestion
  - Dysphagia
  - Airway compromise
  - Drooling
  - Inability to tolerate fluids
  - Inability to tolerate solids
  - Evidence of perforation
  - Active bleeding
- All unstable patients should have immediate airway management and urgent endoscopy.
- FBs lodged superior to the epiglottis may be retrieved by emergency physicians in an emergent situation, but generally, a consultant should be present, whether ear, nose, and throat; gastroenterology; or general surgery.

Contraindications

- Absolute
  - None
- Relative
  - Performing rapid-sequence intubation (RSI) in a patient with an FB that could compromise the airway.
  - Generally, if the patient is breathing on their own, collaborate with a consultant on the best method to secure the airway (emergency department, intensive care unit, operating room).
  - Treating with glucagon repeatedly if it is inducing vomiting and/or not working.
  - Conservatively managing a patient who should otherwise undergo a procedure for removal.

Materials and Methods

- Esophagoscopy/endoscopy is the definitive diagnostic and therapeutic procedure for impacted esophageal FBs:
  - Generally, should not be performed by an emergency physician.
  - Devices used include forceps, baskets, polypectomy snares, and nets.
  - Endoscopic techniques include push into the stomach, push-plus fragmentation, pull with retrieval forceps, and pull with various items (basket, snare, nets).
- Foley catheter removal:
  - Widely used technique for recently ingested single, smooth, blunt, and radiopaque objects
  - #12- to #16-French Foley catheter
  - Forceps (bayonet and Magill) of various sizes
  - Often done under fluoroscopic guidance
- Bougienage:
  - A single, smooth object, such as a coin, lodged less than 24 hours, in a patient with no respiratory distress or esophageal disease can be advanced successfully into the stomach by using bougienage.
  - Dilator size is selected base on age:
    - 1–2 years: 28 French
    - 2–3 years: 32 French
    - 3–4 years: 36 French
    - 4–5 years: 38 French
    - Longer than 5 years: 40 French
- Relaxation of the lower esophageal sphincter (LES):
  - Some FBs lodged at the LES can be medically managed by relaxation of the LES.

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– Most ingested FBs and impacted food boluses eventually pass spontaneously:
  1–2 mg of glucagon intravenously
  0.4–0.8-mg nitroglycerin sublingually
  5–10-mg nifedipine sublingually
  Carbonated beverage

Procedure

- Push technique and push with fragmentation technique (generally performed by specialists):
  – First accepted endoscopic method.
  – Gentle pressure is applied with the tip of the endoscope on the esophageal food bolus after air insufflation.
  – If pressure does not disimpact the bolus, fragmentation can be attempted, but is generally avoided owing to unknown pathology behind the food bolus.
- Foley catheter removal:
  – Moderate sedation and nasopharyngeal topical anesthesia may be used.
  – Place the patient in a head-down Trendelenburg position.
  – Check for symmetrical balloon inflation of the Foley catheter.
  – Under fluoroscopy, visually pass the catheter distal to the FB.
  – Fill the balloon slowly with 3–5 mL of saline or contrast agent.
  – Using steady, gentle traction, withdraw the catheter with the balloon inflated distal to the FB.
  – Grasp the object with fingers, forceps, or clamp once it is visualized in the oropharynx.
- Bougienage:
  – Topical anesthesia is recommended.
  – Blind esophageal bougienage resembles placement of an orogastric tube.
  – Place the patient in a sitting position.
  – Pass a well-lubricated, appropriately sized bougie posteriorly along the roof of the mouth, following the natural curve of the soft palate caudally to the hypopharynx.
  – Encourage the patient to swallow (to help pass the dilator through the cricopharyngeus muscle).
  – Ask the patient to phonate to help exclude accidental laryngeal intubation.
  – Once past the cricopharyngeus muscle, extend the head to aid the bougie in passing distally to the stomach.
  – Post-procedure radiograph is used to confirm passage into the stomach.
- Relaxation of the LES:
  – Pre-medicate with an antiemetic, such as ondansetron.
  – Administer 1–2 mg of glucagon intravenously (0.02–0.03 mg/kg in children, not to exceed 0.5 mg) with the patient in a sitting position over 1–2 minutes.
  – Carbonated beverages given after glucagon ingestion have shown to have higher success rates.
  – An alternative is to use either sublingual nitroglycerin (1–2 0.4-mg tabs) or 5–10 mg of nifedipine to relieve LES tone.
  – This procedure does not work in patients with structural abnormalities.

Complications

- Esophageal FBs may cause esophageal pressure leading to edema, necrosis, infection, laceration, and/or perforation.
- Be cognizant of time (risk of complications is higher the longer the FB is left in place) and treatment side effects (i.e., do not continue to give patient water or glucagon if these induce vomiting).
- Aspiration and perforation during procedures listed previously.
- Late complications: esophageal stricture, abscess, mediastinitis, tracheoesophageal fistula, vascular injuries, pneumothorax, pericarditis, aspiration pneumonia, and vocal cord paralysis.

Pearls

- Esophageal foreign bodies can be lodged in the upper (proximal), middle, or lower (distal) one third:
  – Proximal: cervical web and Zenker's diverticulum
  – Middle: eosinophilic esophagitis, cancer, radiation structure, and spastic dysmotility
  – Distal: peptic stricture, eosinophilic esophagitis, cancer, achalasia, esophageal diverticula, and spastic dysmotility
- Because food bolus impactions are generally associated with pathology, follow-up evaluation for these abnormalities should be considered.
- Esophagus foreign bodies should not be allowed to remain in the esophagus beyond 24 hours from presentation.
- Button/disc batteries in the esophagus (emergent removal):
  – Considered an emergency, because liquefaction necrosis and perforation can occur rapidly.
  – Most common ingestions are hearing aid batteries
  – If in the stomach, and patient is a symptomatic, can wait up to 24 hours.

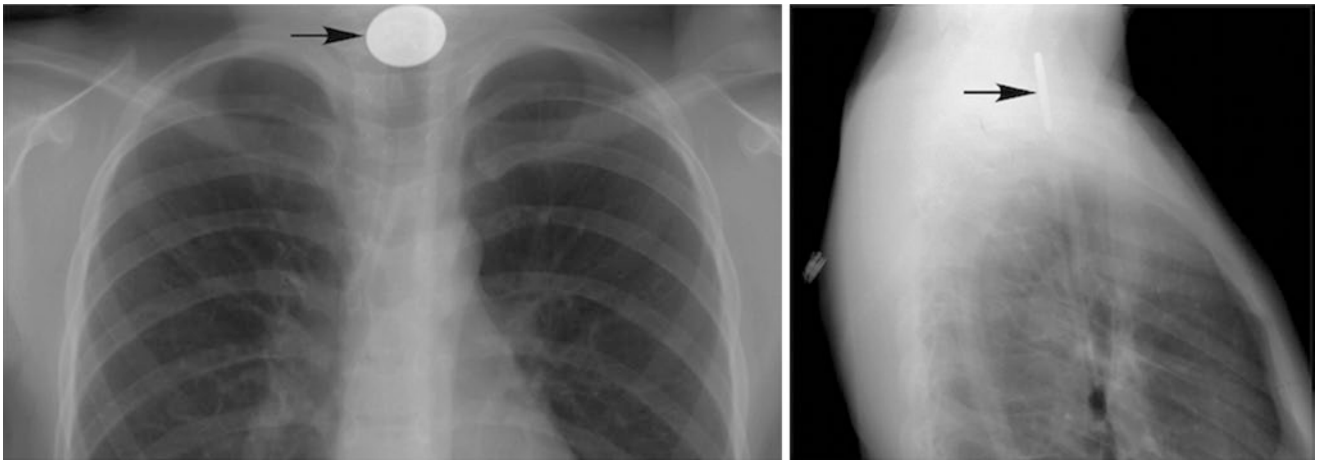

Fig. 80.1 AP and lateral views demonstrating a coin in the esophagus. A coin in the trachea would present in the opposite manner – the coin would be seen on edge in the AP view and flat on the lateral view. (*From* Stead et al. [1]; *with permission from McGraw-Hill*)

- Sharp objects (emergent removal):
  - Cause the majority of complications (~35%) with esophageal FBs.
  - Direct visualization with endoscopy is the only appropriate removal technique.
- Magnets (urgent removal):
  - Can cause necrosis and fistula formation due to the way they adhere to the mucosa
- Esophageal coins (remove within 24 hours) (Fig. 80.1):
  - Up to 80% of coins at the LES will pass spontaneously within 24 hours without interventions. The watchful waiting approach is used only in patients with single coins and who are asymptomatic.
  - Common complications of these procedures include mild bleeding, lip laceration, bradycardia with Foley catheter insertion, and teeth injuries.
  - Some protocols include RSI as part of the management process and should be considered if lifesaving.

References

1. Stead LG, Kaufman MS, Waseem M. First aid for the pediatrics clerkship. New York: McGraw Hill; 2010.

Suggested Reading

Abdurehim Y, Yasin Y, Yaming Q, Hua Z. Value and efficacy of Foley catheter removal of blunt pediatric esophageal foreign bodies. ISRN Otolaryngol. 2014;2014:679378, 4 pages. https://doi.org/10.1155/2014/679378.

Bhargava R, Brown L. Esophageal coin removal by emergency physicians: a continuous quality improvement project incorporating rapid sequence intubation. CJEM. 2011;13:28–33.

Fung BM, Sweetser S, Wong Kee Song LM, Tabibian JH. Foreign object ingestion and esophageal food impaction: an update and review on endoscopic management. World J Gastrointest Endosc. 2019;11(3):174–92. https://doi.org/10.4253/wjge.v11.i3.174.

Mohanty CR, Singh N, Mehta S, Das S. Point-of-care ultrasound as an aid to upper esophageal foreign body removal. Saudi J Anaesth. 2019;13(1):89–90. https://doi.org/10.4103/sja.SJA_716_18. PMID: 30692902; PMCID: PMC6329244.

Schaefer TJ, Trocinski D. Esophagial foreign body. [Updated 2020 Aug 24]. In: StatPearls [internet]. Treasure Island (FL): StatPearls Publishing; 2020. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482131/.

81 Activated Charcoal

Deylin I. Negron Smida and Judith K. Lucas

Indications

- Single-dose activated charcoal (AC) (Fig. 81.1):
  - Does not meet criteria for gastric emptying.
  - Gastric emptying may be too harmful.
  - Ingestion of toxic xenobiotic is known to be adsorbed by AC.
  - Ingestion occurred with a time frame amenable to adsorption by AC, or clinical factors are present that suggest that not all of the xenobiotic had already been systemically absorbed.
  - Ingestion of extended- or sustained-release formulations.
- Multiple-dose activated charcoal (MDAC) therapy:
  - Life-threatening ingestion of:
    - Carbamazepine
    - Phenobarbital
    - Quinine
    - Theophylline
    - Dapsone
  - Life-threatening ingestion of another xenobiotic that undergoes enterohepatic recirculation and is adsorbed to AC
  - Ingestion of a significant amount of a slowly released xenobiotic
  - Ingestion of a xenobiotic known to form concretions or bezoars, such as aspirin

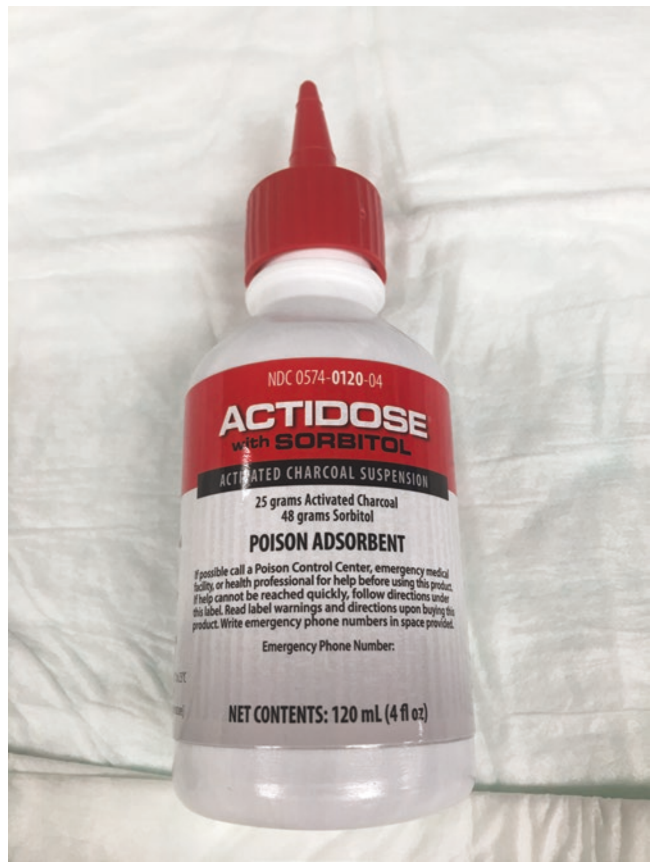

Fig. 81.1 Activated charcoal (AC)

Contraindications

- Absolute
  - Gastric perforation
  - Gastrointestinal ileus, obstruction, or diminished peristalsis
  - Nonintubated patients with the potential of losing protective airway reflexes
  - Intestinal obstruction
  - Ingestion of:

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Corrosives
Petroleum distillates

- Relative
  - Altered or decreased level of consciousness unless intubated.
  - Vomiting.
  - Xenobiotic has limited toxicity at almost any dose.
  - Dose ingested is less than the dose expected to produce significant illness.
  - Presentation many hours after ingestion.
  - Minimal signs or symptoms of poisoning.
  - Ingested xenobiotic has a highly efficient antidote.
  - Administration of charcoal may increase the risk of aspiration (i.e., hydrocarbons).

Materials and Medications

- Nasogastric (NG) tube/orogastric (OG) tube (Fig. 81.2)
- Baby bottle with split nipple (designed for drinking of slurry solutions, such as thickened formulas) or sippy cup without the valve
- Absorbent pad
- Basin
- Water-soluble lubricant
- Tubing connected to suction device
- Flavored syrup

Fig. 81.2 Drinking AC (by cup, sippy cup, or bottle) is effective, but it may also be infused via nasogastric or orogastric tube

Procedure

- Single-dose administration
  - Adult
    Can be taken via a cup and straw (drunk) if the patient is cooperative.
    The optimal dose of AC is unknown.
    50–100 g/dose (1 g/kg), administered at a rate no less than 12.5 g/h or its equivalent.
    If vomiting is anticipated, an intravenous antiemetic is recommended.
  - Children
    1 g/kg or 10:1 ratio of AC to drug ingested.
    After massive ingestion, give 2 g/kg.
    Many children will drink the suspension from a bottle or sippy cup, especially if it is mixed with juice or flavored syrup (e.g., chocolate or strawberry).
- MDAC
  - Adults: 0.5–1 g/kg every 2–4 h for 24–48 h
  - Children (<12 y old): 0.25–0.5 g/kg every 2–4 h or rate of 0.2 g/kg/h for 24–48 h
- Mixtures
  - Ready to drink
  - Powder form:
    Add eight parts water to the selected powdered form.
    Gatorade or juices can also be used to help hide the flavor and texture.
    In children, the AC can be mixed with cold chocolate or some other flavored syrup, which also hides the flavor.
  - Shake liquid suspension well for 1 min.
  - If the patient vomits, the dose should be repeated. Smaller, more frequent, dosing may be better tolerated, and an antiemetic may be needed.

Complications

- Aspiration pneumonitis
- Transient constipation
- Intestinal bezoars
- Bowel obstruction
- Diarrhea, dehydration, hypermagnesemia, and hypernatremia with coadministered cathartics or MDAC
- Vomiting
- Corneal abrasion if spilled in the eyes

Pearls and Pitfalls

- Pearls

  – If an OG or NG tube is used, time should be allowed for the last dose to pass through the stomach before the tube is removed. Suctioning the tube before removal may prevent subsequent AC aspiration.
  – With children, the colder and sweeter the solution and if the color is camouflaged (cup with a lid or a sippy cup), there will be increased success at oral administration (vs NG/OG).
- Pitfalls
  – No evidence-based literature supports the assertion that AC changes clinical outcome.
  – Xenobiotics and AC adsorption (Table 81.1).

Table 81.1 Absorption of xenobiotics by AC

Good absorption	Poor absorption
Acetaminophen	Alkali
Bupropion	Chlorpropamide
Caffeine	Doxepin
Carbamazepine	Ethanol or other alcohols
Chlordecone	Ethylene glycol
Dapsone	Fluoride
Digitoxin	Heavy metals
Nadolol	Imipramine
Phenobarbital	Inorganic salts
Phenylbutazone	Iron
Phenytoin	Lithium
Salicylate	Methotrexate
Theophylline	Mineral acids
	Potassium
	Tobramycin
	Valproate sodium
	Vancomycin

  – Incorrect application (e.g., into the lungs) results in pulmonary aspiration, which can be fatal if unrecognized:
    Incorrect placement of NG/OG tube into the trachea.
    Administration of AC to a patient with an ileus (e.g., in anticholinergic overdoses).
  – No specific contraindication for AC in pregnant women; however, diarrhea or hypernatremia in the mother may adversely affect the fetus.

Suggested Reading

American Academy of Clinical Toxicology; European Association of Poisons Centres and Clinical Toxicologists. Position statement and practice guidelines on the use of multi-dose activated charcoal in the treatment of acute poisoning. J Toxicol Clin Toxicol. 1999;37:731–51.

Chyka PA, Seger D. American Academy of Clinical Toxicology; European Association of Poisons Centres and Clinical Toxicologists. Position statement: single-dose activated charcoal. J Toxicol Clin Toxicol. 1997;35:721–41.

Gude A, Hoegberg LCG. Techniques to prevent gastrointestinal absorption. In: Nelson LS, Lewin NA, Howland MA, et al., editors. Goldfrank's toxicologic emergencies. 9th ed. New York: McGraw-Hill; 2011. p. 93–7,431.

Lie D. Use of activated charcoal in drug overdose. Medscape family medicine. 25 Mar 2004. www.medscape.com/viewarticle/471331.

Olson KR. Emergency evaluation and treatment. In: Olson KR, Anderson IB, Benowitz NL, et al., editors. Poisoning and drug overdose. 5th ed. New York: McGraw-Hill; 2007. p. 1–56.

Stead TS, Jeong J, Ganti L, et al. Massive acetaminophen overdose. Cureus. 2020;12(7):e9262. https://doi.org/10.7759/cureus.9262.

Gastric Lavage

82

Deylin I. Negron Smida and Judith K. Lucas

Indications

- Recent ingestion (<30–60 min).
- Life-threatening exposure where there is a high suspicion that a xenobiotic is still present in the stomach and evacuation is expected to contribute to an improved outcome (e.g., iron, tricyclic antidepressants).
- Ingested agent is not absorbed with activated charcoal (e.g., pesticides, hydrocarbons, iron, alcohols, lithium, and solvents).
- Activated charcoal is unavailable.
- Ingestion exceeds adsorptive capacity of initial activated charcoal dosing (e.g., >100 mg/kg of pills).
- Ingestion of an agent likely to form a durable mass or bezoars after overdose.

Contraindications

- Vomiting
- Unintubated patients with potential to lose airway protective reflexes
- Ingestion of a xenobiotic with aspiration potential (e.g., hydrocarbon) without intubation
- Ingestion of caustic substances (alkali or acidic)
- Ingestion of sharp metals
- Ingestion of a foreign body (e.g., drug packet)
- Risk for hemorrhagic gastrointestinal perforation
- Ingestion of xenobiotic in a form known to be too large to fit into the lumen of the orogastric tube
- Nontoxic ingestions

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Materials and Medications

- Orogastric tube (Ewald tube or the Tum-E-Vac) (Fig. 82.1):
  - Adults and adolescents: 36–40 French
  - Children: 22–28 French
- Pen or tape to mark the length of the tube
- Water-soluble lubricant
- Suction
- Emesis basin
- Absorbent pad
- Catheter-tip syringe with 2 mL water/saline to check position of the tube
- Room temperature irrigation fluid
- Bite block or oral airway to prevent patients from biting down on the tube

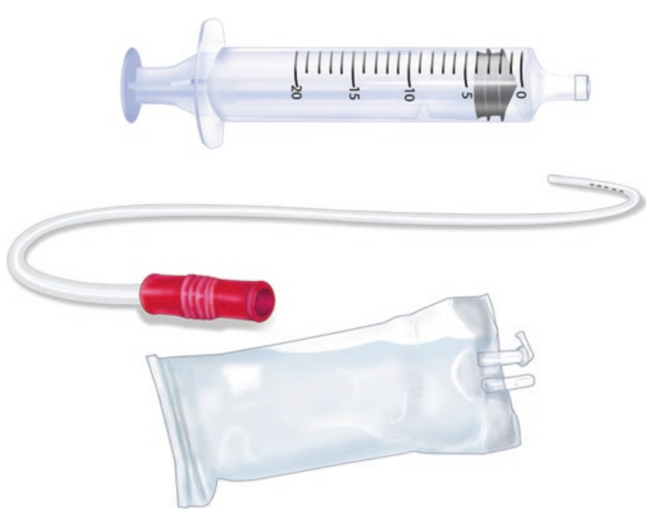

Fig. 82.1 Materials needed for gastric lavage include a large-bore nasogastric tube, a 60-cc non-Luer-Lok syringe, and a solution, typically normal saline, for lavage

L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0_82

Procedure

1. If there is potential airway compromise, endotracheal or nasotracheal intubation should precede orogastric lavage.
2. Place an oral airway or a bite block to prevent biting of the endotracheal tube if the patient recovers consciousness or has convulsions during the procedure.
3. Ensure suction apparatus is available and functioning.
4. Place the patient in an upright-seated position if awake and alert.
5. Place patient in the left lateral decubitus position if obtunded.
6. Before insertion, the proper length of tubing to be passed should be measured from the mouth, back to the ear, and down anterior to the chest and abdomen, beyond the point where any side ports on the tube would be beyond the level of the estimated lower esophageal sphincter (Figs. 82.2 and 82.3).
7. If the patient is still awake, insert the gastric tube to the level of the glottis, and encourage the patient to swallow.
8. Pass the tube to the stomach:
   (a) Coughing, airflow, or fog from the tube raises the concern for inadvertent tracheal positioning.
9. After the tube is inserted, it is essential to confirm that the distal end of the tube is in the stomach, by "popping" 5–10 mL of air into the tube while someone is listening with a stethoscope over the stomach. May consider X-ray for placement confirmation as well.
10. In adults, 250-mL aliquots of a room temperature saline lavage solution are instilled via a funnel or lavage syringe. In children, aliquots should be 10–15 mL/kg to a maximum of 250 mL and suctioned back out of the tube attached to low to moderate continuous wall suction. Instillation of lavage solution and suction is repeated (Fig. 82.4).
11. Orogastric lavage should continue for at least several liters in an adult and/or at least 0.5–1 L in a child if the return is free of debris or until no particulate matter returns and the effluent lavage solution is clear.
12. Those caring for the patient must remain protected at all times, using goggles, mask, gown, and gloves. If the ingested poison is toxic via pulmonary or skin absorption, isolate the ingestant immediately in a self-contained wall suction unit.
13. Any material still in the stomach should be withdrawn, and immediate instillation of the activated charcoal should be considered for large ingestions of xenobiotics known to be adsorbed by activated charcoal.

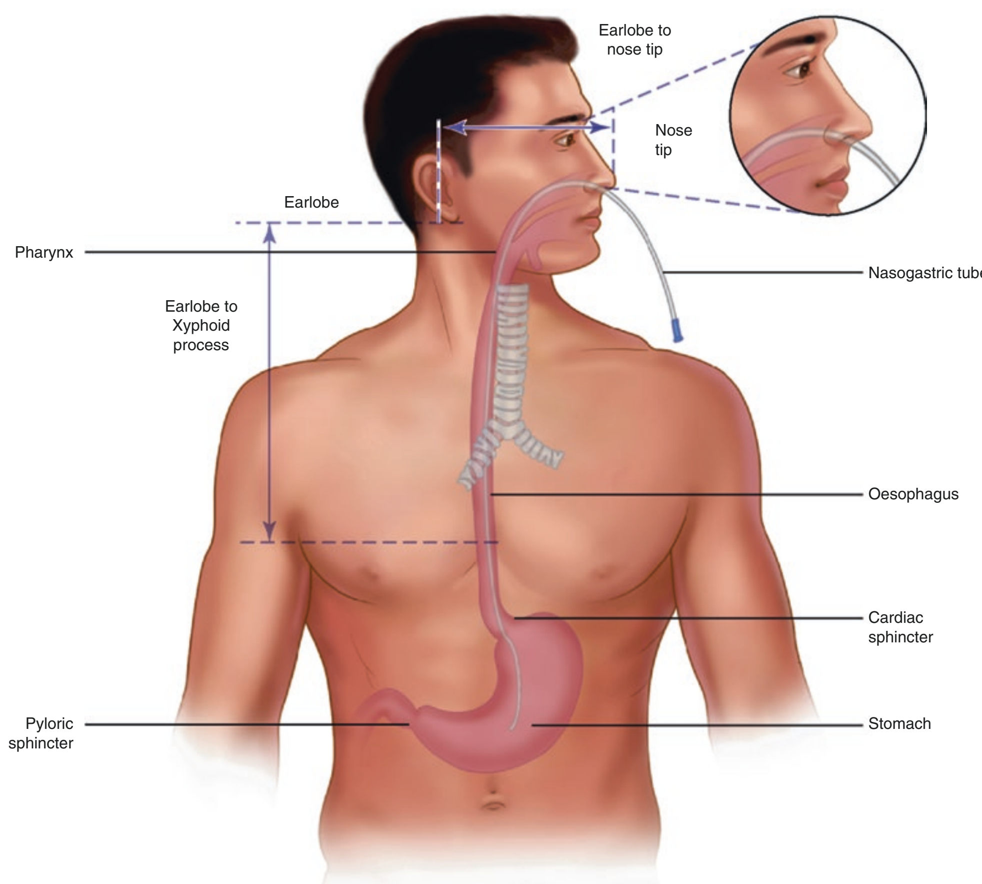

Fig. 82.2 Diagram illustrates appropriate placement of the lavage tube

Fig. 82.3 Measuring correct placement of the tube. Place the distal tip over the stomach and wrap the tube up behind the ear (usually the right ear because the tubes generally pass easier through the right nares) and around the nares. The black line or centimeter mark at the level of the nares is the point of insertion when passage stops

Complications

- Vomiting
- Esophageal tears or perforation after orogastric tube insertion
- Inadvertent tracheal intubation and/or airway trauma
- Aspiration pneumonitis

Pearls and Pitfalls

- Pearls
  - You must use a large-bore orogastric tube for maximal efficacy.
  - The left lateral decubitus position is recommended because the pylorus points upward in this orientation. This position theoretically helps prevent the xenobiotic from passing through the pylorus during the procedure.
- Pitfalls
  - Large drug packets, adherent masses of pills, and plant and mushroom fragments will not pass through a 40-French lavage tube.

Fig. 82.4 Lavage in progress

Suggested Reading

Gude A, Hoegberg LCG. Techniques to prevent gastrointestinal absorption. In: Nelson LS, Lewin NA, Howland MA, et al., editors. Goldfrank's toxicologic emergencies. 8th ed. New York: McGraw-Hill; 2006. p. 91–3.

Olson KR. Poisoning & drug overdose. In: Olson KR, Anderson IB, Benowitz NL, et al., editors. Emergency evaluation and treatment. 6th ed. New York: McGraw-Hill; 2012.

Smilktein MJ. Techniques used to prevent gastrointestinal absorption of toxic compounds. In: Nelson LS, Lewin NA, Howland MA, et al., editors. Goldfrank's toxicologic emergencies. 7th ed. New York: McGraw-Hill; 2002. p. 46–8.

Whole-Bowel Irrigation

83

Judith K. Lucas

Indications

- Whole-bowel irrigation (WBI) should not be used routinely in the management of the poisoned patient (because there is no clinical proof it will change clinical outcome).
- Ingestion of significant amount of medications:
  - Not adsorbed by activated charcoal:
    - Lead, lithium, arsenic, and zinc
    - Substantial amounts of iron (high morbidity and no other effective method to gastrointestinal decontamination)
  - Sustained-release medications or enteric-coated drugs
  - Whole transdermal patches (fentanyl, clonidine, nicotine)
  - Drug concretions
  - Ingested packets of illicit drugs

Contraindications

- Absolute
  - Bowel obstruction
  - Bowel perforation
  - Ileus
  - Hemodynamic instability
  - Compromised or unprotected airway
  - Intractable vomiting
- Relative
  - Concurrent or recent administration of activated charcoal (may decrease the effectiveness of activated charcoal)

Materials and Medications

- Topical anesthesia, although not mandatory, will reduce the pain of nasogastric (NG) tube placement:
  - 10% lidocaine spray
  - Lidocaine gel
- Small-bore (12-French) NG tube (Fig. 83.1).
- Tape for securing the NG tube.

Fig. 83.1 Nasogastric (NG) tube. Typically, the infusion of the lavage solution is too rapid to be taken orally, so an NG tube can be placed. Since the irrigation solution is of low viscosity, a small-bore NG tube should be used for comfort

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Fig. 83.2 Bag from which the lavage solution will drain; it is similar to the bags used for gastrostomy tube feeding

- Reservoir or feeding bag used for NG tube feedings (Fig. 83.2).
- Intravenous pole.
- Bedside commode or toilet (Fig. 83.3).
- Polyethylene glycol-electrolyte solution (PEG-ES) (Fig. 83.4).
- Antiemetic:
  - No absolute indication for prophylactic use
  - May be helpful if vomiting ensues during infusion
    - Metoclopramide:
      - Antiemetic
      - *Increases gastric motility*

Procedure

1. An NG tube is required because most patients will not drink the PEG-ES at the necessary rate.
2. Place a small-bore (12-French) NG tube to a sufficient distance that the tip lies in the central portion of the stomach.
3. Confirm NG placement with a radiograph.

Fig. 83.3 Almost always, the patient will need to be seated on or very near a portable commode, as once the irrigation solution starts to move through the bowels, defecation will occur rapidly

Fig. 83.4 Example brands of intestinal irrigation electrolyte solutions

4. Attach the tube to the reservoir bag of PEG-ES and hang from an elevated site (an extended intravenous pole).
5. The patient should be seated in an upright position:
   - Promotes settling of the intoxicant in the distal portion of the stomach
   - Decreases the likelihood of vomiting
6. Dosing:
   - Children 9 months to 6 years: 500 mL/h
   - Children 6–12 years: 1000 mL/h
   - Adolescents/adults: 1500–2000 mL/h
7. Collect effluent.
8. Continue infusion:
   - Until the rectal effluent is the same color as the influent (i.e., clear), usually between 4 and 6 h.
   - You may continue beyond clear effluent if clinical evidence indicates ongoing effectiveness:

- Continued pill fragments or drug packets are present in the effluent.
- Radiographic evidence that pills, pharmacobezoars, or packets are still present.

Complications

- Nausea, vomiting, and bloating
- Misplacement of the NG tube
- Esophageal perforation owing to NG tube placement
- Aspiration pneumonitis in the unprotected airway

Pearls

- Overall, WBI is probably more effective than gastric lavage, but probably less effective than activated charcoal in preventing poison absorption (when the intoxicant can be adsorbed to charcoal).
- Vomiting:
  - Usually secondary to the ingestant (i.e., emetogenic toxins, such as iron)
  - May be due to rate of infusion:
    - Slow rate by 50% for 30–60 min.
    - Then return to original rate.
- If resistance is encountered during NG tube placement, do not force passage. Remove and redirect.

Suggested Reading

Bailey B. To decontaminate or not to decontaminate? The balance between potential risks and foreseeable benefits. Clin Pediatr Emerg Med. 2008;9:17–23.

Hanhan UA. The poisoned child in the pediatric intensive care unit. Pediatr Clin N Am. 2008;55:669–86. xi.

Lheureux P, Tenenbein M. Position paper: whole bowel irrigation. American Academy of Clinical Toxicology/European Association of Poison Centres and Clinical Toxicologists. J Toxicol Clin Toxicol. 2004;42:843–54.

Othong R. Whole-bowel irrigation. MedScape Reference: drugs, diseases, and procedures. Updated: Aug 2011

Postuma R. Whole bowel irrigation in pediatric patients. J Pediatr Surg. 1982;17:350–2.

Sengstaken-Blakemore Tube

84

Thomas T. Nguyen, Caroline Burmon,
and Stephanie Nguyen

Indications

- Life-threatening esophageal variceal bleed refractory to endoscopy and medical therapy.
- Life-threatening esophageal variceal bleed refractory to medical therapy in the absence of possible endoscopy.

Contraindications

- Absolute.
  – Known esophageal rupture.
  – Unable to intubate or maintain airway.
- Relative.
  – History of prior esophageal trauma or strictures.
  – Recent surgery of the gastroesophageal junction.
  – Resolved or resolving variceal bleeding.

Materials and Medications

- Sengstaken-Blakemore (SB) tube (Fig. 84.1).
- 60-mL syringe with catheter tip (Fig. 84.2)
- Sphygmomanometer (Fig. 84.3) or cuffalator (Fig. 84.4).
- Y-tube connector (Fig. 84.5) or three-way stop-valve connector (Fig. 84.6)
- Vacuum suction device and tubing (Fig. 84.7)
- Tube clamps (4) (Fig. 84.8)
- Lubricant (water soluble)
- Lidocaine spray or gel
- Anchoring device such as a football helmet or oral endotracheal tube fastener (Fig. 84.9)

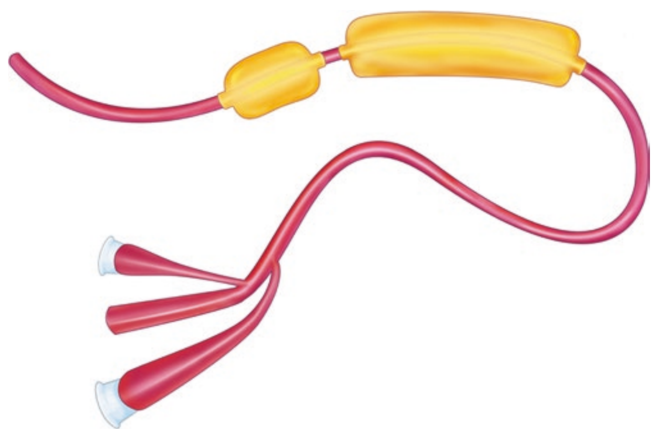

Fig. 84.1 Sengstaken-Blakemore (SB) tube

- Cup of water and straw if the patient is awake
- Scissors (Fig. 84.10)
- Intubation equipment
- Sterile water

Procedure

1. Sedate and/or intubate the patient for adequate control of the patient during the procedure.
2. Elevate the head of the bed 45°.
3. Ensure that the SB tube balloons are functional by inflating and deflating the balloons to ensure the absence of leaks.
4. Perform gastric lavage and irrigate the stomach with copious amount of sterile water.
5. Coat the distal and proximal portions of the SB tube with a thin layer of lubricating jelly or lidocaine gel. Spray the nasal passage with lidocaine spray.
6. Pass the SB tube via the nasogastric (NG) or the orogastric route (in intubated patients) to the 50-cm line.

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Fig. 84.2 Syringe

7. Inflate the gastric balloon initially with 50 mL of air and confirm placement with X-ray. Then inflate an additional 200 mL of air and clamp the tube.
8. Apply gentle traction of approximately1kg of force until it is felt that the gastric balloon has lodged at the gastroesophageal junction (Fig. 84.11).
9. Secure the tube to an anchor (e.g., football helmet or catcher's mask) placed on the patient's head, or an oral endotracheal tube holder (Fig. 84.9).
10. Aspirate and lavage the gastric aspiration port. If it is not clear of blood, try to deflate and reposition the gastric balloon as above.
11. Place an NG tube and aspirate for blood in the esophagus (above the gastric balloon), If it is not clear of blood, connect the esophageal port of the SB tube to the sphygmomanometer/cuffalator using the three-way stop-valve device (Fig. 84.12). You may use the Y-tube connector instead.
12. Inflate the esophageal balloon to the lowest pressure determined to stop the esophageal bleeding, typically 20–45 mmHg. Clamp the balloon.
13. Place an NG tube until it is felt overlying the top of the esophageal balloon of the SB tube. Check for further proximal esophageal bleed through aspiration and gentle lavage. Attach this NG tube to intermittent section to aid in the clearance of secretions.
14. Obtain a portable radiograph to confirm the position of the SB tube.

Fig. 84.3 Sphygmomanometer

15. The esophageal tube should be at the lowest pressure that prevents bleeding and kept inflated for 24 h or until other definitive treatment is obtained.

Complications

- Esophageal rupture:
  – Occurs secondary to esophageal erosion and necrosis owing to a balloon tamponade effect on tissue perfusion or overzealous balloon inflation
- Airway obstruction:
  – Occurs due to gastric tube deflation or failure, allowing the esophageal tube to move up and occlude the airway. Keep scissors near the patient to cut the SB tube lumens and remove the tube as necessary.
- Regurgitation and/or aspiration pneumonia:
  – Occurs due to inadequately suctioned oropharyngeal secretions

Fig. 84.4 Cuffalator

Fig. 84.5 Y-tube connector

Pearls and Pitfalls

- Pearls
  - The esophageal balloon should not be inflated if the gastric balloon alone stops the bleeding.
  - Never inflate the esophageal balloon without inflating the gastric balloon first. This will prevent it from slipping proximally into the oropharynx and obstructing the airway.
  - Nausea, vomiting, or aspiration is highly likely to occur. Use antiemetics and lavage the stomach before the procedure.
  - Intubate if there is airway compromise or risk of aspiration into the lungs.
  - Inflate the esophageal balloon only to the minimum pressure necessary to stop the variceal bleeding.
  - Using a catcher's mask may be more practical and comfortable for the recumbent patient.
- Pitfalls
  - The SB tube may induce hiccups.

Fig. 84.6 Three-way stop-valve tube connector

Fig. 84.7 Suction device and tubing

Fig. 84.8 Tube clamps

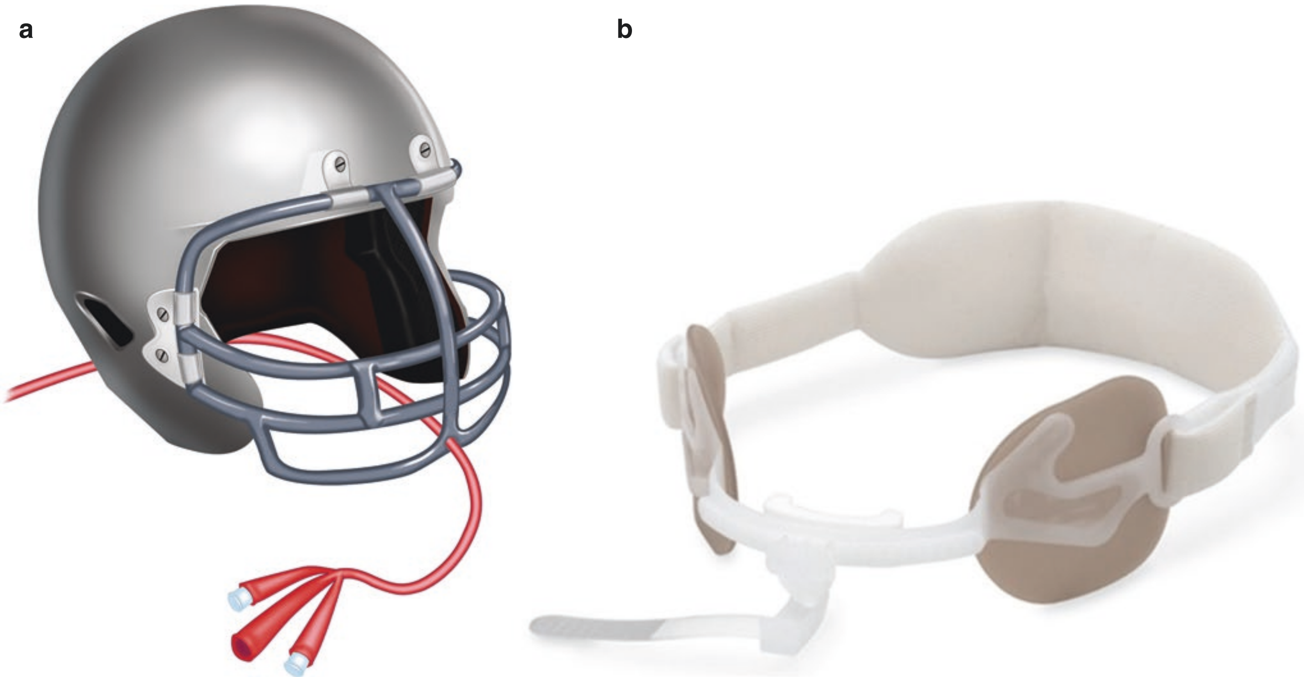

Fig. 84.9 (**a** and **b**) Helmet traction setup or ET holder traction setup

Fig. 84.10 Scissors

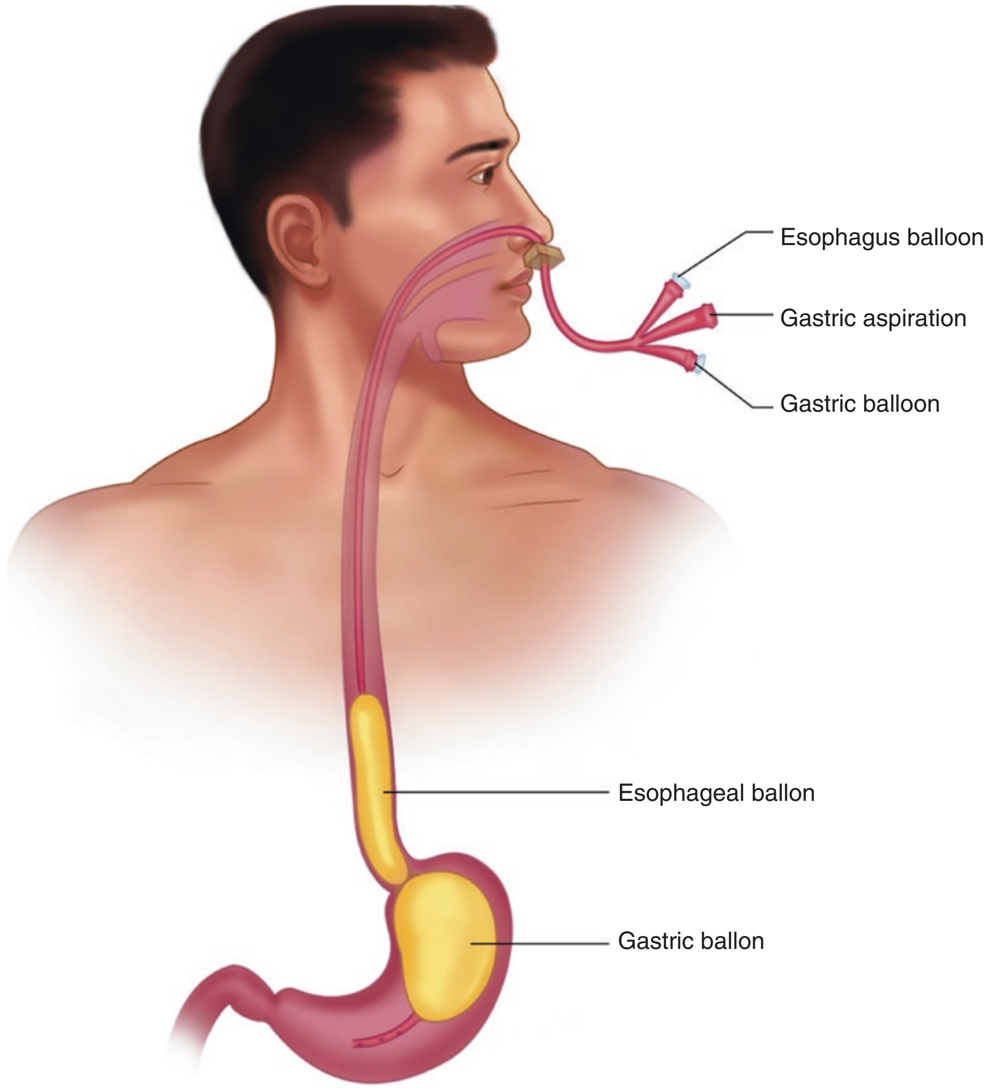

Fig. 84.11 Proper placement of the balloons

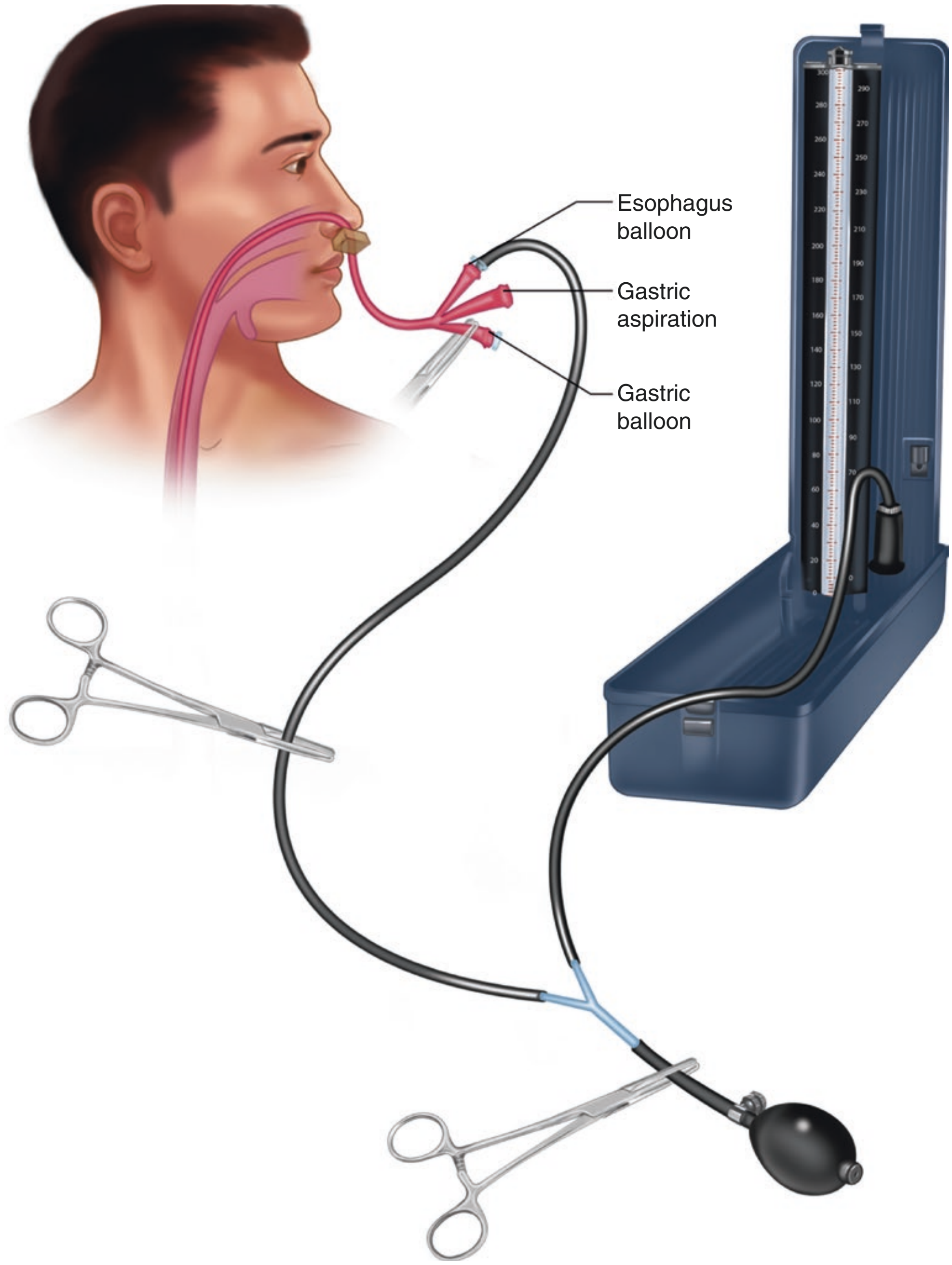

Fig. 84.12 Connection of the sphygmomanometer to the esophagus balloon port

Suggested Reading

Bauer J, Kreel I, Kark A. The use of the Sengstaken-Blakemore tube for immediate control of bleeding esophageal varices. Ann Surg. 1974;179:273–7.

Henneman PL. Gastrointestinal bleeding. In: Rosen P, Barkin RM, editors. Emergency medicine. 6th ed. St. Louis: Mosby; 1998.

Remonda G, Morachioli N, Petruzzelli C. The use of the Sengstaken-Blakemore tube for immediate control of bleeding esophageal varices. Ann Osp Maria Vittoria Torino. 1981;24:115–20.

Sengstaken RW, Blakemore AH. Balloon tamponade for the control of hemorrhage from esophageal varices. Ann Surg. 1950;131:781–9.

Treger R, Graham T, Dea S. Sengstaken-Blakemore tube. Available at http://emedicine.medscape.com/article/81020-overview#a01. Accessed 18 May 2014.

Gastrostomy/Jejunostomy Tube Replacement

85

Lee Barker, Stephanie Iken, and Bobby K. Desai

Indications

Indications for Placement

The decision to place a G-tube often involves the need for an alternate route for enteral feeding, hydration, and medication administration when there is absent or inadequate oral intake. G-tubes are often placed due to the following.

Indication	Example
Reduced levels of consciousness or cognition	Head injury or metabolic disorder
Neurologic conditions	CVA, dementia, Parkinson's disease, MS, etc.
Obstructions	Esophageal cancer, oropharyngeal cancer, etc.
Miscellaneous	Malnourishment, burns, cystic fibrosis, short bowel syndrome

Indications for Replacement

- Mechanical removal of G-tube or J-tube.
- G-tube degradation.
- Malfunctioning PEG tube.
- Clogged G-tube not responding to traditional declogging measures.

Contraindications

- Evidence of infection around G-tube site, such as extensive erythema, exudate or warmth (Fig. 85.1).
- G-tube displacement or malfunction within 4 weeks of initial tube placement (due to track immaturity).
- Any signs of peritonitis.
- If the tube has been displaced for more than 24 hours, and the track has narrowed or closed.
- Severe bleeding.
- If replacement is against the family or mentally competent patient's wishes.

Materials and Medications

- G-tube or J-tube (same size as original tube and one or two tubes one size smaller) (Fig. 85.2).
- Sterile or clean gloves.
- Lubricant.

Fig. 85.1 Erythema and tenderness surrounding a G-tube entry site, indicating local cellulitis. Local wound care and oral antibiotics are typically all that is needed for this complication

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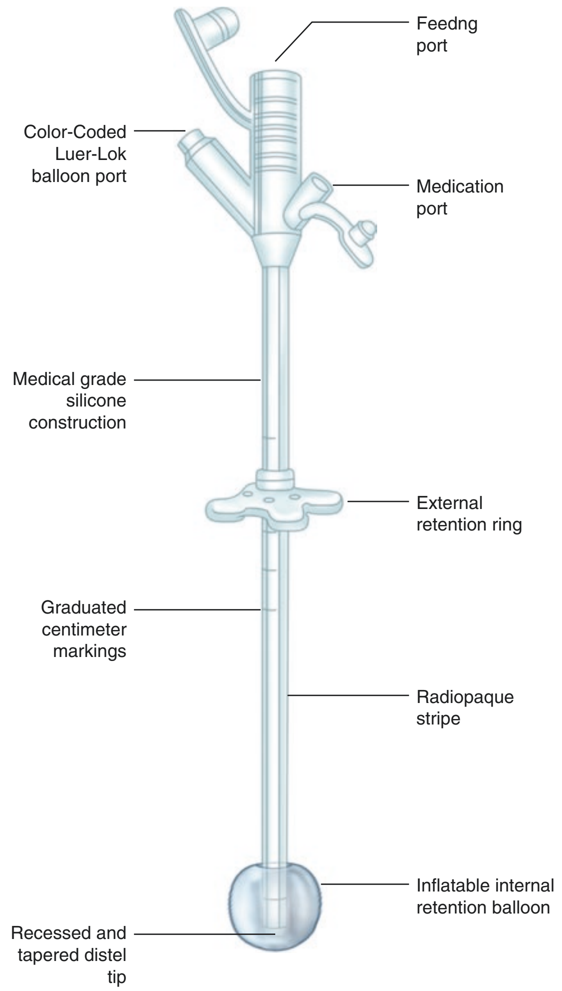

Fig. 85.2 Standard G-tube and its associated components

- Syringe (to inflate balloon; 5–10 cc).
- Sterile water for the balloon.
- Suture kit and suture (if you decide to suture the tube in place).
- Tape.
- Gauze with preformed slit to go around tube between the skin and external retention ring (If preformed gauze not available, cut a slit into a regular 4 × 4.)
- Lidocaine jelly (Only if preferred; however, there is no current literature that supports its use.)

Procedure

- Informed consent may be required. If unable to get consent from patient or caretaker, this can be performed emergently.
- Pick a G-tube most similar to the previously placed tube. Size is most important. Obtaining the same manufacturer is preferred but not required.
- Grab one or two tubes of slightly lesser size in case the same size tube fails to pass through the stoma. *do not* force the tube through the stoma. Being too aggressive when passing the tube through the stoma can cause unnecessary trauma and/or separation of the stomach from abdominal wall.
- This is NOT a sterile procedure. Prepare the skin by washing with a gentle cleaning solution.
- Before placing, read the package instructions to determine the amount of water or saline required to inflate the balloon.
- Open the package, inflate the balloon and check for any leaks.
- Lubricate the end of the G-tube and insert into the stoma using gentle pressure. As stated above, you can use viscous lidocaine in attempt to lessen the pain of insertion.
- Insert the tube through the stoma until the external retention ring is against the skin. Inflate the balloon using the amount of sterile water indicated on the package and pull back on the tube until resistance is felt. This resistance is the balloon coming up against the stomach wall and indicates that the device is now secure from the inside (Fig. 85.3).
- You may slide the external bumper forward until against the skin, or you may leave it in its initial position until x-ray confirmation is obtained.
- To check its placement, order a supine abdominal x-ray with 20–30 milliliters (mLs) of water-soluble iodinated radiopaque contrast medium injected into the G-tube. The x-ray should be taken within 1–2 minutes of dye injection. If the tube is in the correct place, the rugae of the stomach will be visible on x-ray. A water-soluble contrast dye is used due to minimal irritation to intestinal mucosa. Also, if improperly placed, the dye entering the peritoneal cavity will absorb with minimal irritation.
- Once the replacement G-tube is confirmed via x-ray, grab the tube, pulling outward until the balloon rests up against the stomach mucosa, and secure the external retention ring by sliding it downward against the skin. Place the single 4 × 4 gauze with preformed or customized slit onto the tube between the external bolster and skin to provide padding.

Complications

- Introduction of infection to surrounding tissues.
- Bleeding.
- Clogged G-tube.
- Leaking G-tube.
- Displacement of G-tube into the peritoneal cavity – Peritonitis may occur from the tube being mistakenly

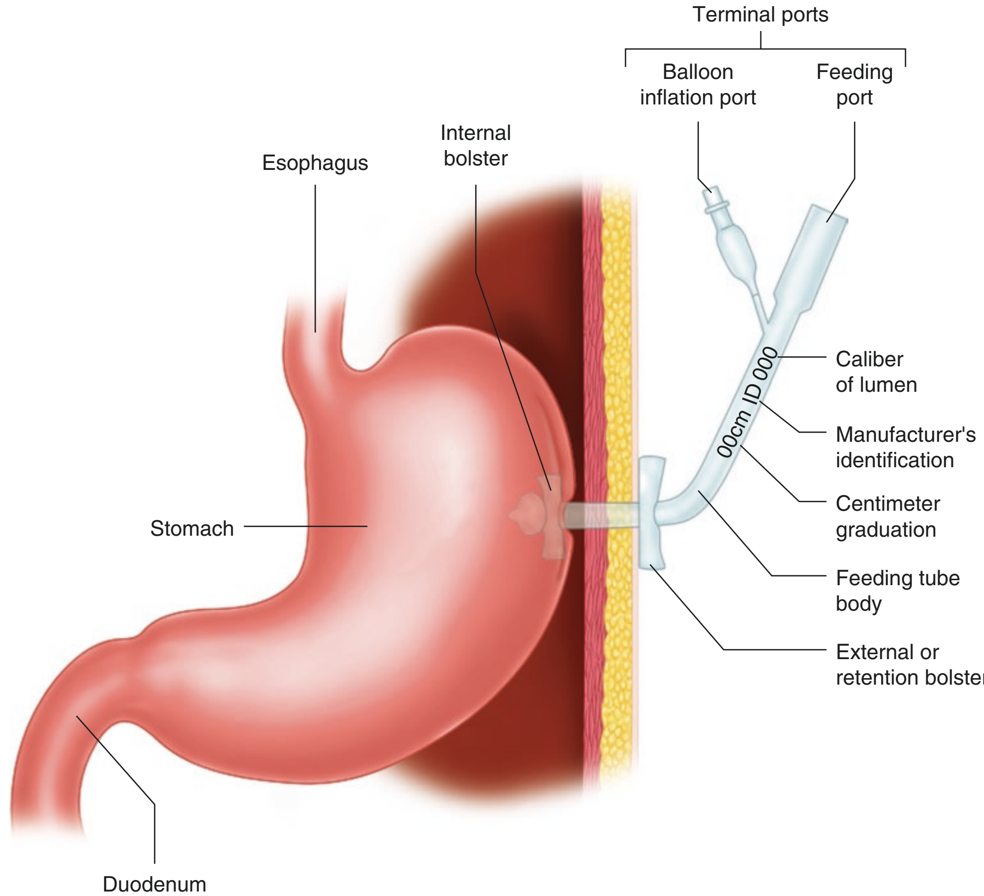

Fig. 85.3 A fully secured G-tube both internally and externally. Not all G-tubes will have the same number of ports or have an internal bolster

placed in the abdominal cavity; therefore, it is important to check the placement of the tube prior to discharge. Evaluate for this by obtaining an x-ray of the abdomen after inserting gastrografin into the G-tube.

Troubleshooting

Leaking G-tube:

- The G-tube will need to be removed and replaced.
- Remove the G-tube with gentle traction after deflating the balloon with a syringe. If syringe does not deflate the balloon, the balloon port may be cut.
- Replace the G-tube via the steps stated above.

Clogged G-tube:

- Performed when a patient presents with inability to give feedings and/or medications via G-tube.
- Use a 60 mL syringe to inject a small amount of warm water in a back-and-forth motion in attempt to dislodge the clog. If unsuccessful, inject warm water and allow to sit for 20–30 minutes.
- ClogZapper enzyme solution or Viokase pancreatic enzyme supplementation can be inserted into the G-tube and allow to sit for 30 minutes to work. Another option is the use of pancrelipase, crushed with a 650 mg bicarbonate tablet, mixed with warm water in a 10 mL syringe.
- Mechanical decloggers may be purchased to unclog a g-tube. A Bionix Enteral Feeding Tube DeClogger is a plastic device with a treaded end that may be inserted into the tube and twisted to break up the clot (Fig. 85.4).

Pearls and Pitfalls

- Remember that the G-tube should not be left out for very long; therefore, replacing the tube sooner rather than later is in the patient's best interest. Track closure is variable, some sources state to leave the G-tube out for no more than 2 hours, while other sources recommend no longer than 24 hours. Even the well-established stoma can begin to close after only a few hours of tube displacement. Track closure can typically begin between 8 and 24 hours and will continue to narrow as time passes.
- If a G-tube has been out for several hours, its stoma may have already started to close. If this occurs, a

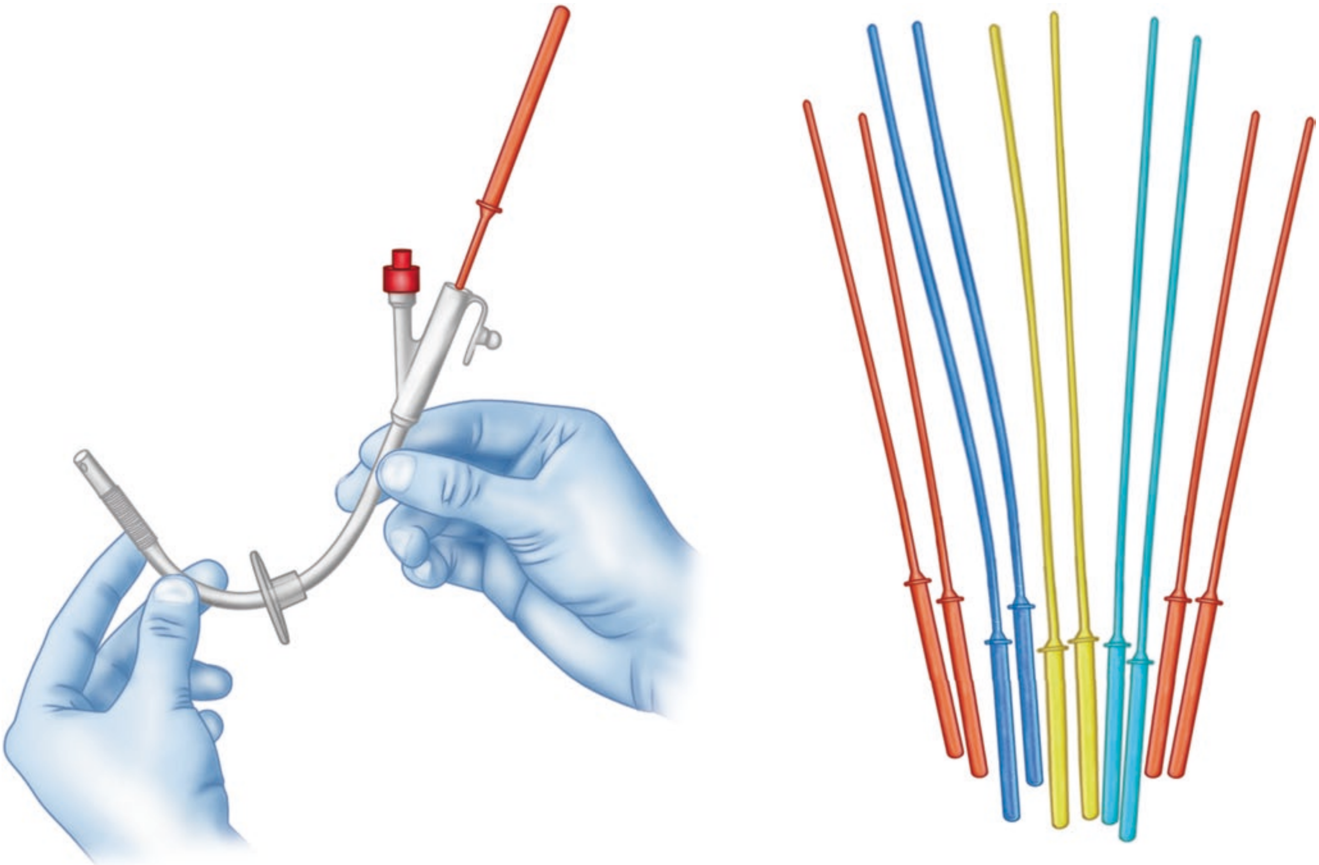

Fig. 85.4 Mechanical decloggers may be purchased to unclog a G-tube. A Bionix Enteral Feeding Tube DeClogger is a plastic device with a treaded end that may be inserted into the tube and twisted to break up the clot

smaller G-tube can be placed, and/or dilation of the stoma can also be attempted using sequential red rubber catheters.

- If unable to replace the G-tube in a timely manner, place a same size Foley catheter in the stoma to keep it open until the correct tube can be placed. To test if the Foley catheter is in the correct place, stomach acid can be drawn up and tested via a pH strip. If the pH is 5.5 or lower, it is likely gastric.
- Insure all equipment is gathered before attempting to replace.
- Again, consensus varies on exact time frame; however, in general a new G-tube takes about 2–4 weeks (some as late as 6 weeks) to form a tract. If the G-tube is **new** or appears fresh, **notify** the physician who placed it; operative or fluoroscopic replacement may be required . Replacing a G-tube in an unformed or poorly formed site could cause misplacement of the tube into the peritoneal space due to separation of the stomach or jejunum from the abdominal wall.
- Grab one or two tubes of slightly lesser size in case the same size tube fails to pass through the stoma. *DO NOT* force the tube through the stoma causing unnecessary trauma.
- It is a good idea to familiarize yourself with both tubes to insure same functionality and size.
- Always check placement of G-tube with an abdominal x-ray using gastrografin or another water-soluble contrast dye before use.
- In patients with a G-tube who present with fever, it is important to consider peritonitis as an etiology.
- When attempting to declog your patient's G-tube or J-tube, be sure to ask your staff about the available methods at your institution.
- If the patient doesn't know the size of their G-tube or the original tube has been lost, start with a 16 or 18 French replacement G-tube or Foley catheter.

Suggested Reading

Fisher C, Blalock B. Clogged Feeding tubes: A Clinician's Thorn. Practical Gastroenterology. 2014;37(3):16.

Herman L. Troubleshooting G-tubes & J-tubes: common scenarios/tips & tricks. EmDOCs.net - Emergency Medicine Education, 14 July 2016. www.emdocs.net/troubleshooting-g-tubes-j-tubes-common-scenarios-tips-tricks/

Schraga ED. Gastrostomy tube replacement. Background, indications, contraindications, Medscape, 9 July 2018. https://emedicine.medscape.com/article/149589-overview

Shah R. Gastrostomy tube replacement. NCBI - The National Center for Biotechnology Information, U.S. National Library of Medicine, 27 Oct 2018. www.ncbi.nlm.nih.gov/books/NBK482422/

Paracentesis

86

Shalu S. Patel and Bobby K. Desai

Indications

- Diagnosis of infection in ascites
- Diagnosis of malignant ascites
- Diagnosis of hemoperitoneum in traumas
- Relief of abdominal pressure/pain or respiratory compromise secondary to ascites

Contraindications

- Severe coagulopathy:
  – Prothrombin time (PT) >21 seconds
  – International normalized ratio (INR) >1.6
  – Platelets <50,000/mm^3
- Skin infection over the needle insertion site
- Acute abdomen that requires surgery
- Pregnancy
- Distended bowel
- Intra-abdominal adhesions

Materials and Medications

- 18- to 22-gauge 1.5- to 3.5-inch needle or angiocatheter, 25-gauge needle
- Lidocaine 1% or 2% (10 mL)
- Syringes:
  – 10 mL (1) and 50 mL (2)
- 1-L vacuum bottle (4) (if therapeutic tap)
- Thoracentesis kit tubing or any high-pressure connection tubing (if therapeutic tap)
- Sterile gloves
- Surgical pen (recommended)
- Povidone-iodine (Betadine) or other skin antiseptic
- Sterile drape
- Sterile gauze (4 × 4)
- Band-Aid
- Bedside ultrasound (recommended)

Procedure (Fig. 86.1)

1. Position the patient supine. If possible, adjust the head of the bed to make a 45° angle to help the fluid accumulate in the pocket. Sometimes, it may also be beneficial to have the patient lie recumbent toward the site of drainage.
2. Scan the abdomen with an ultrasound to determine whether there is a pocket of fluid that can be drained. This also allows the physician to see how far the needle needs to be inserted and how deep it can be placed without risking injury to the bowel (Fig. 86.2).
3. Mark the optimal needle insertion site with a surgical pen.
4. Prepare the skin and drape in a sterile fashion.
5. Using lidocaine, anesthetize the appropriate area subcutaneously and then continue to insert the needle, and inject anesthetic through the deeper tissues until ascitic fluid can be drawn back.
6. Withdraw the needle.
7. When ready for the paracentesis, stretch the skin caudad and insert the needle or angiocatheter (connected to a syringe) while aspirating. Then, release the skin and continue to insert the needle or angiocatheter through the peritoneal wall until fluid is retrieved. This will create a "Z-track" that will decrease leakage of peritoneal fluid through the skin.
8. Once fluid is retrieved, push in the catheter and remove the needle portion (if used) or hold the needle steady.

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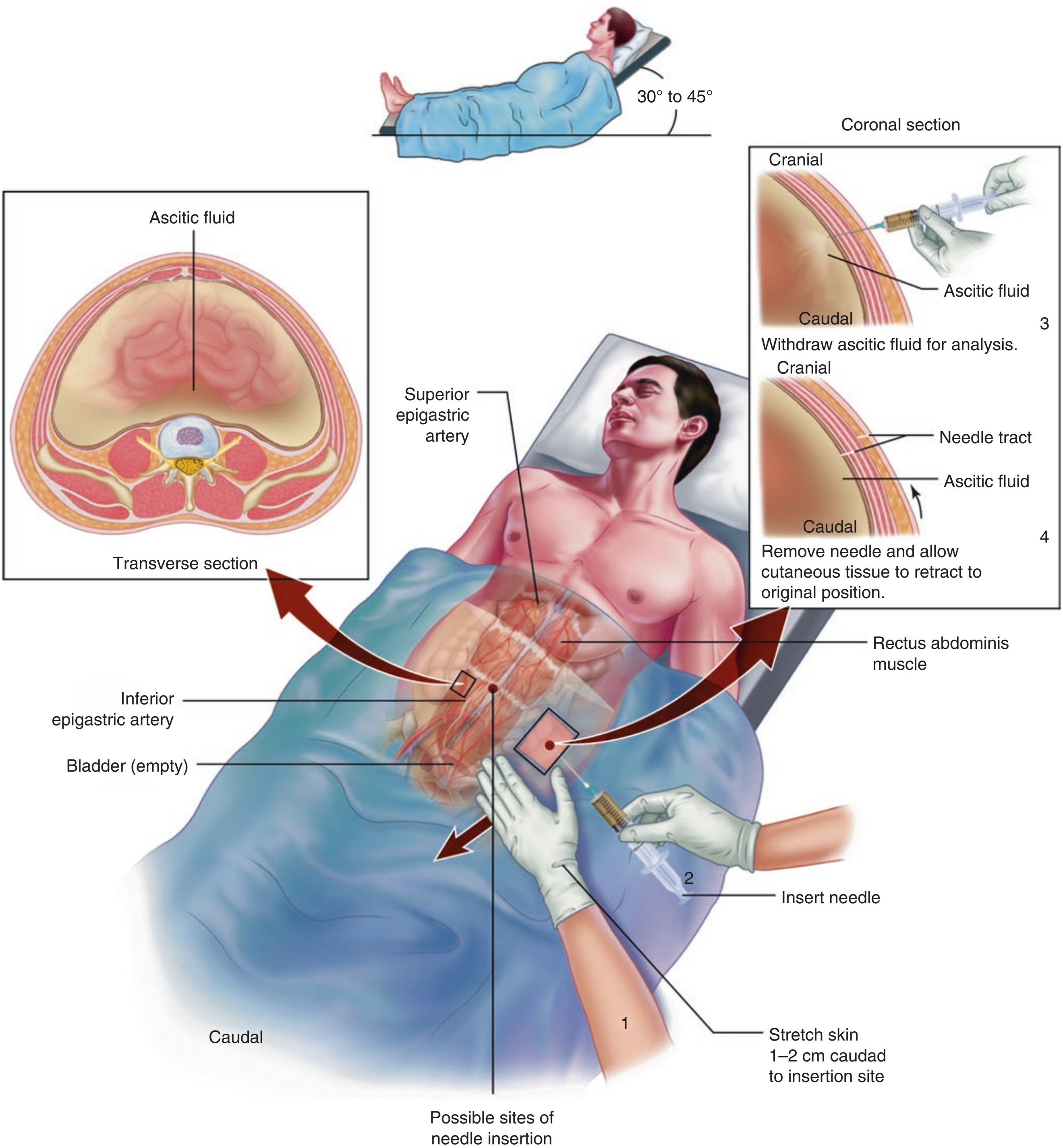

Fig. 86.1 Paracentesis procedure

9. Aspirate from the catheter to ensure that it is in the appropriate location.
10. If fluid easily is aspirated, unscrew the syringe and connect a 50-mL syringe to the needle or catheter and fill it with fluid. This may be done twice. Alternatively, if the procedure is done for therapeutic purposes, attach the tubing that is already connected to the vacuum bottle to the catheter, and allow the vacuum to withdraw fluid into the collection bottles.
11. If fluid cannot be aspirated easily, the catheter can be repositioned further in the pocket or turned by 45° sequentially as needed.

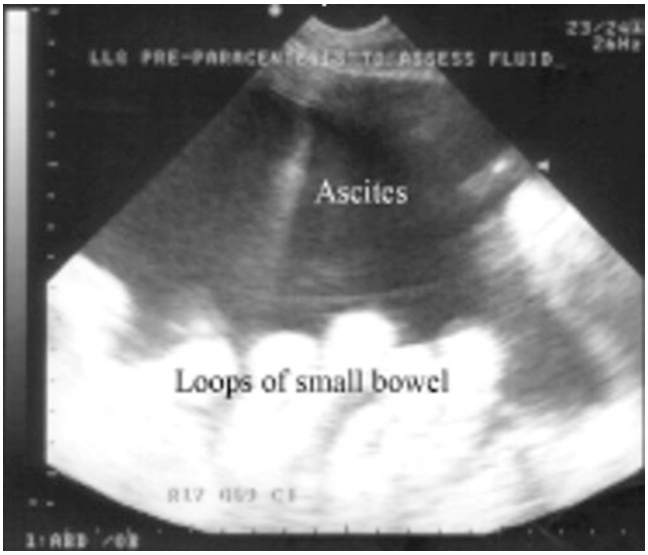

Fig. 86.2 Ultrasound to determine whether there is a pocket of fluid that can be drained

12. Once the fluid is aspirated, pull out the needle or angiocatheter and hold pressure with gauze. Bleeding should be minimal.
13. Place a Band-Aid or other dressing over the site.
14. Send the fluid to the laboratory. Generally, laboratory analyses include protein, albumin, specific gravity, glucose, bilirubin, amylase, lipase, triglyceride, lactate dehydrogenase (LDH), cell count and differential, culture and sensitivity (C&S), Gram stain, acid-fast bacillus (AFB), fungal culture, cytology, and pH.

Complications

- Persistent leakage from the needle insertion site
- Abdominal wall hematoma
- Bowel perforation
- Introduction of infection
- Hypotension (after a large-volume paracentesis)
- Dilutional hyponatremia
- Hepatorenal syndrome
- Bleeding
- Postparacentesis circulatory dysfunction

Pearls and Pitfalls

- Pearls
  – The preferred site of entry is in the midline of the abdomen, below the umbilicus.
  – The serum-ascites albumin gradient (SAAG) can be used to identify the cause of the ascites. It is calculated by subtracting the albumin concentration in the ascites from the albumin concentration in the serum. A high gradient (>1.1 g/dL) suggests portal hypertension, whereas a low gradient (<1.1 g/dL) suggests other causes.
  – Postparacentesis circulatory dysfunction (PPCD) occurs secondary to hypovolemia after large-volume paracentesis (>4 L) in cirrhotic patients. It is associated with worsening hyponatremia, renal dysfunction, shorter time to ascites recurrence, and increased mortality. Prevention of PPCD has been demonstrated with the administration of 6–8 grams of albumin per liter of ascites removed.
- Pitfalls
  – Polymorphonuclear lymphocyte (PMN) count greater than 250/mm^3 is diagnostic of spontaneous bacterial peritonitis.

Suggested Reading

Aponte EM, Katta S, O'Rourke MC. Paracentesis. 2020 Sep 9. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020. PMID: 28613769.

Mildon J, Willers J, Thomson SJ. Paracentesis model for junior doctors. Clin Liver Dis (Hoboken). 2018;12(3):89–92. https://doi.org/10.1002/cld.734. PMID: 30988919; PMCID: PMC6385920.

Millington SJ, Koenig S. Better with ultrasound: paracentesis. Chest. 2018;154(1):177–84. https://doi.org/10.1016/j.chest.2018.03.034.

Wong CL, Holroyd-Leduc J, Thorpe KE, Straus SE. Does this patient have bacterial peritonitis or portal hypertension? How do I perform a paracentesis and analyze the results? JAMA. 2008;299:1166–78.

87 Anal Fissure Management

Larissa O. Dub, David P. Nguyen, L. Connor Nickels, and Giuliano De Portu

An anal fissure is a small ulcer of the mucosa at the anal verge (Fig. 87.1).

Indications

- Pain upon defecation.
- It is the most common cause of intense sudden rectal bleeding.
- Posterior midline anal fissures are the most common type (90%):
  - Mostly found in young adults (30–50 y) but can occur at any age.
  - Usually associated with constipation (firm, large-caliber, painful bowel movements) or chronic diarrhea.
  - Most uncomplicated fissures resolve in 3–4 weeks.
- Can be extremely painful, during and after defecation.
- Classified as acute (<6 weeks duration) or chronic (>6 weeks).

Contraindications

- Digital rectal examination should be avoided unless the diagnosis is in doubt.
- Surgical procedures are generally reserved for when medical management has failed after >3 months of treatment.

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Materials and Medications

- Standard precautions barrier protection for the provider.
- Good light source.
- Optional emergency department treatments:
  - Topical anesthetic/preparation (Anusol [pramoxine hydrochloride; zinc oxide] with cortisone). Best used 10 minutes before bowel movement.
  - Nitroglycerin (0.2%) or nifedipine gel (2%) is second-line therapy (relaxes muscles and promotes blood flow).

Procedure

1. In a private, calm environment, gently spread the buttocks for complete visual inspection:
   - This may cause an increase in the patient's pain and spasming.
   - If a fissure is clearly identified, stop here.
2. Apply topical anesthetic/preparation for symptomatic relief (optional, as the physician may want to just start with the treatments that follow).
3. Discharge the patient with conservative therapy management.
4. In acute anal fissures, medical management is indicated along with dietary modifications (WASH [warm baths, analgesia, stool softeners, high-fiber diet] regimen):
   - Warm sitz baths:
     - Usually 20-min soaking each time
     - Recommended after every bowel movement
     - At least twice per day if not having regular bowel movements
   - High-fiber diet with fiber supplements.
   - Increase fluid intake.
   - May add stool softeners, if needed.
   - If chronic or the previous regimen has been exhausted, one of the following may be considered:
     - 0.2–0.4% nitroglycerin cream applied to anal area:

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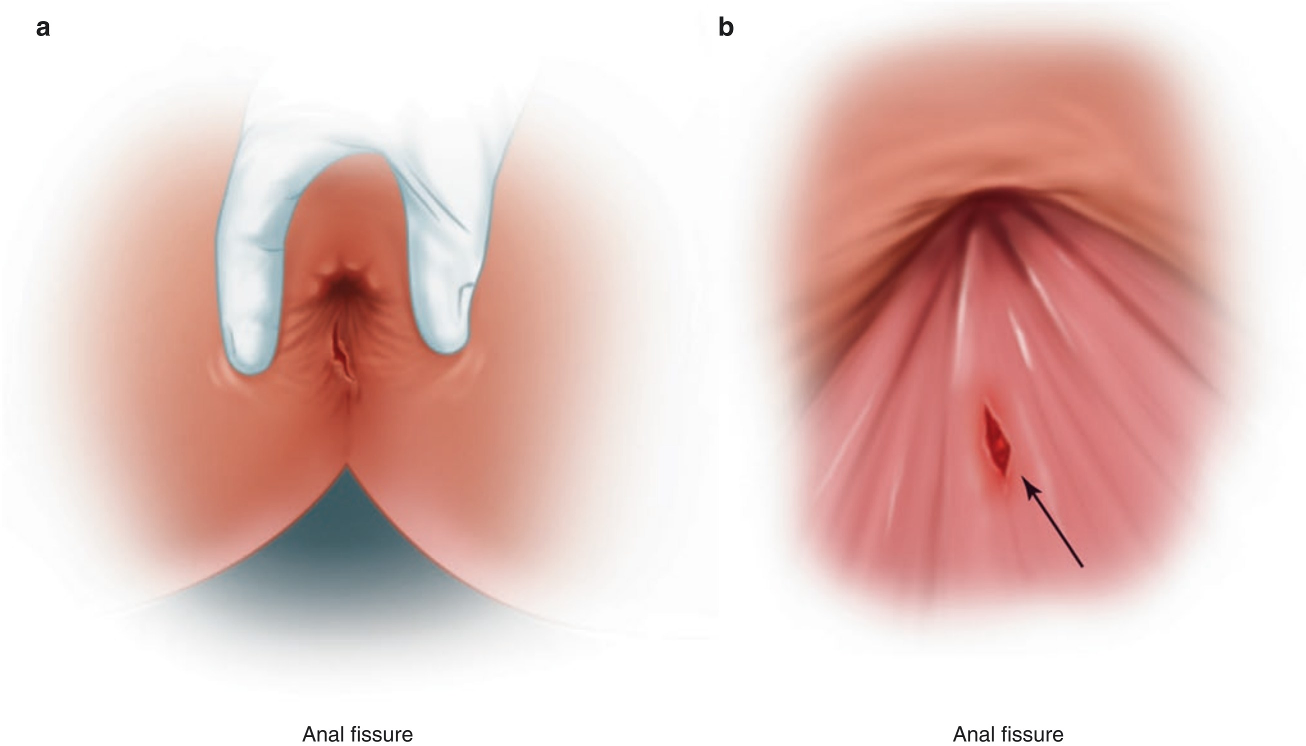

Fig. 87.1 (**a**, **b**) Anal fissures

May cause headache
Recommend wearing a glove to prevent absorption through digital skin
- Calcium channel blockers:
  Topical nifedipine
  2% diltiazem cream
- Botulinum toxin A injection:
  Controversial; may have poorer success rates than surgery

5. Provide surgical referral for nonhealing wounds:
   - Lateral internal sphincterotomy is the surgical procedure of choice.

Complications

- Infection
- Abscess
- Bleeding
- Chronic fissure formation
- Constipation/fecal impaction
- Postsurgical fecal incontinence

Pearls and Pitfalls

- Pearls
  - Primary anal fissures have no known cause.
  - Secondary (chronic) anal fissures can be secondary to Crohn's disease, tuberculosis, syphilis, human immunodeficiency virus (HIV), or malignancy. Suspect when multiple or recurrent fissures are present or when found in locations other than the posterior midline, or lasting >8 weeks.
- Pitfalls
  - Consider child abuse if an anal fissure is found in a child.
  - When to refer:
    Anal fissure present in an adult >8 weeks (suspect secondary cause for anal fissure)
    Anal fissure present for more than 2 weeks in a child

Suggested Reading

Nelson R. Anal fissure (chronic). BMJ Clin Evid. 2010;2010:0407. PMID: 21718564; PMCID: PMC2907591.
Newman M, Collie M. Anal fissure: diagnosis, management, and referral in primary care. Br J Gen Pract. 2019;69(685):409–10. https://doi.org/10.3399/bjgp19X704957.
Oztürk H, Onen A, Dokucu AI, Otçu S, Yağmur Y, Yucesan S. Management of anorectal injuries in children: an eighteen-year experience. Eur J Pediatr Surg. 2003;13:249–55.

Part XI

Genitourinary Procedures

Bladder Catheterization

88

Maritza A. Plaza-Verduin and Judith K. Lucas

Indications

- Obtaining a sterile urine specimen
- Preventing or relieving urinary retention
- Close monitoring of urine output
- Urgent cystourethrography
- Child with contusion or burns to the perineum and at risk for meatal swelling and obstruction to urine outflow
- Temporary measure to relieve lower urinary tract obstruction
- Neurogenic bladder
- Bladder irrigation for gross hematuria

Contraindications

- Absolute
  - Potential urethral injury from trauma:
    - Pelvic fractures
    - Known trauma to the urethra
    - Blood at the meatus
- Relative
  - Recent genitourinary surgery (consult with a urologist before placing a catheter)

Materials and Medications

- Bladder catheterization kit:
  - Sterile gloves
  - Sterile drapes
  - Povidone-iodine (Betadine) solution
  - Cotton sponges or applicators for sterilizing solution
  - Lubricant
  - Specimen collection cup
  - Collection bag
  - Catheter:
    - 5-French feeding tube for neonates
    - 8-French catheters for infants
    - 10- to 12-French catheters in older children
    - 12- to 15-French catheters in adults
- Local anesthetic (if desired—2% lidocaine hydrochloride jelly)
- Absorbent pad

Procedure

1. Inspect the urinary catheterization tray for all the appropriate materials.
2. Place the patient supine with an absorbent pad under the buttocks:
   (a) Females should be placed in the frog-leg position (Fig. 88.1).
3. Before sterilizing the field, locate the urethral opening using nondominant hand.
4. Remove any powder, ointments, or medicated creams that the patient might have on the perineum.
5. Place a sterile drape appropriate and then sterilize the area.
6. If needed, apply anesthetic to the area:
   (a) Soak a cotton ball with anesthetic (2% lidocaine hydrochloride jelly), and hold over the urethral opening for 2 min.
   (b) Anesthetic can also be injected into the urethra.
7. Catheterization of males:
   (a) If uncircumcised, gently retract the foreskin, *if possible*, for cleaning and visualization of the meatus.
   (b) Hold the penis using the nondominant hand at a 90° angle from the body (Fig. 88.2).

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Fig. 88.1 Infant held in the frog-leg position for catheterization

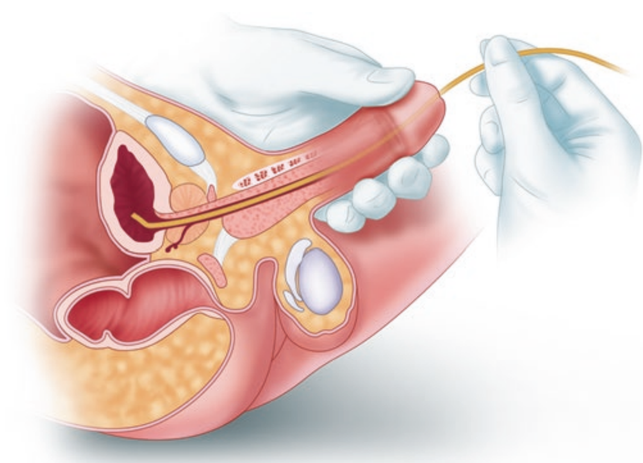

Fig. 88.2 Bladder catheterization of a male; the penis should be held perpendicular to the body

(c) Lubricate the catheter tip.
(d) Insert the lubricated catheter into the meatal opening, and advance it while applying gentle traction to the penis from the base of the penis.
(e) If resistance is met, maintain gentle pressure with the catheter:
   - *Do not attempt to force the catheter that could create a false tract or traumatic fistula.*

(f) Advance the catheter until urine is obtained, approximately inserting the catheter to just beyond the penile length.
(g) Inflate the balloon and gently withdraw the catheter.
(h) Connect the catheter to the specimen collection bag.
(i) Clean the area, wiping away the Betadine solution.
(j) If uncircumcised, pull the foreskin over the glans to avoid paraphimosis.

8. Catheterization of females:
   (a) Sterilization of the area should occur from anterior to posterior.
   (b) Have an assistant hold the labia majora apart:
      (i) If no assistant is available, use the nondominant hand to hold the labia apart:
         - Holding the labia majora with a gentle outward, lateral, and upward traction will help visualize the meatus (Fig. 88.3).
         - Downward displacement of the cephalad aspect of the vaginal introital fold with a cotton-tipped applicator can help visualize the urethral meatus (Fig. 88.4).
   (c) Lubricate the catheter tip.
   (d) Insert the lubricated catheter into the meatal opening. Advance slowly until urine is obtained (Fig. 88.5).
   (e) Inflate the balloon and gently withdraw the catheter.

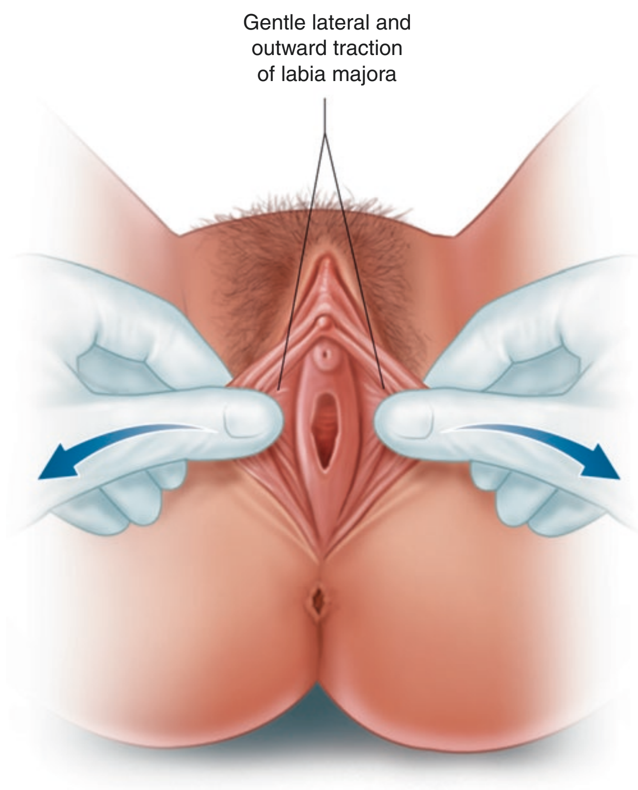

Fig. 88.3 Positioning of labia for better visualization of the meatus

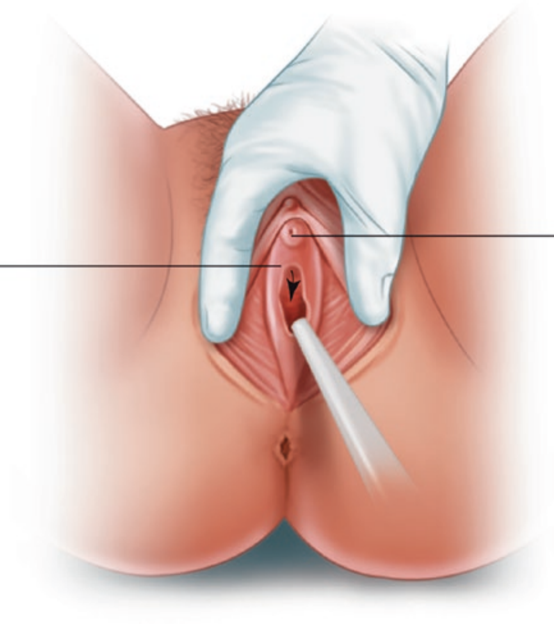

Fig. 88.4 Better visualization of the meatus is achieved with downward displacement of the introital mucosa

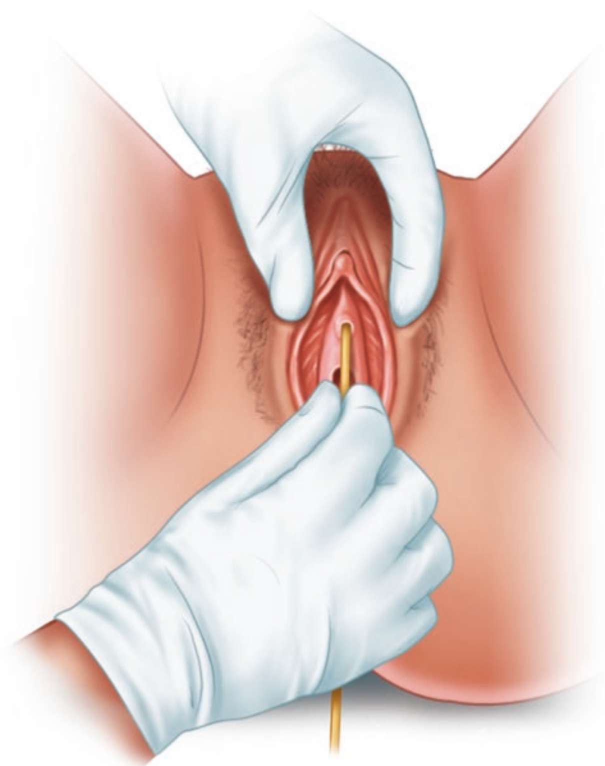

Fig. 88.5 Bladder catheterization of a female

(f) Connect the catheter to the specimen collection bag.
(g) Clean area, wiping away the Betadine solution.

Complications

- Urethral or bladder injury
- Infection if sterile field not maintained
- Paraphimosis owing to failure to restore retracted foreskin to its normal position

Pearls and Pitfalls

- Pearls
  – It is not necessary to fully retract a foreskin. This only causes trauma and increases the likelihood of paraphimosis. As the infant/boy ages, the foreskin will loosen, and the naturally occurring adhesions will spontaneously release.
  – The urethral meatus in an infant female is usually tucked just above the redundant hymen (as opposed to the more anteriorly located meatus in the adult woman) and often looks like a dimple or small blind pouch.
  – In the uncircumcised male, be certain to return the foreskin over the glans to avoid paraphimoses.
- Pitfalls
  – If catheterizing a child in search of infection, send a urine culture regardless of the urinalysis results because the younger infants can have false-negative urinalysis and still have positive cultures.

– In females, if the catheter enters the vagina, it is considered contaminated and a new catheter should be used.

Suggested Reading

American Academy of Pediatrics, Subcommittee on urinary tract infection, steering committee on quality improvement and management. Urinary tract infection: clinical practice guideline for the diagnosis and management of the initial UTI in febrile infants and children 2 to 24 months. Pediatrics. 2011;128:595–609.

Beno S, Schwab S. Bladder catheterization. In: King C, Henretig FM, editors. Textbook of pediatric emergency procedures. 2nd ed. New York: Lippincott Williams & Wilkins; 2008.

Cheng YW, Wong SN. Diagnosing symptomatic urinary tract infection in infants by catheter urine culture. J Paediatr Child Health. 2005;41:437–40.

Gerard LL, Cooper CS, Duethman KS, et al. Effectiveness of lidocaine lubricant for discomfort during pediatric urethral catheterization. J Urol. 2003;170:564–7.

Kozer E, Rosenbloom E, Goldman D, et al. Pain in infants who are younger than 2 months during suprapubic aspiration and transurethral bladder catheterization: a randomized, controlled study. Pediatrics. 2006;118:e51–6.

Pelvic Examination and Wet Preparation

89

Nauman W. Rashid, Elaine B. Josephson,
and Muhammad Waseem

Indications

- Lower abdominal or pelvic pain
- Vaginal bleeding or discharge
- Cancer screening
- Pregnancy
- Exposure to sexually transmitted disease
- Retained foreign body
- Sexual assault

Contraindications

- Physical or mental disability.
- Recent gynecological surgery.
- Third-trimester pregnancy with bleeding.
- Premenstrual females (may not be indicated in adolescents, who are not sexually active, unless there is discharge, bleeding, suspicion for abuse, or a foreign body).
- If a speculum examination is necessary, examination under general anesthesia should be considered.

Materials and Medications

- Examination table with stirrups (Fig. 89.1)
- Reliable light source
- Appropriately sized speculum (Fig. 89.2)
- Culture swab for gonorrhea and chlamydia
- Large cotton swabs for vaginal discharge or bleeding (Fig. 89.2)
- Ringed forceps
- pH paper
- Saline and potassium hydroxide dropper bottles for wet preparations
- Lubricating gel
- Disposable gloves (Fig. 89.2)

Procedure

1. Obtain permission from patient before beginning examination.
2. Chaperone should be present (medical staff member).
3. Make sure the examination table is clean and appropriately draped.
4. Have the patient in a loose-fitting gown.
5. Place the patient on the examination table in the lithotomy position with both feet in the stirrups, and have the patient's pelvis as close to the edge of the table as possible.
6. Turn on the light source and adjust for optimum illumination. Put on the disposable gloves.
7. Communicate the procedure well to the patient.
8. Examine the external genitalia. Evaluate the skin, labia minora and majora, clitoris, urethral meatus, vaginal canal, and Bartholin glands (Fig. 89.3). Look for skin abnormalities, lesions, masses, rashes, excoriation, abscesses, discharge, bleeding, or trauma. Palpate for tenderness.
9. Lubricate the appropriate-size speculum (mostly medium size). Insert the speculum through the vaginal opening with gentle downward pressure. The speculum should advance without any resistance until the cervical os is visualized.
10. Inspect the vaginal walls for any lesions or masses (Fig. 89.4). The cervical os is inspected to see if it is open or closed. Cervical cultures for gonorrhea and

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Fig. 89.1 Examination table with stirrups

Fig. 89.2 Gloves, speculum, and swabs

chlamydia are obtained with a cotton swab and sent for microbiology.

11. A sample of the discharge or bleeding is taken with a large cotton swab. The color, odor, and amount should be noted. The pH of the vaginal discharge can be evaluated. Normal pH is less than 4.5. An elevated pH indicates an infection (Table 89.1).
12. Next, a bimanual examination should be performed (Fig. 89.5). Lubricating gel is applied to the nondominant gloved hand, and the index and middle fingers are inserted into the vagina until the cervix is felt. The other hand is placed on the abdomen to palpate the uterus and ovaries. Pressure is applied to the abdomen while the vaginal hand is elevated upward.
13. The cervix is palpated to elicit any cervical motion tenderness. The uterus is palpated and the size, position, and mobility are noted. The adnexa are examined for masses and tenderness. If a mass is palpated, the size, mobility, consistency, and tenderness are noted.
14. The final part of the pelvic examination is the rectovaginal examination. Lubricate the index and middle fingers of the left hand. Place the index finger in the vagina and the middle finger in the rectum. Palpate for any fistulas or masses. With the finger, also palpate the uterosacral ligaments, the broad ligaments, and the pelvic side walls. The finger is then gently removed, and any feces are inspected for mucous or occult blood.
15. A wet preparation is made by obtaining a sample of the vaginal discharge and placing it in a vial mixed with saline solution. A drop of the solution is placed on a microscopic slide and examined under high magnification for the presence of clue cells (Fig. 89.6) diagnostic for bacterial vaginosis and trichomonads (Fig. 89.7) diagnostic for trichomoniasis. For yeast, two drops of the solution are mixed with two drops of potassium hydroxide. Presence of hyphae is diagnostic of candida (yeast) species (Fig. 89.8).

Complications

- Urinary tract infection
- Vaginal bleeding
- Cramping

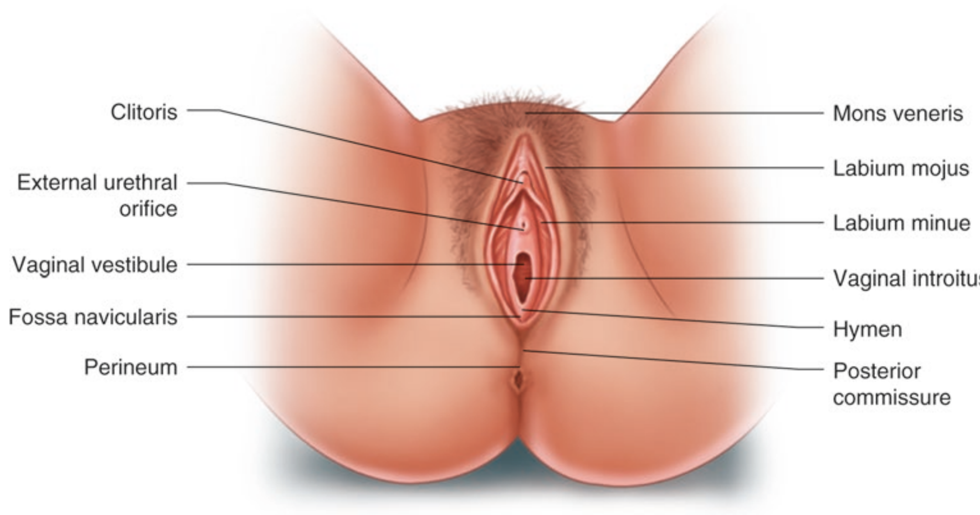

Fig. 89.3 Female external genitalia

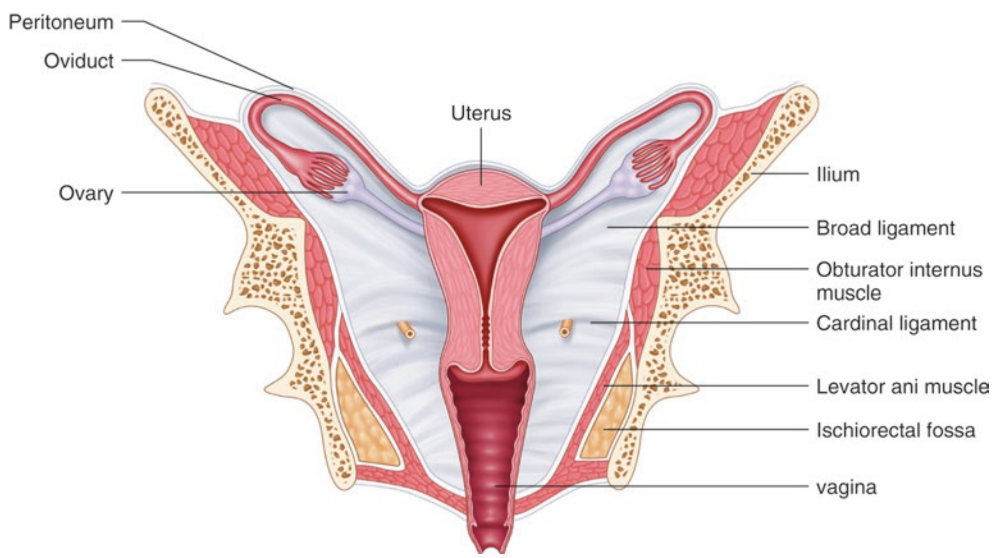

Fig. 89.4 Female internal genitalia

Table 89.1 Wet preparation interpretation

Organism	Preparation	pH	Microscope	Cervix	Appearance of discharge
Bacterial vaginosis	Saline	>4.5	Clue cells	Redness	Thin, milky, fishy odor
Trichomoniasis	Saline	>4.5	Motile flagella	Strawberry red	Yellow-green, foamy
Yeast	Potassium hydroxide	3.8–4.5	Budding yeast pseudohyphae	Normal	White, cottage cheese

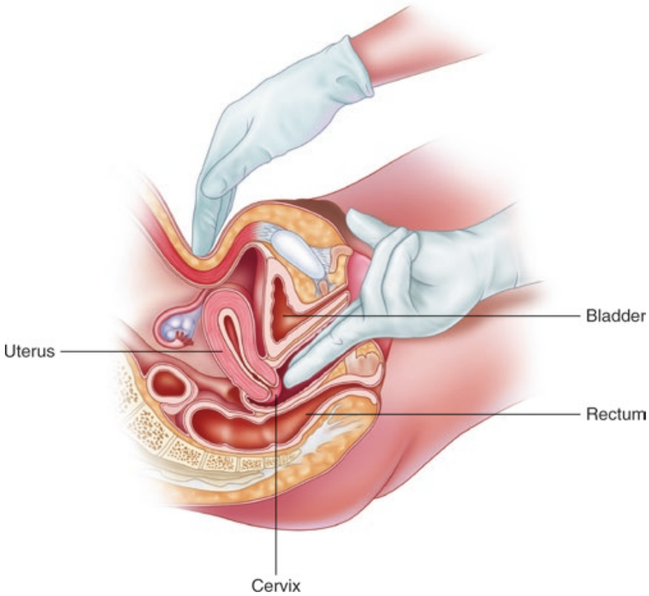

Fig. 89.5 Bimanual pelvic examination

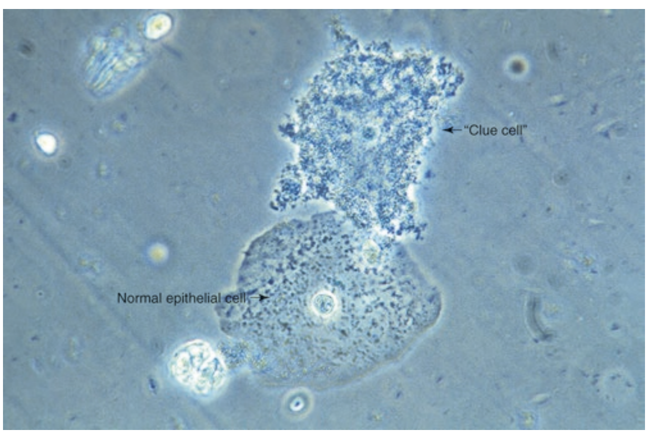

Fig. 89.6 Photomicrograph of a vaginal smear specimen depicting two epithelial cells, a normal cell, and an epithelial cell with its exterior covered by bacteria giving the cell a roughened, stippled appearance known as a "clue cell". (From the CDC Public Health Image library)

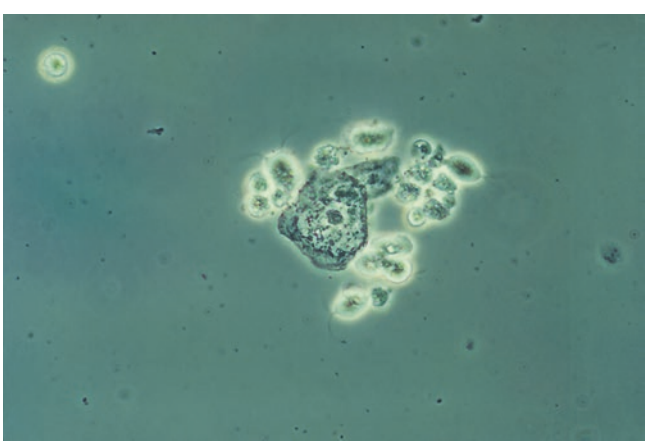

Fig. 89.7 Photomicrograph of trichomonads in wet mount prepared with physiological saline. (From the CDC Public Health Image library)

Fig. 89.8 *Candida albicans* from vaginal wet prep. (From the CDC Public Health Image library)

Pearls and Pitfalls

- Pearls
  - Good communication is essential to ensure the patient is comfortable and not anxious.
  - The chaperone should be a medical staff member.
  - Do not skip the pelvic examination if the patient is menstruating.
  - If there is difficulty with visualizing the cervix, withdraw the speculum slightly and apply inferior pressure.
- Pitfalls
  - Do not forget to perform a complete abdominal exam along with the pelvic exam to rule out any GI etiology.
  - In older females (>50), perform the DRE for a stool occult sample as a possible source of bleeding.

Suggested Reading

Brown J, Fleming R, Aristzabel J, Gishta R. Does pelvic exam in the emergency department add useful information? West J Emerg Med. 2011;12:208–12.

Butler J, Barton D, Shepherd J, Reynolds K, Kehoe S. Gynaecological examinations. Good not bad medicine. BMJ. 2011;342:d1760.

Carr SE, Carmody D. Outcomes of teaching medical students core skills for women's health: the pelvic examination educational program. Am J Obstet Gynecol. 2004;190:1389.

Katz VL, Lentz G, Lobo RA, Gershenson D, editors. Comprehensive gynecology. 5th ed. Philadelphia: Mosby; 2007.

Tiemstra J, Chico P, Pela E. Genitourinary infections after a routine pelvic exam. J Am Board Fam Med. 2011;24:296–303.

Bartholin Gland Abscess/Cyst Drainage

90

Amanda Webb

Indications

- Bartholin gland abscess or cyst that is painful
- Failed conservative measures such as sitz baths, warm baths, and analgesics

Contraindications

- Absolute
  - None
- Relative
  - Small asymptomatic cysts do not require drainage.

Materials and Medications

- Iodine solution
- Sterile gloves
- Lidocaine 1% or 2% with or without epinephrine
- 27-gauge or smaller needle for injecting lidocaine
- 5-mL syringe for injecting lidocaine
- 3-mL syringe for catheter inflation
- No. 11 scalpel
- Small hemostat forceps to break up loculations
- 25-gauge, 1″ needle for catheter inflation
- Normal saline for rinse and catheter inflation
- Gauze
- Word catheter (Fig. 90.1) or
- Jacobi ring catheter (Fig. 90.2)

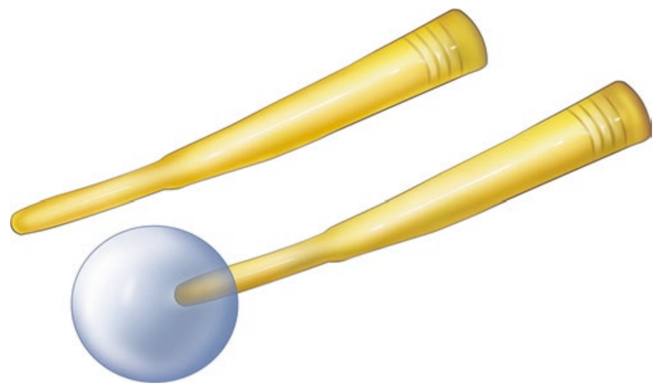

Fig. 90.1 Word catheter (inflated/deflated)

Fig. 90.2 Jacobi ring catheter

Procedure

1. Place patient in the dorsal lithotomy position (Fig. 90.3).
2. Prepare labial and vaginal area with iodine or other antiseptic solution.
3. Inject lidocaine into the vaginal mucosa side of the abscess at the intended site of incision (Fig. 90.5).
4. Using the No. 11 scalpel, make a small (<5 mm) stab incision into the abscess. Entry into the cavity will be evident with pus or mucus drainage. Forceps with teeth may be used to gently grasp the cyst wall as a false tract can easily be made once the cyst/abscess has drained and collapsed (Fig. 90.5).

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5. Insert a small hemostat and break up any loculations.

   Word catheter procedure:
   - Test the Word with 2–3 cc of normal saline and deflate.
   - Insert the Word catheter and inflate once the balloon is fully within the cavity (Figs. 90.6 and 90.7).
   - Inflate the balloon with 2–3 cc of normal saline. Gently tug the catheter to ensure it does not fall out and tuck the end of catheter into the vagina.

   Jacobi ring procedure:
   - Grasp one end of the Jacobi ring with a hemostat and pass it through the initial incision.
   - Pull the Jacobi ring through the abscess cavity (be careful not to pull the suture out of the catheter), and make a second incision to pull the catheter out through it.
   - Form a ring by tying the two ends of the catheter string together.

Fig. 90.3 Cyst/abscess accessible for the procedure

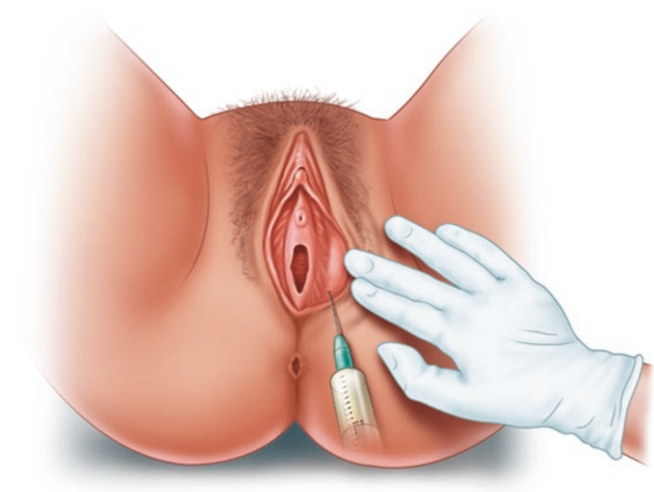

Fig. 90.5 May need to hold traction to the labia to fully expose the cyst/abscess

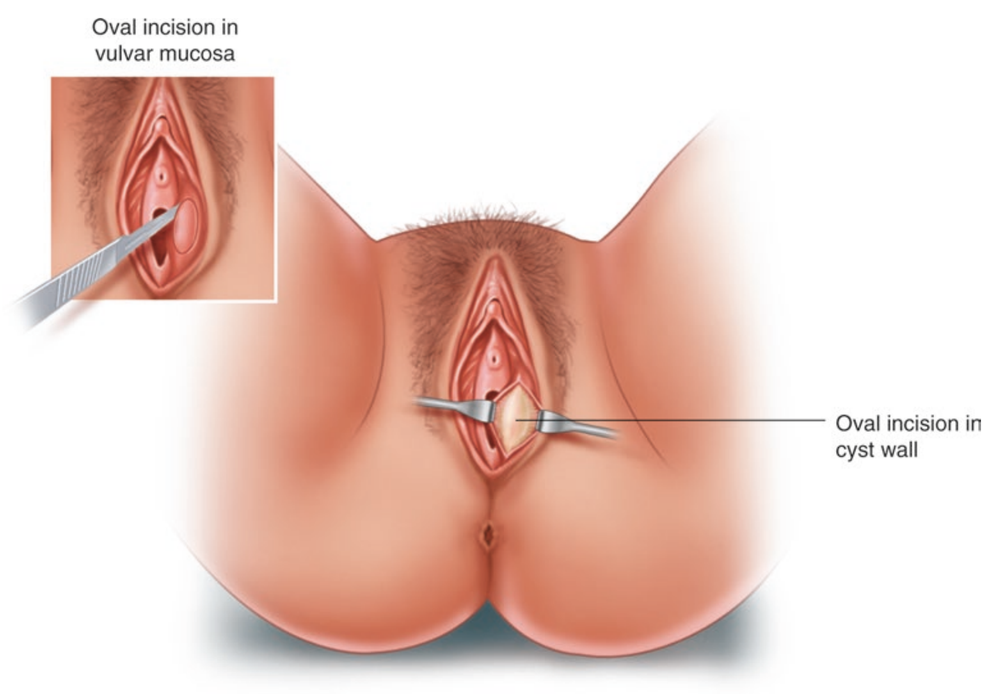

Fig. 90.4 Inject 1–4 mL of lidocaine at the planned site of incision

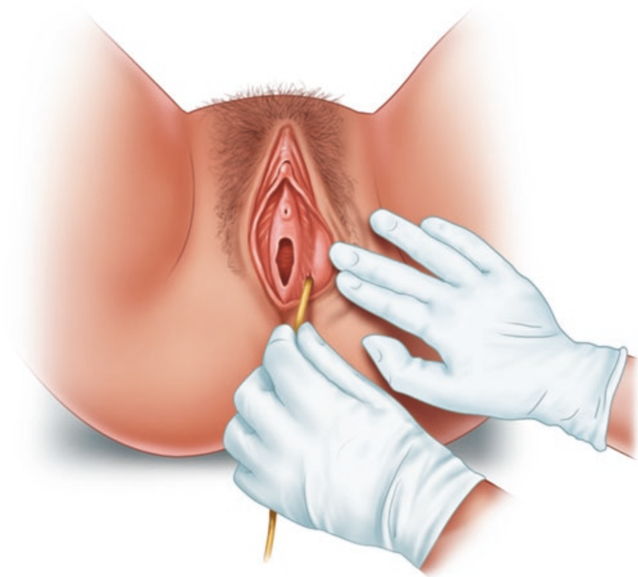

Fig. 90.6 Place the Word catheter into the incision site as deep as possible

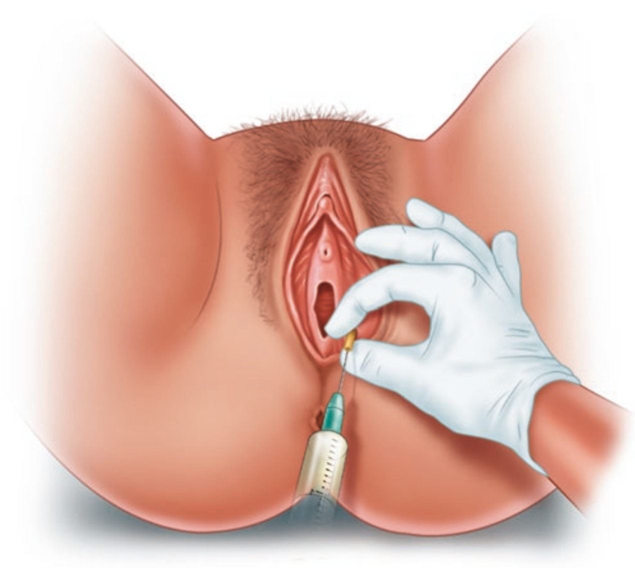

Fig. 90.7 Inflate the balloon of the Word catheter with 2–3 mL of saline or water injected into the hub with a needle and syringe

6. Discharge instructions:
   (a) Diabetics and pregnant women should be prescribed broad-spectrum antibiotics.
   (b) Patients should be instructed to put nothing into the vagina for 48 hours.
   (c) Recommend wearing a pad due to expected discharge.
   (d) Sitz baths for comfort (Fig. 90.8).

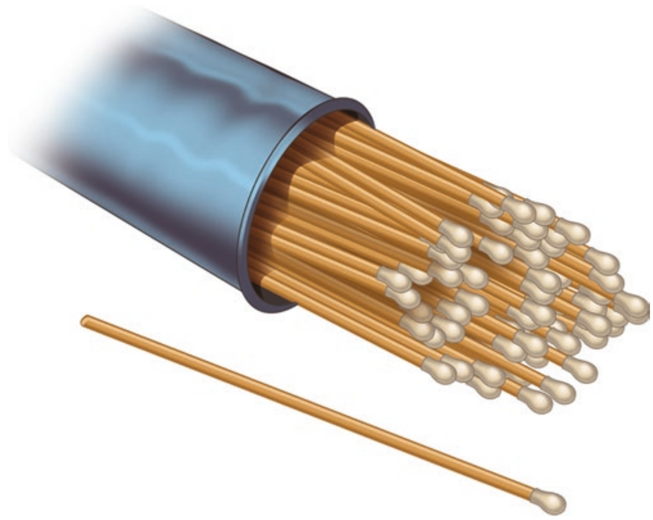

Fig. 90.8 Sitz bath

Complications

- False tracts can occur within the mucosa, especially in smaller cysts leading to incorrect catheter placement and failure of proper drainage.
- Pain, discomfort at the site
- Bleeding, usually minimal
- Recurrence, common
- Infection

Pearls and Pitfalls

- May be performed during pregnancy.
- Consider adjunctive analgesics as the procedure can still be quite painful despite maximal local anesthesia.
- Do not create a large incision as the catheter may fall out.
- Abscesses are usually polymicrobial, with *E. coli* as the most common pathogen. Antibiotics are generally not needed unless there are signs of cellulitis or failure to improve after incision and drainage.
- An 8-Fr Foley catheter may be used if a Word catheter is unavailable.

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Suggested Reading

Kessous R, Aricha-Tamir B, Sheizaf B, Shteiner N, Moran-Gilad J, Weintraub AY, et al. Clinical and microbiological characteristics of bartholin gland abscesses. Obstet Gynecol. 2013;122:791–9.

Mercado J, Brea I, Mendez B, Quinones H, Rodriguez D. Critical obstetric and gynecologic procedures in the emergency department. Emerg Med Clin North Am. 2013;31:207–36.

Tuggy ML. In: Pfenniger JK, Fowler GC, editors. Pfenninger and Fowler's procedures for primary care. 3rd ed. Philadelphia: Elsevier; 2011.

Sexual Assault Forensic Examination

91

Rajnish Jaiswal, Mary T. Ryan, and Muhammad Waseem

When the survivor of a sexual assault seeks medical care, in addition to addressing their medical needs, their forensic needs must also be addressed. This is best achieved by a specialist examiner, who is trained to conduct a Sexual Assault Forensic Examination (SAFE). When the examiner is a nurse, he or she is referred to as a Sexual Assault Nurse Examiner (SANE). In designated centers, the forensic examiner and the nurse, physician, law enforcement officials, social workers, and patient advocates work together as a Sexual Assault Response Team (SART).

The process of caring for survivors of sexual assault continues to evolve and reflects the advances in forensic science, judicial reform, and our understanding of assault survivor psychology.

However, when an emergency medical condition exists, it should be addressed by the designated medical team. The role of the SAFE examiner becomes secondary in these situations. Life- or limb-threatening injuries always take priority over forensic evidence collection, although emergency medical care can often be rendered without compromising existing evidence.

Indications

- Survivors of sexual assault who seek and consent to forensic examination.
- The upper limit of time for evidence collection varies from state to state (e.g., 96 h in New York State [1]).

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Contraindications

- Absolute
  - If the survivor does not consent to evidence collection
- Relative
  - If the upper time limit has been exceeded

Materials and Medications

- Ideally, a designated SAFE room should be available.
- Standardized sexual assault evidence collection kits.
- Gloves.
- Camera.
- Portable light source.
- Swab dryer.
- Wood's lamp.
- Anoscope.
- Colposcope, ideally with a camera.
- Support material for survivors: information pamphlets and clothing.
- Prophylactic medications: antibiotics, antiretrovirals, and contraceptives.

Procedure: "Prepare the Patient, Prepare the Room"

1. Informed Consent
   - A separate consent is required for the SAFE. Obtaining consent has important psychosocial implications for the survivor and returns "control" and "choice" to him or her at this critical time [2]. If the survivor chooses not to undergo a SAFE, the examiner must respect his or her decision. Consent is not an "all-or-none" phenomenon, and survivors can chose to consent to some steps and decline others. The examiner should be respectful of their decision.

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- Consent for the SAFE should include consent for evidence collection, forensic photography, release of evidence to law enforcement, and permission to discuss the findings of the SAFE with investigators.

2. Law Enforcement Involvement
   - State laws vary in terms of reporting requirements for sexual assault. The examiner should be familiar with the requirements in the state in which he or she practices. All survivors should be offered law enforcement involvement, and the benefits of doing so should be outlined to them.
3. Evidence Collection
   - Sexual assault evidence collection kits are specialized preassembled kits containing essential materials for collecting and preserving evidence (Fig. 91.1). The kit contains written instructions, swabs, envelopes, body diagrams, and an integrity seal for the examiner's use.
4. Forensic Interview and History Taking
   - The forensic interview is the first step in the SAFE process. It is a therapeutic as well as a forensic exercise, designed to establish rapport with the survivor, offer support, and gather information to help guide the medical care and direct evidence collection. Acquiring information is a continuous process that ends only when the survivor-SAFE interaction ends.
   - The survivor's exact words with quotation marks should be recorded. A simple factual account of events should be documented. Avoid biased or prejudicial language, such as "allegedly" or "claims." Relevant information includes the time of the assault, the type of contact involved (offender-survivor and survivor-offender), the number of people involved, and the survivor's activities since the assault. A basic medical and obstetrical-gynecological history is also relevant. The SAFE interview is not an investigative interview. Investigation of the sexual assault is the role of law enforcement.
5. General Physical Examination
   - The patient should be asked to undress over a paper sheet to allow any trace evidence to fall and be collected. He or she should be given a gown to wear. A systematic head-to-toe examination should be undertaken. Identify any injuries, no matter how minor. Document them in writing, on a body diagram (Fig. 91.2), and, when possible, with photography. Pay attention to areas that can be easily overlooked: in the mouth, behind the ears, under the chin, and the soles of the feet, for example. Take time to palpate the scalp for areas of tenderness.
6. Injury Documentation
   - Always take time during documentation. Describe the type of injury—abrasion, contusion, laceration, or bite mark. Document the size and site of the injury; ideally include a measuring device in the photograph. A commonly used scale is the one provided by the American Board of Forensic Odontology (ABFO) (Fig. 91.3). If an injury appears to have a shape or

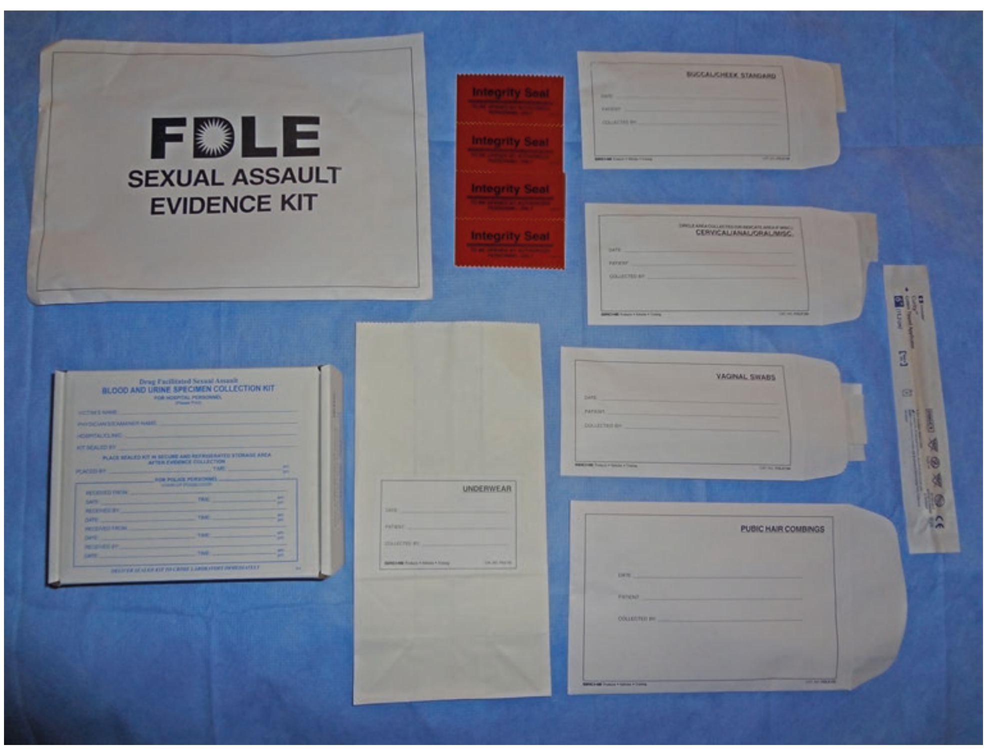

Fig. 91.1 Sexual assault evidence collection kit

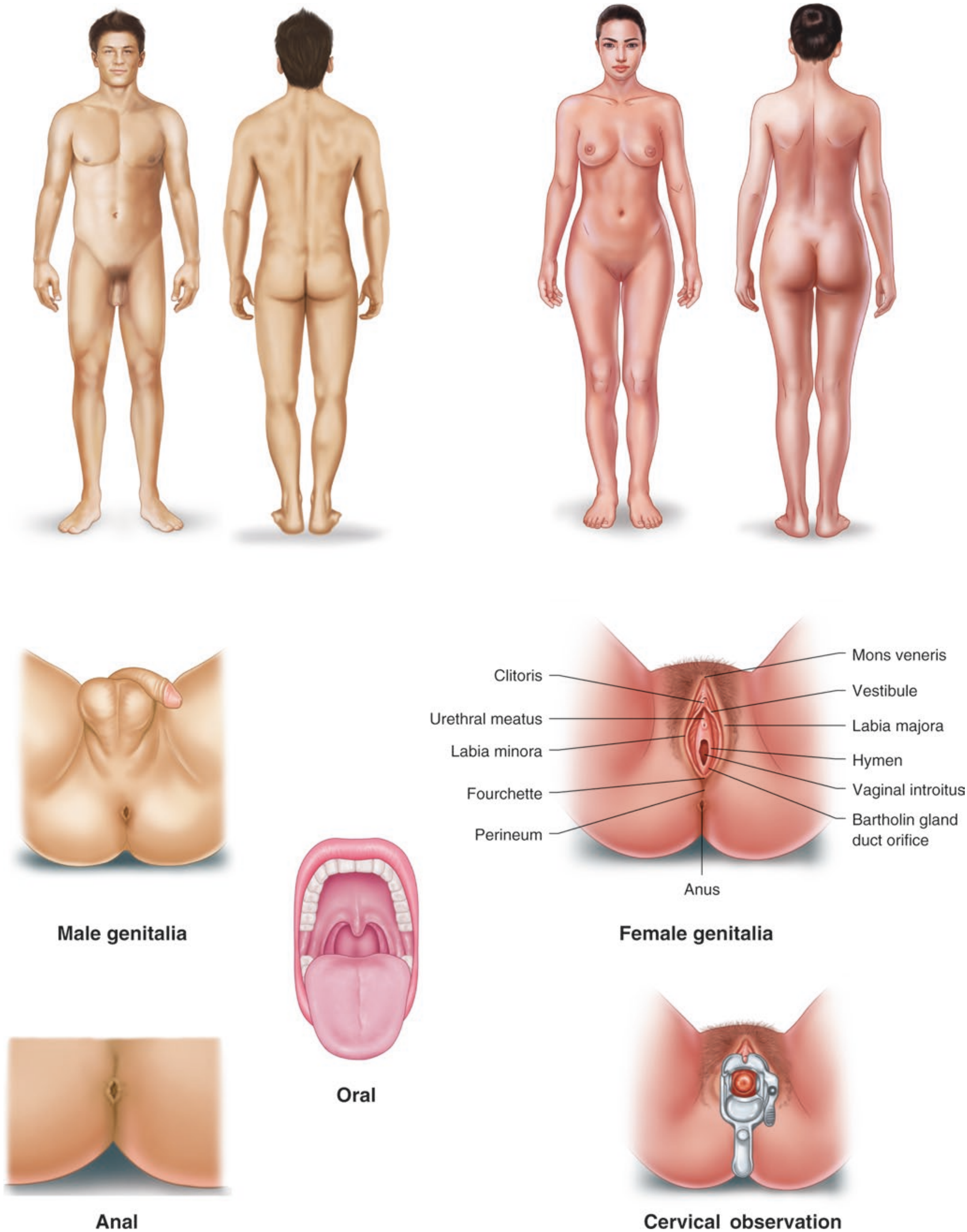

Fig. 91.2 Traumagram

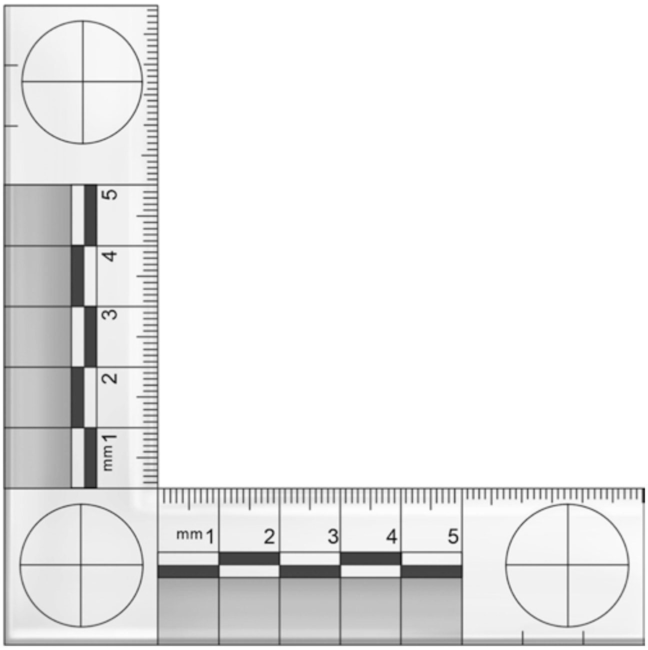

Fig. 91.3 American Board of Forensic Odontology (ABFO) scale. (Courtesy Bronx SART Program)

pattern (e.g., linear, circular, curvilinear, petechial), describe it without drawing specific conclusions.

7. Bite Marks
   - Bite marks require additional evaluation because they may have salivary trace evidence associated with them. In addition to being described and photographed, they should be swabbed and the dried swabs included in the evidence collection kit.
8. Forensic Pelvic Examination
   - The purpose of the genital examination (external and speculum) is to identify injury and collect forensic evidence.
9. Inspection
   - Visually examine the external genitalia. Separate the labia and look in skinfolds and at the posterior fourchette for injury. The TEARS mnemonic (T = tear, E = ecchymosis, A = abrasions, R = redness, S = swelling) is a useful tool while inspecting and documenting. External genital injury findings can be photographed using a standard camera (digital or conventional 35 mm) or a colposcope camera for additional magnification.
10. Speculum Examination
    - Insert a moistened speculum under a good light source, and inspect the vault and cervix for any injuries or possible trace evidence for collection (pooled secretions, hair, retained condom, debris). A colposcope (Fig. 91.4) is a useful adjunct and allows for magnification and assists in injury identification and photodocumentation.

Fig. 91.4 Colposcope. (Courtesy Bronx SART Program)

    - Bimanual pelvic examination may be a part of some protocols but is not mandatory.
11. Rectal Examination
    - Inspect the area looking for fissures, bleeding, or secretions. Anoscopy, if indicated by this history and permitted by the survivor, should be performed and the findings documented and photographed.
12. Evidence Collection
    - The evidence collection kit should be opened and the contents laid out in a systematic way. Once the evidence collection kit has been opened, it cannot be left unattended at any time. Each envelope should be labeled with the survivor's name and the time and date of collection. The required swabs and slides are included in the kit.
13. Collection of Biological Material
    - Evidence collection will include oral, anal, and vaginal swabs. Swabs should be allowed to air-dry before being placed back in the envelopes. Trace evidence should be collected and may include nail scrapings, dried secretions, loose hair collection, and possible foreign bodies (e.g., soil, condom). A Wood's lamp may help the examiner to identify dried secretions on the skin or clothing. When each step is completed, the envelope will be closed, sealed, and signed by the examiner and returned to the box.
    - When completed, the sexual assault evidence collection kit (SAECK) is closed, the provided evidence seal placed on the box, and the seal signed and dated by the examiner. The evidence is then given to law enforcement (if the patient consents) or maintained in a predesignated, secure locked area if law enforcement is not yet involved in the case. Each time evidence is passed from person to person, the transfer must be documented in writing to ensure it is not compromised or tampered with in any way. This is

the underlying principle of maintaining a "chain of custody." This chain must be maintained for evidence to be admissible in court.

14. Collection of Clothing
    - Clothing may be considered "evidence" and collected in some cases. Depending on the case, this may include underwear and any feminine hygiene products. These may fit in the evidence collection kit itself. Larger items of clothing and/or shoes will need to be collected separately. They should be placed in an appropriately sized paper bag and labeled with the patient's name. The bag should be sealed, signed, and dated by the examiner in the same way as all other evidence. Any additional evidence should remain with the SAECK. The survivor should be provided with replacement clothes and underwear.
15. Forensic Photography
    - Although the examiner is not expected to be a specialized forensic photographer, photodocumentation of injuries is an important part of the SAFE. A separate consent is required. Either a conventional 35-mm camera or a high-resolution digital camera is acceptable.
    - At least one image should include the survivor's face or some form of identifying marks. Near and far images should be taken. The camera should be held at 90° to the surface to avoid distortion of the image. A tape measure should be included when an injury is being photographed. An identifier, like medical record number or case number, should be visible in the image if possible. The examiner should document in the records that photographs were taken.
16. Investigations
    - Serologic tests for syphilis, hepatitis B virus (HBV), hepatitis C virus, and HIV should be obtained. Urine should be sent for analysis and pregnancy testing. Urine for toxicology may be useful in selected cases. Testing for gonorrhea and chlamydia before starting prophylactic antibiotics may be undertaken, but this remains controversial.
17. Prophylaxis
    - Survivors should be offered prophylaxis against pregnancy, common sexually transmitted infections, HBV, and HIV. The current Centers for Disease Control and Prevention (CDC) guidelines recommend the following:

    (a) HBV vaccination should be offered to sexual assault victims at the time of the initial examination if they have not been previously vaccinated. Postexposure HBV vaccination, without hepatitis B immunoglobulin (HBIG), should adequately protect against HBV infection. Follow-up doses of vaccine should be administered 1–2 and 4–6 months after the first dose.

    (b) An empirical antimicrobial regimen for chlamydia, gonorrhea, and trichomonas should be offered.
    - Recommended regimens:
      - *Ceftriaxone* 250 mg intramuscularly in a single dose
      - *PLUS*
      - *Azithromycin 1 g* orally in a single dose
      - *PLUS*
      - *Metronidazole* 2 g orally in a single dose
      - *OR*
      - *Tinidazole 2 g orally in a single dose*

    (c) Emergency contraception protocols are state and institution specific. A negative pregnancy test should be documented before evidence collection.

    (d) Update tetanus profile if indicated.

    (e) HIV postexposure prophylaxis:
    - All patients with significant exposure should receive pretest counseling and postexposure prophylaxis as per CDC guidelines [3].

Pearls and Pitfalls

- Pearls
  - Survivors will need to have both medical and psychosocial follow-ups. Medical referrals should include gynecology and primary care for follow-up of their baseline serology, testing and completion of HBV vaccination regimen, and so on.
  - Referrals for counseling and information with 24-h hotlines should be provided. Recovery from a sexual assault is a process and is best achieved by a long-term support network [4].
- Pitfalls
  - It is estimated that survivors are men in fewer than 10% of cases, although sexual assault in males appears to be greatly underreported. The same principles for evidence and prophylaxis apply for the SAFE.

References

1. Department of Health, State of New York. Acute care of the adult patient reporting sexual assault. 2004.
2. Criminal Victimization in the United States 2010. Washington, DC: US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics; 2010.
3. Varghese B, Maher JE, Peterman TA, et al. Reducing the risk of sexual HIV transmission. Sex Transm Dis. 2002;29:38–43.
4. Parekh V, Brown CB. Follow up of patients who have been recently sexually assaulted. Sex Transm Infect. 2003;79:349.

Treatment of Priapism

92

Jeffrey Kile, Katrina John, and Amish Aghera

Indication

- Ischemic (“low-flow”) priapism

Contraindications

- To cavernosal aspiration/irrigation:
  - Nonischemic (“high-flow”) priapism
  - Overlying cellulitis
  - Uncontrolled bleeding disorder
  - Skin infection at the site of injection
- To intracavernosal injection of vasoactive agents (α-adrenergic sympathomimetics):
  - Severe hypertension
  - Dysrhythmias
  - Monoamine oxidase inhibitor use

Materials and Medications (Fig. 92.1)

- Sterile gloves
- Antimicrobial solution and swabs
- 4 × 4 gauze sponges
- Local anesthetic (1% lidocaine 5 mL and 0.5% bupivacaine 5 mL, without epinephrine)
- 10-mL syringe
- 20-mL syringe
- 19- or 21-gauge butterfly or straight needles (2)
- Blunt needle
- 27-gauge needle
- Normal saline, 1000 mL
- Phenylephrine 1% solution (10 mg/mL), 1 mL

Noninvasive Therapy Preprocedure

1. Administer analgesia (e.g., parenteral opiates, benzodiazepines).
2. Administer subcutaneous terbutaline as soon as the diagnosis is suspected (0.25–0.5 mg subcutaneous in quadriceps, deltoid, or gluteus maximus):
   - If resolution of priapism does not occur with subcutaneous terbutaline, proceed to cavernosal aspiration.

Procedures

Dorsal Penile Nerve Block Procedure: Often Unnecessary

1. Position the patient in the supine position.
2. Apply povidone-iodine solution liberally to the penis and scrotum using a 4 × 4 gauze pad.
3. Clean the glans and shaft of the penis in a circular motion.
4. Establish a sterile field by placing drapes between the scrotum and the shaft, above the shaft, and on either side (Fig. 92.2).
5. Draw up 5 mL 0.5% bupivacaine and 5 mL 1% lignocaine (both without epinephrine) into a single syringe.
6. Using a 27-gauge needle, inject local anesthetic superficially to raise skin wheals at the (dorsal) 2 and 10 o’clock positions as proximal to the base of the penis as possible.
7. Insert the needle through the wheal at the 2 o’clock position at the base of the penis until it contacts the pubic symphysis.

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Fig. 92.1 Materials and medications

Fig. 92.2 Priapism in sterile field

8. Withdraw the needle slightly and walk the needle in a caudal fashion down the pubis until the needle passes immediately below the symphysis, and advance to a depth of 5 mm deeper than the depth of the pubic symphysis (Fig. 92.3):
   - A transmitted "pop" may be felt as the needle penetrates the superficial penile fascia beneath the symphysis.
9. Aspirate to confirm the tip of the needle is not within the lumen of a vessel.
10. Inject 4 mL of solution.
11. Repeat the injection of local anesthetic as outlined at the 10 o'clock position of the penile base to anesthetize the right dorsal penile nerve (Fig. 92.4).

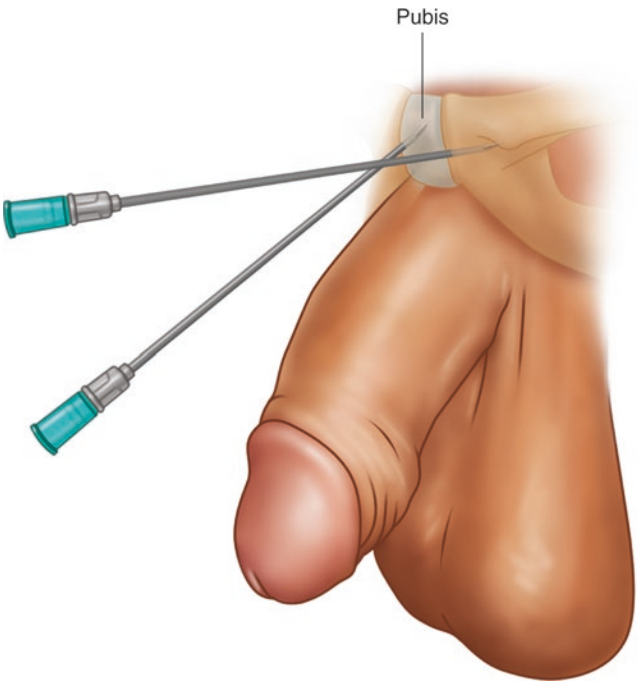

Fig. 92.3 Schematic anatomy of dorsal penile nerve block

Fig. 92.4 Injection of local anesthetic

Intracorporeal Injection Procedure

1. Prepare a diluted concentration of 100 µg/mL (1 mg/10 mL) phenylephrine solution by aspirating 0.1 mL of standard 1% (10 mg/mL) phenylephrine solution into a 10-mL syringe and then adding normal saline to a total volume of 10 mL.
2. Attach a 25- or 27-gauge needle to the syringe.
3. Puncture the corpus cavernosum at the 2 o'clock *or* 10 o'clock position (~+60° or −60° from the midline) on the suprapubic aspect of the penis approximately 1 cm from the penile base:
   - Puncture only one side of the penis.
4. Confirm the position of the needle by drawing back on the plunger to aspirate blood from the corpus cavernosa.
5. Inject 1 mL of phenylephrine solution every 3–5 min:
   - Repeat injections of phenylephrine (up to the maximum dose of 1000 µg) should be continued until the erection resolves; only thereafter should this procedure be abandoned in favor of the more invasive approach of surgical shunt.
6. Wrap the detumescent penis in gauze or an elastic bandage to prevent the return of priapism and to compress the puncture site(s).

Cavernosal Aspiration Procedure

1. Attach a 19- or 21-gauge butterfly or straight needle to a syringe.
2. Puncture the corpus cavernosa at the 2 o'clock or 10 o'clock position (~+60° or −60° from the midline) on the suprapubic aspect of the penis approximately 3 cm from the penile base, directing the needle straight toward the center of the ipsilateral cavernosum:
   - Never use the glans as a puncture site during this procedure.
3. Advance the needle slowly while drawing back on the plunger until blood is visible in the syringe (blood is usually easily aspirated).
4. Once blood is obtained, do not advance further, stabilize the needle, and use one hand to aspirate 20–30 mL of blood while milking the corpus with the free hand (Fig. 92.5):
   - The needle should not be advanced further once blood is visible in the syringe to minimize the risk of injury to the cavernosal artery.
   - Avoid excessive negative pressure on the plunger because this often halts aspiration.
   - If detumescence is not achieved using the above steps, proceed with the following steps.
5. Insert an irrigation needle by puncturing the corpus cavernosum on the same side of the penis punctured with the aspiration needle, approximately 1 cm from the penile base.

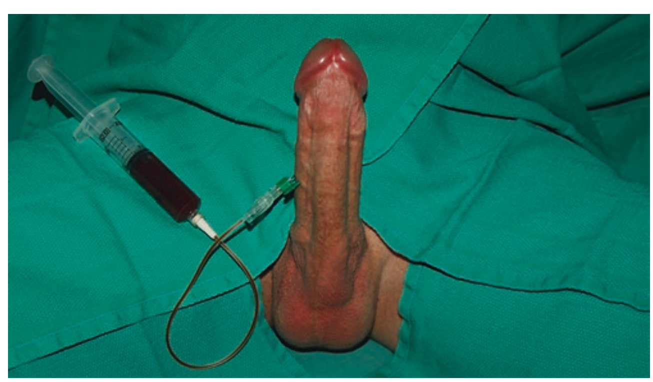

Fig. 92.5 Aspiration of cavernosal blood

6. Irrigate the oxygen-depleted blood in the cavernosa by injecting 20–30 mL of 0.9% normal saline via the proximal needle in exchange for the blood aspirated (Fig. 92.6).
7. Repeat the cycle of aspiration of 20- to 30-mL volumes of blood from the distal needle followed by irrigation with an equal volume of 0.9% normal saline via the proximal needle until flow into the syringe of dark red (oxygen-depleted) blood ceases and bright red (oxygen-rich) blood is aspirated or until detumescence is achieved (Fig. 92.7):
   - When removing the needle after cavernosal aspiration, compress the puncture site for approximately 1 min to prevent hematoma formation.
8. Wrap the detumescent penis in gauze or an elastic bandage to prevent return of priapism and to compress the puncture site(s) (Fig. 92.8).

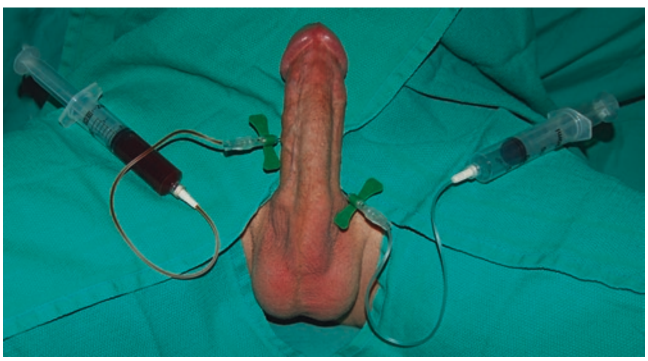

Fig. 92.6 Aspiration and irrigation of cavernosal blood

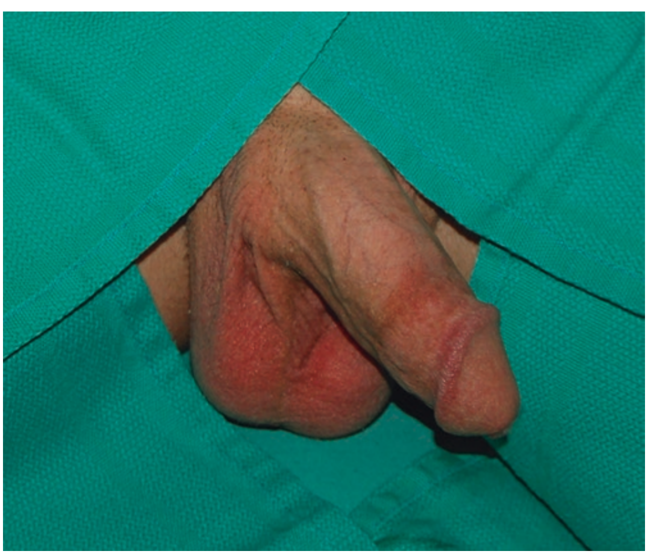

Fig. 92.7 Detumescence

Fig. 92.8 Detumescent penis wrapped in compression dressing

Complications

- Of intracavernosal injection of vasoactive agents (α-adrenergic sympathomimetics):
  – Fibrosis of the corpora, pain, penile necrosis, and urinary retention
  – Phenylephrine toxicity
  – Acute hypertension, headache, reflex bradycardia, tachycardia, palpitations, and cardiac arrhythmia
- Of cavernosal aspiration/irrigation:
  – Hematoma (at puncture site)
  – Infection (at insertion site or systemic)
  – Thrombosis
  – Arteriovenous fistula
  – Pseudoaneurysm formation
  – Traumatic puncture of dorsal penile or urethra
  – Exsanguination (secondary to dislodgement of catheter)
  – Cerebrovascular accident (secondary to air embolism)

Pearls and Pitfalls

- Pearls
  – In ischemic priapism, the penis and corpora cavernosa are rigid and tender to palpation.
  – Ischemic priapism commonly results from an underlying hypercoagulable state, tumor, infection, neurological impairment ("spinal shock"), or vasoactive drug use.
  – During intracorporeal injection, the patient should be monitored for known side effects of sympathomimetics, including hypertension, headache, reflex bradycardia, tachycardia, palpitations, and cardiac arrhythmia.
  – Seek a urological consult as soon as possible for any patient presenting with priapism.

- Resolution of priapism can be verified by measurement of cavernous blood gases or measurement of blood flow by color duplex ultrasonography.
- Phenylephrine is the sympathomimetic agent of choice for intracavernosal injection because it is has a lower likelihood of causing adverse cardiovascular side effects than other agents. If this is unavailable, alternatives include epinephrine and norepinephrine
- Intracavernous aspiration/irrigation/injection therapy is unlikely to resolve ischemic priapism lasting for 48 h or longer. In such cases, immediate surgical shunting is first-line treatment.
- Once detumescence is achieved, any unmetabolized drugs in the corpus cavernosa enter the venous circulation, and thus, dosages of any vasoactive drugs injected must be monitored carefully.

• Pitfalls
  - The most common complication of ischemic priapism is complete erectile dysfunction.

Considerations

Blood Gas Analysis

This investigation provides a rapid distinction between ischemic and nonischemic priapism. Blood aspirated from the corpus cavernosum in ischemic priapism is dark in color with partial pressure of oxygen (PO_2) less than 30 mmHg, partial pressure of carbon dioxide (PCO_2) greater than 60 mmHg, and pH less than 7.25. In nonischemic priapism, respective values will be PO_2 greater than 90 mmHg, PCO_2 less than 40 mmHg, and pH of 7.4 (Table 92.1).

Sickle Cell Testing

The sickle-solubility test detects any sickle hemoglobin (therefore, it is positive in patients with either sickle cell train or sickle disease). Hemoglobin electrophoresis with 10% or greater HbS suggests sickle cell disease. Anemia and increased reticulocyte count may also be present in sickle cell disease.

Table 92.1 Summary of cavernosal blood gas findings

	pH	PO_2 (mmHg)	PCO_2 (mmHg)
Ischemic priapism	<7.25	<30	>60
Arterial blood	7.40	>90	<40
Mixed venous blood	7.35	40	50

PCO_2 partial pressure of carbon dioxide, *PO_2* partial pressure of oxygen

Hemoglobin Electrophoresis

Confirmatory test for sickle status after a positive sickle-solubility test.

Complete Blood Count

White blood cell (WBC) count may suggest infection or blood dyscrasia. Hemoglobin (Hb) and reticulocyte counts may suggest sickle cell disease.

Color Duplex Ultrasonography

Blood flow in cavernosal arteries is absent or minimal in ischemic priapism, whereas flow velocity is normal to high in nonischemic priapism.

Urine Toxicology and Psychoactive Drug Screen

The following drugs have been associated with priapism: antihypertensives, anticoagulants, antidepressants, alcohol, marijuana, cocaine, and other illegal substances. Intracavernous injection therapy using drugs such as alprostadil, papaverine, prostaglandin E1, phentolamine, and others may precipitate priapism.

Suggested Reading

Burnett AL, Bivalacqua TJ. Priapism: new concepts in medical and surgical management. Urol Clin North Am. 2011;38:185–94.

Dubin J, Davis JE. Penile emergencies. Emerg Med Clin North Am. 2011;29:485–99.

Montague DK, Jarow J, Broderick GA, et al.; Members of the Erectile Dysfunction Guideline Update Panel; American Urological Association. American Urological Association guideline on the management of priapism. J Urol. 2003;170:1318–24.

Shrewsberry A, Weiss A, Ritenour CW. Recent advances in the medical and surgical treatment of priapism. Curr Urol Rep. 2010;11:405–13.

Vilke GM, Harrigan RA, Ufberg JW, Chan TC. Emergency evaluation and treatment of priapism. J Emerg Med. 2004;26:325–9.

93 Reduction of Paraphimosis

Justin Chen and Muhammad Waseem

Indication

- Reduction is always indicated.

Contraindications

- Absolute
  - Failure to rule out penile swelling and pain due alternative conditions (e.g., posthitis/balanoposthitis, angioedema, insect bite, constricting band)

Materials and Medications

- Latex-free gloves (sterile)
- Local anesthetic:
  - 2% lidocaine without epinephrine (preferred)
  - 2% lidocaine gel or eutectic mixture of local anesthetics (EMLA) cream (2.5% prilocaine and 2.5% lidocaine)
- 25- to 27-gauge 1.5-in. needles (2)
- Small plastic syringe, 10 mL (1)
- Bag of ice (1)
- 2-inch elastic pressure dressing (1)
- Sterile gauze (1)

Procedure: Manual Reduction for Paraphimosis

1. Place the patient in the supine position, and carefully inspect the penis for constricting bands or foreign bodies (e.g., piercings).
2. Usage of penile block to provide analgesia to the shaft and glans penis depends on urgency, patient age, and cooperativeness.
3. Relieve tissue edema before attempting reduction by using:
   (a) Bag of ice (3 min at a time)
   (b) Granulated sugar (*contraindicated* in emergent situations owing to time required)
   (c) Manual compression (squeezing the foreskin and glans for 5 min)
   (d) Pressure dressing (2-in. elastic bandage over the glans for 5 min)
4. Grasp the swollen foreskin and elevate upward with one hand while pushing the glans into the foreskin with the other hand.
5. Place both thumbs over the glans, with both index fingers and long fingers surrounding the trapped foreskin proximal from the paraphimotic tissue. Use the thumbs to push the glans back into the foreskin while pulling the trapped foreskin distally, which may require a few minutes of constant pressure (Fig. 93.1).
6. Can also attempt using Babcock (one in each quadrant) or Adson (3 and 9 o'clock positions) forceps to grasp the paraphimotic tissue (Fig. 93.2):
   (e) If ineffective owing to extreme tissue edema, seek emergent urological consultation.
   (f) Follow-up with urologist is always recommended; circumcision may be performed once infection and edema have resolved to prevent recurrence (Fig. 93.3).

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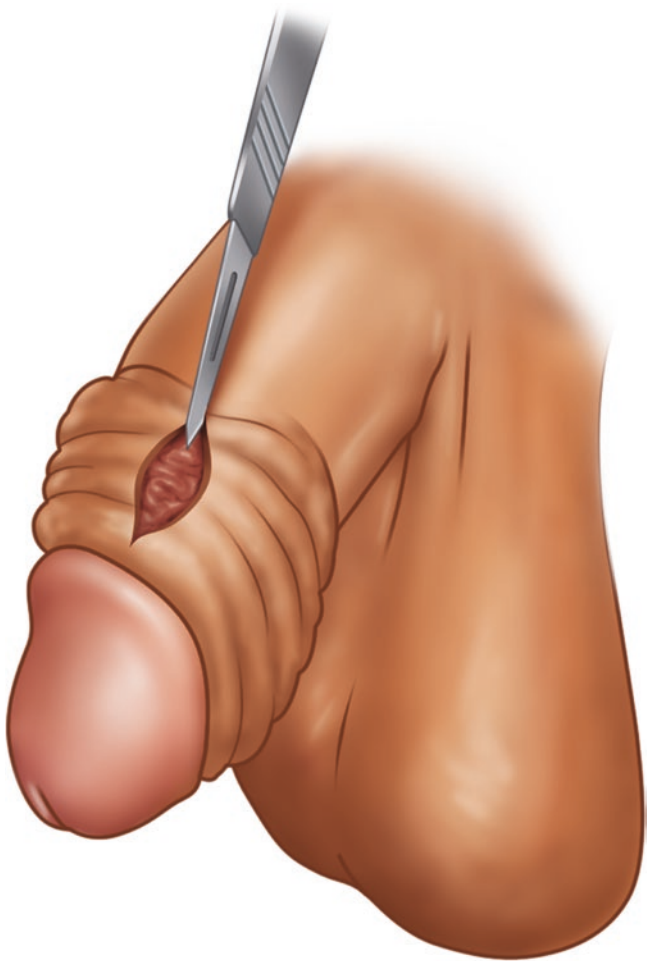

Fig. 93.1 Use the thumbs to push the glans back into the foreskin while pulling the trapped foreskin distally

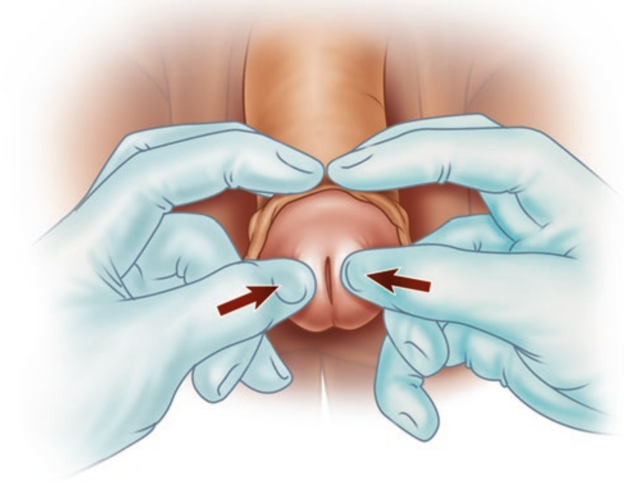

Fig. 93.2 (**a**) Babcock forceps. (**b**) Adson forceps

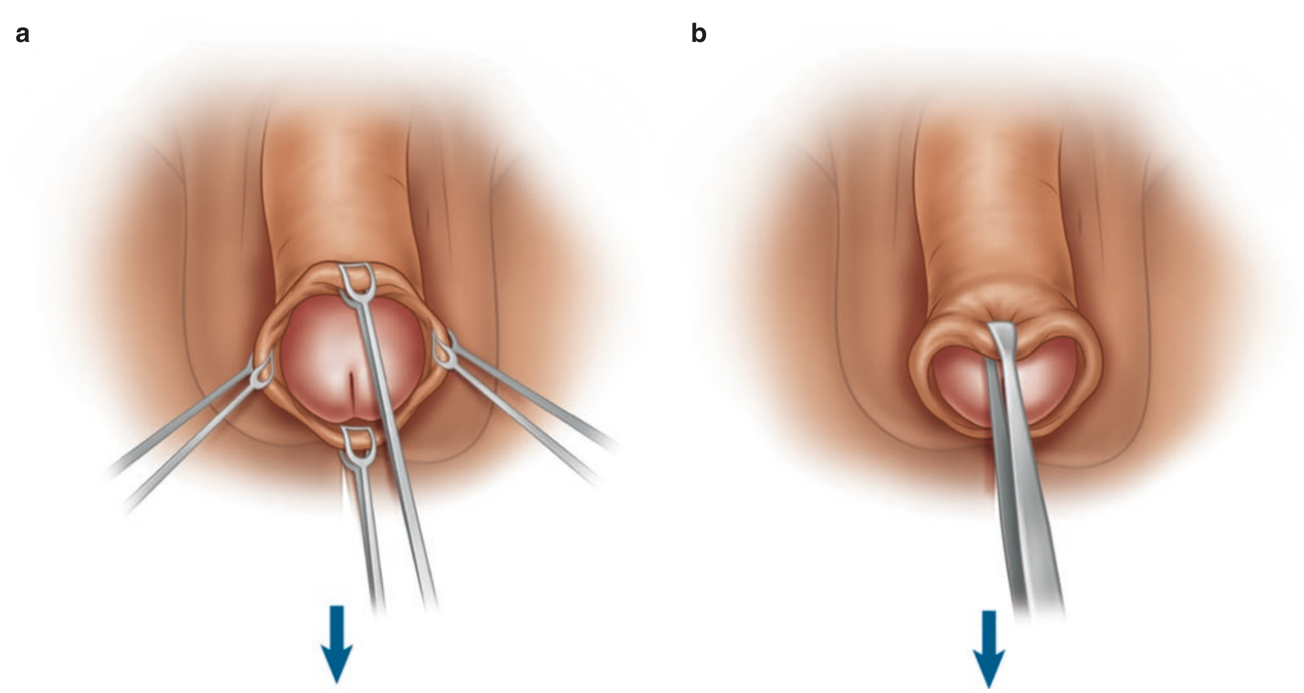

Fig. 93.3 Circumcision may be performed once infection and edema have resolved to prevent recurrence

Complications

- Bleeding/infection of injection site(s).
- Phimosis and scarring due to foreskin manipulation.
- Usage of Adson or Babcock forceps may result in minor bruising and abrasion to the foreskin and glans penis.

Pearls and Pitfalls

- Pearls
  – If arterial compromise is imminent in paraphimosis, the emergency physician should attempt reduction if urological consult is unavailable.
- Pitfalls
  – Reduction of phimotic tissue over the coronal sulcus may lead to emergent paraphimosis.

Suggested Reading

Doherty GM, editor. Current diagnosis and treatment: surgery. 13th ed. New York: McGraw-Hill Medical; 2010.

King C, Henretig FM, editors. Textbook of pediatric emergency procedures. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2008.

Knoop KJ, editor. Atlas of emergency medicine. 3rd ed. New York: McGraw-Hill Professional; 2010.

Smith DR, Tanagho EA, McAninch JW, editors. Smith's general urology. New York: Lange Medical Books/McGraw-Hill; 2008.

94 Manual Testicular Detorsion

Sapan Shah and Latha Ganti

Testicular torsion, where the testicle rotates around the spermatic cord (Fig. 94.1), is a common urologic emergency which requires immediate assessment and intervention in the emergency department. It typically presents in males after birth or during adolescence, with an incidence of 1 in 4,000 in males under 25 years of age. Early detection and manual detorsion by hand are key to preventing testicular infarction and resultant sterility, especially if surgical exploration and orchidopexy are not immediately available. Torsion is a clinical diagnosis but can be confirmed with ultrasonography when in doubt (Fig. 94.2).

Indications

- Twisting of testicle around spermatic cord
- Can present as:
  - Acute onset asymmetric severe scrotal pain
  - Scrotal edema
  - Thickened spermatic cord
  - Absent cremasteric reflex
  - Nausea and vomiting
  - Palpable, tender "knot-like" mass superior to the affected testis

Contraindications

- Significant scrotal wall thickening
- Torsion duration >12 hours

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Materials and Equipment

- Barrier precautions for clinician

Procedure

1. Position patient supine or standing. Stand in front of the patient.
2. Use contralateral hand to hold the affected testicle between the thumb and index fingers.
3. Pushing upwards to promote cremasteric reflex, as if opening a book, rotate affected testicle 180 degrees from medial to lateral (clockwise for the right testicle, counterclockwise for the left testicle) (Fig. 94.3).
4. Assess patient to determine if testicular pain is still present.
5. If pain has not immediately ceased, continue to rotate the affected testicle 180 degrees at a time laterally, lifting caudal to cranial (because more than one rotation may be necessary if cord is twisted multiple times) (Fig. 94.4).
6. Upon cessation of testicular pain, assess for descent of affected testis and gradual return of cremasteric reflex to confirm successful detorsion.

Pearls and Pitfalls

Pearls

- If pain has not ceased after 1,080 degrees of rotation (6 rotations), the patient may be experiencing a lateral rotation or residual detorsion, detected via surgical exploration.
- Successful testicular torsion does not preclude the need for urological surgical exploration and orchiopexy; residual torsion after cessation of symptoms and recurrence of symptoms are common.

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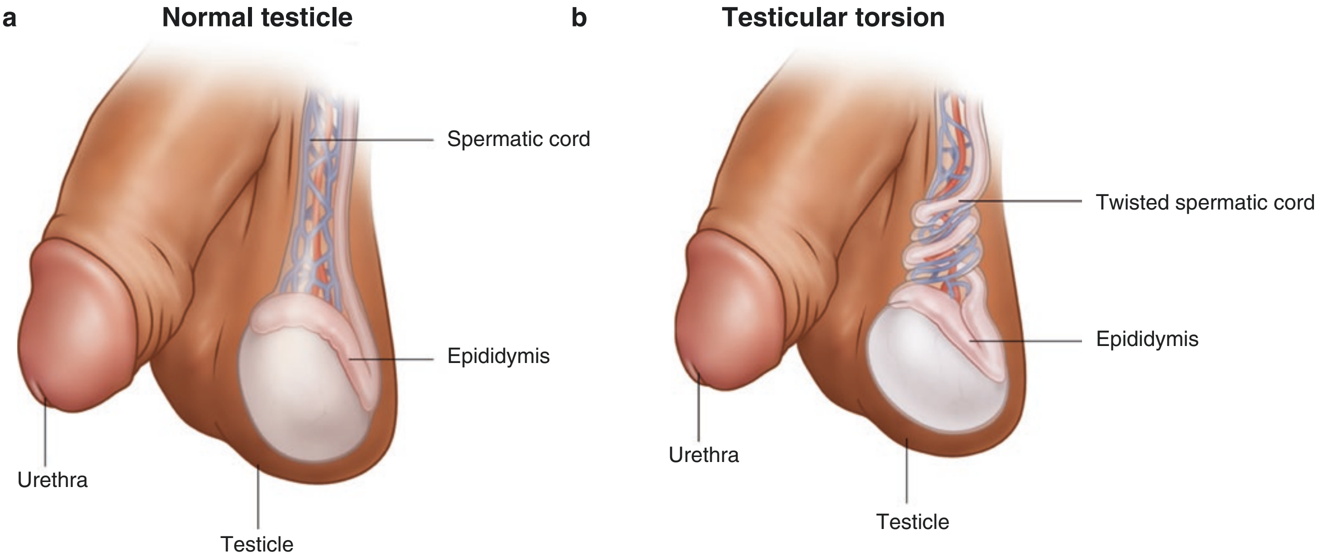

Fig. 94.1 Schematic of normal testicle (**a**) and testicular torsion (**b**)

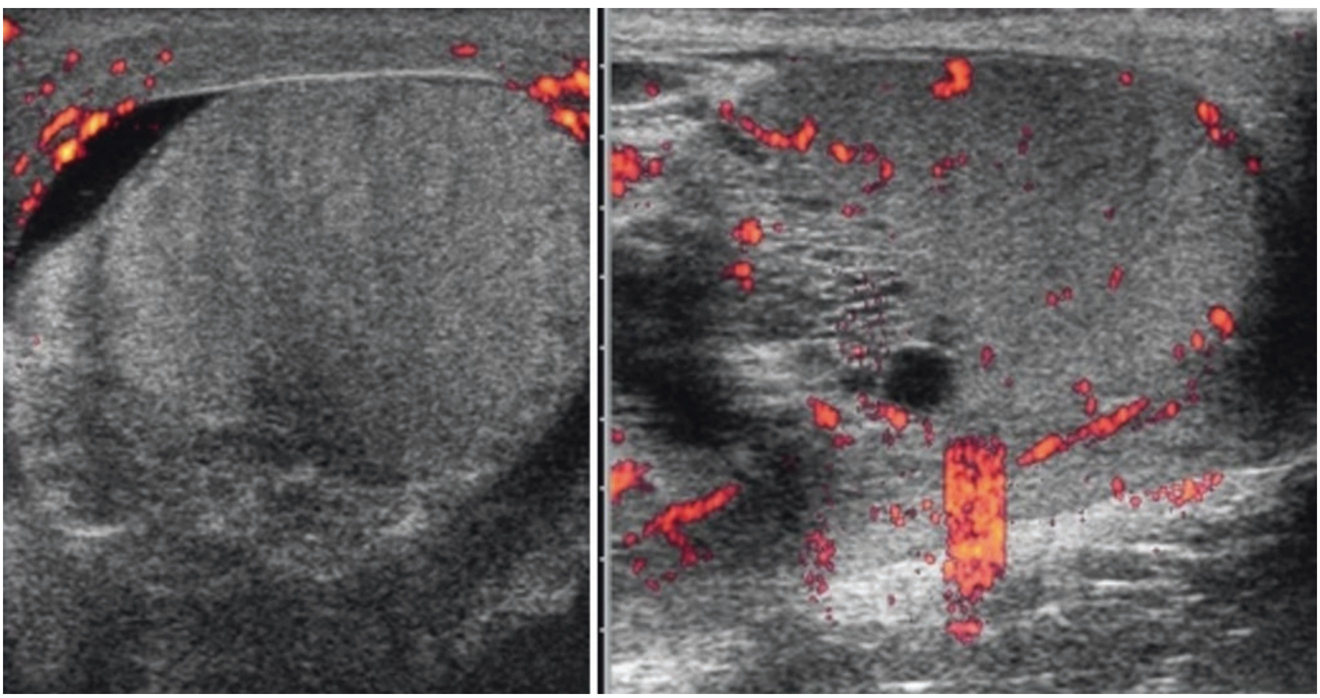

Fig. 94.2 Doppler ultrasound of bilateral testes shows swollen right testis with hypoechoic areas within and reduced arterial signal suggesting testicular torsion with necrosis (*left panel*). This is compared to the left testis which has normal flow (*right panel*). (Reproduced with permission from Bhagra et al. 2008)

- Differential diagnoses include epididymitis (most common), varicocele, hydrocoele, urinary tract infection, and sexually transmitted infection
- The Testicular Workup for Ischemia and Suspected Torsion (TWIST) criteria are helpful for testicular torsion diagnosis. A score of 6–7 is high risk, and all delay needs to be avoided so consider going straight to the OR. Ultrasonography should be considered for scores less than 6.

Testicular swelling	Present = 2 points
Hard testicle	Present = 2 points
Cremasteric reflex	Absence = 1 point
Nausea/vomiting	Present = 1 point
High-riding testicle	Present = 1 point

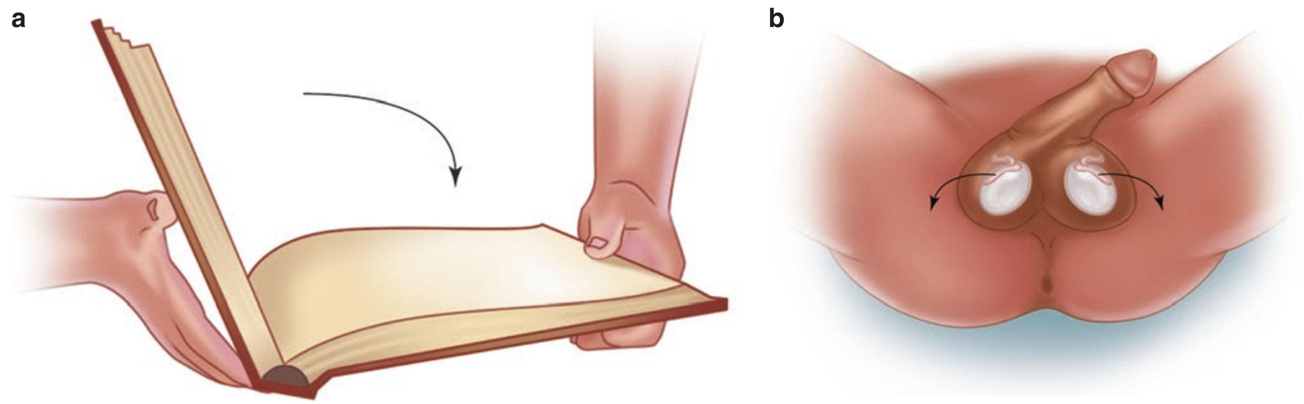

Fig. 94.3 (**a**) As if opening a book, rotate the testicle laterally, away from the midline. (**b**) Affected testicle should be rotated 180° from medial to lateral"

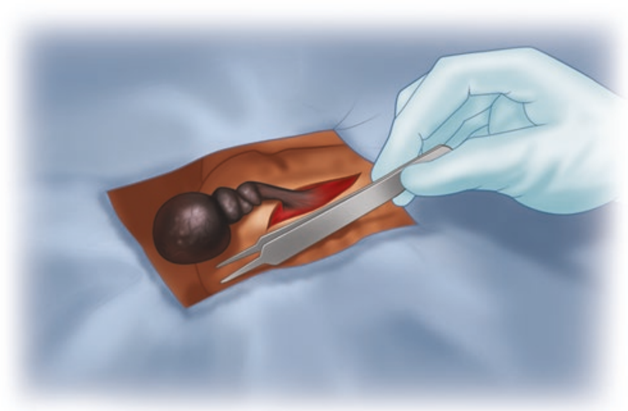

Fig. 94.4 Surgical scrotal orchiopexy of twisted testicle due to testicular torsion. Because torsion of greater than 180° degrees is possible, more than one rotation may be needed to fully detorse the affected testis

Pitfalls

- Without early detection and intervention, testicles are at risk of ischemia and vascular engorgement, leading to lifelong sterility.
- Delaying manual detorsion for imaging or transferring directly impacts testicle salvageability (Frohlich et al. 2017):
  - < 6 hrs: 90+%
  - 6-12 hrs: 20–50%
  - > 12hrs: <10%
- Analgesia or local anesthesia is not recommended in detorsion, as relief of pain is an indication of procedural success.
- Testicular torsion can be easily mistaken for epididymo-orchitis, and must be differentiated prior to detorsion. Look for the following to confirm testicular torsion:
  - Absent cremasteric reflex (cremasteric reflex is present in epididymo-orchitis)
  - Absence of detectable Doppler signal on ultrasonography of affected testicle
  - Whirlpool sign present on ultrasonography of affected testicle

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Suggested Reading

Bhagra A, Suravaram S, Schears RM. Testicular torsion–a common surgical emergency. Int J Emerg Med. 2008;1(2):147.

Cornel EB, Karthaus HF. Manual derotation of the twisted spermatic cord. BJU Int. 1999;83(6):672–4.

Epomedicine. Manual detorsion of testis in Testicular Torsion. Epomedicine; 2017 Oct 28. Available from: https://epomedicine.com/emergency-medicine/manual-detorsion-testis-testicular-torsion/.

Frohlich LC, Paydar-Darian N, Cilento BG Jr, Lee LK. Prospective validation of clinical score for males presenting with an acute scrotum. Acad Emerg Med. 2017;24(12):1474–82. https://doi.org/10.1111/acem.13295.

Laher A, Ragavan S, Mehta P, Adam A. Testicular torsion in the emergency room: a review of detection and management strategies. Open Access Emerg Med. 2020;12:237–46.

Sessions AE, Rabinowitz R, Hulbert WC, Goldstein MM, Mevorach RA. Testicular torsion: direction, degree, duration and disinformation. J Urol. 2003;169(2):663–5.

Part XII

Skin and Soft Tissue Procedures

Check for updates

Local Anesthesia

95

Derek Ailes, Muhammad Waseem, James Chiang, and Ilya Aleksandrovskiy

Indications

- Laceration repair
- Abscess incision and drainage
- Wound exploration
- Vascular access procedures
- Foreign body removal
- Lumbar puncture

Contraindications

- History of allergy (usually to the ester class [e.g., procaine, tetracaine]), amide class (e.g., lidocaine [Xylocaine], bupivacaine, mepivacaine) may be safely substituted if true allergy to esters and vice versa. One percent diphenhydramine (4-mL normal saline: 1-mL 5% intravenous [IV] diphenhydramine [Benadryl] mixture) can be used as local anesthetic in patients with true allergy.
- Topical preparations on mucous membranes, burns, abraded/denuded skin, or eyes owing to potential toxicity from increased absorption and corneal injury.
- Common teaching is to avoid epinephrine-containing anesthetic solutions in the ears, nose, penis, and digits for concern of ischemia owing to end-artery constriction. Recent studies including prospective trials and comprehensive literature reviews, however, do not validate this concern [1, 2].

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Materials and Medications (Fig. 95.1)

- 1% Xylocaine with or without 1:200,000 epinephrine, 0.25% bupivacaine solution. 8.4% (1 mL/mL) sodium bicarbonate (optional)
- 18-gauze fill needle, 25- or 27-gauge needles, and syringes up to 10 mL
- Sterile and nonsterile gloves and face shield
- Alcohol pads and povidone-iodine swabs

Procedure

1. Position the patient in a comfortable position (supine, sitting, anticipating vasovagal response).
2. Draw the anesthetic with an 18-gauge needle into a syringe. Be aware of the maximum dose for the particular local anesthetic to avoid systemic toxicity (Table 95.1).
3. Take steps to minimize the pain of infiltration.
4. Prepare the area with povidone-iodine solution; cover surrounding areas with sterile drapes.
5. Inject subcutaneously by direct infiltration with a 25- to 27-gauge needle noting wheal and blanching. If a clean wound, may inject into wound edges. Usually no aspiration is needed because the infiltration is superficial to major blood vessels.
6. For contaminated wounds or abscess incision and drainage, perform field block by inserting the needle into the clean intact skin adjacent to the wound and continuing in a circular manner around the wound, injecting into the previously anesthetized area (Fig. 95.2).
7. Wait several minutes for the local anesthetic to provide the maximum effect.
8. Test the area for sharp sensation with a needle tip or other sharp object.

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Fig. 95.1 Local anesthesia materials

Table 95.1 Common anesthetics and their characteristics

Medication	Time to onset (min)	Length of action (minutes)	Maximum dose without epinephrine (mg/kg)	Maximum dose with epinephrine (mg/kg)
Bupivacaine 0.25%	5–10	240–480	2–2.5	3.0
Lidocaine 1%	2–5	50–120 (without epi) 60–180 (with epi)	4–5	5–7
Mepivacaine 1%	2–5	50–120 60–180	5	5–7
Procaine 1%	5–10	60–90	7–10	NA
Lidocaine-prilocaine (EMLA)	60	60–120	1–2g per $10cm^2$ area	NA
Lidocaine-epinephrine-tetracaine (LET)	20–30	45–60	NA	1–3mL
Tetracaine gel	30–45	240–360	1g per $6.25cm^2$	

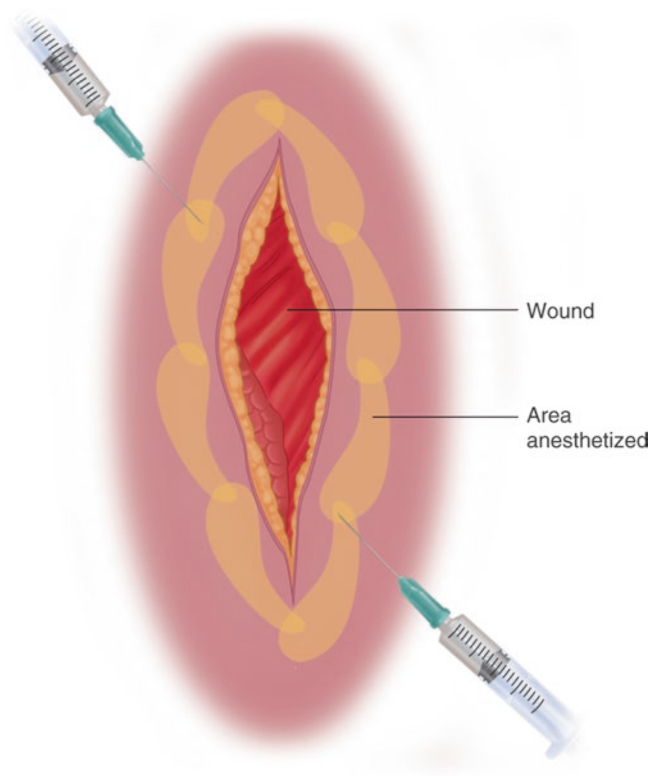

Fig. 95.2 Local infiltration should be performed in a circular fashion with each injection performed over the prior anesthetized area

Complications

- Systemic toxicity
- Allergic reaction
- Infection
- Digital artery vasospasm from accidental injection of epinephrine (can be reversed with topical nitroglycerine or subcutaneous phentolamine)
- Vasovagal response

Pearls

- Minimize or reduce the pain of infiltration by use of the following:
  - Warm Xylocaine before infiltration (blanket warmer or water bath) [3].
  - Buffer Xylocaine with 1-mL 8.4% sodium bicarbonate for every 10 mL of Xylocaine. Buffer bupivacaine with 0.05–0.10-mL sodium bicarbonate for every 10 mL of bupivacaine (greater chance of precipitation).
  - Use a small-gauge needle (e.g., 27 gauge) and inject slowly.
  - Use a small syringe (1–3 mL) to reduce the pressure of injection.
  - Withdraw the needle and, just before exiting the skin, redirect and inject.
  - Inject in a circular manner around the wound with each subsequent injection entering a previously anesthetized area, such that the patient feels only one needle stick (Fig. 95.2).
  - Inject into the subcutaneous plane as opposed to the intradermal plane.
  - Consider using a topical anesthetic before infiltration, especially in pediatrics (lidocaine-epinephrine-tetracaine [LET]).

  Beware of toxicity by not exceeding the maximum dose, especially in large or multiple lacerations. Even at standard doses, toxicity can occur with inadvertent vascular injection, injection into highly vascular areas, or onto mucous membranes:
  - Convert % mg/mL into mg/kg by moving the decimal one place to the right (e.g., 1% Xylocaine becomes 10 mg/mL and 0.25% bupivacaine becomes 2.5 mg/mL).
  - Xylocaine can be safely injected up to 3.5 mg/kg every 30 min, up to 300 mg/dose. If the mixture contains epinephrine, 5–7 mg/kg is safe.
  - Bupivacaine can be injected at 2.5 mg/kg and 3.5 mg/kg with epinephrine and can be injected every 3 h with daily maximum of 400 mg.

When treating a wound, it is important to first anesthetize so debridement, cleansing, and irrigation can adequately be performed.

Choose appropriate anesthetics. Xylocaine lasts approximately 75 min, and bupivacaine lasts several hours. Adding epinephrine to either increases vascular constriction, thereby decreasing systemic absorption and significantly increasing the duration of effect.

Topical anesthetics have a role in pediatric populations and in conjunction with or as an alternate to local infiltrative anesthesia. TAC is a mixture of 0.5% tetracaine, 0.05% epinephrine, and 11.8% cocaine. LET is 4% lidocaine, 0.1% epinephrine, and 0.5% tetracaine. LET has been found to be safer and more cost-effective [4].

References

1. Muck AE, Bebarta VS, Borys DJ, Morgan DL. Six years of epinephrine digital injections: absence of significant local or systemic effects. Ann Emerg Med. 2010;56:270–4.
2. Schnabl SM, Ghoreschi FC, Scheu A, Kofler L, Häfner HM, Breuninger H. Use of local anesthetics with an epinephrine additive on fingers and penis - dogma and reality. J Dtsch Dermatol Ges. 2021;19(2):185–96. https://doi.org/10.1111/ddg.14434.
3. Hogan ME, vanderVaart S, Perampalades K, Machado M, Einarson TR, Teddio A. Systematic review and meta-analysis of the effect of warming local anesthetics on injection pain. Ann Emerg Med. 2011;58:86–98.
4. Kumar M, Chawla R, Goyal M. Topical anesthesia. J Anaesthesiol Clin Pharmacol. 2015;31(4):450–6. https://doi.org/10.4103/0970-9185.169049.

Regional Anesthesia (Nerve Blocks)

96

Derek Ailes, Muhammad Waseem, and James Chiang

Indications

- Repair of wounds where preserving anatomical landmarks or having precise anatomical alignment is important (e.g., vermillion border of the lip)
- Pain control in dislocation or fracture reductions
- Incision and drainage of abscesses
- Burn and wound care
- Extensive or multiple lacerations (reduces total amount of local anesthetic needed)
- Foreign body removal

Contraindications

- Allergic to local anesthetic (see Chap. 95)
- History of coagulopathy or bleeding disorder
- Injection through infected tissue
- Noncooperative patient
- Distorted anatomical landmarks

Materials and Medications (Fig. 96.1)

Povidone-iodine, chlorhexidine, or alcohol swabs

- Sterile gloves and drapes
- Local anesthetic solution (e.g., lidocaine, Marcaine with or without epinephrine)
- 18-gauge, 20- to 30-gauge needles 2 in. in length
- 22- to 24-gauge spinal needles
- Syringes up to 60 mL

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Procedure: General Block

1. Obtain consent after explaining the risks of procedure including temporary paresthesias and expected duration of block. Perform neurological examination before procedure, documenting any preexisting deficits.
2. Position the patient comfortably, preferably supine, anticipating vasovagal response.
3. Identify landmarks for the block. Clean area, prepare with povidone-iodine or chlorhexidine, and surround with sterile drapes.
4. A small skin wheal of local anesthetic may be placed at the site of needle entry before block.
5. Insert the needle into the site while aspirating to ensure it is not in a vessel.
6. If paresthesia is elicited, withdraw the needle slightly allowing paresthesia to improve and inject.
7. Wait 5–15 min for the block to reach full effect.
8. Test for sharp sensation in the anesthetized area and document.

Complications

- Infection
- Hemorrhage
- Hematoma
- Allergic reaction
- Systemic toxicity (exceeded maximum dose or inadvertent injection into vasculature)
- Paresthesias and pain
- Intraneural injection causing ischemia
- Intra-arterial injection of epinephrine causing vasospasm and tissue ischemia

Pearls and Pitfalls

- Pearls

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Fig. 96.1 Materials

- It is important to aspirate before injecting anesthesia when performing regional anesthesia because, unlike local techniques, the needle is deeper and in proximity to larger vessels.
- Shooting pain and/or paresthesia occurs when the needle contacts the nerve. When this happens, withdraw the needle 2 mm and wait for the paresthesia to resolve before injecting.
- Injury can occur to a limb or digit if the patient manipulates it before the anesthesia wears off. The patient should be cautioned not to use the affected area until motor and sensation return. If an extensive block was done, monitor the patient in the emergency department until return of baseline neurological function.

• Pitfalls
  - It is traditionally taught to avoid epinephrine-containing solutions in blocks in end-artery blocks (e.g., digital blocks). However, evidence for any vascular insufficiency and necrosis as a result is lacking in standard commercially available lidocaine with epinephrine preparations. They should, however, be avoided in patients with peripheral artery disease [1, 2].

Selected Specific Blocks

• Contraindications and materials are the same as general block.

Facial Blocks: Trigeminal Nerve (Fig. 96.2) [2, 3]

Supraorbital (Fig. 96.3) and Supratrochlear Nerve Block

• Indications
  - To anesthetize the forehead from the orbital ridge to the vertex of the scalp. The supraorbital nerve emerges from the supraorbital foramen/notch and is a branch of the ophthalmic division of the trigeminal nerve. The supratrochlear nerve also is a branch of the ophthalmic division of the trigeminal nerve and exits through the superior medial aspect of the orbit.

• Procedure
  1. Inject local anesthetic solution over the midline of the forehead at eyebrow level.

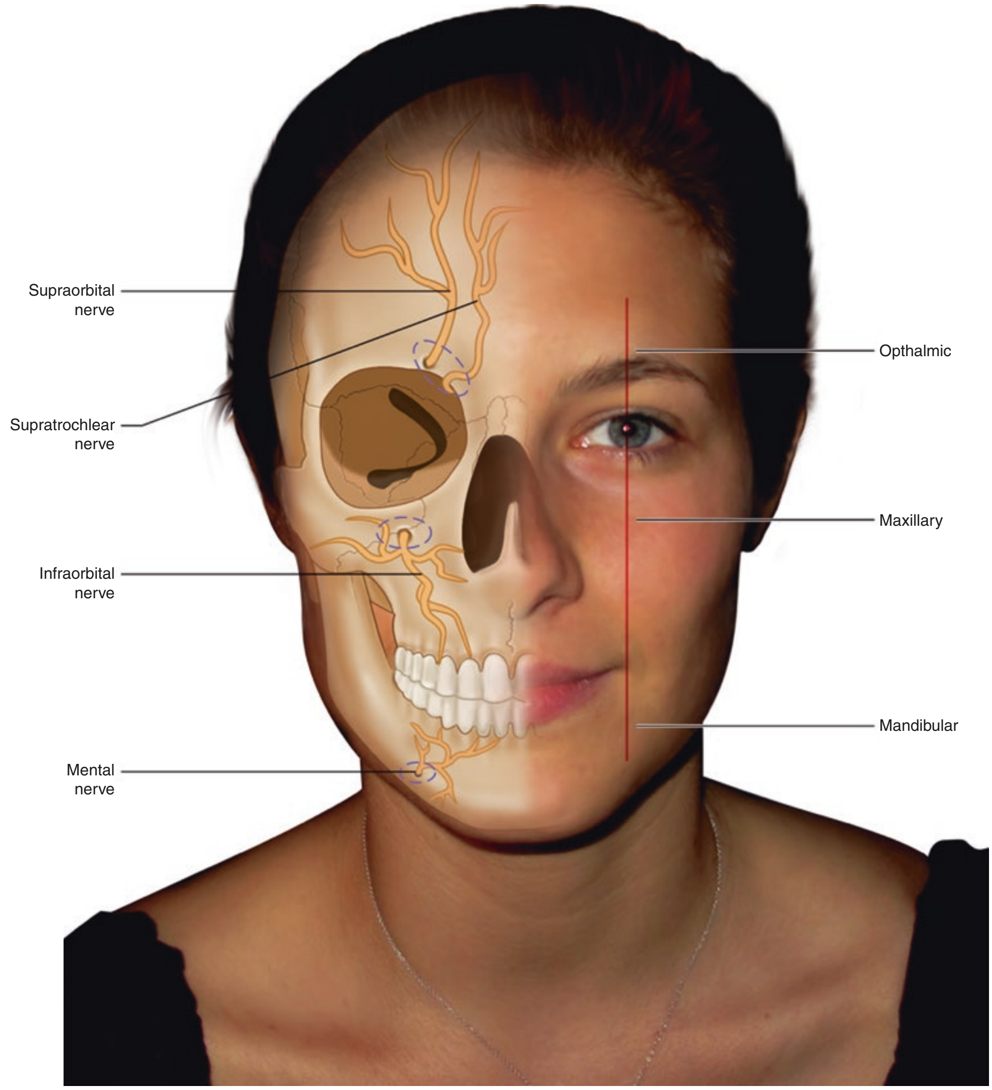

Fig. 96.2 Vertical plane through the midposition of the pupil shows the position of the supraorbital foramen, infraorbital foremen, and mental foramen

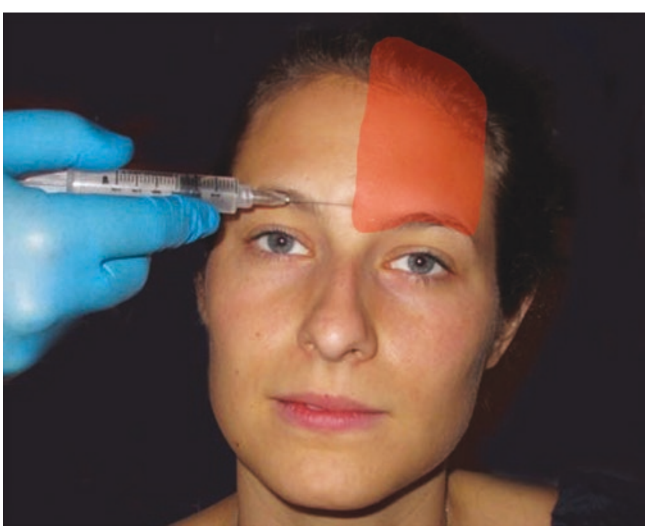

Fig. 96.3 Supraorbital nerve block

2. Inject a 25- or 27-gauge needle through skin wheal aimed laterally while injecting 3–5-mL local anesthetic subcutaneously.
3. Apply light pressure over the upper eyelid to prevent filtration and swelling of upper eyelid.
4. Stop infiltrating when the needle slightly passes the midline of the orbit.
5. Massage the area for 10–15 seconds to spread the anesthetic.

Infraorbital Nerve Block

- Indications
  - To anesthetize the medial cheek, upper lip, philtrum, skin between the lips and the nose, and nasal ala. The infraorbital nerve emerges from the infraorbital foramen and is a branch of the maxillary division of the trigeminal nerve. Anesthesia to the infraorbital nerve

will also provide anesthesia to its terminus, the superior alveolar nerves.
  – Intraoral approach is possible and preferred because it is less painful.
- Procedure: Extraoral Approach (Fig. 96.4)
  1. Palpate the inferior orbital foramen in its midline position. The infraorbital nerve is often tender on palpation as it exits the foramen.
  2. Inject a 25- or 27-gauge needle just above the infraorbital foramen injecting 1–2 mL of local anesthetic.
  3. Take care not to inject into the foramen because there is an increased risk of intraneural injection.
  4. Hold a finger on the inferior orbital rim to avoid ballooning of the lower eyelid with injection.
- Procedure: Intraoral Approach (Fig. 96.5) [3]
  1. Apply topical benzocaine or lidocaine gel to the point of insertion, which is the height of the mucobuccal fold over the first premolar, which is the site of insertion. Wipe off after 1–3 min.

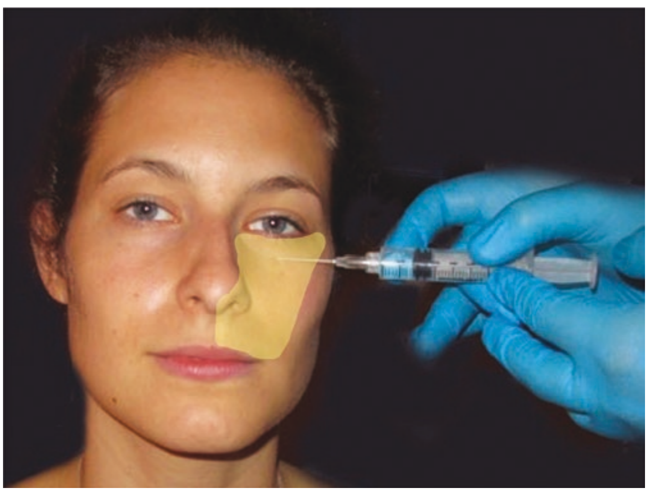

Fig. 96.4 Extraoral approach to the infraorbital nerve block

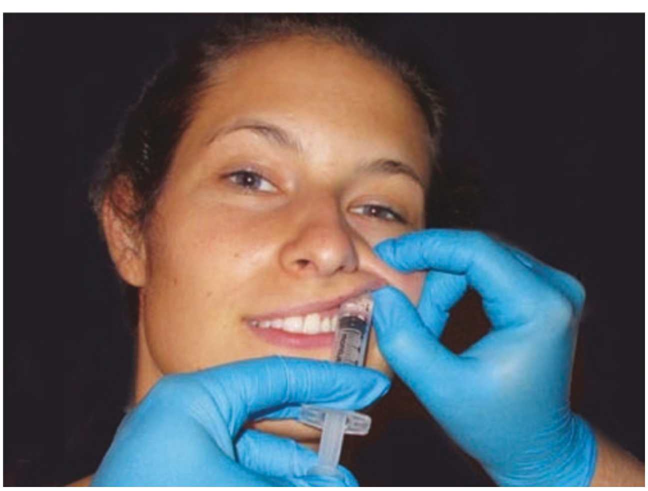

Fig. 96.5 Intraoral approach to the infraorbital nerve block

  2. Palpate with the finger of the noninjecting hand over the inferior border of the inferior orbital rim. Retract the lip with the noninjecting hand.
  3. Using a long 25- to 27-gauge needle, with the bevel toward the bone, advance the needle at the insertion site toward the infraorbital foramen. Once the target is reached, and needle contacts the periosteum, aspirate and inject 1 mL of local anesthetic.
  4. Exert pressure on the foramen for 1 min after injection to force the anesthetic through the infraorbital foramen.
  5. If the needle is difficult to advance and the patient experiences pain on insertion, redirect the needle laterally and advance.
  6. If analgesia is attained for the lip but not the eyelid, the analgesia was placed inferior to foramen, and if analgesia is attained for the eyelid but not the lip, placement was superior to the foramen.

Mental Nerve Block

- Indications
  – To anesthetize the lower lip and chin and is especially useful in laceration repair at those sites. The mental nerve emerges from the mental foramen and is a branch of the mandibular division of the trigeminal nerve. Mental foramen lies in the vertical plane with the midpoint of the pupil and sits in the middle of the body of the mandible.
  – Intraoral approach is possible and preferred because it is less painful.
- Procedure: Extraoral Approach (Fig. 96.6)
  1. Inject local anesthetic solution over the identified location of the mental foramen, creating a skin wheal.
  2. Advance a 25- or 27-gauge needle through the skin wheal until the mandible is contacted, injecting 1–2 mL of local anesthetic.
- Procedure: Intraoral Approach (Fig. 96.7) [3]

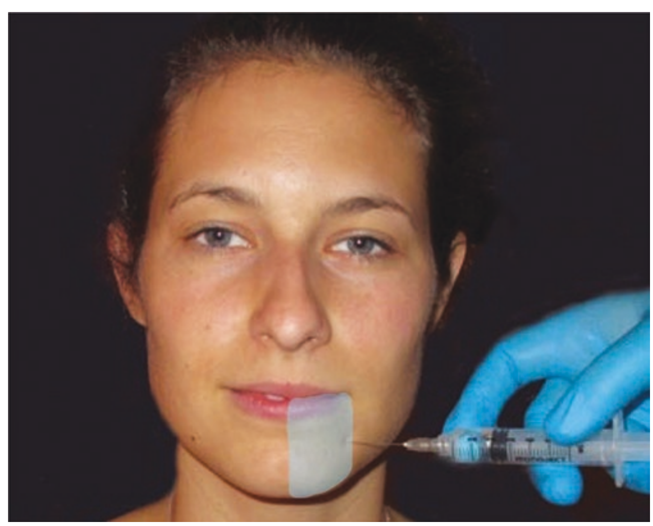

Fig. 96.6 Extraoral approach to the mental nerve block

Fig. 96.7 Intraoral approach to the mental nerve block

1. Apply topical benzocaine or lidocaine gel to the point of insertion, which is the mucobuccal fold between the apices of the first and the second premolars. Wipe off after 1–3 min.
2. Insert a 25- to 27-gauge needle, with the bevel toward the mandible, aimed toward the mental foramen.
3. After advancing one-third the depth of the mandible and contacting the mandible, inject 1–2 mL of local anesthetic.
4. By pressing firmly on the mental foramen for 2–3 min after the mental foramen has been blocked, an incisive nerve block is also created. This is useful if anesthesia to the lower anterior teeth is also desired.

External Ear Block (Fig. 96.8) [4]

- Indications
  - To anesthetize the entire external ear, excluding the external auditory canal and the concha
  - Especially useful in large lacerations of the ear and surrounding skin, hematoma evacuations, or incision and drainage of abscess
- Procedure: Auricular Ring Block (Fig. 96.9) [4]
  1. Using a 25- to 27-gauge needle, insert the needle just inferior to the earlobe directing it toward the tragus.
  2. Aspirate and advance the needle superiorly subcutaneously until needle tip is anterior and inferior to the tragus, and slowly inject 2–3 mL of local anesthetic along the needle tract while avoiding the cartilage (Fig. 96.9, #1).

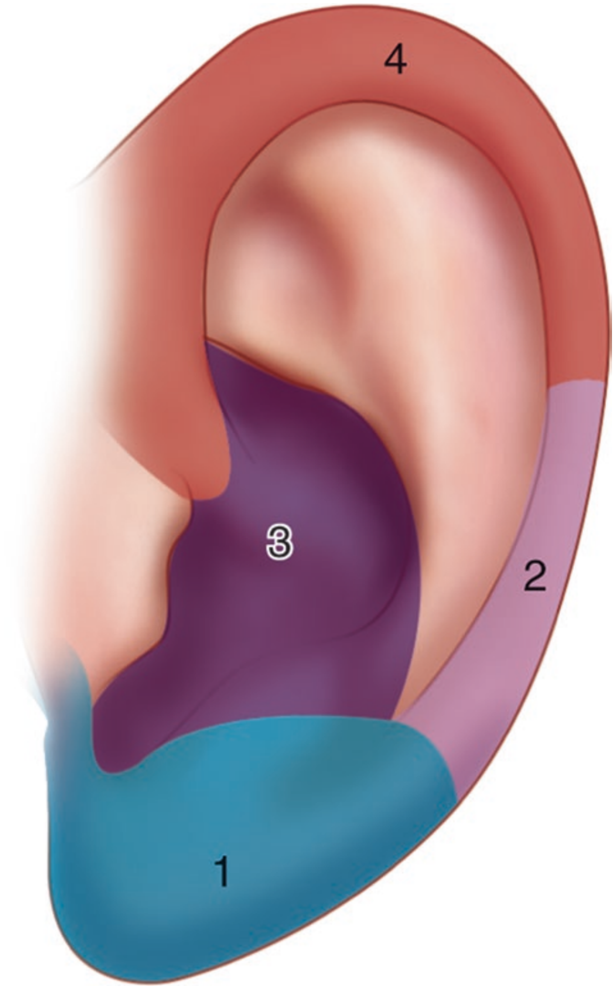

Fig. 96.8 Auricular block anesthetizes four nerves that innervate the auricle. *1* Great auricular nerve, *2* lesser occipital nerve, *3* auricular branch of vagus nerve, *4* auriculotemporal nerve

Fig. 96.9 Auricular ring block technique

3. Withdraw the needle without fully removing it and redirect it posterosuperiorly, then aspirate and advance needle tip to the mastoid process along the inferior posterior auricular sulcus, and then inject 2–3 ml of local anesthetic along the tract (Fig. 96.9, #2).
4. Remove the needle and insert it just superior to the point of helix insertion into the scalp.
5. Aspirate and advance the needle tip inferiorly subcutaneously until needle tip is superior and medial to the tragus, and slowly inject 2–3mL of local anesthetic along needle tract, again avoiding the ear cartilage (Fig. 96.9, #3).
6. Withdraw and redirect the needle posteriorly and inferiorly toward the mastoid process, injecting as before (Fig. 96.9,#4).
7. Beware of inadvertent cannulation of the superficial temporal artery, which crosses the zygomatic arch and crosses medial to the ear. If the artery is violated, it requires 20–30-min application of firm pressure.

Wrist Block (Fig. 96.10) [3, 5, 6]

- Indication
  – To anesthetize the hand in preparation for laceration repair, fracture or dislocation reduction, or pain relief

Wrist Block: Median Nerve (Fig. 96.11)

- Procedure
  1. Position the patient supine with the palmar surface of the hand face up.
  2. Have the patient oppose the thumb and fifth digit and flex at the wrist so that the palmaris longus and flexor carpi radialis tendons become prominent.
  3. Create a skin wheal of local anesthetic between the two tendons between proximal and distal skin creases (or 2–3cm proximal to distal wrist skin crease):
     - The palmaris longus tendon is absent normally in 10–20% of the population. In this case, inject over the midpoint of the proximal skin crease at the level of the styloid process.
  4. Angle the needle perpendicular to the skin and aspirate while advancing through the retinaculum until paresthesia is observed, or until bone is contacted; then pull needle back 1–2mm.

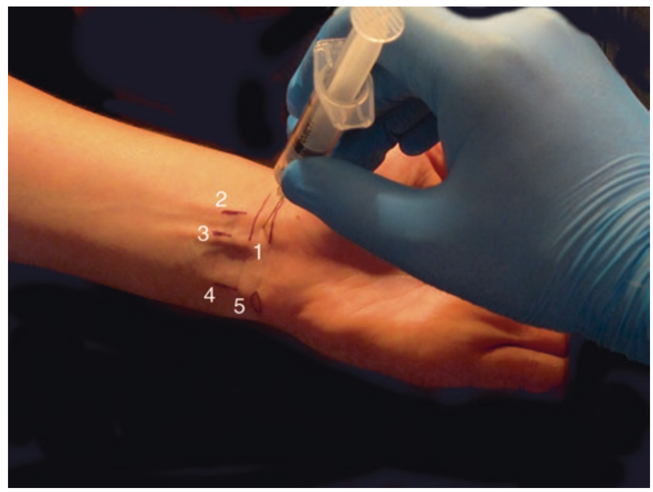

Fig. 96.11 Median nerve block at the wrist: *1* proximal and distal wrist creases, *2* flexor carpi radialis tendon, *3* palmaris longus tendon, *4* ulnar artery, *5* styloid process

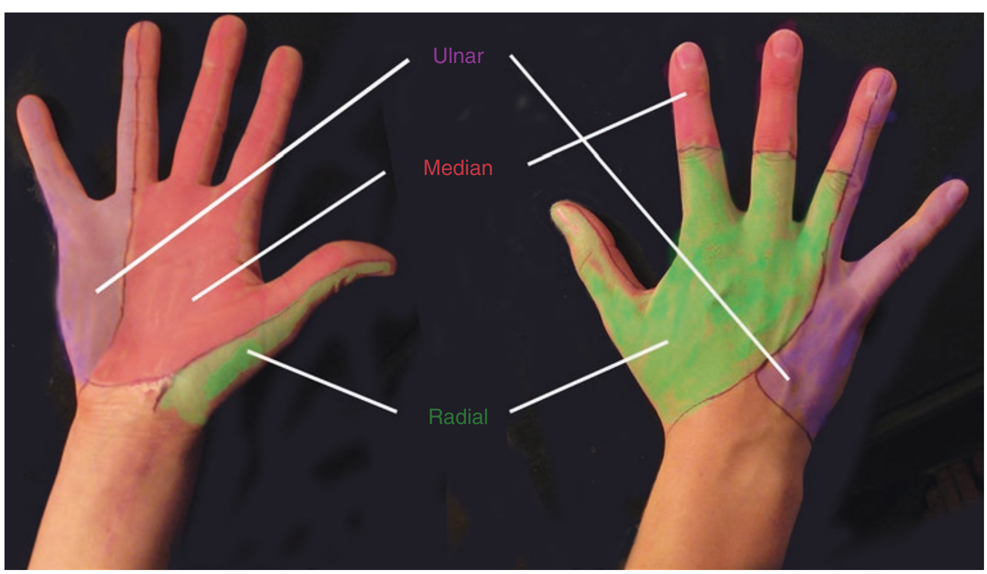

Fig. 96.10 Nerve distribution in the hand

Fig. 96.12 Radial nerve block at the wrist: *1* radial artery, *2* flexor carpi radialis tendon, *3* palmaris longus tendon, *4* ulnar artery, *5* proximal and distal wrist creases

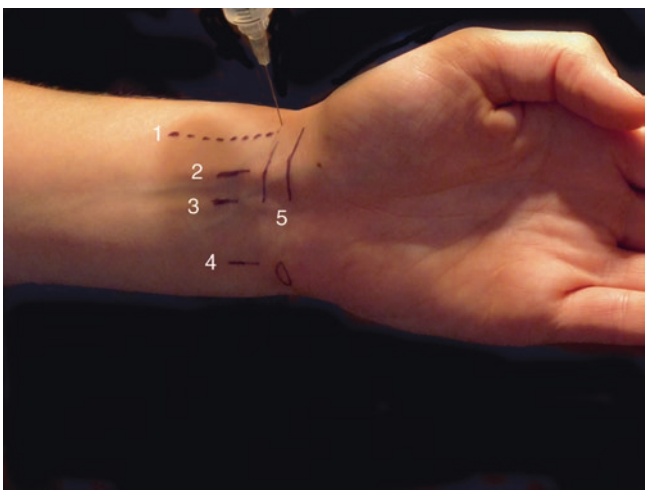

Fig. 96.13 Radial nerve block at the wrist: *1* radial artery, *2* anatomical snuffbox

5. Inject 3–5ml of local anesthetic as you withdraw the needle.

Wrist Block: Radial Nerve (Figs. 96.12 and 96.13) [3, 7, 10]

- Procedure
  1. Position the patient's thumb pointing up in neutral position.
  2. Palpate the radial pulse at the proximal palmar crease. Insert the needle 2mm lateral to the radial artery, aspirate to make sure you are not injecting intravascularly, and inject 2–5mL of local anesthetic at the depth of the artery.

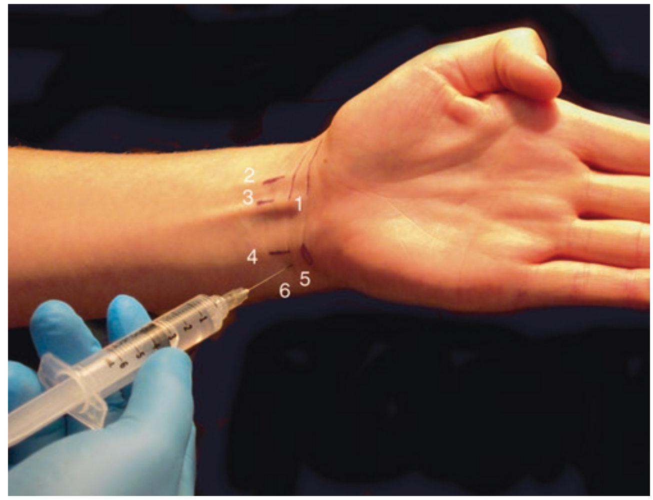

Fig. 96.14 Ulnar nerve block at the wrist: *1* proximal and distal wrist creases, *2* flexor carpi radialis tendon, *3* palmaris longus tendon, *4* ulnar artery, *5* styloid process, *6* flexor carpi ulnaris

3. Reinsert the needle lateral to the first injection site in the anatomical snuffbox, and infiltrate the area over the extensor pollicis longus and extensor pollicis brevis tendons, and inject 5–6 mL of local anesthetic subcutaneously until you have reached midline dorsal wrist.

Wrist Block: Ulnar Nerve (Fig. 96.14)

- Procedure
  1. Position the patient with the palm face up.
  2. Palpate the styloid process of the ulna and pisiform, and find the ulnar artery pulse and flexor carpi ulnaris tendon. The ulnar nerve is immediately medial to the ulnar artery and deep to the tendon.
  3. Create a skin wheal of local anesthetic lateral to the flexor carpi ulnaris tendon just proximal to the styloid process. This is at the level of the proximal wrist crease.
  4. Aspirate and advance needle under the flexor carpi ulnaris tendon and inject 3–5 mL of local anesthetic
  5. Redirect the needle toward the medial aspect of the wrist, and inject 5–6mL of local anesthetic around the wrist to the dorsal midline to anesthetize the cutaneous branches of the ulnar nerve.

Digital Nerve Blocks: Ring, Web Space, and Tendon Sheath (Fig. 96.15) [3, 8–11]

- Indication
  – To anesthetize the digits in preparation for laceration repair, nail bed repair, joint reduction, or pain relief

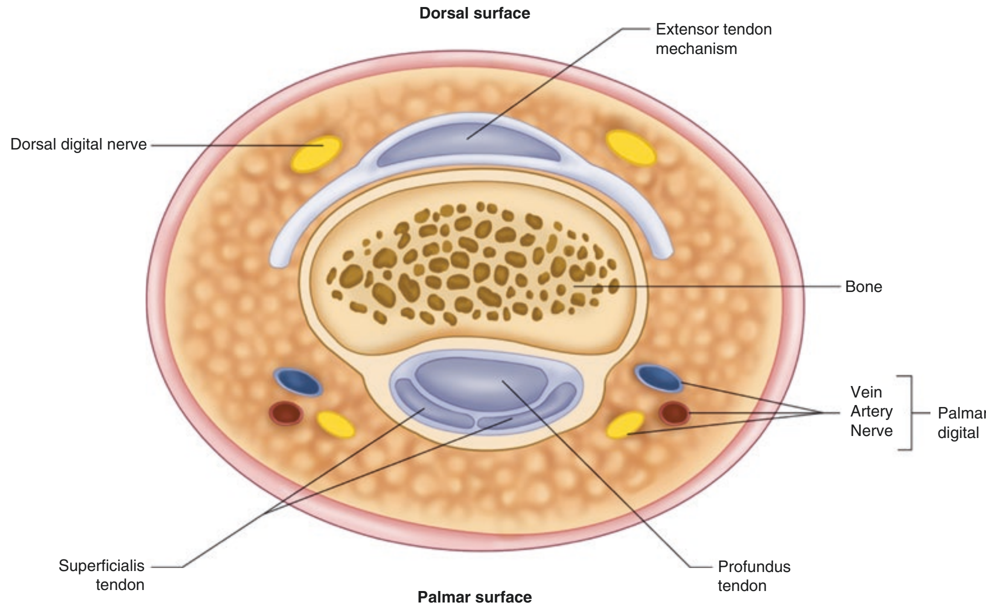

Fig. 96.15 Cross section of the finger

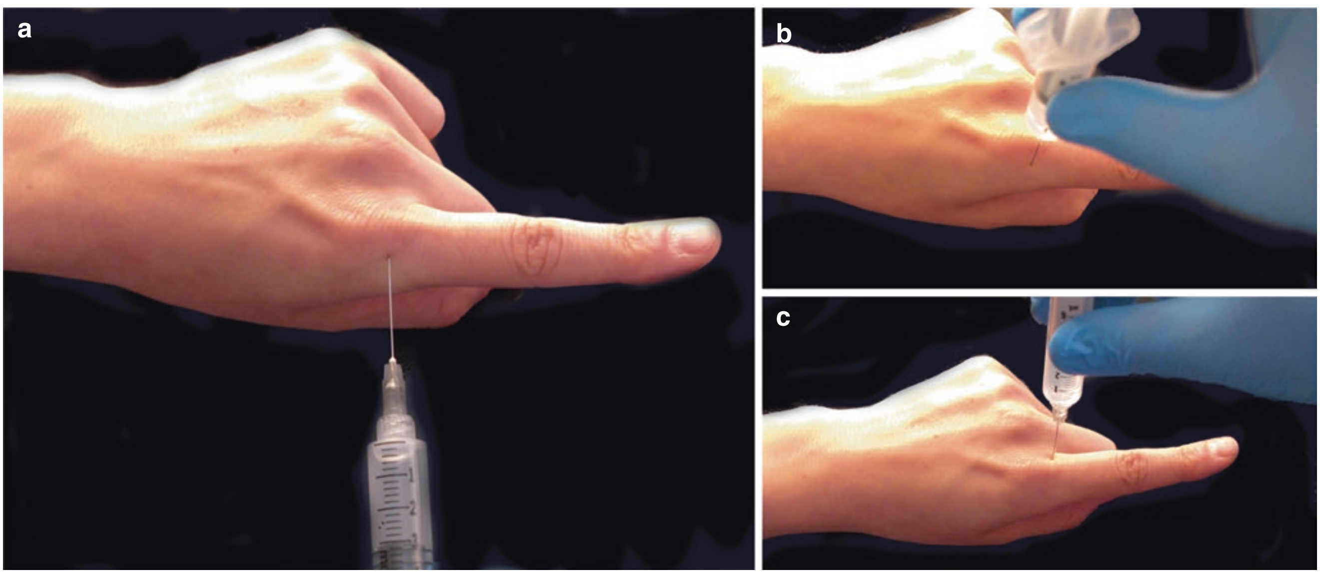

Fig. 96.16 Dorsal surface injection of digital nerve ring block. Digital nerve block is performed by injecting onto the (**a**) dorsal, (**b**) lateral, and (**c**) medial surfaces of the proximal phalanx

- Pearls
  - Aim to have anesthetic infiltrate the dorsal-lateral and plantar-lateral areas of the finger where nerves are located in the ring and web space blocks.
  - Ring and web space blocks may be less painful, equally effective, and easier than tendon sheath approach, however are less effective for anesthesia at the dorsum of proximal phalanx.
  - Toe blocks are similar to finger ring blocks, except that the great toe may require plantar surface injection as well, owing to its unique nerve supply in the plantar surface.
  - In a ring block, there is potential risk of digit ischemia with vascular compression, so do not use more than recommended volume of anesthetic.

Ring Block (Fig. 96.16) [3, 10]

- Procedure
  1. Insert a 27- to 30-gauge needle on the dorsal surface just below the skin at the proximal phalanx of the digit to be anesthetized. Inject 1 mL along the dorsal surface.
  2. Redirect the needle laterally or reinsert the needle more laterally and aiming plantarly, aspirate and

Fig. 96.17 Web space approach to the digital block, requiring injection on the medial and lateral web spaces for a blocked digit

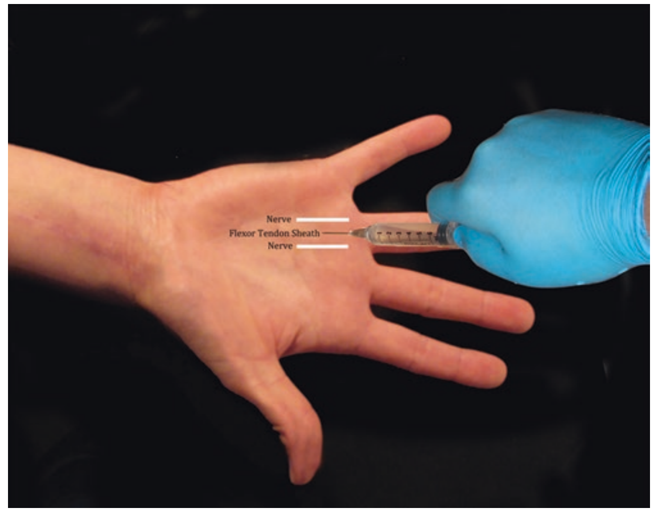

Fig. 96.18 Intrathecal/tendon sheath approach to the digital block

advance the needle tip to the plantar-lateral surface of the phalanx, and inject 1 mL of local anesthetic.

3. Repeat the injection in the same fashion on the medial aspect of the phalanx.

Web Space Digital Block (Fig. 96.17) [9]

- Procedure
  1. Have the patient abduct the fingers.
  2. Palpate the metacarpophalangeal joint and then insert a 25- to 27-gauge needle into the lateral web space subcutaneously, directing it dorsally. Aspirate and then inject 1 mL of local anesthetic.
  3. Withdraw the needle, but before the exiting skin, redirect toward the palmar aspect until the tip is next to the metacarpophalangeal joint, and inject 1 mL of local anesthetic.
  4. Repeat the procedure on the medial web space of the digit. Each digit blocked requires injection on both the lateral and the medial web spaces.

Intrathecal Digital Block: Flexor Tendon Sheath (Fig. 96.18) [8]

- Procedure
  1. Inject anesthetic directly into the flexor tendon sheath. Palpate on the palmar surface over and proximal to the metacarpophalangeal joint. Gentle flexion of digit may better reveal the sheath. Have the patient abduct the fingers.
  2. Insert a 25-gauge needle at a 45° angle to the skin and along the long axis of the digit directly into the flexor tendon sheath at the level of the distal skin crease.
  3. Inject 2 mL of local anesthetic. The anesthetic should flow freely if it is in the sheath. If it does not, it is likely in the tendon and should be withdrawn slightly.
  4. Contraindications to intrathecal block are local infection and preexisting flexor tendon injury.
  5. Risk of tenosynovitis; sterilize the skin before introducing the needle.
  6. If laceration has involved the tendon, anesthetic may leak from the wound.

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References

1. Muck AE, Bebarta VS, Borys DJ, Morgan DL. Six years of epinephrine digital injections: absence of significant local or systemic effects. Ann Emerg Med. 2010;56:270–4.
2. Waterbrook AL, Germann AC, Southall JC. Is epinephrine harmful when used with anesthetics for digital blocks? Ann Emerg Med. 2007;50:472–5.
3. Reichman EF, Simon RR, editors. Emergency medicine procedures. New York: McGraw-Hill Medical; 2004. p. 961–3.
4. Benko K. Fixing faces painlessly: facial anesthesia in emergency medicine. Available at: Emergency Medicine Practice (ebmedicine.net). 2009;11.
5. Rosh AJ. Ear anesthesia. Medscape reference. Available at: http://emedicine.medscape.com/article/82698-overview#a15.
6. Butterworth JF. Atlas of procedures in anesthesia and critical care. Philadelphia: WB Saunders; 1992. p. 160–4.
7. Brown DL. Atlas of regional anesthesia. Philadelphia: WB Saunders; 1992. p. 52.
8. Morrison WG. Transthecal digital block. Arch Emerg Med. 1993;10:35–8.
9. Mueller J, Davenport M. Digital nerve block (web space and tendon sheath). New York: McGraw-Hill's Access Emergency Medicine. Available at: http://www.accessemergencymedicine.com/videosPDF/DigitalNerveBlock.pdf .
10. Roberts J, Custalow B, Thomsen T. Nerve blocks of the upper extremity. Roberts and Hedges' clinical procedures in emergency medicine and acute care. 7th ed. Elseviers; 2019.
11. Hung VS, Bodavula VK, Dubin NH. Digital anaesthesia: comparison of the efficacy and pain associated with three digital nerve block techniques. J Hand Surg Br. 2005;30(6):581.

97 Burn Care

Ilya Aleksandrovskiy, Thomas Parry, and Jeffrey Pepin

Burn Description

The burn classification system has replaced the traditional nomenclature of first-, second-, and third-degree burns with a more physiologic classification of superficial thickness, partial thickness (superficial vs deep), and full thickness (Fig. 97.1):

- Superficial thickness: burn that remains confined to the epidermis (e.g., sunburn). The skin is erythematous and mildly painful, with intact capillary refill.
- Superficial partial-thickness burn: burn that extends into the superficial dermis. Can see blisters, look wet, and tend to be more painful with intact capillary refill.
- Deep partial-thickness burn: burn that includes the deep dermis. The skin can look cherry red or pale and have slow capillary refill. These may be less painful and generally require grafting to minimize scar and expedite healing.
- Full thickness: burn that involves all layers of the skin and subcutaneous tissue, underlying fascia, muscle, and bone. Can look white or waxy or brown and leathery without capillary refill and are generally painless in the immediate area. These will require surgical intervention.

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Indications

- Superficial partial thickness, deep partial thickness, and full thickness.
- Superficial thickness burns generally need only supportive care.

Materials and Medications

- Appropriate analgesia.
- Antibiotic ointment.
- Silver sulfadiazine (avoid on the face).
- Sulfamylon for ears.
- Alternative agents include bacitracin or polymyxin B ointments.
- Cleansing solution such as chlorhexidine prep and water.
- Basin.
- Petroleum gauze.
- Several 4×4 gauze pads.
- Rolled gauze.
- Tape.
- Gloves.

All burn patients are trauma and toxicology patients first. Airway, breathing, circulation, and cervical spine should be immediately assessed before any burn wound management. It is important to remember that any patient suspected of an inhalation injury or carbon monoxide poisoning should receive 100% oxygen until carboxyhemoglobin levels return to normal. Inhalation injuries may not present themselves until after fluid resuscitation has already been started, so early intubation is recommended in these cases. Cyanide poisoning is also associated with burn injuries and should be considered.

L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0_97

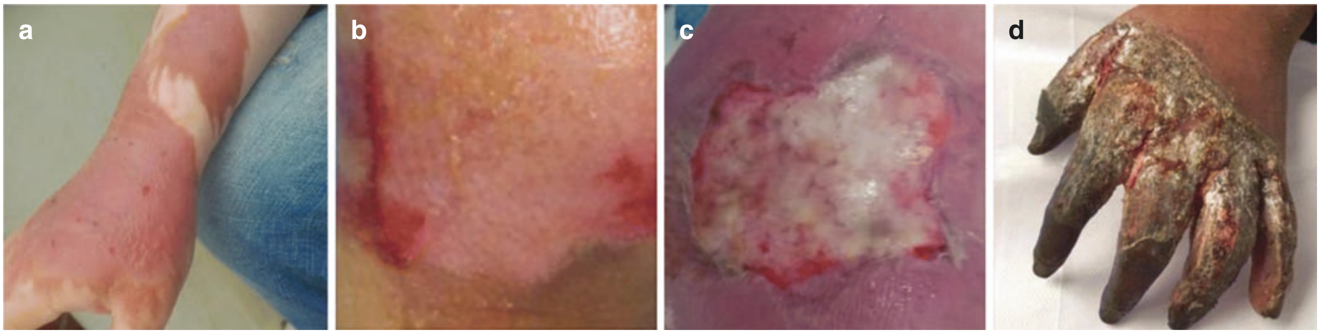

Fig. 97.1 (**a**–**d**) Different burn depth. From left to right is superficial, superficial thickness, deep partial-thickness, and full-thickness burn. (*From* Jiao et al. [1]; Creative Commons Attribution 4.0 International License; http://creativecommons.org/licenses/by/4.0.)

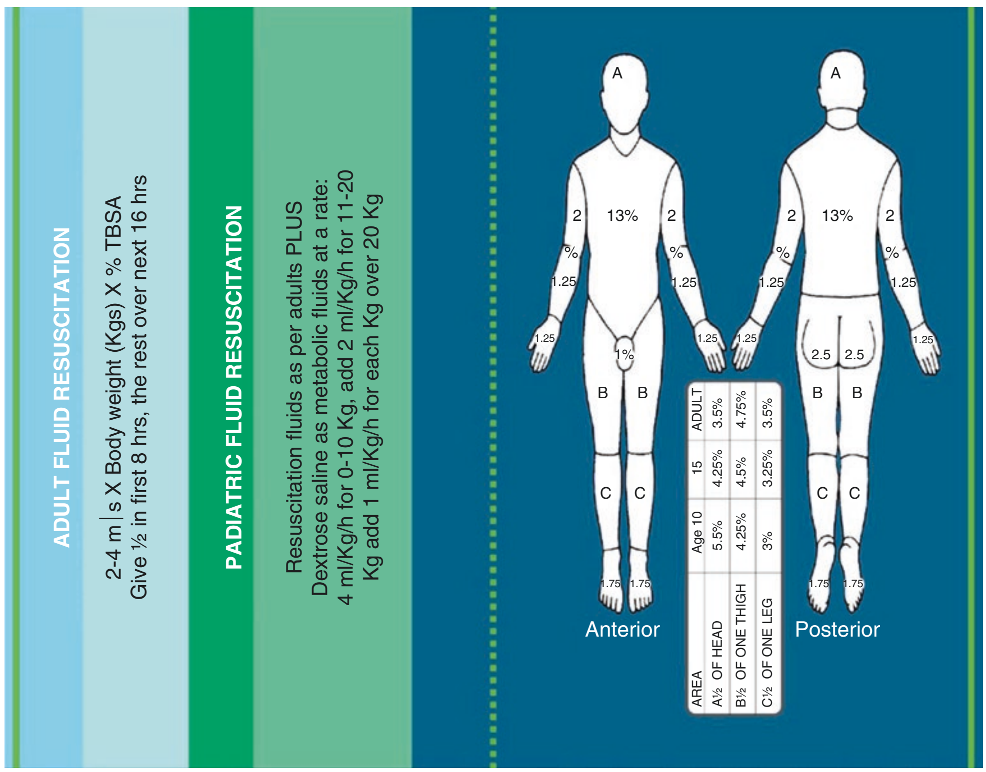

Fig. 97.2 Lund-Browder chart for estimating total body surface area of burns, with suggested fluid resuscitation guidelines. (*From* Malic et al. [2]; *with permission from Elsevier*)

Sizing

Total body surface area (TBSA) of body parts is estimated by multiples of 9 (rule of nines):

- Adults
  - Head and neck: 9
  - Arms: 9 each
  - Legs: 18 each
  - Trunk: 18 front and 18 back
  - Perineum and palms: 1
- Infants/children
  - Head and neck: 18
  - Arms: 9 each
  - Legs: 14 each
  - Trunk: 18 front and 18 back

A second way to estimate TBSA in <15% TBSA burns is by using the palm surface area: using the patient's palm as a guide, each palmar surface equals 1%.

A third way to estimate TBSA is via the use of the Lund and Browder chart (Fig. 97.2).

Fluid Resuscitation

Because fluid resuscitation is absolutely essential in the early aspects of burn care, the Parkland formula has been used to estimate fluid requirements in burn patients. The patient's weight in kilograms is multiplied by the % total body surface area (TBSA) involved for partial-thickness and full-thickness burns; this number is multiplied by 2 mL of lactated Ringer's solution. Half of this amount is given during the first 8 h, and the remaining amount is given over the next 16 h of resuscitation. The goal is to keep urine output approximately 0.5 mL/kg/hr for adults or 30–50 mL/hr.

For children < 14 years old, the fluid rates require 3 mL of LR multiplied by the weight in kg, multiplied by the % TBSA. Urine output should be maintained at 1 mL/kg/hr. In infants and young children ≤ 30 kg, D5LR should also be given at maintenance rate.

Procedure

1. Provide appropriate analgesia.
2. Clean the wound with antiseptic solution and water (if it is a dry chemical burn, make sure to brush off as much chemical before using copious amounts of water to clean the wound).
3. Debride any loose, devitalized skin or foreign debris to promote quicker healing and less infection risk using a dry 4×4 or rolled gauze.
4. Use a nonadherent dressing that will cause less pain on removal.
5. Apply a petrolatum-based antibiotic ointment to the dressing; then place the dressing over the wound.
6. Use loose 4×4 gauzes, and "fluff" them to make a thick layer of padding to place over the petroleum gauze to absorb excessive moisture and allow ventilation of dressing.
7. Either wrap the entire area with a rolled gauze or tape a small layer of 4×4 gauze over the "fluffed" layer of 4×4 gauze.

Complications

- Wound infection
- Nonhealing wound requiring skin graft (deep second-degree and third-degree burns)
- Compartment syndrome (circumferential burns may require escharotomy)
- Rhabdomyolysis

Pearls and Pitfalls

- Pearls
  - Determination of the depth of burns on initial presentation is difficult (especially when covered with petroleum). A good rule of thumb is if it blanches and/or hurts, it is a partial-thickness burn.
  - First-degree burns are not included in burn size estimations for fluid resuscitation calculation.
  - Burn size determines fluid requirements and transfer decision.
  - Burn of greater than 20% TBSA should receive intravenous fluids.
  - Fluid resuscitation should be adjusted according to physiological response such as urine output (30–50 mL/h in adults and 1 mL/kg/h in children).
  - Assure tetanus is up to date.
- Pitfalls
  - Burns can worsen over the first few days, so it is difficult to know the true extent of a burn for at least 48–72hrs.
  - Keep the patient warm in the first few hours. There is no need to apply ice.
  - All jewelry and rings should be removed.
  - Prophylactic antibiotics are not recommended.
  - Under- or overresuscitation of burn patients. Underresuscitation results in hypoperfusion and end organ injury. Overresuscitation results in increased edema, which can result in burn depth progression or abdominal and extremity compartment syndrome. The goal of resuscitation is to maintain a balance as indicated by urine output.
  - Silver sulfadiazine should be avoided in facial burns because of the risk of staining of the skin.

Blister care is a very controversial topic. Current research suggests that it may be beneficial to keep the blister intact unless it appears to be tense or over a joint. Most blisters will rupture in 2–4 days. Ruptured blisters should be debrided with all the extra skin removed. Most burn units will scrub everything off once they receive a patient.

Wounds should be kept clean to prevent an environment that will increase the chances of infection. Wrap in saline-soaked sterile gauze prior to transfer.

Dressing changes should be done daily with all previously applied antibiotic ointment removed before a reapplication of new ointment. It is important to provide analgesic 30 min before a dressing change.

Admission Criteria

- Partial-thickness burns of noncritical areas not including the eyes, ears, face, hands, feet, or perineum that total a BSA of 10–20% in adults.
- Partial-thickness burns of noncritical areas involving 5–10% of BSA in children younger than 10 years.
- Suspicious of non-accidental trauma.
- Patients unable to care for wounds in outpatient settings.
- Prompt referral to a burn specialist is required in the following cases:
  - Partial-thickness and full-thickness burns greater than 10% of the TBSA.
  - Partial-thickness and full-thickness burns involving the face, eyes, ears, hands, feet, genitalia, or perineum or the skin overlying major joints.
  - Full-thickness burns in any age group.

- Electrical burns, including lightning injury: significant volumes of tissue beneath the surface may be injured and result in acute renal failure and other complications.
- Significant chemical burns.
- Inhalation injury.
- Burn injury in patients with preexisting illness that could complicate management, prolong recovery, or affect mortality.
- Any burn patient in whom concomitant trauma poses an increased risk of morbidity or mortality may be treated initially in a trauma center until stable before transfer to a burn center.
- Children with burns seen in hospitals without qualified personnel or equipment for their care should be transferred to a burn center with these capabilities.
- Burn injury in patients who will require special social and emotional or long-term rehabilitative support, including cases involving suspected child abuse and neglect.

References

1. Jiao C, Su K, Xie W, Ye Z. Burn image segmentation based on Mask Regions with Convolutional Neural Network deep learning framework: more accurate and more convenient. Burn Trauma. 2019;7(6) https://doi.org/10.1186/s41038-018-0137-9.
2. Malic CC, Karoo RO, Austin O, Phipps A. Resuscitation burn card–a useful tool for burn injury assessment. Burns. 2007;33(2):195–9.

Suggested Reading

Advanced Burn Life Support Course Provider Manual, 2018. http://ameriburn.org/wp-content/uploads/2019/08/2018-abls-providermanual.pdf. Accessed 14 Feb 2021.

ATLS Advanced Trauma Life Support 10th Edition. American College of Surgeons; 2018. ISBN 0996826238

Bezuhly M, Fish JS. Acute burn care. Plast Reconstr Surg. 2012;130(2):349e–58.

Rex S. Burn injuries. Curr Opin Crit Care. 2012;18(6):671–6.

Wasiak J, Cleland H, Campbell F, Spinks A. Dressings for superficial and partial thickness burns. Cochrane Database Syst Rev. 2013;(3):CD002106.

98 Wound Closure

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Indications

- Open wound of skin or mucosal tissues
- Purpose
  - Preserve function
  - Control bleeding
  - Promote healing
  - Cosmesis

Contraindications

- Wounds caused by animal or human bites
- Contaminated, infected, or puncture wounds
- Complex wounds (may require operating room)

Methods

- Suture placement
- Tissue adhesives
- Adhesive tapes
- Staples

Preparation

- Obtain a complete history of injury:
  - Mechanism
  - Time since injury
  - Tetanus status
  - Comorbidities
- Examine the extent of the wound, remove any contaminants, debride devitalized tissue, and inspect for foreign bodies. Obtain a radiograph if foreign body or underlying fracture is suspected.
- Copious irrigation with normal saline.
- Clean around the wound with a povidone-iodine solution.
- Drape the area in a sterile manner.
- Inject the anesthetic agent into the wound edges using a 25- or 27-gauge needle. The most common agent is lidocaine 2% with or without epinephrine 1% (maximum dose is 3 mg/kg without epinephrine and 5 mg/kg with epinephrine).
- Close the wound using the appropriate technique (see later).
- Dress the wound.
- Update tetanus and diphtheria vaccination if needed.

Suture Repair

Materials and Medications

- Commercial kits commonly contain all the following except the suture material (Fig. 98.1):
  - Povidone-iodine solution
  - Normal saline for irrigation
  - 5- to 12-mL syringe with a 25-gauge needle
  - Anesthetic agent
  - Needle holder
  - Pickups

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Fig. 98.1 Suture kit

- – Suture scissors
- – Suturing material
- – Sterile drape or sheet, gloves, and gauze

General Guidelines

- Local anesthetic lidocaine 1% or lidocaine 1% with epinephrine.
- Minimize direct use of instruments on the tissues.
- Wound edges should be everted to maximize healing and cosmetic effect. This is achieved by inserting the needle at 90° to the skin.
- Sutures should be evenly spaced, placed 1–3 mm apart and 2 mm from the wound edge.
- Optimal tension is achieved by tying the sutures so the edges lightly approximate.

Suture Material

- Nonabsorbable
  - – Silk: for specialty use, reactive and weak:
  - – Nylon (Ethilon) and polypropylene (Prolene): good strength and good overall material for cutaneous wounds
  - – Polypropylene: good strength and difficult to use
  - – Require removal at a specified time
- Absorbable
  - – Undergo rapid degradation in tissues, losing their tensile strength within 60 days
  - – Indication: buried suture to reduce wound edge tension
  - – Vicryl: subcutaneous placement and mucous membranes
  - – Chromic: use for intraoral lacerations
  - – Removal not required

Suture Techniques

- Simple interrupted sutures (Fig. 98.2):
  - – Most common method.
  - – Position needle 2 mm from the wound edge at a 90° angle. Enter the needle into the skin and arc through the wound edge and into the opposing edge at the same level, exiting the skin on the opposing side 2 mm from wound edge, and tie.
- Deep dermal suture (Fig. 98.3):
  - – Also known as buried sutures, used to minimize tension in a wound.
  - – Use absorbable suture material.
  - – The needle is placed at the base of the wound wall and arched upward, exiting the ipsilateral wall more superficially. The needle is then directed across to the opposing wound wall at the same level and directed downward, exiting deep, and tie. Note: The knot will be deep in the wound.
- Simple running suture (Fig. 98.4):
  - – This method provides rapid closure of long and relatively linear lacerations.
  - – Place the initial suture in the same manner as a simple suture, tie, cut the free strand, and leave the needle attached. Reintroduce the needle into the skin on the opposite side so the suture crosses the wound superficially at a 65° angle. The needle is then inserted perpen-

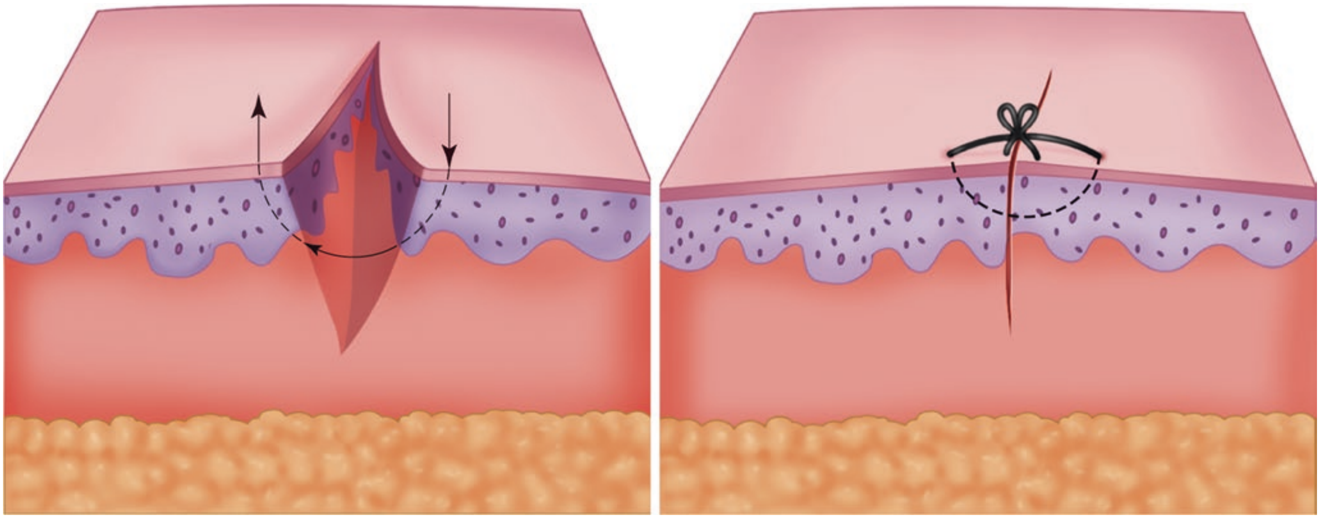

Fig. 98.2 Simple suture

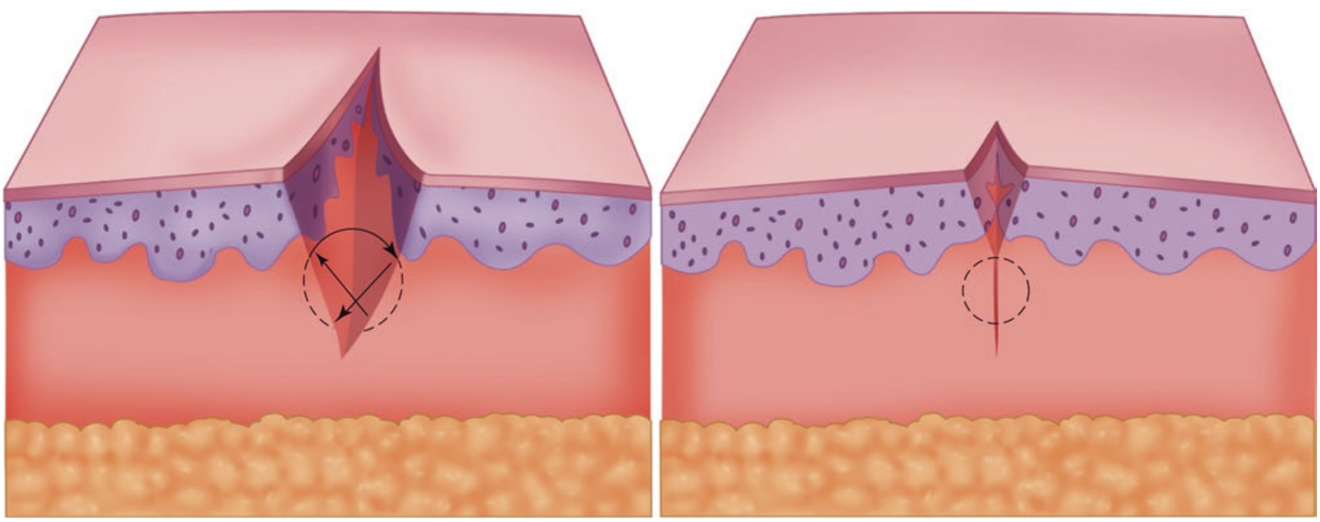

Fig. 98.3 Deep suture

dicular to the skin, emerging on the opposite side about 3 mm from the wound edge. Repeat without tying until closure is complete, maintaining appropriate tension. When the last stitch is placed, leave a loose loop of suture on one side so that both ends can be tied together.

- Vertical mattress suture (Fig. 98.5):
  – Provides the benefits of both simple and deep techniques. For use on deeper, gaping wounds and wounds over high-tension areas such as joints.
  – Position the needle 1 cm from skin edge, at a 90° angle, and drive a deep arc perpendicular through the wound, exiting the skin on the opposing side the same distance from the wound edge. Next, reinsert the needle on the ipsilateral side 2 mm from the edge, emerging on the opposing side and approximate, and tie.
- Horizontal mattress suture (Fig. 98.6):
  – For large wounds with tension.
  – Place the initial suture in the same manner as a simple suture; only do not tie. Reposition the needle on the ipsilateral side, horizontally 5 mm to the side of the exit at the same distance from the wound edge and drive through to the other side, tie. Note: The tie lies parallel to the wound.
- Half-buried horizontal mattress suture (Fig. 98.7):
  – Used on wounds with skin flap.
  – On one side, drive the needle percutaneously, and then pass horizontally through the dermal tissue of the tip of flap, finally passing into the dermis of the opposing edge and exiting the skin, and tie.
- Figure-of-eight suture (Fig. 98.8):
  – Used to control a bleeding vessel that is surrounded by other tissue and not easily visible, or bleeding that is not able to be controlled by direct compression or with hemostats.

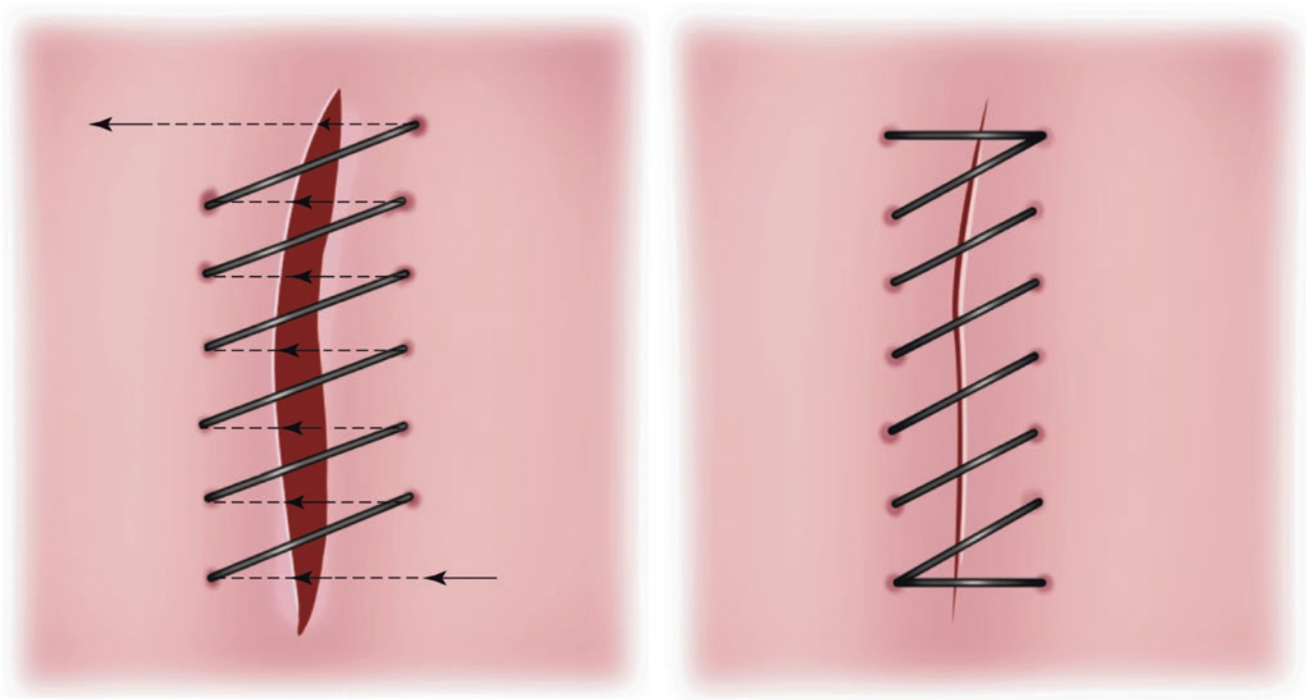

Fig. 98.4 Running suture

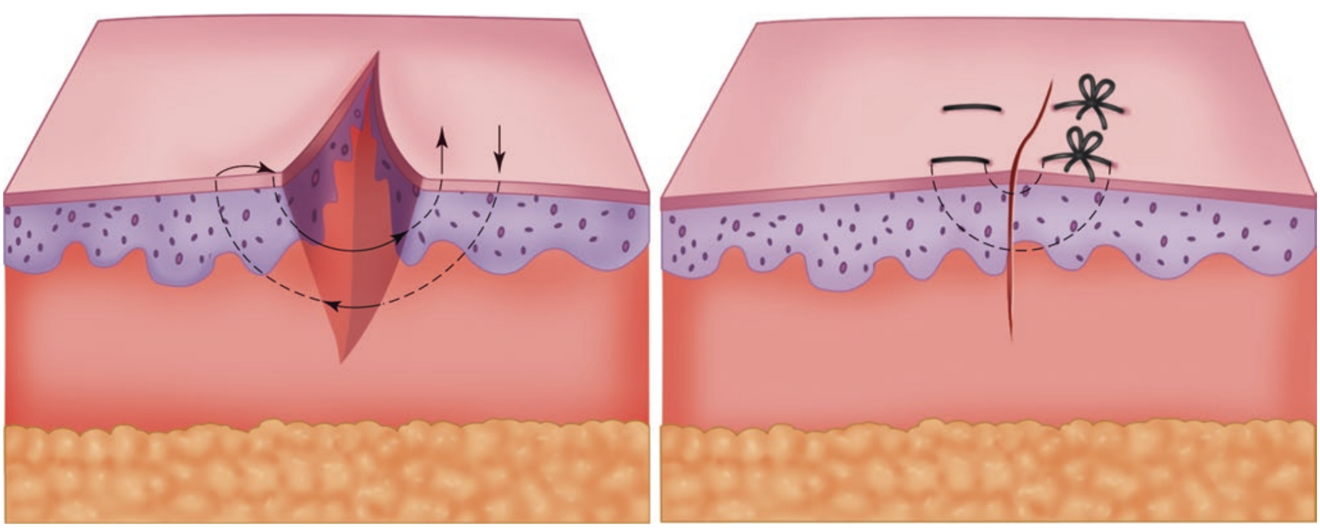

Fig. 98.5 Vertical mattress suture

- Not to be used on major arteries
- Identify the area of bleeding. May need to wash and clean the area and debride any dead tissue or remove any foreign bodies.
- Imaging a box around this area with the source of bleeding in the center of the box.
- With your suture, start at point "1," and going superficial to deep, throw the needle tip toward the corner across from your start position at point "2."
- Your next throw will be at a diagonal from your exit point from the first throw, which will bring your suture across the middle of the bleeding area. From this point "3," you will again go superficial to deep with the throw toward point "4."
- Take the ends of the suture at point "1" and point "4," and perform your ties, making sure that there is proper tension on the suture to allow for hemostasis. The tissue surrounding the bleeding vessel should now be compressed by the suture stemming bleeding.
- If bleeding should still occur, another figure of eight can be placed in the same area for additional control/compression of this tissue.

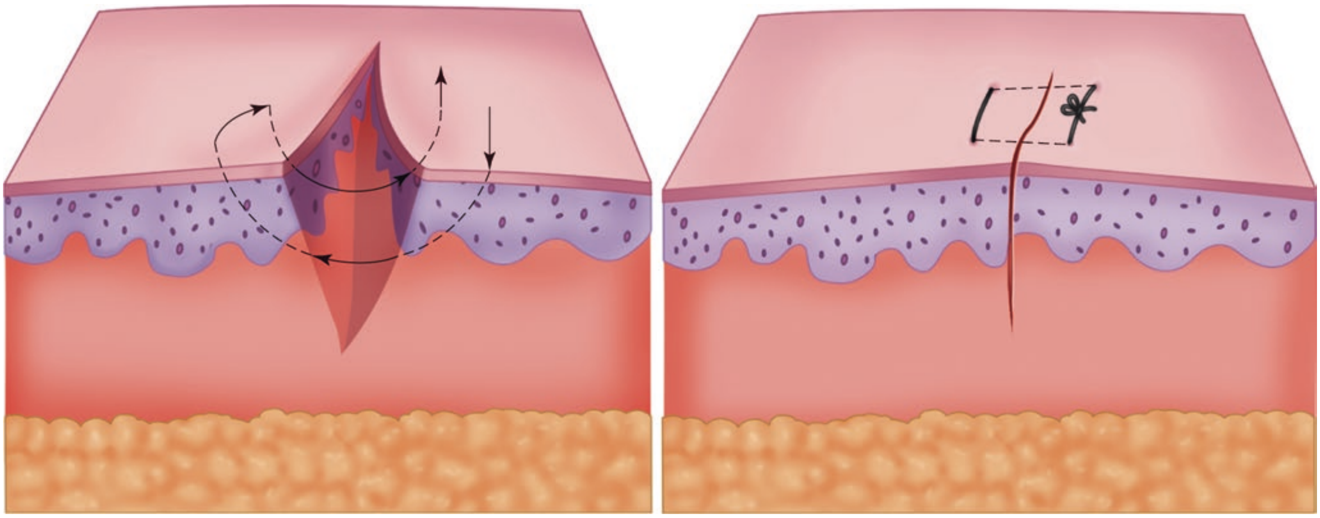

Fig. 98.6 Horizontal mattress suture

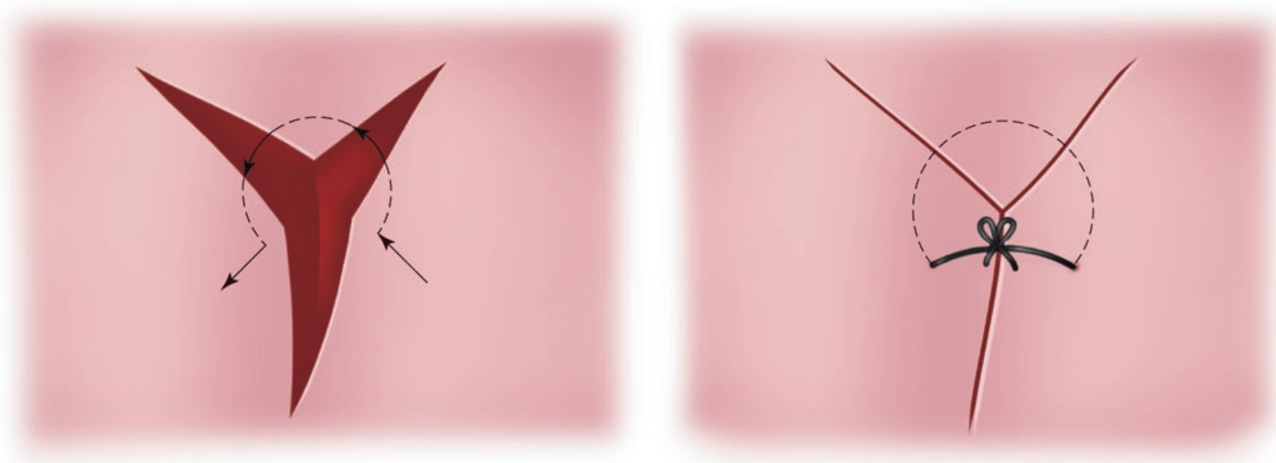

Fig. 98.7 Half-buried horizontal mattress suture

- Always recheck neurovascular status post procedure. As this technique is a somewhat "blind" technique, where you are compressing the tissues around a vessel, you want to make sure that the any major arterial blood supply to the area distal to the repair is intact.
- Be sure to use absorbable sutures as these will be hemostatic and will need to be left inside the wound. If sutures are not absorbable, they will be a nidus for infection.

Suture Size Recommendations

- Face
  - 5.0–6.0 nylon.
  - Remove after 3–5 days.
- Scalp
  - 2.0–3.0 nylon or staple.
  - Remove at 8–10 days.
- Hand
  - 4.0–5.0 nylon; consider vertical or horizontal mattress.
  - 5.0–6.0 Monocryl for nail bed.
  - Remove at 10–14 days; use for a longer time if directly over the joint.
- Extremity
  - Nonmobile skin: 3.0–4.0 nylon; remove at 8–10 days.
  - Over the joint: 3.0–4.0 nylon; remove at 10–14 days.
- Trunk
  - Anterior trunk: 3.0–4.0 nylon; remove at 8–10 days.
  - Posterior trunk: 2.0–3.0 nylon; remove at 10–14 days.
  - Consider staples.
- Oral mucosa
  - Thin mucosa: 4.0 Vicryl will absorb; duration, 5–7 days.
  - Tongue: 3.0 Vicryl will absorb; duration, 5–7 days.

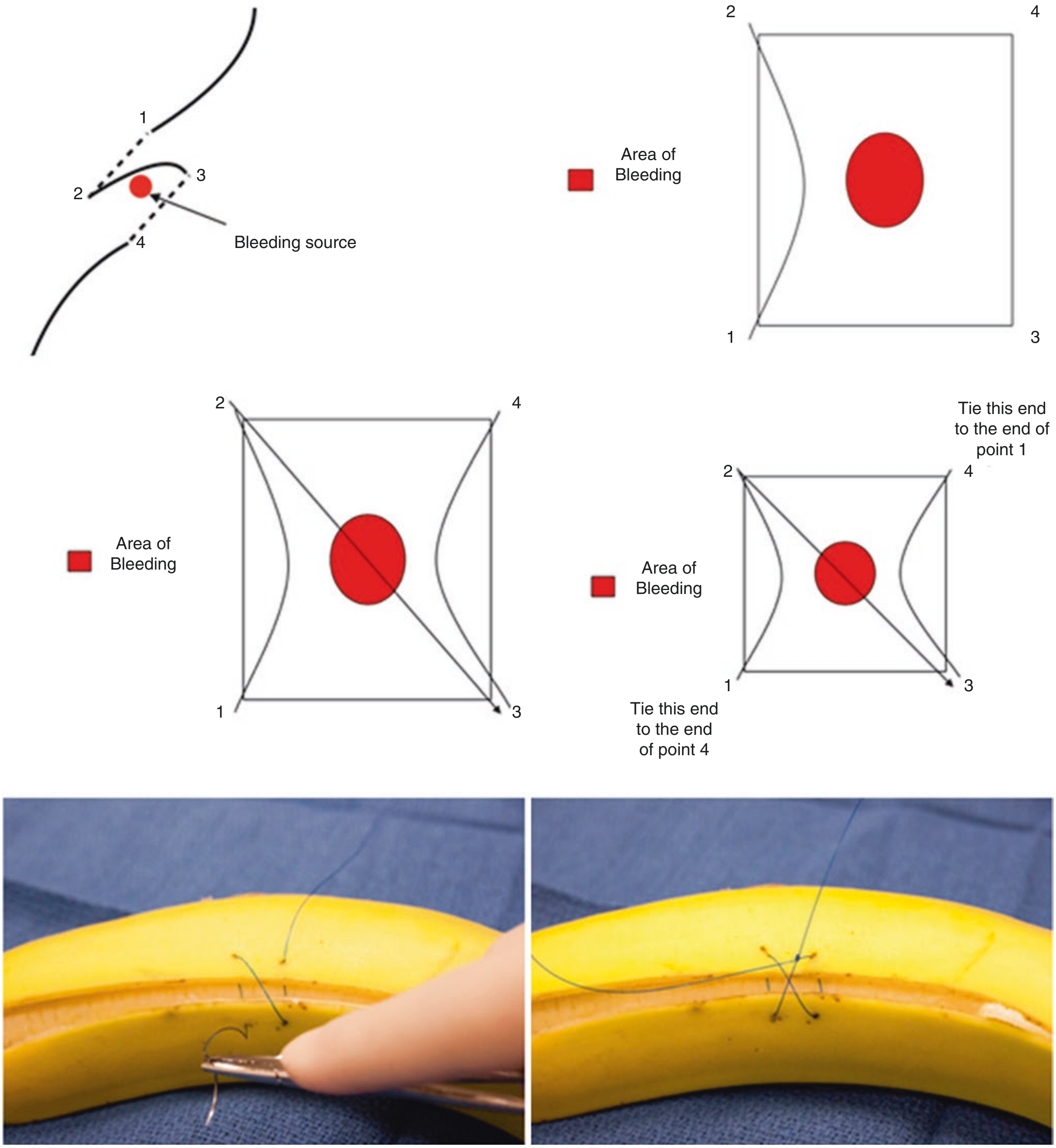

Fig. 98.8 Figure-eight suture technique: schema and demo on banana peel

Alternative Methods of Wound Closure

Cyanoacrylate Tissue Adhesives

See Chap. 93.

Adhesive Tape

- Advantages
  - Rapid and painless application
  - Inexpensive
  - Good cosmetic result
- Disadvantage
  - Minimal strength
- Contraindication
  - Allergy to product
- Precaution
  - For use with wounds under little tension
- Procedure
  - Thoroughly clean the wound as described previously.
  - Approximate the wound edges.
  - Apply adhesive tape directly over the wound with 2–3 mm of space between strips.
  - An adjunct adhesive, such as benzoin, may be used to improve durability.

Staple Closure (Fig. 98.9)

- Advantages
  - Rapid
  - Inexpensive
- Disadvantage
  - Minimal strength
- Contraindication
  - Wounds on the face, hands, or feet
- Procedure
  - Thoroughly clean the wound as described previously.
  - Anesthetize the wound edges.
  - Approximate the wound edges (may require an additional set of hands).
  - Apply staples.

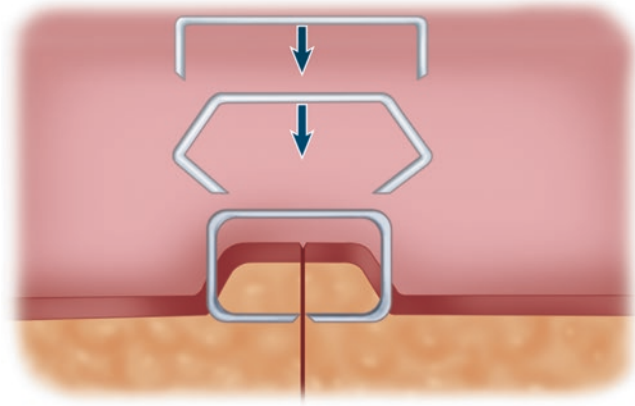

Fig. 98.9 Staple

Pearls and Pitfalls

- Pearls
  - Sutures should not remain in place longer than the recommended period. If the wound is not completely healed, sutures should be removed, and an adhesive tape may be used for edge approximation.
  - Remember to verify tetanus status.
  - Antibiotics should be used judiciously.
- Pitfalls
  - Wound infection.
  - Incomplete healing may lead to wound separation.
  - Tissue reaction to suture or adhesive materials.
  - Allergy to anesthetic agent.

Suggested Reading

http://apps.med.buffalo.edu/procedures/repairoflacerations.asp?p=17. Accessed 19 May 2014.

Singer AJ, Hollander JE. Methods for wound closure. In: Ma OJ, Cline DH, Tintinalli JE, Kelen GD, Stapczynski JS, editors. Emergency medicine manual. 6th ed. New York: McGraw Hill; 2003. Chap. 13, Fig. 13–14.

Singer AJ, Hollander JE. Laceration and acute wounds: an evidence-based guide. Philadelphia: FA Davis; 2003. p. 122.

University of Connecticut Health Center, suturing 101. fitsweb.uchc.edu/suturing101. Accessed 19 May 2014.

Zuber TJ. The mattress sutures: vertical, horizontal and corner stitch. Am Fam Physician. 2002;66:2231–6.

Wound Closure with Tissue Adhesive

99

Pratik S. Patel and Latha Ganti

Indications

- Small superficial skin incisions or laceration repairs which require 5.0 or smaller-diameter sutures

Contraindications

- Absolute
  - Large irregular/stellate lacerations
  - Infected/contaminated wounds
  - Animal/human bites
  - Puncture wounds
  - Crush wounds
  - Skin ulcers
  - Mucous membranes and mucocutaneous junctions
  - Axillae and perineum (owing to high moisture)
  - Wounds under tension
- Relative
  - Wounds on hands (unless kept dry)
  - Joints (unless kept immobilized with a splint)

Materials and Medications

- Tissue adhesive (such as 2-octyl cyanoacrylate)
- Betadine (povidone-iodine) solution
- 0.9% normal saline solution
- 20-mL sterile syringe
- Sterile gloves
- Dry 4×4 gauze

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Optional Materials

- Topical anesthesia
- 1:1000 epinephrine solution
- Forceps
- Bacitracin ointment or sterile petroleum jelly ointment
- Gown and protective eyeglasses
- Splint

Procedure

1. Have the patient rest comfortably on a chair or bed.
2. Use universal precaution measures: sterile gloves (gown and eye-screen, if necessary for wound irrigation).
3. Wash the wound with 0.9% normal saline irrigation.
4. Use a topical anesthetic such as LET (lidocaine, epinephrine, tetracaine) or EMLA (eutectic mixture of local anesthetics) cream (lidocaine and prilocaine), or a 1:1000 epinephrine solution soaked into gauze can be used to achieve hemostasis in a bleeding wound.
5. Approximate the edges of the wound with fingers. Toothed forceps or other skin approximation devices may be used as an adjunct. Apply bacitracin ointment or Vaseline to the tips of the forceps and the glove fingertips, and wipe off the excess to prevent sticking of Dermabond glue to the forceps or the glove.
6. Crush tissue adhesive vial between the thumb and the finger while in the inverted position until the adhesive is seen at the applicator tip (Fig. 99.1).
7. Squeeze gently until a drop of adhesive forms at the applicator tip.
8. Gently brush the adhesive at the applicator tip over the approximated wound edges (Fig. 99.2). (Do not force or press the applicator tip over the wound.)
9. Cover the entire wound with single coat of adhesive.
10. Hold the wound edges for 30 s to 1 min until it dries.

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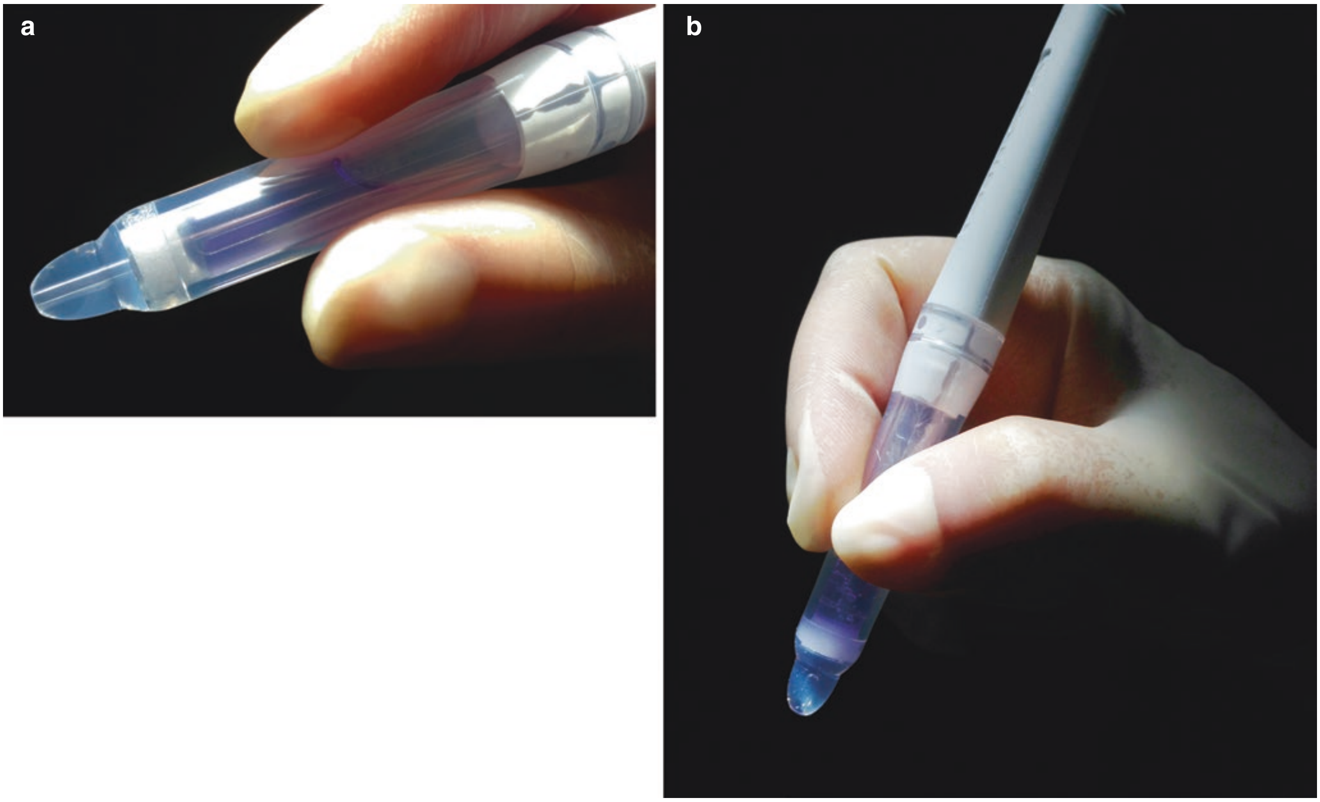

Fig. 99.1 (**a**) Before the tip has been crushed. (**b**) The purple tissue adhesive (Dermabond in this case) is in the tip

Fig. 99.2 Closing the wound: use tip of Dermabond pen to "paint" over the laceration

11. Apply two or three more coats of adhesive over and around the wound in a circular or oval movement to provide extra strength.
12. Wipe off extra adhesive in the surrounding skin with gauze if needed.
13. Apply a splint (optional) to provide wound stability over the joints.
14. Recommend the patient to keep the wound dry for 4–5 days. Patients may shower but should be instructed to pat dry instead of rubbing a towel over the skin.
15. No topical antibiotic ointment is required before or after application of tissue adhesive.

Complications

- Wound dehiscence
- Wound infection

Pearls and Pitfalls

- Pearls
  – Advantages of tissue adhesives for wound repair compared with sutures include faster repair time, better acceptance by patients (especially children), water-resistant covering, and no need for a second visit to remove sutures (sloughs off in 5–10 days).

  - Tissue adhesives can also be used on the perimeter of a wound in patients with thin, fragile skin (such as the elderly) to provide “reinforcement” to the skin such that sutures can subsequently be placed through the skin.
- Pitfalls
  - Dermabond is a super adhesive. Take care not to have the glove, finger, drape, gauze, or instrument inadvertently stuck to the wound or the patient by having a bacitracin or petroleum jelly coating around the wound, on gloved fingers, and on forceps as needed.
  - Avoid using Dermabond near the eye. If tissue adhesive inadvertently comes in contact with the eyelid, eyelash, or eye, use ophthalmic antibiotic ointment with gentle manual traction to break down the adhesive. Patient should be assessed for corneal abrasion since dried tissue adhesive is firm and abrasive.

Suggested Reading

Bruns TB, Worthington JM. Using tissue adhesive for wound repair: a practical guide to Dermabond. Am Fam Physician. 2000;61:1383–8.

Farion K, Osmond MH, Hartling L, et al. Tissue adhesives for traumatic lacerations in children and adults. Cochrane Database Syst Rev. 2002;(3):CD003326.

Joyce K, Potter S. A novel skin closure technique for the management of lacerations in thin-skinned individuals. Cureus. 2020;12(9):e10702. Published 2020 Sep 29. https://doi.org/10.7759/cureus.10702.

Fishhook Removal

100

Judith K. Lucas

Indication

- Removal of a fishhook from nonvital structures (Fig. 100.1)

Contraindications

- Removal of hooks located near/in eyes or eyelids, embedded near or within neurovascular structures, or embedded within vital structures such as the peritoneum, testicle, or urethra:
  – Fishhooks in these areas require specialist consultation.

Materials and Medications (Depend on Method Utilized)

- Antiseptic cleansing solutions
- Betadine (povidone-iodine)
- ChloraPrep
- Local anesthetic
- 1% lidocaine, with or without epinephrine
- Needle drivers or pliers
- 18- or 20-gauge needle
- 3-0 silk suture or umbilical tape
- Wire cutters
- Protective eyewear

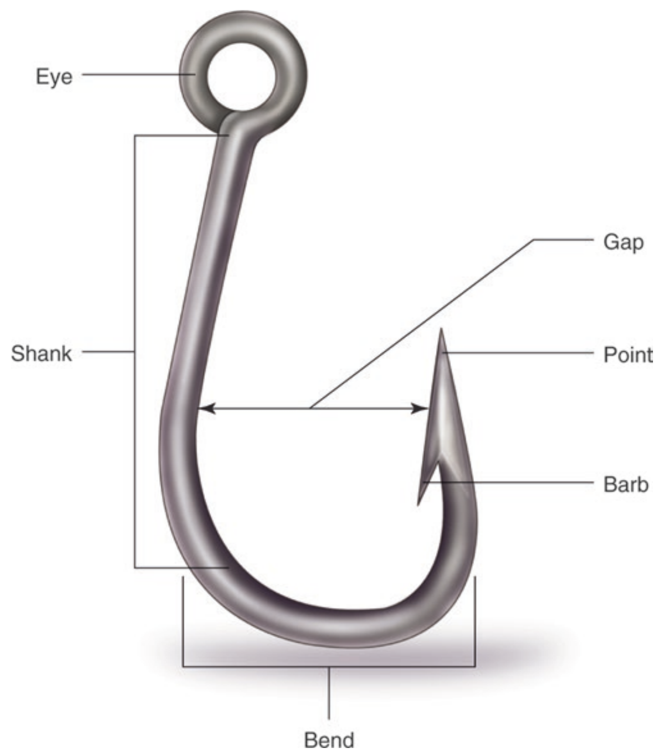

Fig. 100.1 Anatomy of a fishhook

Procedures

- Retrograde technique (Fig. 100.2): Simplest, least traumatic, but least successful; good for small to medium hooks, superficially embedded hooks, and hooks with no barbs or a single barb:
  1. Detach extra hooks, line, or foreign materials (e.g., worms, fish, debris).
  2. Cleanse the puncture site and surrounding tissue with antiseptic solution.
  3. Infiltrate the entry site and surrounding area with local anesthetic.

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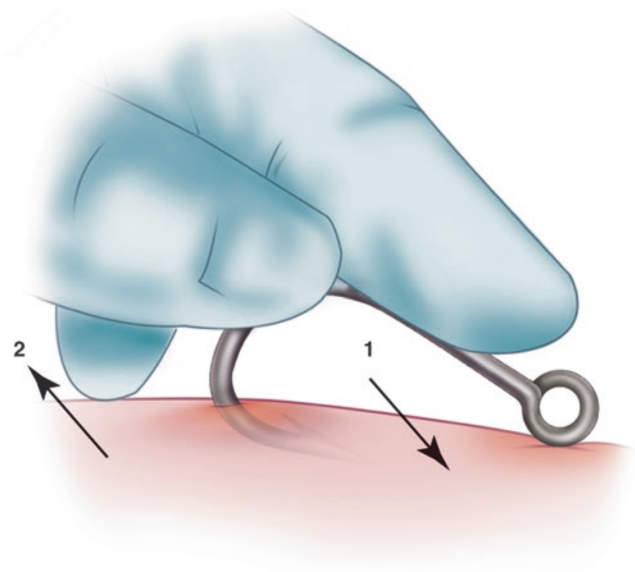

Fig. 100.2 Retrograde technique

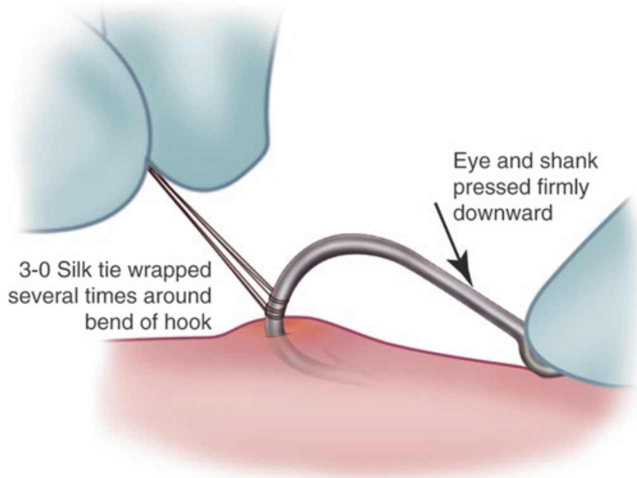

Fig. 100.3 String and yank technique

4. Apply downward pressure on the shank or shaft of the hook, near the eye, thus disengaging the barb from the tissue.
5. Back the hook out of the skin along the path of entry.

- String and yank technique (Fig. 100.3)**:** Good for small to medium hooks. Often it can be done without local anesthesia. It is good for areas of deep soft tissue penetration. It cannot be used on parts of the body that are not fixed, such as earlobes:
  1. The hook will "fly" out quickly. Be certain to wear eye protection.
  2. Detach extra hooks, line, or foreign materials (e.g., worms, fish, debris).
  3. Cleanse the penetration site and surrounding area with antiseptic solution.
  4. Consider infiltrating the entry site with local anesthetic if necessary.
  5. Wrap 3-0 silk suture, fishing line, or umbilical tape several times around the bend of the hook (at the point of greatest curvature) which should be directly in front of the clinician with the shank pointed in the opposite direction.
  6. The loose ends of the string need be held tightly. Sometimes the loose ends can be more firmly held if wrapped around a pencil or tongue depressor.
  7. The skin around the entry site should be well stabilized, while simultaneously depressing the shank, close to the eye of the hook.
  8. While stabilizing the skin and applying downward pressure on the shaft, quickly and firmly yank the string, in a parallel line to the shaft. Be certain downward pressure is applied along the shank.
  9. Examine the freed hook to ensure that the barb of the hook is present and not broken off within the wound.
- Needle cover technique (Fig. 100.4): Good method to remove large hooks with a single barb, especially if superficially embedded:
  1. Detach extra hooks, line, or foreign materials (e.g., worms, fish, debris).
  2. Cleanse the penetration site and surrounding area with antiseptic solution.
  3. Infiltrate the entry site and surrounding area with local anesthetic.
  4. Advance an 18-gauge needle along the entrance wound of the hook. Pass the needle parallel to the shank. The bevel should be pointed downward, toward the barb and point.
  5. The needle is advanced until it disengages the barb, entrapping it within the needle lumen.
  6. The hook and needle are advanced just enough to disengage the barb.
  7. The hook and needle are withdrawn along the track of the wound.
- Advance and cut technique (Fig. 100.5): Almost always successful, but does cause additional tissue trauma:
  1. Detach extra hooks, line, or foreign materials (e.g., worms, fish, debris).
  2. Cleanse the penetration site and surrounding area with antiseptic solution.
  3. Infiltrate the entry site and surrounding area with local anesthetic.
  4. If the hook has a single barb:
     - Grip the hook on the shank, near the bend, with either a needle driver or pliers.
     - Push the hook through along its natural trajectory, until the point and barb pass completely through the skin.

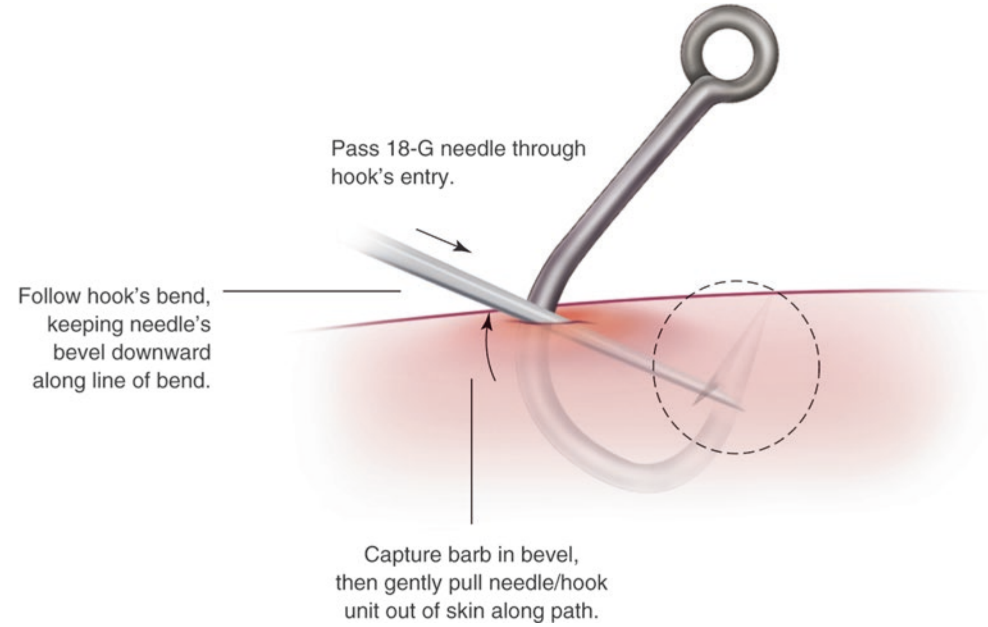

Fig. 100.4 Needle technique

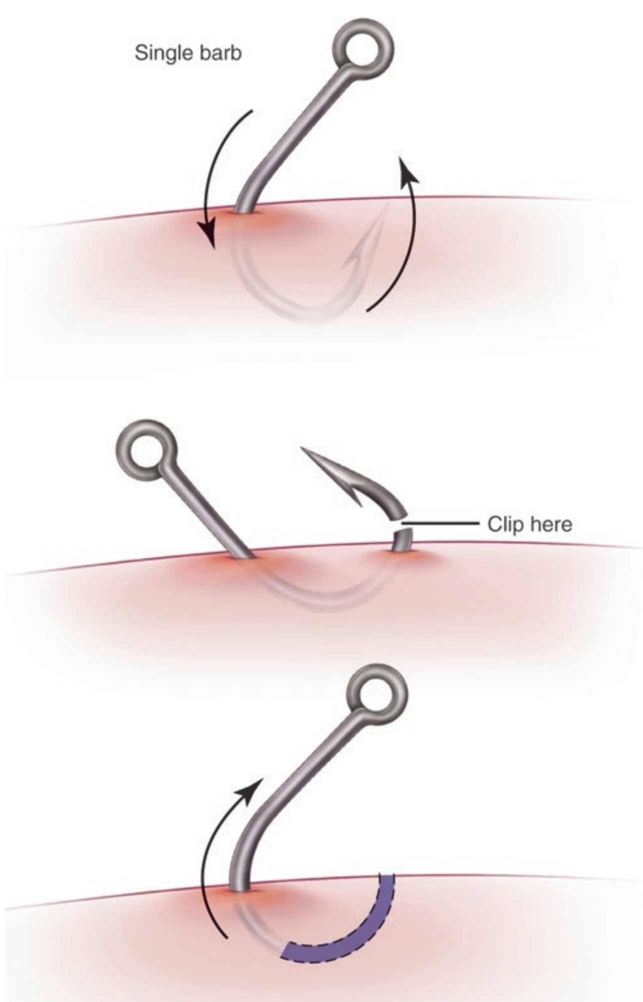

Fig. 100.5 Advance and cut technique

- Clip the point proximal to the barb. Be certain to wear eye protection because the point can fly off in an unpredictable direction.
- Withdraw the hook out back along its entry path.

5. If the hook has multiple barbs (Fig. 100.6):
   - Grip the hook on the shank, near the hook's bend with either a needle driver or pliers.
   - Push the hook through along its natural trajectory, until the point and barb pass completely through the skin.
   - Clip the eye of the hook with wire cutters.
   - Grasp the point and withdraw the hook through the skin forward along its natural course.

Post-Removal Wound Care

Immune competent, without peripheral vascular disease:

1. Explore the wound for possible foreign bodies.
2. Irrigate or scrub the wound copiously with soapy solution.
3. Apply antibiotic ointment and sterile dressing.
4. Tdap (or DTaP) should be given to anyone in whom the last tetanus booster has been longer than 5 years.
5. Wound check in 24–48 hours with care provider.

Immunocompromised, or a patient with peripheral vascular disease:

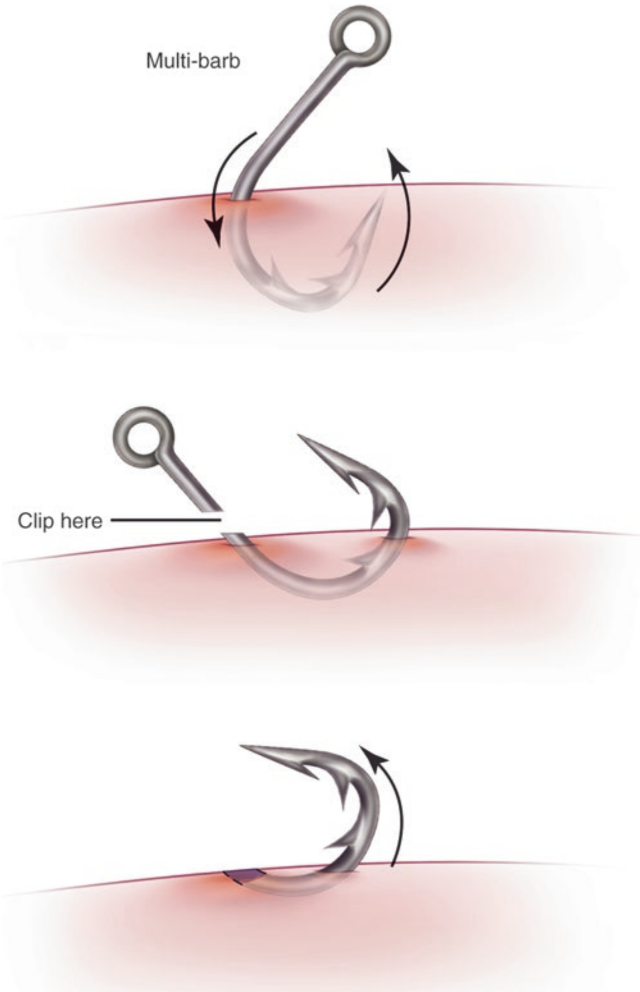

Fig. 100.6 Advance and cut a hook with multiple barbs present

1. As previously.
2. Give strong consideration to treating prophylactically with antibiotics, choosing a fluoroquinolone, third-generation cephalosporin, or aminoglycoside.

Complications

- Infection
- Retained foreign body
- Injury to neurovascular structures, if method of removal is not carefully selected
- Injury to provider if adequate (eye) protection not used

Pearls and Pitfalls

- Pearls
  - Begin with either the retrograde method or the string-yank method as these result in less tissue damage and are the easiest to perform, although they have the lowest rate of success.
  - Eye protection is imperative, especially if utilizing the string-yank method or clipping any portion of the hook (eye or point) because the retraction of the hook, or its parts, is generally at a high velocity and travels an unpredictable path.
  - When trying the advance and cut technique, stop immediately if, when advancing the hook, impasse or resistance is met because this may indicate bone or neurovascular structures are blocking the natural path of the hook.
  - Fishhooks that embed into or near the eye or lids should be covered with a metal patch or cup, and the patient should be sent (immediately) for ophthalmologic consultation.
  - Close follow-up is imperative to watch for signs of infection.
- Pitfalls
  - When utilizing the advance and cut technique, do not cut anything until certain there is another portion of the hook on which to grasp.

Suggested Reading

Ahmad Khan H, Kamal Y, Lone AU. Fish hook injury: removal by "push through and cut off"' technique: a case report and brief literature review. Trauma Mon. 2014;19(2):e17728. https://doi.org/10.5812/traumamon.17728. Epub 2014 Mar 24. PMID: 25032153; PMCID: PMC4080619.

Beasley K, Ouellette L, Bush C, Emery M, Wigstadt S, Ambrose L, Jones J. Experience with various techniques for fishhook removal in the emergency department. Am J Emerg Med. 2019;37(5):979–80. https://doi.org/10.1016/j.ajem.2018.09.028. Epub 2018 Sep 22.

Julian E, Mammino J. Don't get hung up on fishhooks: a guide to fishhook removal. Cutis. 2016;97(3):195–8.

101 Tick Removal

David N. Smith and Judith K. Lucas

Indication

- Tick attachment to the skin

Contraindications

- None

Materials and Medications

- Gloves
- Skin disinfectant (commercially available product, such as ChloraPrep, isopropyl alcohol, or Betadine [povidone-iodine])
- Fine-toothed forceps

Procedure

1. Comfortably position the patient with the tick site exposed.
2. Grasp the tick with the forceps as close to the skin surface as possible (e.g., grasp the mouthparts).
3. Gently pull upward with steady, non-twisting, even traction (Figs. 101.1 and 101.2).
4. After removal, clean the bite area and apply antibiotic ointment.

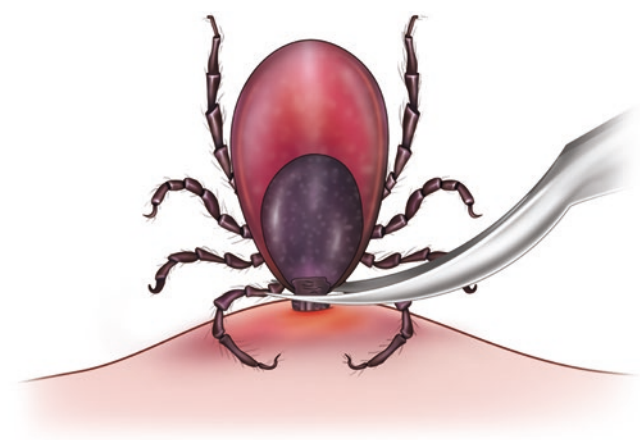

Fig. 101.1 Place the forceps as close to the mouth of the tick as possible, hold firmly, and pull straight up with steady gentle traction

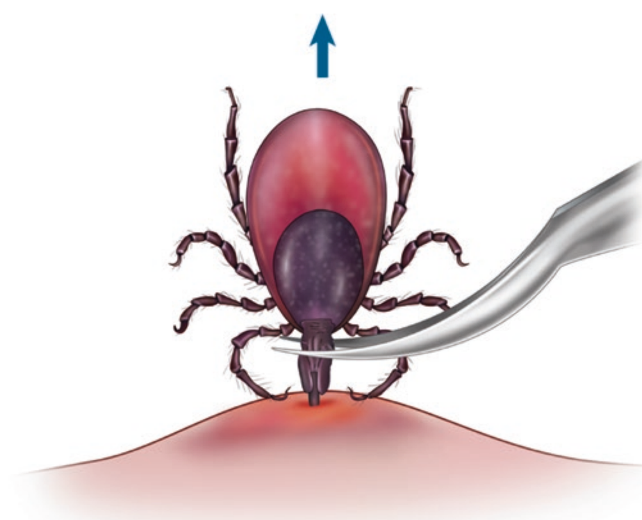

Fig. 101.2 Steady upward traction

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Complications

- Multiple diseases including:
  - Lyme disease
  - Human granulocytic and monocytic ehrlichiosis
  - Babesiosis
  - Relapsing fever
  - Rocky Mountain spotted fever
  - Colorado tick fever
  - Tularemia
  - Q fever
  - Tick paralysis
- Secondary infection (methicillin-resistant *Staphylococcus aureus* [MRSA] and group A streptococcus).
- Scratching can lead to lichenification.
- Rare cases of alopecia when tick located in the scalp.

Pearls and Pitfalls

- Pearls
  - Do not twist or jerk the tick out (may cause breakage of mouthparts; they may remain in the skin). If mouthparts remain in the skin, leave them alone as they will normally be expelled spontaneously.
  - Do not squeeze the body of the tick.
  - Do not use a hot match, gasoline, or other noxious stimulus for removal (causes irritation of tick and release of internal contents).
  - Lyme disease transmission increases significantly after 24–48 hours of attachment, so early removal is key.
  - Patients should be monitored for up to 30 days for signs of tick-borne diseases, including erythema migrans (bull's-eye rash) indicating Lyme disease (Fig. 101.3).
  - Prophylactic antibiotic treatment, a single dose of doxycycline, is used only in patients with an identified *Ixodes scapularis* tick that has been attached for longer than 36 hours and if treatment can start within 72 hours of tick removal.
  - Serological testing for Lyme disease is not indicated for a reported tick bite.

Fig. 101.3 Erythema migrans (the bull's-eye rash), the rash typically associated with Lyme disease. Often the rash is so pale as to go unnoticed

- Pitfalls
  - Use of lidocaine subcutaneously can irritate the tick and cause it to regurgitate its stomach contents, increasing the risk of disease transfer.
  - Tick saliva can cause transient erythema that should not be confused with erythema migrans.

Suggested Reading

Benzoni T, Cooper JS. Tick removal. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020.

Centers for Disease Control and Prevention. Tick removal. In: Ticks. 2019. http://www.cdc.gov/ticks/removing_a_tick.html. Accessed 14 Feb 2021.

Roupakias S, Mitsakou P, Nimer AA. Tick removal. J Prev Med Hyg. 2011;52(1):40–4.

Schneider LA, Dissemond J. When professional forceps are not available: efficient tick removal using a no. 15 scalpel as a spade. Eur J Dermatol. 2015;25(2):193–4. https://doi.org/10.1684/ejd.2014.2489.

Conducted Energy Weapon (e.g., TASER) Probe Removal

102

Tracy MacIntosh

Indications

There are two methods of conducted energy weapon probe application: direct application and deployed probes. Probe removal applies to the latter, and probes should be removed if still in place (Fig. 102.1).

Fig. 102.1 TASER X26P

Contraindications

Not applicable

Materials and Medications

Personal protective equipment:

- Face and eye shield
- Gloves
- Lidocaine
- Kelly forceps
- 11 Blade scalpel

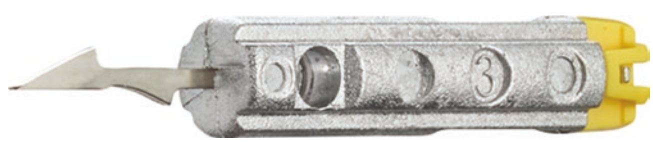

Fig. 102.2 Old TASER probe

Procedure

1. Support the patient's skin with nondominant hand so the skin is taught, stabilize, and provide countertraction.
2. With dominant hand, grasp barb with fingers (Figs. 102.2 and 102.3), or Kelly forceps if unable to grip safely or easily with fingers, and quickly pull in opposite direction that probe tip is embedded.
3. Superficial blood vessels may bleed and cause hematoma; apply pressure if necessary.
4. Consider application of lidocaine and small incision at the site of probe tip if caught on tissue and unable to remove easily.
5. Update tetanus if necessary.
6. Discard probe in sharps container.

Complications

- Consider specialist consultation for ocular, laryngeal, and urethral penetration.

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Fig. 102.3 New TASER probes

Pearls and Pitfalls

- Medical screening should evaluate the probe site for damage to muscles, nerves, bones, and lungs.
- Routine labs, EKGs, or other diagnostic tests are rarely useful in the absence of clinical indication.
- Consider the possibility for retained probe tip if barb is embedded in the bone and/or was difficult to remove.

Suggested Reading

Guidelines for Evaluation of Hospital Guest Receiving a TASER Device Application (TDA). In AXON (Ed.); 2012.

Vilke GM, Bozeman WP, Chan TC. Emergency department evaluation after conducted energy weapon use: review of the literature for the clinician. J Emerg Med. 2011;40(5):598–604. https://doi.org/10.1016/j.jemermed.2010.10.019.

Entrapped Ring Removal

103

James Chiang

Indications

- Entrapped ring on swollen digit or penis, due to traumatic or nontraumatic reasons, and simple traction is unsuccessful

Contraindications

- Relative
  – Fracture, laceration, avulsion, or degloving injury is present at the involved finger, and traction can potentially injure neurovascular structures, worsen the laceration/avulsion significantly, or tear already injured tendinous structures.

Non-cutting Techniques

Materials and Medications

- Water-soluble lubricant or liquid soap
- String (may use 3.0 or larger sutures, Penrose drain, or umbilical tape)
- Manual or electric ring cutter
- Dental drill, Dremel saw, or grinder
- Locking pliers or vice grip
- Analgesia or sedation medications as needed

Procedure: Winding Technique

1. Lubricate the finger.

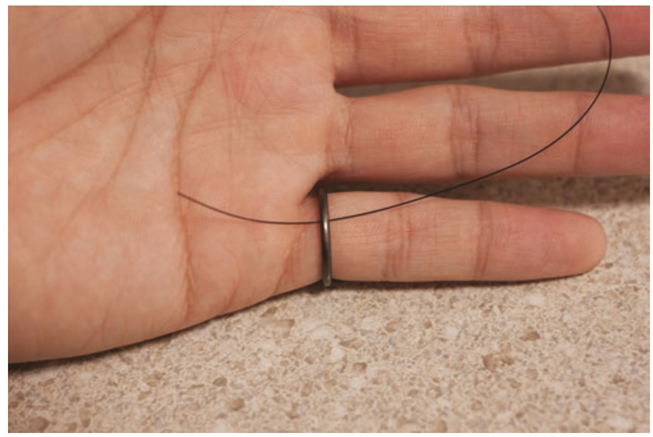

Fig. 103.1 Winding technique: thread string through ring with plier, or use suture attached to suture needle, and thread under ring using the blunt end of the needle

2. Thread string through the ring with a plier, or use a suture attached to a suture needle, and thread it under the ring using the blunt end of the needle (Fig. 103.1).
3. Tightly wrap the string on the distal side of the ring around the finger until the proximal interphalangeal joint is wrapped (Fig. 103.2).
4. Pull the proximal end of the string toward the fingertip, and the ring should slowly move distally as the string unwinds (Fig. 103.3).

Procedure: Compression Technique

1. Apply Penrose drain tightly distal to PIP joint.
2. Lubricate the finger.
3. Wrap a second Penrose drain tightly around the finger starting from the first Penrose drain, and wrap toward the ring. The goal to is decrease edema and swelling of the finger by direct compression.
4. Remove the second Penrose and attempt to pull the ring out.

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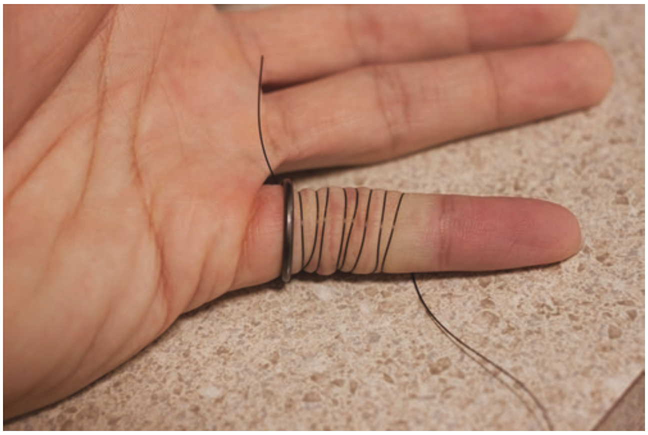

Fig. 103.2 Winding technique: tightly wrap the string on distal side of ring around the finger until proximal interphalangeal joint is wrapped

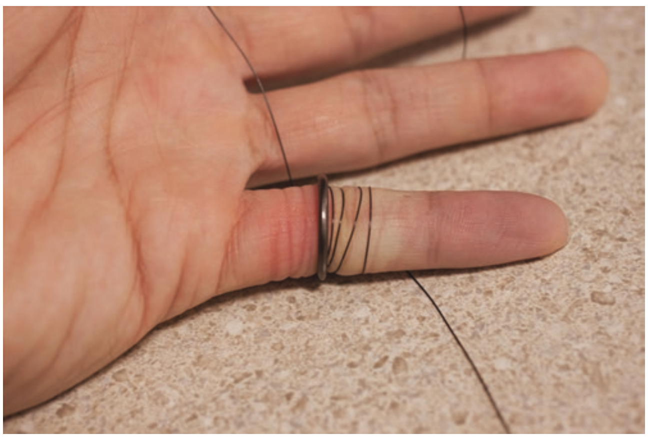

Fig. 103.3 Winding technique: pull proximal end of the string toward fingertip. Ring should slowly move distally as the string unwinds

5. Steps 3 and 4 may be repeated a few times to further decrease swelling.
6. You can combine the winding technique with the compression technique by threading the second Penrose drain through the ring after the finger is wrapped, and then pull the threaded string toward the tip of the finger. The ring should move distally as the Penrose drain unwinds.

Complications

- Skin lacerations and abrasions may occur or worsen as a result of skin traction.

Pearls and Pitfalls

- Perform a neurovascular exam before and after ring removal, and clean the finger fully after ring removal to examine the finger for any abrasions/lacerations, and consider tetanus vaccine.
- The non-cutting techniques may be unsuccessful if the finger is significantly swollen.
- If there are signs of ischemia (mottled skin, pain out of proportion, lack of two point discrimination), the non-cutting technique should only be attempted briefly before the cutting technique.
- Ring entrapped around a penis for greater than 72 hours is associated with urethral injury or penile ischemia/necrosis and is a urologic emergency, and urology should be consulted. In severe cases, penile needle pricks with manual compression or aspiration of the corpus cavernosum similar to management of priapism may be done if ring removal is difficult.

Cutting Techniques

Indications

- Non-cutting techniques of ring removal have failed.
- Signs of ischemia are present and prompt ring removal is needed.

Contraindications

- None

Materials and Medications

- Manual or electric ring cutter (for soft metals such as gold, silver, platinum)
- Dental drill, Dremel saw, or grinder (for hard metals such as steel, titanium)
- Locking pliers or vice grip (for extremely hard but brittle materials such as tungsten or ceramic rings)
- Small pliers/hemostats
- Analgesia or sedation medications as needed

Procedure

For soft and hard metals:

1. Examine the finger for any open wounds, and cover it with gauze to prevent metal filing entering wound.
2. Identify the thinnest portion of the ring.
3. Insert the guard of ring cutter on palmar surface of the hand or plantar surface of feet. If using a handheld saw or grinder without a guard, use other items such as tongue

Fig. 103.4 For soft or hard metals: insert the guard of ring cutter on palmar surface of the hand or plantar surface of feet

depressor and flat handle blade of forceps or scalpels to protect the finger (Fig. 103.4). Also place a gauze over the hand to prevent sawdust from burning the patient.
4. Allow the saw blade to lightly touch the ring while spinning at near maximum speed. Do not press too firmly or blade will slow down and will cut inefficiently. Periodically cool down the ring with cold saline to avoid burning the patient. It will take several minutes to completely cut through the ring.
5. One the ring is cut, pull the ring apart with two hemostats, and slide the ring off the finger carefully without cutting the skin with the ring's sharp edges.

Extremely hard materials (tungsten or ceramic):

1. Provider and patient should wear eye protection.
2. If using a locking plier, clamp the locking plier and adjust it so that it gently grips the ring.
3. Unclamp the plier, turn the adjusting knob quarter to half a turn, and reclamp the plier on the ring.
4. With gradually increasing tightness, the ring will shatter.

Complications

- Metal filings that enter open wounds may cause foreign body reactions and/or chronic synovitis, so cover any open wounds with gauze and irrigate wounds well after ring removal.
- Potential burn from heat generated during cutting.
- Inadvertently injure patient with a saw if the skin is not protected well.

Pearls and Pitfalls

- Perform a neurovascular exam before and after ring removal, and clean the finger fully after ring removal to examine the finger for any abrasions/lacerations, and consider tetanus vaccine.

Suggested Reading

Fasano FJ Jr, Hansen RH. Foreign body granuloma and synovitis of the finger: a hazard of ring removal by the sawing technique. J Hand Surg Am. 1987;12(4):621.

Fuchs SM. Ring removal. In: Henretig FM, King C, editors. Textbook of pediatric emergency procedures. 2nd ed. Philadelphia: Lippincott, Williams, & Wilkins; 2008. p. 1107.

Kalkan A, Kose O, Tas M, Meric G. Review of techniques for the removal of trapped rings on fingers with a proposed new algorithm. Am J Emerg Med. 2013;31(11):1605. Epub 2013 Sep 23.

Silberstein J, Grabowski J, Lakin C, Goldstein I. Penile constriction devices: case report, review of the literature, and recommendations for extrication. J Sex Med. 2008;5(7):1747.

Stone DB, Scordino DJ. Foreign body removal. In: Roberts JR, Custalow CB, Thomsen TW, editors. Roberts and Hedges clinical procedures in emergency medicine. 6th ed. Philadelphia: Elsevier Saunders; 2014. p. 708.

Subungual Hematoma Drainage

104

Pratik S. Patel and Latha Ganti

Causes

- Crushing injury to the finger or toe
- Ill-fitted shoes/inadequate space for toes

Indication

- Pain that is not tolerable with nail edges intact

Contraindications

- Relative
  - Disrupted nail edges
  - Tolerable pain that can be managed conservatively
  - Skin infections around the toe/finger
  - Bleeding disorder

Materials and Medications

- Electrocautery tool
- 18-gauge single-bevel needle or 23-gauge double-bevel needle
- Betadine (povidone-iodine) solution
- Gloves
- Topical antibiotic

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Optional Materials

- Finger splint
- Lidocaine (1 or 2% without epinephrine)

Procedure

1. Have the patient rest the affected finger comfortably on a flat surface.
2. Use universal precaution measures: gloves, gown, and eye screen.
3. Sterile skin preparation with Betadine.
4. Optional (for complicated subungual hematoma): use 1 or 2% lidocaine without epinephrine for providing local digital block.
5. Using the thumb and index finger, gently twist the 18-gauge needle with light pressure over the base of the nail bed or in the center of the hematoma until no resistance is felt. Do not apply any further pressure in order to avoid nail bed damage. Nail penetration is confirmed by return of dark blood from the hole. This procedure is known as trephination (Figs. 104.1 and 104.2). A single hole should suffice for an 18-gauge needle. A 23-gauge needle may require multiple holes.
6. Apply light pressure around the tip of the finger and hematoma to facilitate drainage. In case of continuous bleeding, elevate the digit and apply firm and continuous pressure over the nail with a gauze piece.
7. Apply topical antibiotic ointment (e.g., bacitracin) over the puncture hole.
8. Apply a gauze dressing or a bandage over the wound site/fingernail.
9. Apply a finger splint (optional) to provide additional comfort.
10. Recommend the patient to keep the finger or toe dry (avoid soaking) and elevated for 1–2 days.

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Fig. 104.1 Subungual hematoma of the right index finger

Fig. 104.2 Positioning of needle to perform subungual hematoma drainage

Complications (Rare)

- Infection
- Injury to nail bed or underlying bone if too much pressure is applied with puncture
- Onycholysis when there is incomplete drainage in rare cases

Pearls and Pitfalls

- Pearls
  - Multiple holes may be necessary for appropriate drainage of the hematoma.
  - When using electrocautery for hole puncture, execute high caution with acrylic nails because they are flammable.
  - Avoid using a paper clip and heating with flame since many paper clips are made with aluminum, which is difficult to heat sufficiently to contain adequate heat to penetrate the nail, and increase risk of excess downward force and potential inadvertent nail bed injury once nail is penetrated. Open flame in the hospital setting should be avoided.
  - Take a radiograph of the finger whenever necessary to rule out phalangeal fracture.
  - Check for avulsion of the extensor tendon.
  - Inform the patient that the existing nail may fall off and will regenerate in a few months if the nail bed is intact.
  - Systemic or oral antibiotics are not recommended.
  - There is no need to drain a subungual hematoma if it is not painful.
- Pitfalls
  - Development of a dark color change over the nail bed without any history of trauma should raise suspicion of a tumor and should be evaluated accordingly.
  - Do not remove the nail to evaluate injury to nail bed.

Suggested Reading

Antevy PM, Saladino RA. Management of finger injuries. In: King C, Henretig FM, editors. Textbook of pediatric emergency procedures. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2008. p. 939.

Brown RE. Acute nail bed injuries. Hand Clin. 2002;18:561–75.

Dean B, Becker G, Little C. The management of the acute traumatic subungual haematoma: a systematic review. Hand Surg. 2012;17:151–4.

105 Nail Removal and Nail Bed Laceration Repair

James Chiang

Indications

- In crushing injuries causing subungual hematoma extending to the proximal nail fold or where there is proximal or lateral nail fold disruption/laceration (Fig. 105.1)
- Fingertip lacerations/avulsions involving nail matrix where there are signs of misalignment of nail matrix

Contraindications

- No absolute contraindications

Materials and Medications

- Antiseptic cleansing solution
- 1 or 2% lidocaine without epinephrine and 0.25% bupivacaine (optional)
- Sterile gloves, surgical towel/drape, and 4 x 4 gauze
- Laceration repair kit (needle driver, hemostat, small/iris scissors)
- 18-gauge single-bevel needle or electrocautery tool
- 6-0 rapidly absorbing sutures
- Skin adhesive
- 5-0 nonabsorbable suture
- Protective eyewear and bouffant cap
- Finger tourniquet (may use Penrose drain or regular IV tourniquet)
- Finger splint (optional)

Procedure

- Prep adjacent fingers and affected finger with antiseptic solution.
- Perform digital block (see Chap. 96).
- Place a sterile glove with the affected glove-finger cut off around the PIP joint, and place it on patient's hand.
- Place finger tourniquet on proximal finger.
- Create sterile field with sterile drape/towels.
- Use iris scissors and peel paronychium and eponychium off nail.
- Insert iris scissors with the blades closed at the hyponychium and keeping it as close to the nail as possible to not damage the nail matrix, push 3–5mm toward the eponychium, and slowly open the blades to peel the nail matrix off the nail (Fig. 105.2). Keep the nail intact so it may be reattached later. Once the entire visible nail matrix is detached, pull the nail off with a clamp.
- Thoroughly explore the nail bed for lacerations, retained nail fragments, and bone fragments, and irrigate the nail bed with sterile normal saline. Ensure the nail matrix is not entrapped in the fracture line.
- If present, repair skin lacerations on paronychium first for better alignment using 5-0 nonabsorbable sutures with simple interrupted technique. Then use 6-0 absorbable sutures and simple interrupted technique to re-approximate nail bed lacerations. Refer to Chap. 98 for simple interrupted suture technique. If the laceration can be easily aligned without much deformity, skin adhesive may be used to repair the nail bed.
- Take the removed nail, clean thoroughly with antiseptic solution, and puncture a hole in the middle of the nail with the 18-gauge needle to allow for drainage of hematoma.
- To reattach the nail, use skin adhesive or nonabsorbable sutures to stitch it back.
- If suturing, use figure-of-eight stitch (Fig. 105.3).
- If reattaching the whole nail back, consider pre-drilling holes (Fig. 105.4).

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Fig. 105.1 Nail anatomy

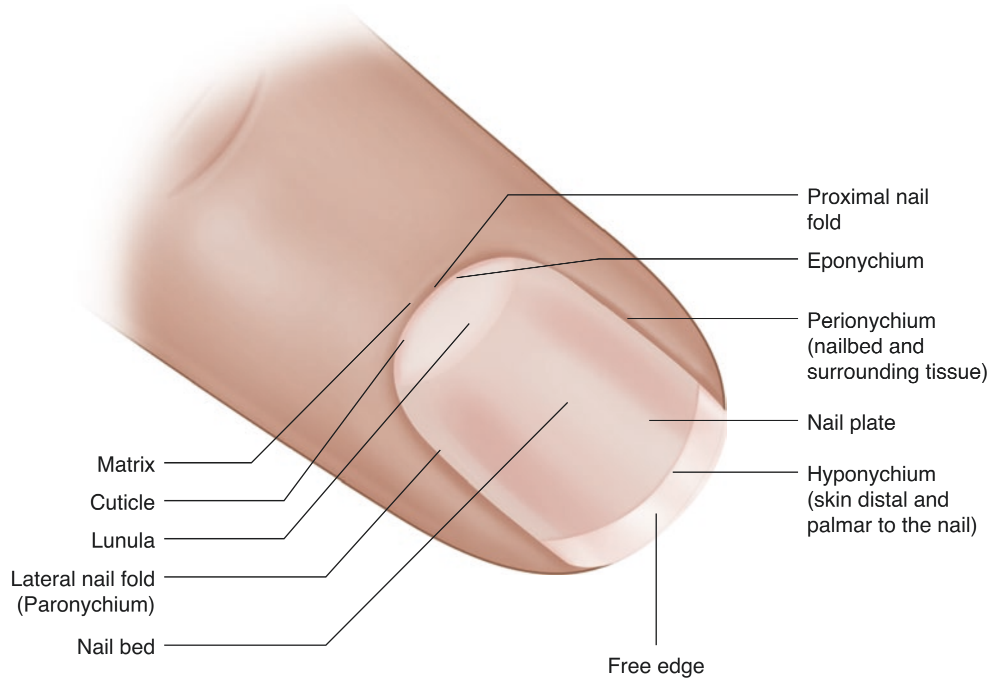

Fig. 105.2 Insert iris scissors with the blades closed at the hyponychium and keeping it as close to the nail as possible to not damage the nail matrix, push 3–5mm toward the eponychium, and slowly open the blades to peel the nail matrix off the nail

- Place the nail back under the eponychium, and then glue it in place or using simple interrupted technique through the paronychium and the side holes you created.
- If the nail is not intact due to the nature of the injury, you can cut inert material into the same size and shape as the nail, and stitch it in place as described in the previous step.
- Dress the finger with gauze and protect it with plenty of dressing or with finger splint.
- Wound should be rechecked in 3–5 days, and sutures used to reattach the nail should be removed after 2 weeks. The reattached nail may fall off then or be pushed off by a new nail. Allow 6 months for complete nail regrowth.

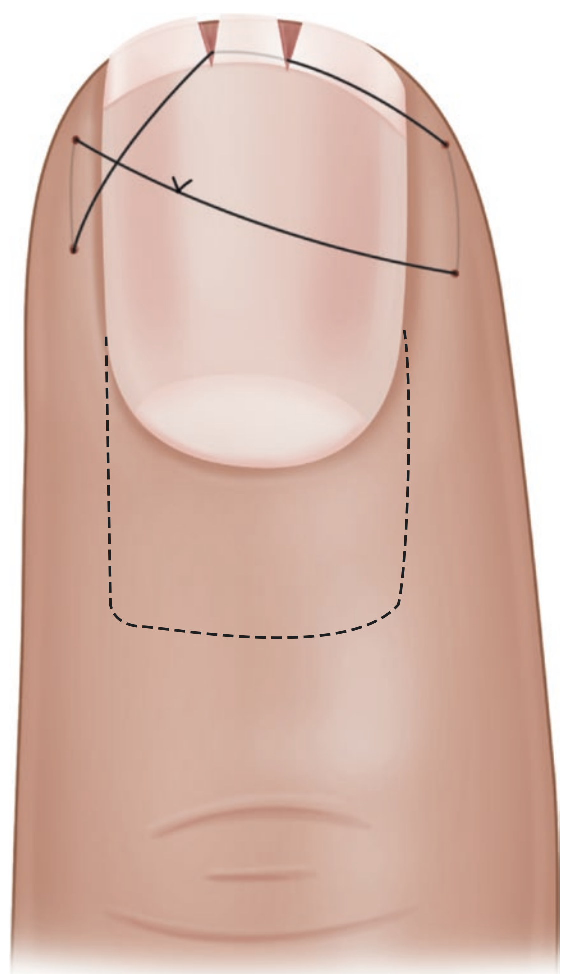

Fig. 105.3 Figure-of-eight suture for nail bed laceration repair

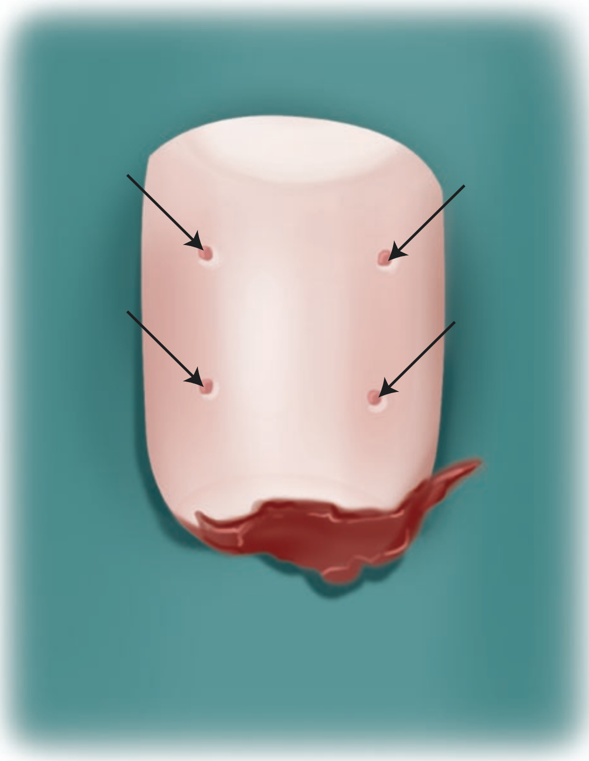

Fig. 105.4 Nail with pre-drilled holes prior to reattaching

- Cover the finger with gauze and protect it with adequate dressing or finger splint.
- Give tetanus prophylaxis and antibiotics as indicated.

Complications

- Infection
- Bleeding
- Loss or deformity of the nail

Pearls and Pitfalls

- Soaking the nail to soften it prior to sewing it back on can make reattachment easier.
- It has been traditionally taught that subungual hematoma involving more than 25% of nail should be managed with nail removal and exploration. However, it has been shown that in simple subungual hematomas, regardless of underlying tuft fracture or size of hematoma, long-term cosmetic outcome is unchanged with nail bed laceration repair or trephination alone.
- 50% of nail bed lacerations involve distal phalanx or tuft fracture; thus during nail bed laceration repair, fully evaluate for bone fragments and foreign bodies, and clean thoroughly as it may be an open fracture once the nail is removed.
- During consent for nail bed laceration repair, advise patient of possibility of poor long-term cosmesis even when nail bed is repaired.

Suggested Reading

Chiche L, Jeandel C, Lyps C, Joly-Monrigal P, Alkar F, Louahem M'Sabah D, et al. Fingertip nail bed injuries in children: comparison of suture repair versus glue (2-octylcyanoacrylate) with 1-year follow-up. Hand Surg Rehabil. 2020;39(6):550–5. https://doi.org/10.1016/j.hansur.2020.09.001.

Hawken JB, Giladi AM. Primary management of nail bed and fingertip injuries in the emergency department. Hand Clin. 2021;37(1):1–10. https://doi.org/10.1016/j.hcl.2020.09.001.

Wells ME, Scanaliato JP, Kusnezov NA, Nesti LJ, Dunn JC. The burden of fingertip trauma on the US military. Hand Clin. 2021;37(1):155–65. https://doi.org/10.1016/j.hcl.2020.09.010.

Bone Rongeur for Distal Finger Avulsion

106

Mortatha Al-Bassam and Bobby K. Desai

Fingertip injuries are a common challenge in the emergency department and can be the result of laceration, crush injuries, or avulsion. Adequate repair can provide a durable fingertip while also minimizing poor cosmetic outcomes. When the distal phalanx protrudes past the soft tissue that is damaged, the bone rongeur can be a valuable tool in proper closure of the wound.

Indications

- Distal phalanx avulsion:
  - When the distal phalanx protrudes past the soft tissue in type I and II injuries.
  - Injury does not extend to insertion point of flexor tendon.

Materials and Medications

- 27 gauge hypodermic needle
- Blunt tip needle
- 10 cc syringe
- 1% lidocaine or similar anesthetic
- Splash cap
- 1 L 0.9% normal saline
- 10.5% Betadine solution
- Basin
- Eye protection
- Bone rongeur
- Laceration repair kit:
  - Tooth forceps
  - Needle driver
  - Scissors
  - Surgical drapes
  - 4”x4” gauze
  - Sterile gloves
- 4-0 or 5-0 nonabsorbable suture
- Petroleum-infused gauze such as Xeroform
- Cotton gauze

Procedure

1. Draw up 10 cc’s of 1% lidocaine or similar anesthetic using blunt tip needle. Replace blunt tip needle with 27 gauge needle.
2. Clean the indicated area of local anesthetic injection with gauze and Betadine. Allow Betadine to air-dry.
3. Inject local anesthetic into necessary areas. Provide time for medication to sufficiently anesthetize the digit.
4. Apply tourniquet to the base of the finger (Fig. 106.1). If a tourniquet is not available, one of the digits of a non-latex glove may be cut at the base and at the distal end. The finger is then placed through the material, which is then rolled down to form a circular, makeshift tourniquet.
5. Using splash cap, normal saline, and basin, thoroughly irrigate the wound. Explore for foreign bodies, assess level of damage, and determine whether there is an indication for exposed bone shortening. Verify that the injury does not involve the joint or the flexor tendon.
6. Use the bone rongeur to shorten the bone by the minimum amount necessary to allow for flap closure (Fig. 106.2). The proximal nail bed should not extend beyond the distal phalanx, as this can result in hook nail (Fig. 106.3). If the injury extends beyond 50–60% of the nail bed, consider removal of the entire nail bed including under the eponychial fold. This reduces the risk of devel-

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Fig. 106.1 Apply tourniquet to the base of the finger. (Screenshot used with permission of EM:RAP.org [1])

Fig. 106.2 Use the bone rongeur to shorten the bone by the minimum amount necessary to allow for flap closure. (Screenshot used with permission of EM:RAP.org [1])

Fig. 106.3 The proximal nail bed should not extend beyond the distal phalanx, as this can result in hook nail. (Screenshot used with permission of EM:RAP.org [1])

opment of hook nail. Counsel patient that hook nail may still develop because, despite best efforts, a small portion of nail germinal matrix may be retained and can grow into a hook nail.

7. Suture the distal volar skinfold to the dorsal skinfold (Fig. 106.4). If the nail is intact, sutures may be passed through the nail and into the distal volar skinfold (Fig. 106.5).
8. Remove tourniquet prior to dressing with gauze to prevent accidentally covering the tourniquet with gauze (Fig. 106.6).
9. Apply petroleum-infused gauze to the wound, and wrap thoroughly with cotton gauze (Fig. 106.7).

Fig. 106.5 If the nail is intact, sutures may be passed through the nail and into the distal volar skinfold. (*Screenshot used with permission of* EM:RAP.org [1])

Fig. 106.6 Remove tourniquet prior to dressing with gauze to prevent accidentally covering the tourniquet with gauze. (Screenshot used with permission of EM:RAP.org [1])

Fig. 106.4 (**a** and **b**), Suture the distal volar skinfold to the dorsal skinfold. (Screenshots used with permission of EM:RAP.org [1])

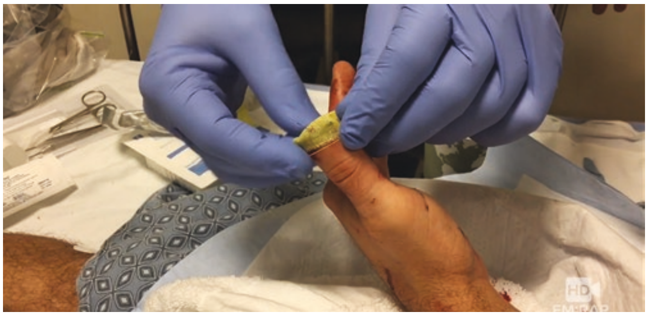

Fig. 106.7 Apply petroleum-infused gauze to the wound, and wrap thoroughly with cotton gauze. (Screenshot used with permission of EM:RAP.org [1])

Pearls and Pitfalls

- Bone removal:
  - The goal should be to remove just enough bone to allow the existing skin flap to be used to close the wound.
  - The bone should not be removed if it does not extend beyond the skin flap.
- Use in the emergency department:
  - The bone rongeur can be a valuable tool in the emergency department within the indications specified.
  - If the injury extends into the joint or tendon insertion point, then evaluation by a hand specialist is recommended.

References

1. EM:RAP.org. Bone rongeur for fingertip amputation. Accessed January 13, 2021. https://www.emrap.org/episode/bonerongeurfor/bonerongeurfor

Suggested Reading

Ramirez MA, Means KR Jr. Digital soft tissue trauma: a concise primer of soft tissue reconstruction of traumatic hand injuries. Iowa Orthop J. 2011;31:110–20.

Incision and Drainage of Abscess

107

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Indication

- Abscess greater than 5 mm in diameter and in accessible areas (e.g., axilla, extremities, trunk)

Contraindications

- Absolute

  Absence of fluctuationAbscess: incision and drainage of:

- Large, deep, and complicated (multiloculated) abscesses
- Location
  – Perirectal
  – Mastoid

- Relative
  – Location
    Face (e.g., nose, nasolabial fold)
    Hand
    Breast abscess (especially near the areola or nipple)
    Anterior and lateral neck potentially arising from thyroglossal duct or branchial cyst
  Coagulopathy
  – Recurrent pilonidal cysts (may mandate operative excision)
  – Area of cosmetic importance where aspiration may be preferred

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Materials and Medications

- Incision and drainage tray (Fig. 107.1):
  – Drape
  – Betadine (povidone-iodine) swabs
  – 1% lidocaine
  – 18- and 27-gauge needles
  – 12-mL syringes and gauze pads
  – #11 scalpel and mosquito clamps (hemostat)
  – Iodoform packing of appropriate size if indicated
- Ultrasound machine (Fig. 107.2)

Procedure

1. Ultrasound (optional) may be helpful when abscess is suspected in the absence of fluctuation. Using the vascular probe (7 mHz), confirm the clinical suspicion of abscess, and check the depth and width of the abscess (Fig. 107.3).
2. Sterile skin preparation with Betadine swab and sterile drape.
3. Anesthetize the appropriate area subcutaneously with 5 mL of 1% lidocaine by inserting the 27-gauge needle at an acute angle into the intradermal space (Fig. 107.4a, b).
4. Using a #11 blade, make an approximately 1- to 2-cm skin incision over the desired area parallel to the Langer lines. The incision must approach into the abscess cavity (Fig. 107.4c):
   - Some physicians still advocate the technique of making a cruciate incision. This may leave a larger scar and should be discussed with patient before doing so because of cosmetic consequences.
5. Allow for spontaneous drainage. After resolution of drainage, you may express more pus with gentle downward pressure.
6. Using the hemostat, enter the incision to break any suspected loculations. This should be done with the clamps

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Fig. 107.1 Supplies necessary for incision and drainage

Fig. 107.2 Bedside SonoSite ultrasound

closed and curved part down. The clamps should then be opened and removed slowly (Fig. 107.4d).

7. Packing abscesses is traditionally done, but studies do not show any proven benefit in reducing recurrence of abscesses and packing increases pain during and after the procedure. However, packing should be considered for abscesses larger than 5 cm, for pilonidal abscesses, or in immunocompromised or diabetic patients:
   - If packing the wound, follow the next step.
8. Take the iodoform packing with the hemostat, and place the packing into the incision site until no further packing will easily fit. Do not overly pack the abscess so to avoid ischemic necrosis of surrounding tissue as the purpose of packing is to keep the abscess open, not to absorb excess drainage. If gauze pads are used instead of a single gauze strip, be sure to count and chart the number of pads so all gauze is removed in follow-up evaluations.
9. Cut the packing leaving a tail out of the incision site (Fig. 107.4e).
10. Apply generous amounts of dressing with 4 × 4 gauze to absorb drainage and adhesive tape (2 in.).
11. Advise for follow-up in 1–3 days. Small, unpacked abscesses should be cleaned daily with a cotton swab reaching the base of the abscess.
12. If there is overlying cellulitis, consider antibiotic administration with MRSA and streptococcal coverage.

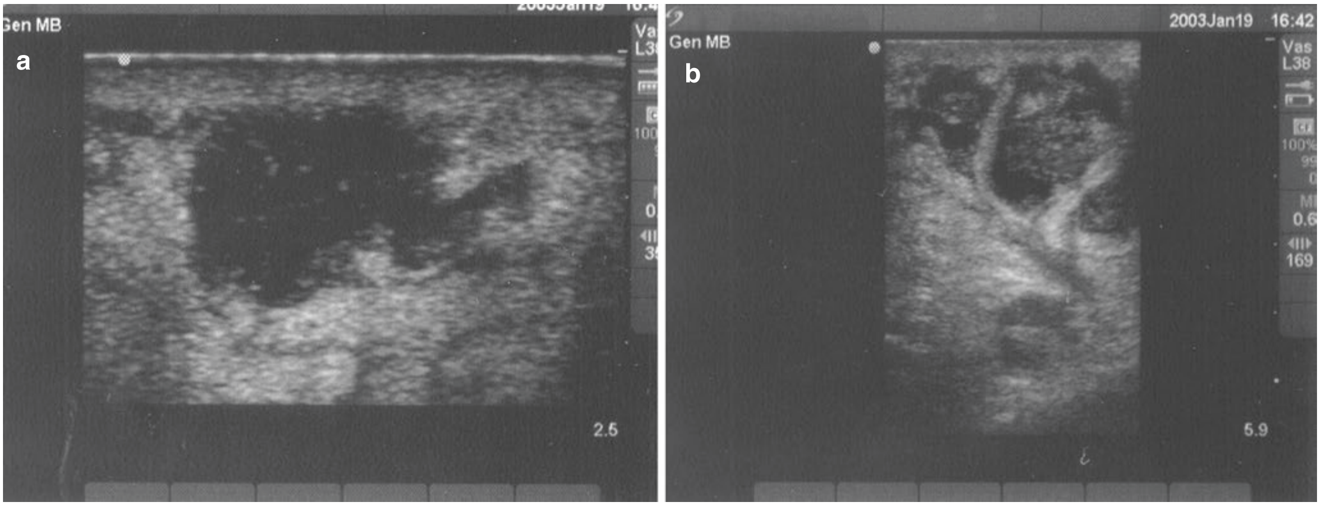

Fig. 107.3 (**a**) Example of an abscess as viewed on bedside ultrasound. (**b**) A multiloculated abscess

Loop Drainage Technique

In the interest of creating smaller skin incisions, the loop drainage technique was developed to allow adequate drainage of purulent material and promote continued drainage by filling the abscess cavity with a "loop." The original research used a silicone vessel loop, a small Penrose drain, or a sterile rubber band as the packing:

1. With a # 11 blade, make a small (5–10 mm) incision at the periphery of the abscess. If there is an area that is already draining, place the first incision there.
2. Probe the cavity with a hemostat to break up loculations (Fig. 107.5a).
3. Find the opposite edge of the abscess with the hemostat, and position the tip underneath the area you will make the second incision.
4. Make the second incision with the # 11 blade, up to 4 cm from the first.
5. Using the hemostat, grab the end of the loop drain and pull it back through the wound.
6. Tie the ends of the loop without tension. You can place a syringe in between the skin and the loop to make sure there isn't tension when you tie the loop. Tie approximately five knots (Fig. 107.5b).
7. Patient should bathe or shower twice a day for the first 3 days and change the dressing at least twice a day or whenever saturated. The loop can be pulled back and forth once or twice a day to help keep the wound open.
8. The drain is removed when the discharge stops and cellulitis improves, approximately 5–10 days but can be removed sooner for small abscesses or rapid healing.

Complications

- Recurrence of abscess
- Progression of cellulitis
- Neurovascular injury to adjacent structures

Pearls

Antibiotic coverage is a controversial topic. Although 2014 IDSA guidelines for management of soft tissue and skin infections do not recommend routine antibiotics for healthy individuals with uncomplicated abscesses <2cm, multiple large systematic reviews and randomized control studies have found that antibiotic use is associated with higher cure rates and lower recurrence. Methicillin-resistant *Staphylococcus aureus* (MRSA) is a concern not only in the immunocompromised and diabetic patients. *S. aureus* has been detected in up to 51% of patients with abscesses. Of these isolates, approximately 75% were MRSA. Clindamycin or Bactrim (trimethoprim/sulfamethoxazole) should be utilized for all prophylactic measures.

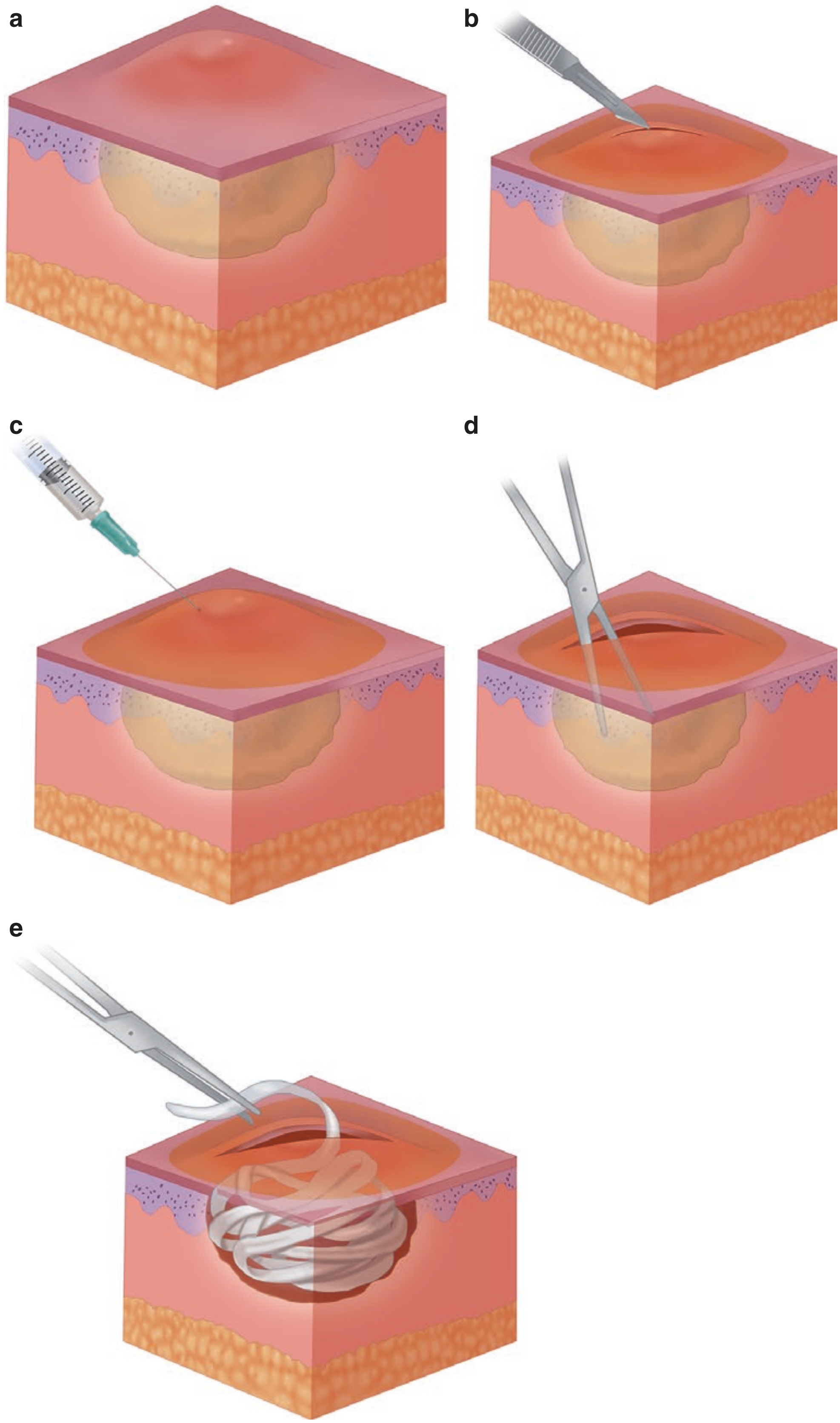

Fig. 107.4 (**a**) Abscess with overlying erythema. (**b**) Lidocaine injection in the superficial layer. (**c**) Linear incision with #11 blade. (**d**) Expression of purulent material and breaking of loculations with clamps. (**e**) Optional placement of packing

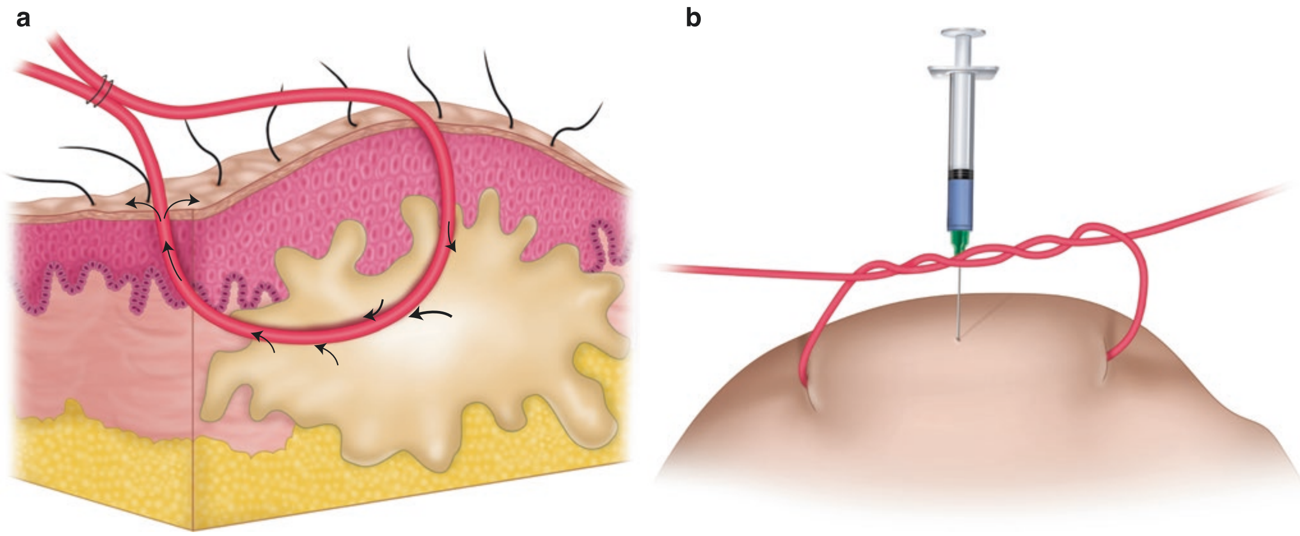

Fig. 107.5 (**a**) Probe the cavity with a hemostat to break up loculations. (**b**) Tie the ends of the loop without tension. You can place a syringe in between the skin and the loop to make sure there isn't tension when you tie the loop. Tie approximately five knots

Suggested Reading

Challen K, Bond C, Westafer L, Heitz C, Milne WK. Hot off the Press: LOOP technique versus drainage and packing in ED abscess management. Acad Emerg Med 2021. https://doi.org/10.1111/acem.14230. Epub ahead of print.

Gottlieb M, DeMott JM, Hallock M, et al. Systemic antibiotics for the treatment of skin and soft tissue abscesses: a systematic review and meta-analysis. Ann Emerg Med. 2019;73(1):8.

Leinwand M, Downing M, Slater D, et al. Incision and drainage of subcutaneous abscesses without the use of packing. J Pediatr Surg. 2013;48(9):1962–5.

Talan DA, Moran GJ, Krishnadasan A, et al. Subgroup analysis of antibiotic treatment for skin abscesses. Ann Emerg Med. 2018;71(1):21.

Part XIII

Orthopedic Procedures

Splinting

108

Christopher H. Stahmer, Muhammad Waseem,
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Indications

- Need for immobilization for fracture, dislocation, or soft tissue injury
- Suspicion for occult injury of an extremity
- Immobilization for pain management

Contraindications

- Absolute
  - Open fracture (requires operative intervention)
- Relative
  - Infection
  - Compartment syndrome

Materials and Medications (Fig. 108.1)

- Choose one of the following splinting materials depending on availability in your ED:
  - Plaster of Paris:
    - Fast drying: 5–8 min to set
    - Extra fast drying: 2–4 min to set
  - Prefabricated splinting materials:
    - Plaster OCL (Orthopedic Casting Laboratories):
      - 0–20 sheets of plaster with padding and cover
      - Faster setup time but less customizable
    - Fiberglass splints:
      - Stronger and lighter
      - Less moldable
- Stockinette
  - Some orthopedic surgeons do not recommend the use of stockinette as it may cause skin breakdown.
- Cotton padding (soft wrap such as Webril)
- Elastic bandage (such as Ace wrap):
  - Variety of sizes depending
- Water
- Measuring tape
- Towel
- Shears

Procedure

1. Completely expose and examine the afflicted body part for tissue, vascular, or neurological injury:
   (a) Address respective injuries before proceeding.
2. Measure the length needed of splinting material on the contralateral extremity. Cut the splint to approximately 2 cm longer than the desired length:
   (a) See Figure 108.2 for splint-specific measuring recommendations.
3. Lay out all splinting materials before initiating procedure.
4. Administer appropriate anesthesia:
   (a) Conscious sedation
   (b) Hematoma block/intra-articular injection
   (c) Intravenous or oral pain medication
5. If fracture with displacement is present:
   (a) Hang fractures as indicated for improved success of reduction to relax muscles before reduction attempt.
   (b) Reduce afflicted extremity.
   (c) While maintaining reduction, apply respective splint.
6. The splint should be applied in the following order:
   (a) If using stockinette, select the appropriate diameter according to the size of the extremity (generally 3 inch diameter is used for the forearm and larger for lower extremity splints) (Fig. 108.3):

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Fig. 108.1 Posterior splint materials: plaster of Paris, Ace wraps, and soft roll. Note cotton padding has an inner and outer layer: the inner layer to face the patient (eight layers) and the outer layer to pad the exterior (two layers)

(i) Cut the stockinette to a length approximately 20 cm longer than the total length of the desired splint.
(ii) Apply the stockinette to the injured limb so that the stockinette extends approximately 10 cm beyond the region to be splinted proximally and distally.

(b) Wrap cotton padding circumferentially around the entire region to be splinted, with each turn overlapping the previous turn by approximately 25% of its width (Fig. 108.4):
(i) Apply extra padding to bony protuberances/joints.
(ii) Extend the padding at least one inch beyond the desired splint length so that it may later be folded back over the jagged ends of the plaster or fiberglass splint roll.

(c) Lightly moisten prefabricated splinting material by running under warm water. Immediately soak up excess water either by rolling splint in a towel or running fingers in a "squeegee" manner from top to bottom to smooth the splint:
(i) If using plaster of Paris material, see Section 108.4.7 for further preparation instructions.

(d) Apply splinting material and have an assistant maintain the splint in its desired position (Fig. 108.5).

(e) Fold the underlying cotton padding and stockinette back over the ends of the splint, which both protects the skin and holds the splint in place.

(f) Apply Ace wrap circumferentially starting from one end and moving to the other end while the assistant maintains splint in its desired position (Fig. 108.6):
(i) Applying the Ace wrap too tightly may cause ischemia.

Upper Extremity Splints[1]			
	Indications	Construction	
Thumb Spica 	**Indications:** • Scaphoid and lunate injuries • First digit and first metacarpal injuries • De Quervian's tenosynovitis • Gamekeeper's/Skier's thumb **Construction:** • Mid-distal phalanx of first digit to mid-forearm	**Radial Gutter** 	**Indications:** • Second and third digit injuries • Second and third metacarpal injuries **Construction:** • Mid forearm to the second and third distal phalanx • Cut hole in splint for the thumb • Form a gutter along the radial side from the second and third distal interphalangeal joint to mid forearm
Ulnar Gutter[2] 	**Indications:** • Fourth or fifth digit injury • Fourth or fifth metacarpal injury (Boxer's fracture[2]) **Construction:** • Mid-forearm to the fifth distal phalanx • Form a gutter along the ulnar side from the fifth distal interphalangeal joint to mid forearm	**Volar** 	**Indications:** • Soft tissue injuries of the hand and wrist • Carpal bone injuries • Second to fifth metacarpal injuries **Construction:** • Palmar metacarpal heads to distal forearm
Sugar Tong 	**Indications:** • Distal radius and ulnar injuries **Construction:** • Dorsal metacarpal heads wrapping around the elbow to the volar metacarpal heads	**Posterior Long Arm** 	**Indications:** • Olecranon injuries • Humerus injuries • Radial head and neck injuries **Construction:** • Mid posterior arm to extensor surface of elbow to the metacarpal heads
Lower Extremity Splints[3]			
Posterior Short 	**Indications:** • Ankle sprains • Distal tibia and fibula injuries • Reduced ankle dislocations Construction: • Plantar metatarsal heads to posterior leg at the level of the fibular head • Follow with ankle stirrup splint	**Ankle Stirrup** 	**Indications:** • Ankle sprains • Distal tibia and fibula injuries • Reduced ankle dislocations Construction: • Lateral fibular head around the plantar surface of the foot to medial proximal tibia • Place posterior ankle splint first

Fig. 108.2 Splint-specific measuring recommendations.
[1] All upper extremity splints should be positioned in the position of function: the wrist in slight extension (10–20°), the metacarpophalangeal joints in 50° of flexion, and the proximal and distal interphalangeal joints in slight flexion (10–15°). If the elbow is involved, it should be positioned at a 90-degree angle
[2]For Boxer's fractures, the metacarpophalangeal joints should be positioned at 90 degrees of flexion
[3]The ankle should be positioned at a 90-degree angle

Fig. 108.3 Stockinette applied to the forearm and hand

Fig. 108.4 Cotton padding applied to the forearm and hand

Fig. 108.5 Splint folded around the ulnar aspect of the forearm and hand

Fig. 108.6 Splint secured in place with an elastic bandage

(g) Mold the splint using your palms while taking caution to avoid making indentations with the fingertips:
   (i) An indentation may cause a pressure point, which may result in an ulcer.
(h) Allow the splint to cure while the practitioner maintains the appropriate position. This will take approximately 5 minutes depending upon water temperature and splint thickness.
(i) Reexamine the extremity for neurovascular compromise. Consider observing the patient after splinting for 30 minutes for tingling, burning, pain, or discomfort.

7. Preparing plaster of Paris:
   (a) Decide on the appropriate number of layers:
      (i) Upper extremity: 8–10 layers
      (ii) Lower extremity: 12–15 layers
      (iii) Up to 20 for a large person
   (b) Layer the plaster with no overlap.
   (c) Submerge completely into water.
   (d) Crumple into ball without letting go of the ends of the splint.
   (e) Release the lower end of the splint while holding the top tightly together.
   (f) Run fingers in a "squeegee" manner from top to bottom to smooth the splint (Fig. 108.7).
   (g) Apply two to three layers of cotton padding to the exterior of plaster of Paris for padding and to facilitate drying.

Complications

- Ischemia may occur as a result of compartment syndrome if the splint is too tight.

Fig. 108.7 Hold the top of the saturated plaster securely with one hand while removing excess water with the other hand

- Burns may occur with application of plaster-based splinting material, as splint drying is an exothermic reaction:
  - If pain is troubling the patient, remove the splint and add more padding.
- Pressure sores:
  - Apply ample padding.
  - Smooth all wrinkles.
- Infection:
  - Clean and debride all devitalized tissue before application.
  - Requires close follow-up to reevaluate wounds.
- Joint stiffness from prolonged immobilization.
- Instruct the patient to return for increased discomfort.

Pearls and Pitfalls

- Pearls
  - Advise the patient to unwrap the splint for the following indications: increasing pain; discoloration of fingers, toes, or the splinted extremity; and loss of sensation of splinted extremity.
  - Simple plaster of Paris splints are inexpensive and allow a thoroughly customizable fit but can be damaged by water and require more time to set and more cleanup than prefabricated foamcore or fiberglass splint rolls.
  - Simple fiberglass splints set quickly, are not damaged by water, are stronger and lighter than simple plaster and prefabricated splints, and offer a fully customized fit, but are not applied as quickly as prefabricated splints.
  - Prefabricated fiberglass splints are quickly applied, require virtually no cleanup, and are not damaged by water, but are relatively expensive and provide a somewhat less customizable fit than simple splint rolls.
- Pitfalls
  - Avoid wrinkling the cotton padding beneath the splinting material because, once under the pressure of the elastic bandage, wrinkles can cause unnecessary skin pressure.
  - Avoid using more or fewer layers of splinting material than recommended. Additional layers can result in excessive heat during the setting process and a splint that is too heavy, whereas insufficient layers can result in a splint that is too weak.

Suggested Reading

Fitch MT, Nicks BA, Pariyadath M, McGinnis HD, Manthey DE. Basic splinting techniques. N Engl J Med. 2008;359:e32.

Marx JA, Hockberger R, Walls R, editors. Rosen's emergency medicine: concepts and clinical practice. 7th ed. Philadelphia: Mosby; 2010.

Simon R, Sherman S, Koenigsknecht S. Emergency orthopedics—the extremities. New York: McGraw-Hill; 2007.

Shoulder Dislocation Reduction Techniques

109

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Indications

- Subjective history of new-onset dislocation or recurrent dislocations combined with clinical assessment consistent with shoulder dislocation:
  - Anterior dislocations (96%):
    - Typical mechanism of injury being indirect, with a combination of abduction, extension, and external rotation. Rarely, the etiology is a direct blow to the posterior shoulder.
    - Prominent acromion with a palpable drop off below the acromion and subclavicular region fullness is consistent with anterior shoulder dislocation.
- Posterior dislocations (4%):
  - Mechanism of injury is indirect with a combination of internal rotation, adduction, and flexion. Precipitating events include seizure, electrical shock, and falls.
  - More subtle presentation. Patient will maintain arm locked in internal rotation and adduction; he or she cannot externally rotate. The shoulder is flattened anteriorly and rounded posteriorly.
  - Ultrasound can be used to prevent missed or delayed diagnosis (Figs. 109.1 and 109.2 show probe positioning and a diagram of abnormal ultrasound anatomy).
- Inferior dislocations (luxatio erecta):
  - The arm will be held fixed in overhead position.
- Radiographs reveal shoulder dislocation.
- Ultrasound can be used to identify the nature of the dislocation (anterior or posterior) and can be determined by the position of the humeral head relative to the transducer and glenoid. Although at this point, it should not replace radiographs owing to missed fractures. Advantages may include less radiation (decreased need for postreduction X-rays) and re-sedation if reduction is not complete.

Contraindications

- Associated fracture:
  - This warrants orthopedic evaluation.
- Associated neurovascular deficit:
  - May attempt reduction once but avoid multiple attempts.

Materials and Medications

- 1% lidocaine, with syringe and needle and povidone-iodine prep if administering intra-articular local anesthesia
- Moderate sedation medications if administering moderate sedation
- Bed sheet for traction-countertraction method
- Dangling weight for Stimson maneuver
- Sling and swath (or shoulder immobilizer)

Procedure

- Physical examination:
- Compare affected with unaffected shoulder.
- Perform a complete neurovascular examination: test axillary, radial, ulnar, and median nerves for sensory and motor deficits.
- Radiographs:
- Always obtain before attempting reduction for assessment of possible fracture and type and position of dislocation.
- Obtain three views: anteroposterior, scapular Y, and axillary lateral views.

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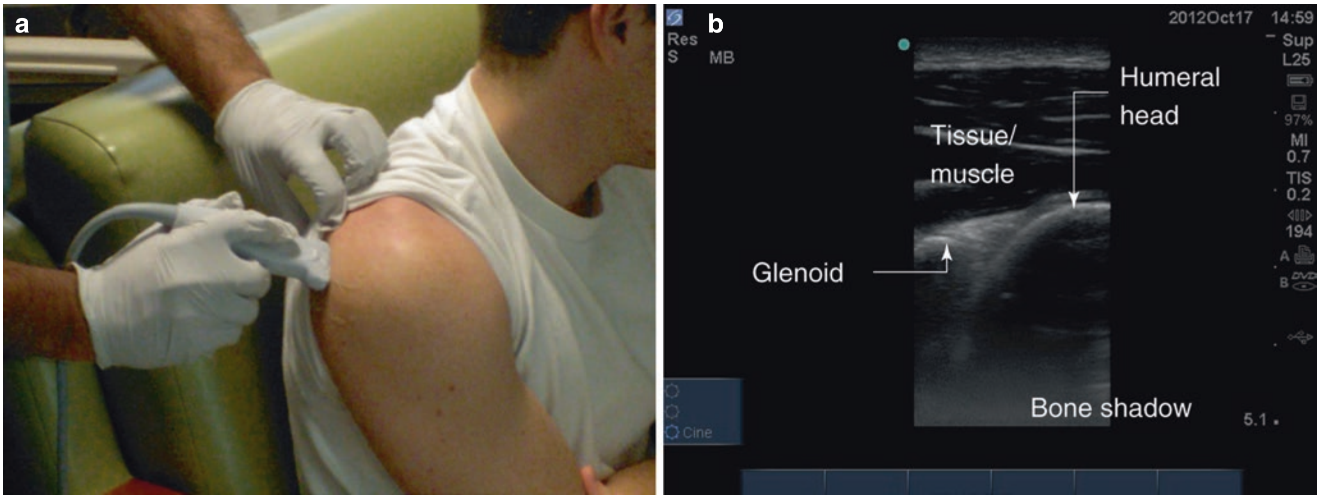

Fig. 109.1 (**a**, **b**) Ultrasound image of normal shoulder anatomy. "Dot fits the dot" means when looking at the ultrasound machine from the sonographer's standpoint, the side of the probe marker corresponds to the side the marker is on the screen. This ensures when doing procedures, the direction of needle correction is the same as the orientation of the probe. (Images courtesy of Dr. Rohit Patel)

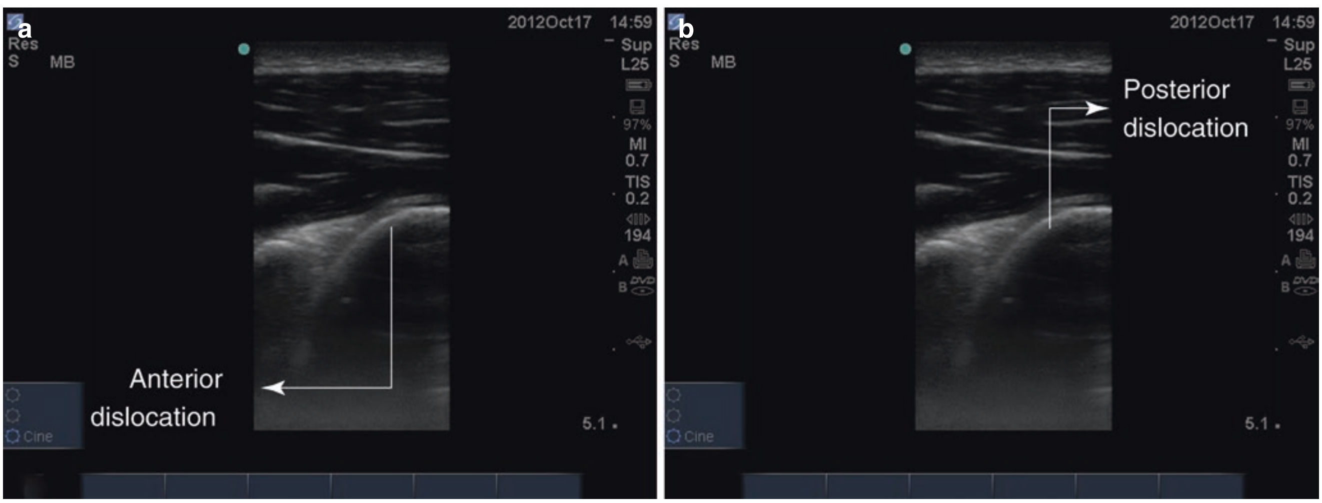

Fig. 109.2 Anterior (**a**) and posterior (**b**) dislocations. (Images courtesy of Dr. Rohit Patel)

- Anterior dislocations: humeral head appears anterior to the glenoid fossa on lateral or Y views.
- Posterior dislocations: on anteroposterior view (vacant glenoid sign, 6-mm sign, lightbulb sign; on lateral or Y view: humeral head appears posterior to the glenoid fossa).
- Pain management and sedation:
- Decide whether to use intra-articular lidocaine versus procedural sedation and analgesia.
- For intra-articular lidocaine:
  - Use 10–20 mL of 1% lidocaine.
  - Attach a 1.5-in., 20-gauge needle.
  - Prepare the shoulder with povidone-iodine.
  - Insert the needle lateral to the acromion process and 2 cm inferiorly into the sulcus.
  - After withdrawing to ensure that the needle is not in a vessel, inject 10–20-mL lidocaine into the joint.
- Reduction techniques: it is important for the emergency department physician to be familiar with several different techniques. The following techniques are presented.

Stimson Maneuver (Fig. 109.3)

1. Patient is placed prone with 2.5–5 kg of weight hanging from the wrist.
2. Reduction may be facilitated by traction and external rotation of the arm.
3. A success rate of 96% has been reported using the combined prone position, hanging weights, intravenous drug therapy, and scapular manipulation.
   - Advantage: can be performed by one person only.

Fig. 109.3 Stimson maneuver

Fig. 109.4 Scapular manipulation method

- Disadvantages: requires time to gather materials; the danger involved in the patient falling off the stretcher, requiring staff to monitor the patient.

Scapular Manipulation Technique (Fig. 109.4)

1. Place the patient in the prone position with the affected arm hanging downward.
2. Apply traction down on the arm.
3. Locate the inferior tip of the scapula. Simultaneously push the inferior tip of the scapula medially toward the spine, and use the other hand push the superior scapula laterally.
   - Advantages: high success rate, greater than 90%; and very safe to perform.
   - Disadvantages: it requires the patient to assume the prone position; it may require another person to perform traction.

External Rotation Method (Fig. 109.5)

1. Place the patient in the supine position with the affected arm adducted directly next to the patient's side with the elbow flexed to 90°.
2. The operator uses one hand to direct downward traction on the affected arm while maintaining it next to the patient's side.
3. The operator uses the other hand to hold the patient's wrist and guide the arm into slow external rotation.
4. Reduction usually takes place between 70° and 110° of external rotation.
   - Advantages: requires no strength by operator; well tolerated by patients.
   - Disadvantage: patient may have persistent dislocation during procedure, requiring operator to make adjustments.

Milch Technique (Fig. 109.6)

1. Technique looks as though one is reaching up to grab an apple from a tree.
2. Abduct the injured arm up to the overhead position.
3. Once in the overhead position, apply gentle vertical traction with external rotation.
4. An adjustment may need to be made if the reduction does not occur easily; push the humeral head upward into the glenoid fossa.
   - Advantages: lack of complications; patient tolerance
   - Disadvantage: variable success rate reported, 70–90%

Spaso Technique (Fig. 109.7)

1. Place the patient in the supine position.
2. Operator grasps the affected arm at the wrist and lifts the straight arm directly upward while applying longitudinal traction.
3. Apply external rotation.
   - Advantages: single operator, high level of success
   - Disadvantage: may require more time to allow the shoulder muscles to relax

Traction-Countertraction Technique (Fig. 109.8)

1. With the patient is sitting up, have an assistant wrap a sheet around the upper chest and under the axilla of the affected shoulder. Have the assistant wrap the sheet behind her or his back. Now have the patient lay supine.

Fig. 109.5 (**a**–**d**) Kocher technique: external rotation method

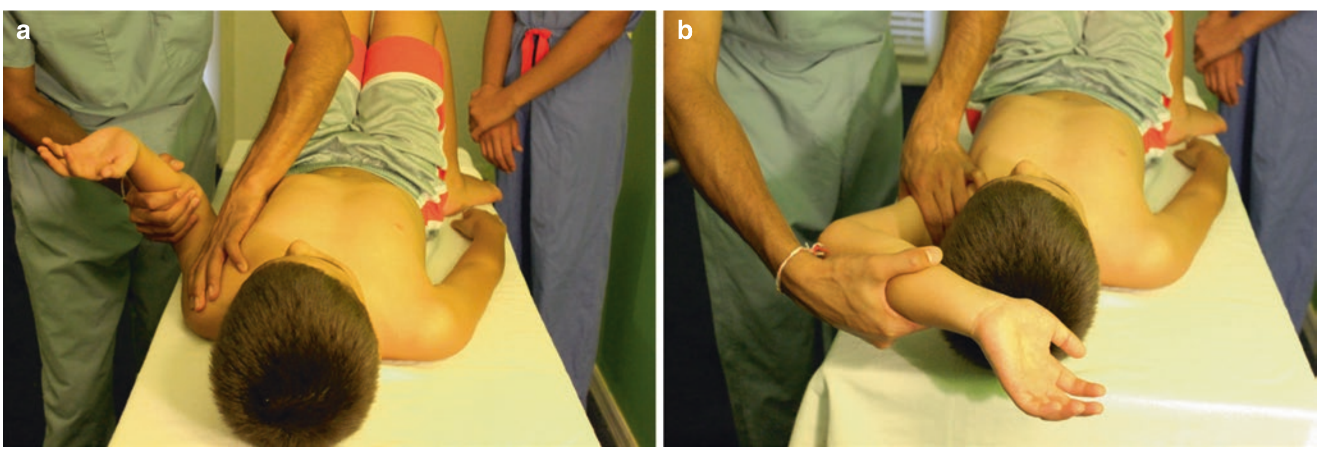

Fig. 109.6 (**a**, **b**) Milch technique

2. Wrap another sheet around the flexed elbow of the affected arm and behind the operator's back.
3. Both the operator and the assistant lean back, applying gentle traction.

- Advantage: many older physicians are familiar with this method and, therefore, have a high degree of success.
- Disadvantages: requires two people; may cause skin tears on elderly patients.

Fig. 109.7 (**a**–**c**) Spaso technique. (Photographs courtesy of Dr. Pratik S. Patel)

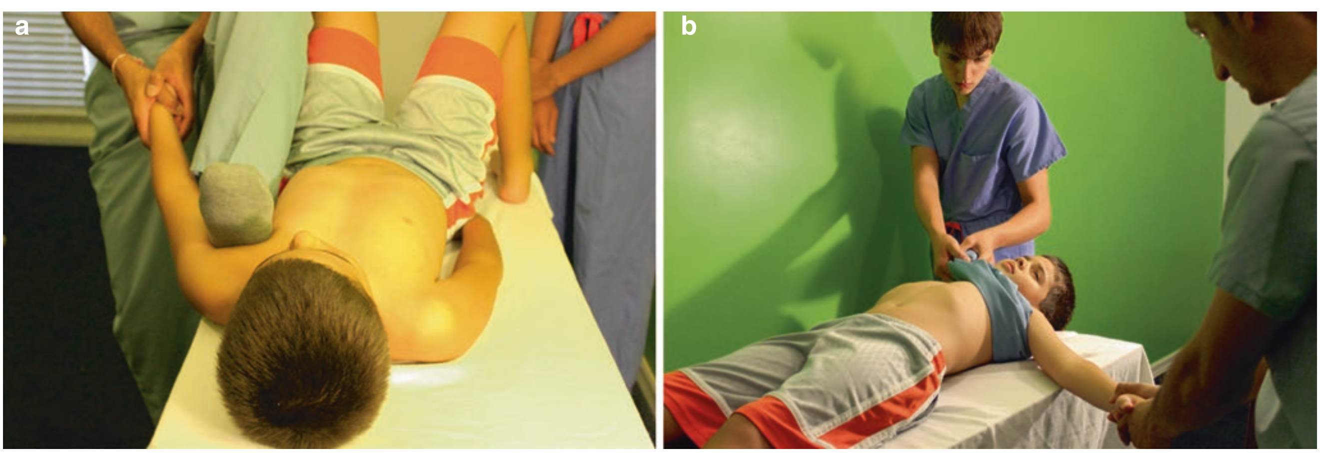

Fig. 109.8 (**a**, **b**) Hippocrates method/traction-countertraction method

Posterior Shoulder Dislocation Reduction

1. Give adequate premedication.
2. Place the patient supine and apply lateral traction on the proximal humerus.
3. Have an assistant apply pressure anteriorly to the posteriorly located humeral head.
   - Advantage: logical methods for reduction
   - Disadvantages: require sufficient premedication because often posterior dislocations present late; may require open reduction

Postreduction

- Obtain postreduction X-rays. There is some literature on using ultrasound to confirm adequate reduction, which allows repetitive assessments throughout procedure, as well as reduce radiation (*see* Fig. 109.2 for ultrasound of anterior and posterior dislocations).
- Do a postreduction neurovascular examination.
- Sling and swath or shoulder immobilizer for 2–3 weeks.
- Orthopedic follow-up in 1 week.

Complications

- Fractures
- Adhesive capsulitis, or frozen shoulder; especially a concern in the elderly with prolonged immobilization in sling
- Brachial plexus injury, especially of the axillary nerve
- Vascular laceration, most commonly of the axillary artery
- Rotator cuff tears

Pearls

- It is imperative to document the pre- and postreduction neurovascular status in the medical record.
- If unsure whether the reduction was successful, attempt to place the palm of the injured extremity on the contralateral shoulder. This is a good sign the reduction was successful.

Acknowledgment The authors would like to thank Karthik Stead for serving as the subject in many of the photographs in this chapter.

Suggested Reading

Beck S, Chilstrom M. Point-of-care ultrasound diagnosis and treatment of posterior shoulder dislocation. Am J Emerg Med. 2013;31:449.e3–5.

Blakeley CJ, Spencer O, Newman-Saunders T, Hashemi K. A novel use of portable ultrasound in the management of shoulder dislocation. Emerg Med J. 2009;26:662–3.

Dala-Ali B, Penna M, McConnell J, Vanhegan I, Cobiella C. Management of acute anterior shoulder dislocation. Br J Sports Med. 2014;48(16):1209–15.

Simão MN, Noqueira-Barbosa MH, Muqlia VF, Barbieri CH. Anterior shoulder instability: correlation between magnetic resonance arthrography, ultrasound arthrography, and intraoperative findings. Ultrasound Med Biol. 2012;38:551–60.

Yuen CK, Chung TS, Mok KL, Kan PG, Wong YT. Dynamic ultrasonographic sign for posterior shoulder dislocation. Emerg Radiol. 2011;18:47–51.

110 Elbow Dislocation Reduction

Katrina John, Jeffrey Kile, Amish Aghera, and Jessica Houck

Direction of the dislocation (i.e., anterior, posterior, lateral and divergent radius, and ulnar dislocations) is determined by the position of the ulna relative to the joint space (Fig. 110.1).

Indication

- Any dislocation of the elbow joint

Contraindications

- Relative
  - Compound fracture dislocation
  - Open fracture/dislocation

Materials and Medications

- Parenteral sedation and analgesia medications
- Local anesthetic for local and intra-articular anesthesia
- Splinting material
- Splinting material (plasterglass or fiberglass)
- Stockinette
- Cotton padding
- Elastic bandage
- Tape
- Sling

General Approach to Reduction

1. Check the neurovascular status of the affected extremity.
2. Obtain a true lateral and anteroposterior radiographs of the affected elbow.
3. Ensure adequate sedation and analgesia.
4. Consider intra-articular analgesia.
5. Follow a selected method for reduction as detailed later.
6. Following successful reduction gently flex the elbow to ensure full range of motion.
7. Place a long-arm posterior splint with the elbow in at least 90° flexion, and secure the arm in a regular sling.
8. Check neurovascular status.
9. Obtain a postreduction radiograph of the elbow.

Procedure for Posterior Dislocations

Method A (Fig. 110.2)

1. Position the patient on a stretcher in the supine position.
2. Apply steady traction at the supinated distal forearm keeping the elbow slightly flexed while an assistant applies countertraction to the midhumerus with both hands.

Method B (Fig. 110.3)

1. Position the patient on a stretcher in the supine position.
2. Extend the affected extremity over the edge of the stretcher.

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Fig. 110.1 Anatomical depiction

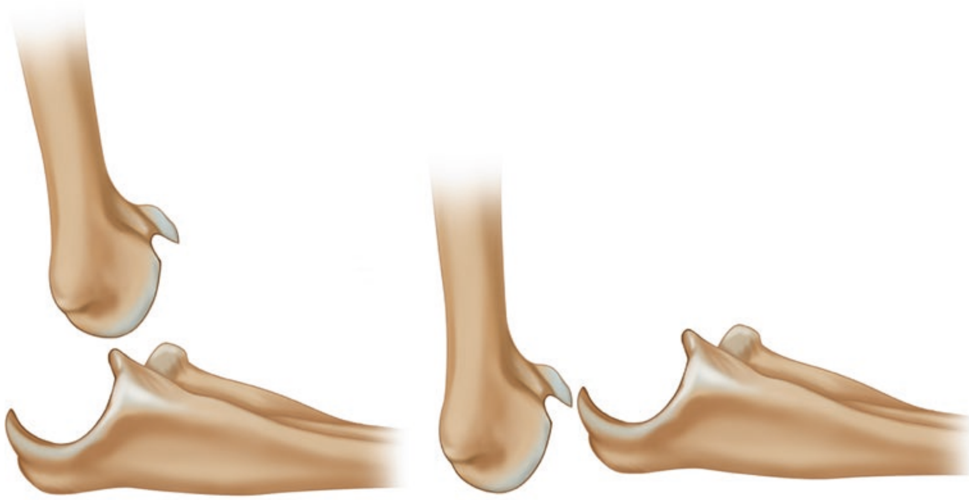

Fig. 110.2 Posterior method A

Fig. 110.3 Posterior method B

3. Apply traction to the supinated forearm slightly flexed at the elbow while an assistant holds the distal humerus with both hands and uses thumbs to apply pressure to the olecranon as if pushing it away from the humerus.

Method C (Fig. 110.4)

1. Position the patient on a stretcher in the prone position.
2. Hang the affected extremity over the side of the stretcher toward the floor.
3. Apply downward traction to the pronated distal forearm, and with the other hand just above the patient's antecubital fossa, lift the humerus toward you.

Procedure for Anterior Dislocations (Fig. 110.5)

1. Position the patient on a stretcher in the supine position.
2. With one hand, apply traction to the supinated distal forearm with the elbow extended while an assistant applies countertraction with both hands around the distal humerus.
3. With the other hand, apply downward and backward pressure over the proximal forearm just below the antecubital fossa.

Fig. 110.4 Posterior method C

Fig. 110.5 Anterior elbow

Procedure for Radial Head Subluxations

1. This procedure can normally be performed without any sedation or parenteral analgesia.
2. Position the patient, most commonly a child aged 1–3 years, facing forward on the caretaker's lap.
3. Hold the flexed elbow of the affected extremity placing your thumb firmly over the radial head.
4. With the other hand, take the child's hand and wrist, and in one continuous movement, hyperpronate and flex the forearm (Figs. 110.6 and 110.7).
5. Another method is to supinate and flex the forearm instead of hyperpronating it (Fig. 110.8).

Fig. 110.6 Subluxation hyperpronated

Fig. 110.7 Subluxation hyperpronated and flexed

Fig. 110.8 Subluxation supinated

6. Leave the room, encourage the caretaker to engage the child with distracting activities, and reexamine the child in 10–20 min, at which stage, if reduction was successful, the child should be using the extremity normally again.
7. No postreduction radiograph or immobilization is required.

Complications

- Concomitant fractures
- Vascular injury, most commonly to the brachial artery
- Median nerve injury/entrapment
- Recurrent dislocation—rare

Pearls and Pitfalls

- Pearls
  - A true lateral radiograph is necessary to accurately detect and identify elbow fractures, dislocations, and soft tissue abnormalities (i.e., the fat pad sign). It is obtained with the patient's elbow in 90° flexion, in neutral rotation with the thumb pointing up and the arm and forearm resting on the radiograph cassette and the beam nearly perpendicular to the cassette. On a true lateral, the "hourglass" or "figure-of-eight" formation at the distal humerus should be clearly visible, and the rings of the capitellum and trochlea should be concentric.
  - During nursemaid elbow reduction, provide age-appropriate distractions to divert the child's attention and minimize resistance.
- Pitfalls
  - On the pre- and postreduction radiographs, search for commonly associated fractures of the distal humerus, radial head, and coronoid process.
  - Inability to range the elbow after apparent reduction indicates possible trapped fracture fragments and the need for operative intervention.
  - Vascular or open injuries are common with anterior dislocations, and early orthopedic consultation is advised.
  - Ninety percent of simple elbow dislocations are posterior, and this injury is rarely associated with vascular injury. However, it does occur, and vascular evaluation after every reduction is good clinical practice.

Suggested Reading

Jain K, Shashi Kumar Y, Mruthyunjaya RR, Nair AV. Posterior dislocation of elbow with brachial artery injury. J Emerg Trauma Shock. 2010;3:308.

Kuhn MA, Ross G. Acute elbow dislocations. Orthop Clin North Am. 2008;39:155–61.

McDonald J, Witelaw C, Goldsmith LJ. Radial head subluxation. Comparing two methods of reduction. Acad Emerg Med. 1999;6:715.

Sheps DM, Hildebrand KA, Boorman RS. Simple dislocations of the elbow: evaluation and treatment. Hand Clin. 2004;20:389–404.

Villarin LA Jr, Belk KE, Freid R. Emergency department evaluation and treatment of elbow and forearm injuries. Emerg Med Clin North Am. 1999;17:843–58.

Part XIV

Obstetric Procedures

Distal Interphalangeal Joint Reduction

111

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Distal interphalangeal (DIP) joint dislocation is rare. It occurs when an axial force is applied to the distal phalanx (Fig. 111.1). It is sometimes associated with distal tuft fractures and avulsion fractures. Some complications include deformity and recurrent dislocation.

Fig. 111.1 Distal interphalangeal (DIP) joint dislocation

Indication

- DIP joint dislocation

Contraindications

- Absolute
  - Absence of radiographic confirmation (anteroposterior, true lateral, and oblique) of simple DIP joint dislocation, especially in pediatric cases
- Relative
  - Open joint dislocation, associated fracture, or entrapped volar plate
  - Digital neurovascular compromise

Materials and Medications

- Gloves
- Local anesthetic:
- 2% lidocaine without epinephrine (5 mL)
- 0.5% bupivacaine (5 mL)
- 25-gauge × 1.5-in. needle (can substitute with 27 or 30 gauge)
- 10-mL syringe
- Padded, malleable, aluminum digital splint
- Tape

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Procedure

1. Place the patient in the seated position with the arms at rest on a bedside table or supported by an assistant.
2. Pronate the patient's hand and rest on a flat surface:
   (a) Remove rings if present.
3. Local anesthesia:
   (a) Insert a 25-gauge needle at the lateral aspect of the volar surface of the proximal base of the finger and form a wheal of anesthetic medication.
   (b) Advance the needle anteriorly toward the dorsal aspect of the phalangeal base. Inject 1–2 mL of local anesthetic continuously as the needle is withdrawn.
   (c) Repeat on medial side of the proximal base of the finger.
   (d) Allow at least 10 minutes for the entire digit to be properly anesthetized.
4. Joint reduction:
   (a) While applying longitudinal traction, hyperextend the DIP joint followed by immediate joint flexion at the base of the distal phalanx.
5. DIP splinting:
   (a) Cut an aluminum digital dorsal splint to fit from the dorsal aspect of the middle phalanx to the tip of the finger.
   (b) Place the splint on the dorsal aspect of the finger and secure with tape (Fig. 111.2).
   (c) Advise patient to keep the splint on for at least 2 weeks.
6. Postreduction radiograph is recommended for confirmation.

Fig. 111.2 Padded aluminum splint applied to block the DIP joint from extension but allow further flexion (Reproduced with permission from HandLab Clinical Pearls Feb 2011, No 12. www.handlab.com)

Complications

- Irreducible dislocations
- Stiffness
- Recurrent dislocation
- Extensor lag in joints with residual subluxation
- Associated with dorsal joint prominences, swan-neck/boutonnière deformity, and degenerative arthritis

Pearls and Pitfalls

- Pearls
  – Lidocaine without epinephrine is preferred owing to the risk of vasoconstriction of the digital vessels with epinephrine.
  – Regardless of the mechanism of trauma, all joints (DIP, proximal interphalangeal, metacarpophalangeal) should be assessed for instability.
  – Joint dislocations involving volar plate entrapment may require surgical repair (open reduction internal fixation) for successful reduction.
- Pitfalls
  – Irreducible DIP joint dislocations may be due to entrapment of an avulsion fracture, the profundus tendon, or the volar plate.

Suggested Reading

Calfee RP, Sommerkamp TG. Fracture-dislocation about the finger joints [review]. J Hand Surg Am. 2009;34:1140–7.
Knoop KJ. Atlas of emergency medicine. 3rd ed. New York: McGraw-Hill Professional; 2010.
Simon RR, Sherman SC, Sharieff GQ. Emergency orthopedics. 6th ed. New York: McGraw-Hill Medical; 2011.
Stone CK, Humphries RL. Current diagnosis & treatment emergency medicine. 6th ed. New York: McGraw-Hill; 2008.
Tintinalli JE, Stapczynski JS, Ma OJ, Cline D, Cydulka R, Meckler G, editors. Tintinalli's emergency medicine: a comprehensive study guide. 7th ed. New York: McGraw-Hill; 2012.

Hip Dislocation Reduction

112

Katrina John, Jeffrey Kile, Amish Aghera,
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Indications

Displacement of the femoral head in relation to the acetabulum without concomitant femoral neck, head, or acetabulum fractures:

- Posterior
- Anterior
  - Obturator
  - Pubic
  - Iliac
  - Central
  - Inferior
- Prosthetic hip dislocations

Contraindications

- Absolute
  - Femoral neck fracture: attempted reduction may increase the displacement of the fracture and increase the probability of avascular necrosis.
- Relative
  - Fractures in other parts of the affected lower extremity: these may limit the pressure that can be applied necessary for traction during reduction.

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Materials and Medications

- Parenteral sedation and analgesia medications
- Sheet or belt to fix the pelvis to the stretcher
- Knee immobilizer
- Abduction pillow

Procedure

1. Check the neurovascular status of the affected extremity.
2. Obtain anteroposterior (AP) views of the pelvis and lateral views of the hip.
3. Ensure adequate parenteral sedation and analgesia.
4. Decide upon a technique, as detailed later, and position the patient accordingly.
5. Once the hip has been successfully reduced, test the joint for stability by moving it gently thought its range of motion.
6. Place a knee immobilizer and an abduction pillow between the knees.
7. Check the neurovascular status.
8. Obtain repeat AP films of the pelvis.

Stimson Maneuver

1. Place the patient prone on the stretcher with the affected extremity hanging over the edge and the hip flexed to 90°.
2. Flex the knee and the foot to 90°.
3. Apply downward pressure to the area just distal to the popliteal fossa with a hand (Fig. 112.1) or knee (Fig. 112.2) while using the opposite hand to internally and externally rotate the hip at the ankle.
4. Have an assistant simultaneously manipulate the displaced femoral head into position with both hands, applying downward pressure over the affected buttock (Fig. 112.3).

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Fig. 112.1 Stimson maneuver with the hand

Fig. 112.2 Stimson maneuver with the knee

Allis Maneuver

1. Position the patient supine on the stretcher.
2. The operator should stand on the stretcher to achieve maximum leverage or have the patient on a backboard on the ground.
3. Have an assistant apply downward pressure to both iliac crests.
4. Apply constant, gentle upward traction in line with the deformity while maneuvering the hip to 90° flexion and through internal and external rotation (Fig. 112.4).
5. Have a second assistant provide lateral traction to the midthigh.
6. Once the femoral head has cleared the outer lip of the acetabulum, continue traction while keeping the hip in external rotation and gently abducting and extending the hip (Fig. 112.5).

Whistler Technique

1. Position the patient supine on the stretcher with the knee and hip flexed to 45°.
2. Have an assistant stabilize the pelvis with downward pressure on both iliac crests.
3. Stand on the side of the affected extremity and place one arm under the knee, resting the hand on the flexed knee of the unaffected extremity.
4. Secure the ankle of the affected extremity with the other hand, and elevate the shoulder of the opposite arm, providing upward traction at the distal thigh and a strong fulcrum to reduce the dislocation (Fig. 112.6).
5. Internal and external rotation can be achieved with the opposite hand at the ipsilateral ankle.

Captain Morgan Technique

1. Position the patient supine on the stretcher with the knee and hip flexed to 90°.
2. Stabilize and fix the pelvis with a sheet tied securely over the pelvis and under the stretcher.
3. Standing on the side of the affected extremity, the operator's foot should be resting perpendicular on the stretcher with the knee placed under the patient's knee.
4. With the opposite hand, apply downward pressure to the ankle, and provide a sustained upward force to the patient's thigh by elevation of the knee through plantar

Fig. 112.3 Manipulation of the femoral head

Fig. 112.4 Allis flexion

flexion of the toes and upward pressure of the other hand placed behind the patient's knee.

5. Internal and external rotation can be applied simultaneously if necessary by gently twisting the ankle (Fig. 112.7).

Fig. 112.5 Allis extension

Fig. 112.6 Whistler technique

Complications

- Sciatic nerve injury
- Avascular necrosis of the femoral head due to delay in adequate reduction
- Inability to perform reduction due to occult fractures and fracture fragments, incarceration of the joint capsule, or associated tendons
- Unstable or irreducible dislocations
- Traumatic arthritis and joint instability

Fig. 112.7 Captain Morgan technique

Pearls and Pitfalls

- Pearls
  - On AP radiograph, posterior dislocations can be more easily detected by the presence of a smaller femoral head compared with the unaffected side and poor visualization of the lesser trochanter.
  - On AP radiographs, anterior dislocations can be detected by a larger femoral head and a clear lesser trochanter seen in profile alongside the femoral shaft.
  - Posterior hip dislocations make up 80–90% of cases. Anterior hip dislocations make up 10–15% of cases. These are classified into obturator, pubic, iliac, central, or inferior types. Central dislocations are associated with comminuted acetabulum fractures, and inferior dislocations are a rare occurrence normally occurring in children younger than 7 years of age.
  - Pay close attention to the femoral vessels and the sciatic nerve. Injury to the sciatic nerve most commonly affects the common peroneal branch, therefore causing weakness in great toe extension and foot dorsiflexion. Sensation may also be reduced over the dorsum of the foot.
  - Check the femoral head is intact and clearly in the acetabulum and for intact Shenton lines, symmetrical intra-articular spaces, and clear outlines of the lesser trochanters.
  - For any of the techniques requiring stabilization of the pelvis, an alternative is to fix it to the stretcher using a sheet or belt.
  - To overcome the powerful muscles that oppose successful reduction, it is important to provide adequate muscle relaxation and steady, prolonged traction.
  - An assistant should stand on the floor behind to support the operator if standing on a stretcher.
- Pitfalls
  - Owing to the force necessary to dislocate a native hip, this injury should serve as a red flag to the physician to consider other potentially life- or limb-threatening occult injuries.
  - Hip dislocation is a true orthopedic emergency and must be treated without delay. Delay in reduction, especially greater than 6 h, results in increased incidence of avascular necrosis of the femoral head and sciatic nerve injury.
  - Review imaging carefully because associated fractures of the femoral head, neck, and acetabulum are often present.
  - It is recommended that anterior dislocations be reduced by orthopedic surgeons under general anesthetic in the operating room. These are often more complicated and difficult to reduce, and failure at closed reduction in the operating room can be followed by an open procedure.
  - Multiple attempts at reduction should not be performed in the emergency department because these are unlikely to be successful and will only delay definitive management and lead to an increased risk of complications.

Suggested Reading

Hendey GW, Avila A. The captain Morgan technique for the reduction of the dislocated hip. Ann Emerg Med. 2011;58:536–40.

Newton EJ, Love J. Emergency department management of selected orthopedic injuries. Emerg Med Clin North Am. 2007;25:763–93.

Nordt WE. Maneuvers for reducing dislocated hips. Clin Orthop Relat Res. 1999;360:160–4.

Rupp JD, Schneider LW. Injuries to the hip joint in frontal motor-vehicle crashes: biomechanical and real-world perspectives. Orthop Clin North Am. 2004;35:493–504.

Walden PD, Hamer JR. Whistler technique used to reduce traumatic dislocation of the hip in the emergency department setting. J Emerg Med. 1999;17:441–4.

Knee Dislocation Reduction

113

Jeffrey Kile, Katrina John, and Amish Aghera

Indication

- Dislocation of the knee/fibular head/patella

Contraindications

- Absolute
  - None
- Relative
  - Immediate availability of orthopedic consultation

Materials and Medications

- Parenteral sedation and analgesia medications
- Knee immobilizer or splinting materials

Procedure

Knee (Femur/Tibia) Dislocation Reduction

1. Assess neurovascular function.
2. Pretreat the patient with sedation or analgesia as appropriate.
3. Position the patient supine with the affected leg fully extended.
4. Instruct an assistant to stand near the patient's hip, and, facing the patient's affected knee, grasp the distal femur firmly with both hands to fix it in place.
5. Stand near the patient's foot and, facing the patient's affected knee, grasp the distal tibia and apply straight traction in a distal direction:
   - Longitudinal traction-countertraction alone, as described previously, will usually reduce the dislocation. If reduction does not occur, proceed with the following steps.
6. While applying straight traction in a distal direction to the tibia with the dominant hand, with the nondominant hand:
   (a) Anterior dislocation: push the proximal tibia in a posterior direction (Fig. 113.1).
   (b) Posterior dislocation: lift the proximal tibia in an anterior direction (Fig. 113.2).

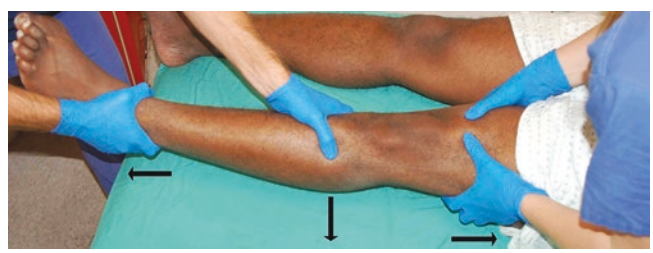

Fig. 113.1 Anterior dislocation of the knee: the proximal tibia is pushed in a posterior direction

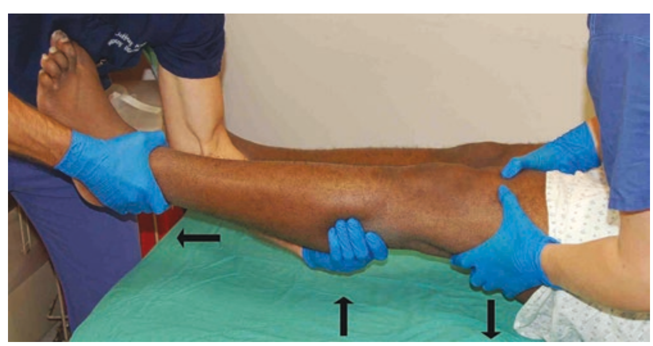

Fig. 113.2 Posterior dislocation of the knee: the proximal tibia is pushed in an anterior direction

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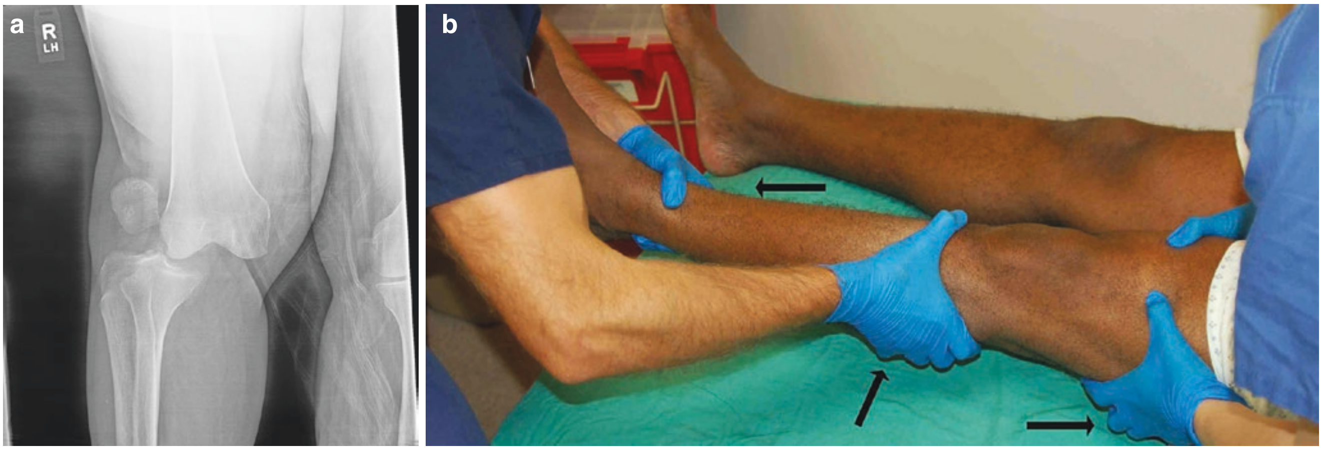

Fig. 113.3 (**a**) Lateral knee dislocation on AP radiograph (photo courtesy L. Ganti, MD). (**b**) Lateral dislocation of the knee: the proximal tibia is pushed in a medial direction

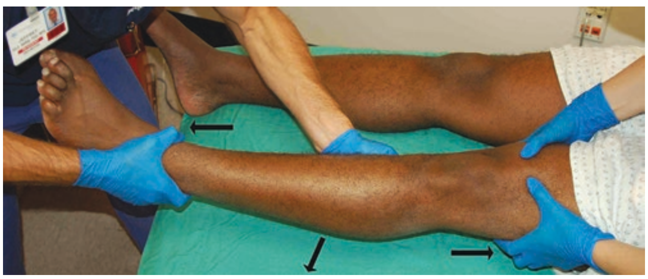

Fig. 113.4 Medial dislocation of the knee: the proximal tibia is pushed in a lateral direction

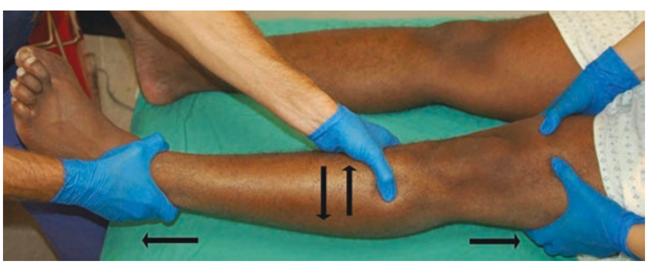

Fig. 113.5 Rotary dislocation of the knee: the proximal tibia is rotated into proper alignment with the femoral condyles

(c) Lateral dislocation: push the proximal tibia in a medial direction (Fig. 113.3).
(d) Medial dislocation: push the proximal tibia in a lateral direction (Fig. 113.4).
(e) Rotary dislocation: rotate the proximal tibia into proper linear alignment with the femoral condyles (Fig. 113.5).
   - Reduction may be facilitated by the use of two assistants rather than just one. The second assistant grasps the distal tibia and applies straight traction in a distal direction, freeing the operator to manipulate the proximal tibia as described previously using both hands.

Fig. 113.6 Anterior dislocation of the fibular head: the fibular head is pushed in a posterior direction

7. After reduction, reassess neurovascular function and, if available, obtain angiography.
8. Immobilize the knee in 15° of flexion in a knee immobilizer or long-leg posterior splint.

Fibular Head Dislocation Reduction

1. Assess neurovascular function.
2. Pretreat the patient with sedation or analgesia as appropriate.
3. Position the patient supine.
4. Flex the knee to 90° to relax the biceps femoris tendon.
5. Instruct an assistant to stand near the patient's hip, and, facing the patient's affected knee, grasp the distal femur firmly with both hands to fix it in place.
6. Stand near the patient's foot, and, facing the patient's affected knee, grasp the distal tibia and apply straight traction in a distal direction with the dominant hand and with the nondominant hand:
   (a) Anterior dislocation: push the fibular head in a posterior direction (Fig. 113.6).

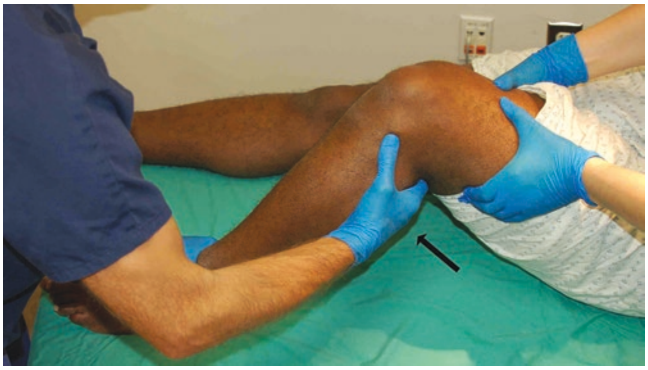

Fig. 113.7 Posterior dislocation of the fibular head: the fibular head is pushed in an anterior direction

(b) Posterior dislocation: push the fibular head in an anterior direction (Fig. 113.7).
   - Reduction may be facilitated by the use of two assistants rather than just one. If a second assistant is available, instruct the second assistant to stand near the patient's foot, and, facing the patient's affected knee, grasp the distal tibia and apply straight traction in a distal direction. This enables the operator to grasp and move the proximal fibula as described previously using both hands.
   - Reduction is often signified by a palpable and audible click as the fibula snaps back into position.

7. After reduction, reassess neurovascular function and, if available, obtain angiography:
   - After reduction, patients should receive orthopedic referral, avoid weight-bearing for the first 2 weeks, and then gradually increase weight-bearing over the next 6 weeks.
   - Typically immobilization is not required following reduction of an isolated fibular head dislocation.

Lateral Patellar Dislocation Reduction

1. Pretreat the patient with sedation or analgesia as appropriate.
2. Stand at the side of the affected knee, and, facing the knee, grasp the distal tibia and slowly extend the knee with one hand and with the other hand simultaneously apply gentle pressure to the patella in a medial direction:

- The lateral edge of the patella may be lifted slightly to facilitate its travel over the femoral condyle during reduction (Fig. 113.8).
- After reduction, the knee should be immobilized in full extension in a knee immobilizer or long-leg posterior splint, and the patient should receive orthopedic referral, avoid weight-bearing for the first 2 weeks, and then gradually increase weight-bearing over the next 6 weeks.

Fig. 113.8 Lateral dislocation of the patella: the patella is pushed in a medial direction

Complications

Knee (Femur/Tibia) Dislocations

- Distal ischemia (even requiring amputation)
- Degenerative arthritis
- Joint instability due to ligamentous injury

Fibular Head Dislocations

- Peroneal nerve injury
- Fibular head instability/subluxation
- Degenerative arthritis

Patellar Dislocations

- Failure of reduction
- Degenerative arthritis
- Recurrent dislocation/subluxation

Pearls and Pitfalls

Knee (Femur/Tibia) Dislocations

- Pearls
  – Dislocations of the knee are described in terms of the tibia's position in relation to the femur.
  – All knee dislocations require orthopedic evaluation at the earliest possible opportunity.
  – Owing to the frequency of associated popliteal artery and peroneal nerve injury, a neurovascular examination should be performed before and after any attempts at reduction or manipulation of the knee.

- Dislocations of the knee should be reduced as soon as possible, particularly if distal neurovascular compromise exists.
- Operative ligamentous repair is often required approximately 2 weeks postreduction (once acute swelling has resolved) to achieve the maximum functional recovery.

• Pitfalls
  - If the knee hyperextends more than 30° when the horizontal leg is lifted by the foot, the knee is considered severely unstable. This is likely due to a previous dislocation, and thus, the knee should be evaluated for the neurovascular complications of dislocation.
  - Because the joint capsule is commonly disrupted during knee dislocation, synovial fluid may diffuse into the surrounding tissue, such that an effusion is not always present.
  - A posterolateral dislocation may be irreducible because the medial femoral condyle traps the medial capsule within the joint

Fibular Head Dislocations

• Pearls
  - Fibular head dislocations are usually anterolateral, but these do not result in neurovascular compromise.
  - A knee joint effusion is usually not seen in a fibular head dislocation because the tibiofibular ligaments are contained within a separate synovium.
  - Anterior dislocations typically result from a fall on the flexed, adducted leg, often combined with ankle inversion.
  - Flexion of the knee relaxes the fibular collateral ligament, reducing the stability of the tibiofibular joint.
  - Superior dislocation is accompanied by interosseus membrane damage and proximal displacement of the lateral malleolus.

• Pitfalls

• Posterior fibular head dislocations usually result from direct trauma to the flexed knee and may be accompanied by peroneal nerve injury.

Patellar Dislocations

• Pearls
  - Patellar dislocation occurs most frequently among adolescents.
  - Patellar dislocation typically occurs in the setting of external rotation combined with a strong valgus force and quadriceps contraction.
  - Patellar dislocations are described in terms of the patellar relationship to the normal knee joint.
  - The most common patellar dislocations are lateral.
  - If a spontaneous reduction has occurred, a knee effusion and tenderness along the medial aspect of the patella are likely to be present on examination, and the patellar apprehension test will be positive.
  - To perform the patellar apprehension test, flex the knee to 30° and push the patella laterally. If the patient senses an impending redislocation, the test is considered positive.
  - Isolated lateral patellar dislocations do not usually require hospitalization, but orthopedic follow-up is recommended owing to the likelihood of persistent instability.
  - Intracondylar and superior dislocations require surgical reduction.
  - Patients with an isolated patellar dislocation typically present with the knee in 20°–30° of flexion, and the patella displaced laterally.

• Pitfalls
  - Dislocations tend to be recurrent, particularly in patients with patellofemoral anatomical abnormalities.

Selected Reading

Ganti L, Hanna A. Lateral knee dislocation. NEJM. 2019;381:205. https://doi.org/10.1056/NEJMicm1904635.

Martinez D, Sweatman K, Thompson EC. Popliteal artery injury associated with knee dislocations. Am Surg. 2001;67:165–7.

Peskun CJ, Levy BA, Fanelli GC, et al. Diagnosis and management of knee dislocations. Phys Sportsmed. 2010;38:101–11.

Rihn JA, Groff YJ, Harner CD, Cha PS. The acutely dislocated knee: evaluation and management. J Am Acad Orthop Surg. 2004;12:334–46.

Ankle Dislocation Reduction

114

Katrina John, Jeffrey Kile, Amish Aghera, and Jessica Houck

Dislocation of the ankle joint. This is defined by the articulation of the talus with the mortise that is formed by the distal tibia and fibula. Dislocations can be posterior, anterior, superior, or lateral and are classified by the position of the talus in relation to the tibial mortise.

Indication

- Dislocation of the ankle joint

Contraindications

- Relative
  - Open dislocations where there is no evidence of acute neurovascular compromise are better managed definitively in the operating room to avoid further contamination.

Materials and Medications

- Parenteral sedation and analgesia medications
- Local anesthetic for local and intra-articular anesthesia
- Parenteral sedation and analgesia medications
- Local anesthetic for local and intra-articular anesthesia
- Splinting material:
  - Splinting material (plasterglass or fiberglass)
  - Stockinette
  - Cotton padding
  - Elastic bandage
  - Tape

Procedure

1. Check the neurovascular status of the affected foot and ankle.
2. If there is no evidence of critical neurovascular compromise, obtain a lateral and an anteroposterior radiograph of the affected ankle.
3. Once a dislocation has been identified, select a reduction approach from methods below.
4. Ensure adequate parenteral sedation and analgesia to maximize success and limit pain and suffering.
5. Position the patient on a stretcher with the knee flexed at 90° over a folded pillow or rolled-up sheet or with the lower leg and knee hanging over the edge of the stretcher.

Posterior Dislocations

1. Hold the heel in one hand and pull with longitudinal traction.
2. With the other hand, hold the top of the foot and gently plantarflex it downward while an assistant provides countertraction at the back of the midcalf (Fig. 114.1).
3. Continue longitudinal traction at the heel and countertraction at the calf.
4. Dorsiflex the foot while another assistant applies downward pressure to the distal anterior leg (Fig. 114.2).
5. Examine the foot for restoration of normal anatomy and for any new lacerations or defects to the skin.
6. Recheck neurovascular integrity.

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Fig. 114.1 Plantarflexion with longitudinal heel traction

Fig. 114.2 Dorsiflexion with longitudinal heel traction

7. Place the leg in a posterior and sugar-tong splint with the foot at 90°.
8. Recheck neurovascular integrity.

Anterior Dislocations

1. Hold the heel in one hand and pull with longitudinal traction.
2. With the other hand, hold the top of the foot and dorsiflex while an assistant provides countertraction at the back of the midcalf (Fig. 114.3).
3. Continue longitudinal traction at the heel and countertraction at the calf.
4. Keeping the foot at 90° to the leg, hold the foot firmly and push the foot downward toward the floor while another assistant applies upward pressure to the distal posterior leg (Fig. 114.4).
5. Examine the foot for restoration of normal anatomy and for any new lacerations or defects to the skin.

Fig. 114.3 Dorsiflexion with longitudinal heel traction

Fig. 114.4 Downward movement of the foot (toward the floor) with longitudinal heel traction

6. Recheck neurovascular integrity.
7. Place the leg in a posterior and sugar-tong splint with the foot at 90°.
8. Recheck neurovascular integrity.

Complications

- Compound fractures
- Neurovascular injury
- Skin and soft tissue damage
- Compartment syndrome

Pearls and Pitfalls

- Pearls
  - The ankle rarely dislocates without associated fractures.
- Pitfalls

– Ankle dislocation is an orthopedic emergency, and reduction should not be delayed by imaging if there is evidence of neurovascular impairment. Complications that are exacerbated by delay in management include concomitant fractures, gross deformity of the ankle, severe stretching and tenting of the skin with resultant skin blisters, skin necrosis, and possible conversion to a compound fracture.
– Be sure to check the radiograph carefully for commonly associated fractures notably of the malleoli.

Suggested Reading

Collins DN, Temple SD. Open joint injuries: classification and treatment. Clin Orthop. 1989;243:48.

Hamilton WC. Injuries of the ankle and foot. Emerg Med Clin North Am. 1984;2:361.

Kelly PJ, Peterson FP. Compound dislocations of the ankle without fractures. Am J Surg. 1986;103:170.

Simon RR, Sherman SC, Koenigsknecht SJ. Emergency orthopedics—the extremities. 5th ed. New York: McGraw-Hill; 2007. p. 264.

Wedmore IS, Charette J. Emergency department evaluation and treatment of ankle and foot injuries. Emerg Med Clin North Am. 2000;18:85.

Arthrocentesis

115

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Arthrocentesis is a critical part in the evaluation of a joint effusion in the emergency department. Synovial fluid analysis will help differentiate between noninflammatory, inflammatory, and septic etiologies. Results can be used to both guide therapy and patient disposition.

Indications

- Diagnosis of septic joint
- Diagnosis of traumatic effusion
- Diagnosis of inflammatory effusion
- Diagnosis of crystal-induced arthritis
- Therapeutic relief of pain from effusion

Contraindications

- Severe coagulopathy
- Skin infection over the needle insertion site
- Joint prosthesis
- Patients with bacteremia or sepsis (except to diagnose a septic joint)

Materials and Medications

- Skin antiseptic agent:
  - Povidone-iodine
  - Chlorhexidine
- Sterile gloves
- Sterile towels
- Local anesthetic:
  - Lidocaine 1% or 2% (5 mL)
  - Ethyl chloride spray
- Needles:
  - 18 gauge: knee
  - 20 gauge: most other joints
  - 27 gauge: for anesthetic
- Syringes:
  - 5 mL: for anesthetic
  - 30–60 mL: for aspiration
- Sterile gauze (4 × 4)
- Band-Aid
- Sterile collection tubes
- Consider use of ultrasound

Procedure

1. Informed consent should be obtained prior to performing procedure.
2. Position the patient appropriately.
3. Palpate the joint and identify anatomical landmarks. See joint-specific approaches in Section 115.4.2.
4. Mark the injection site by impressing the skin with a hard object:
   (a) Sterile end of a needle sheath
   (b) Ballpoint pen with tip retracted
5. Prepare the skin with a topical antiseptic (povidone-iodine or chlorhexidine) by making three separate concentric outward spirals.
6. Drape the injection site in a sterile fashion using sterile towels.
7. Anesthetize the injection site:
   (a) Lidocaine: inject approximately 5 mL using a 27-gauge needle into the marked injection site by first making a wheel and then advancing deeper into

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subcutaneous tissue. Always aspirate prior to injecting to avoid intravascular injection.
   (b) Ethyl chloride: spray the injection site for approximately 10–15 seconds.
8. Secure the 18- to 20-gauge needle on the 30- to 60-mL syringe (depending on the size of the joint), and insert it into the skin at the marked injection site.
9. Advance the needle slowly into the joint space while aspirating until joint fluid can easily be withdrawn. Aspirate as much fluid as possible. If fluid cannot be aspirated easily, you may try:
   (a) Reposition the catheter further in the joint space or turn it by 45° sequentially as needed.
   (b) Switch anatomic approach (e.g., from medial to lateral knee).
   (c) Switch to a larger-gauge needle with a smaller syringe.
   (d) While attempting to aspirate, compress the contralateral joint gutter in order to "milk" the joint (Fig. 115.1).

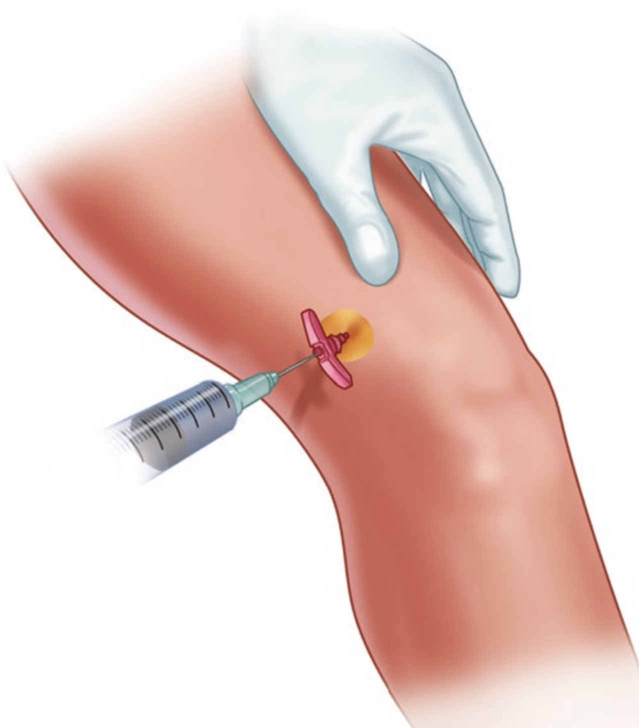

Fig. 115.1 Compress the opposite side of the joint to aid in aspiration

   (e) Consider the use of ultrasound for guidance.
10. Once the joint fluid is aspirated, pull out the needle and hold pressure with gauze. Bleeding should be minimal.
11. Place a Band-Aid or other dressing over the site.
12. Inspect the fluid for color and clarity. Send the synovial fluid to the laboratory (*see* Table 115.1 for synovial fluid analysis):
   (a) Generally, laboratory analyses should include:
      (i) Cell count and differential
      (ii) Gram stain and culture
      (iii) Crystal analysis (see *Table* 115.2 for crystal analysis)

The Approach

- Knee: there are multiple acceptable ways to perform an arthrocentesis of the knee. Approach can be medial or lateral or superior or inferior to the patella. The knee may be fully extended or in partial flexion (20 degrees). Some specific approaches include:
  – Inserting the needle 1 cm from the midpoint (either medially or laterally) of the patella and directing your needle posterior and horizontally toward the joint space. (Fig. 115.2)
  – For a suprapatellar approach, insert the needle 1 cm lateral and 1 cm superior to the superior aspect of the patella. Guide the needle medially in a horizontal plane.
- Acromioclavicular (AC) joint: insert the needle at the superior surface of the AC joint, and guide the needle posteriorly and slightly inferior (Fig. 115.3).
- Shoulder: two general approaches both with the patient sitting upright:
  – Anterior approach: with the shoulder externally rotated, the needle is inserted medial to the humeral head and inferolateral to the coracoid process. Direct the needle posteriorly and slightly superolaterally (Fig. 115.4).

Table 115.2 Crystal analysis

	Crystal	Birefringence	Shape
Pseudogout	Calcium pyrophosphate	Positive	Rhomboid
Gout	Calcium urate	Negative	Needle

Table 115.1 Synovial fluid analysis

	Normal	Noninflammatory	Inflammatory	Septic
Clarity	Transparent	Transparent	Cloudy/opaque	Cloudy/opaque
Color	Clear	Yellow	Yellow	Yellow
WBC	<200	<2,000	>2,000	>20,000[1]
PMN	<25%	<25%	>50%	>75%
Culture	Negative	Negative	Negative	>50% positive[2]

[1]A WBC count >50,000 increases the likelihood of septic arthritis
[2]Gram stains are only positive in <25% of gonococcal septic joints and positive in 50–75% of nongonococcal septic joints

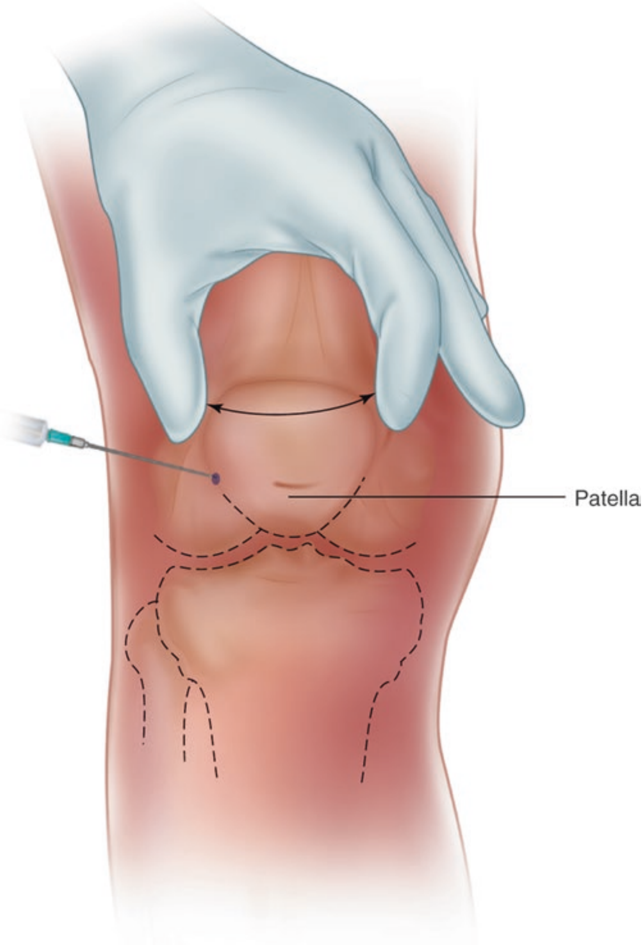

Fig. 115.2 Arthrocentesis of the knee

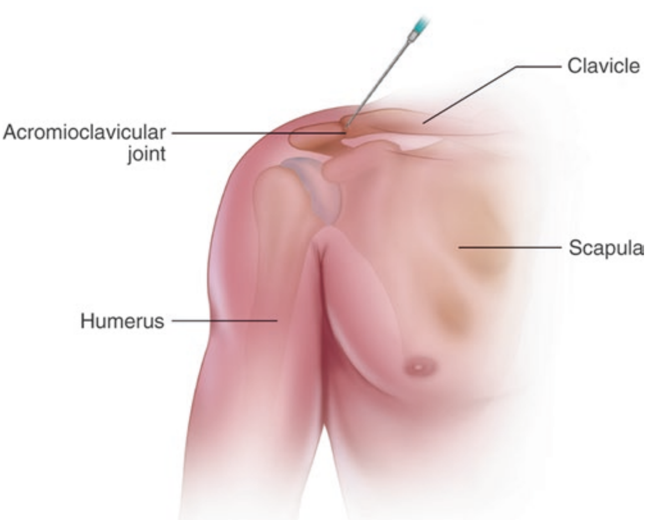

Fig. 115.3 Acromioclavicular joint arthrocentesis

– Posterior approach: palpate along the spine of the scapula until you reach the lateral border and identify the posterolateral corner of the acromion. Insert the needle 1 cm inferior and 1 cm medial to this corner, angling your needle anterior and medially to a depth of approximately 1.5 inches (Fig. 115.5).

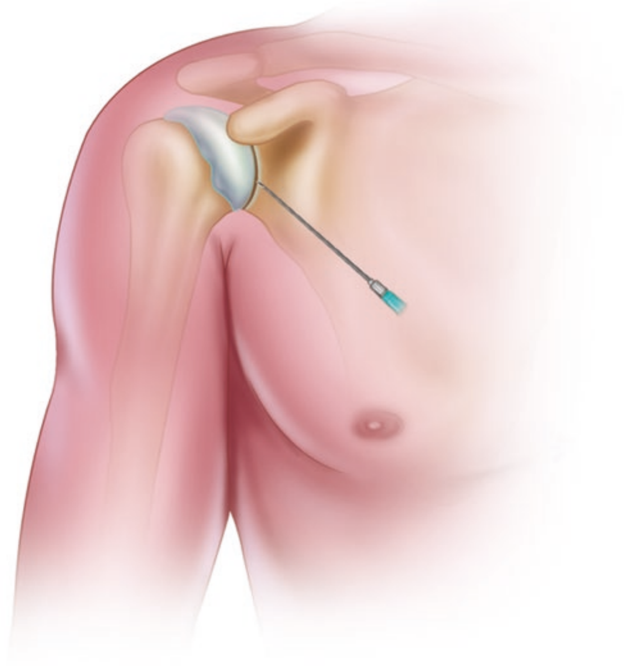

Fig. 115.4 Anterior approach to the glenohumeral joint

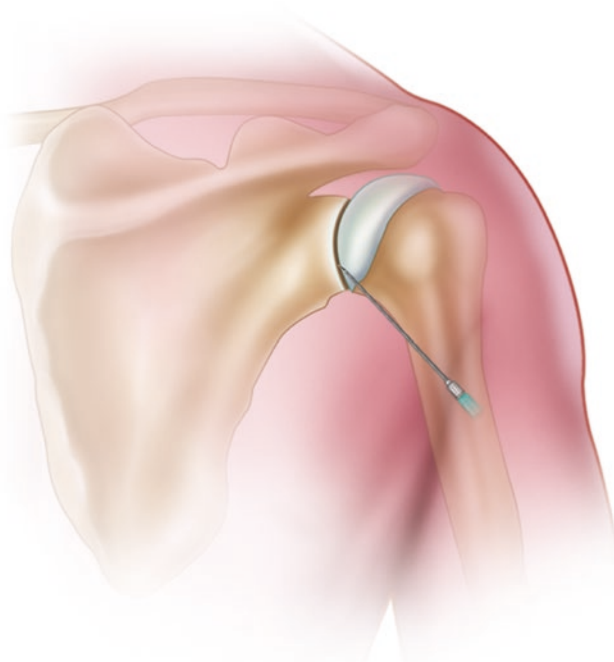

Fig. 115.5 Posterior approach to the glenohumeral joint

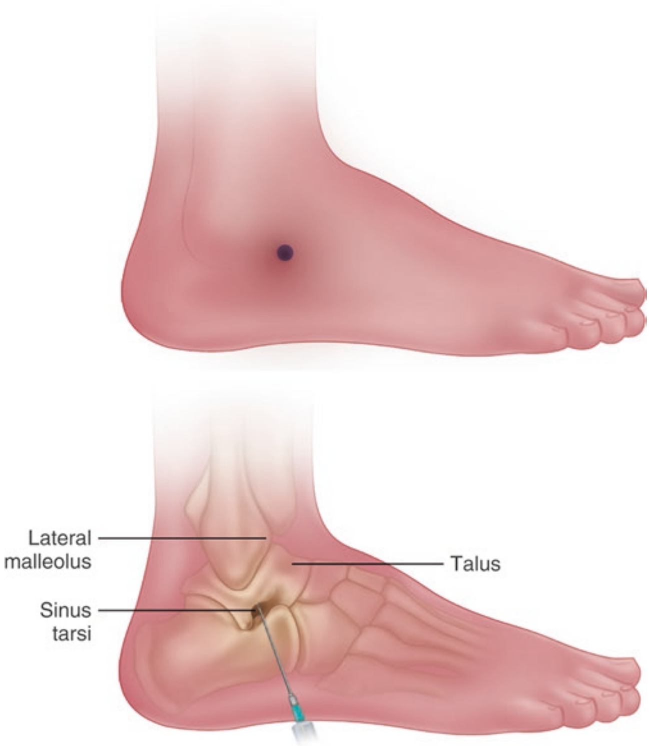

Fig. 115.6 Lateral approach to the ankle

- Ankle
  - Lateral approach (subtalar): enter the subtalar joint just below the tip of the lateral malleolus and direct the needle medially (Fig. 115.6).
  - Medial approach (tibiotalar): plantar flex the foot and palpate the sulcus that is anterolateral to the medial malleolus and medial to the tibialis anterior ligament. Insert the needle in this sulcus and angle the needle slightly cephalad into the joint space (Fig. 115.7).

Complications

- Introduction of infection
- Bleeding
- Dry tap (unable to aspirate fluid)

Pearls and Pitfalls

- The preferred site of entry is over the extensor surface of the joint. This will reduce the risk of damage to neurovascular bundles.

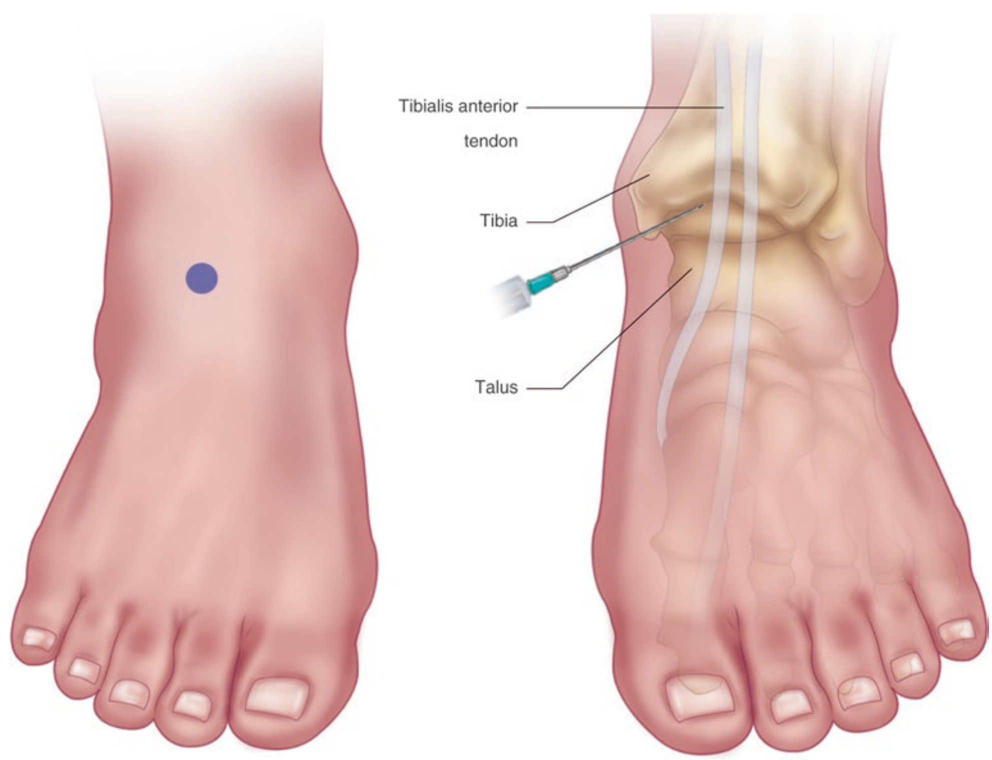

Fig. 115.7 Medial approach to the ankle

- When assessing synovial fluid, the "rule of twos" may be used to differentiate among normal, inflammatory, and septic fluid:
  - Normal: <200 WBCs
  - Noninflammatory: between 200 and 2,000 WBCs
  - Inflammatory: >2,000 WBCs (but <50,000 WBCs)
  - Septic: >20,000 WBCs (greater than 50,000 increases the likelihood of septic arthritis)
- Only septic synovial fluid will have a positive Gram stain and culture.
- Consider use of ultrasound to evaluate for joint effusion and procedural guidance.

Suggested Reading

Biundo JJ, Roberts N, Deodhar A. Regional musculoskeletal complaints. In: Stone JH, editor. A clinician's pearls and myths in rheumatology. New York: Springer Science; 2009. p. 433–4.

Parrillo SJ, Fisher J. Arthrocentesis. In: Roberts JR, Hedges J, editors. Clinical procedures in emergency medicine. 4th ed. Philadelphia: Saunders; 2004. p. 1042–57.

Self WH, Wang EE, Vozenilek JA, del Castillo J, Pettineo C, Benedict L. Dynamic emergency medicine. Arthrocentesis Acad Emerg Med. 2008;15:298.

Thomsen TW, Shen S, Shaffer RW, Setnik GS. Arthrocentesis of the knee. N Engl J Med. 2006;354:e19.

116 Intra-articular Injection

Bharat Kothakota, Muhammad Waseem, and Jessica Houck

Intra-articular injection of steroid medication may be performed for relief of pain and swelling in patients with a history of arthritis. It is usually performed after arthrocentesis and aspiration of fluid from the joint. In addition, an intra-articular injection can be used for local anesthesia in joint reduction procedures.

Indications

- Therapeutic glucocorticoid injection of joints with inflammatory or osteoarthritis
- Intra-articular anesthesia prior to joint reduction

Contraindications

- Cellulitis
- Bacteremia
- Fracture

Materials and Medications

- Glucocorticoid (see Table 116.1 for drug comparisons):
  - Methylprednisolone acetate
  - Triamcinolone acetonide
  - Triamcinolone hexacetonide
  - Dexamethasone acetate
  - Dexamethasone sodium
- Skin antiseptic agent:
  - Povidone-iodine
  - Chlorhexidine
- Sterile gloves
- Sterile towels
- Local anesthetic:
  - Lidocaine 1% or 2% (5 mL)
  - Ethyl chloride spray
- Needles:
  - 18 gauge: knee
  - 20 gauge: most other joints
  - 25 gauge: joints in the hand
  - 27 gauge: for anesthetic
- Syringes:
  - 5 mL: for anesthetic
  - 30–60 mL: for aspiration
  - 10 mL: for medication
- Hemostats
- Sterile gauze (4×4)
- Band-Aid
- Sterile collection tubes
- Consider use of ultrasound

Procedure

1. Prior to starting procedure, select a steroid medication from Table 116.1 and draw up the medication in a 10-mL syringe:
   (a) Consider adding a few mL of lidocaine to the steroid to reduce the risk of the patient having a postinjection flare.
2. Review Chapter 106 on arthrocentesis and complete steps 1–9. Stop after aspiration of fluid has been performed.
3. Leaving the needle in place, stabilize the hub with either hemostats or your fingers, and remove the syringe with the aspirated fluid (Fig. 116.1).
4. Replace with medication-filled syringe and inject medication:
   (a) Avoid injecting corticosteroids if the aspirate appears purulent.
5. Pull out the needle and hold pressure with gauze. Bleeding should be minimal.

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Table 116.1 Glucocorticoid selection, dosing, and duration of action

	Small joints[1]	Medium joints	Large joints	Duration of action (days)
Methylprednisolone (Depo-Medrol)	4–10 mg	10–40 mg	20–80 mg	8
Triamcinolone acetonide (Kenalog)	2.5–5 mg	10–20 mg	20–40 mg	14
Triamcinolone hexacetonide (Aristospan)	2–6 mg	10–20 mg	10–20 mg	21
Dexamethasone acetate (Decadron LA)	0.8–1 mg	2–4 mg	2–4 mg	8
Dexamethasone sodium (Decadron Solurex)	0.8–1 mg	2–4 mg	2–4 mg	6

[1]Small joints include joints of the hand; large joints include the knee, hip, and shoulder. All other joints are considered medium joints
Triamcinolone acetonide and methylprednisolone are the most commonly used intra-articular steroids

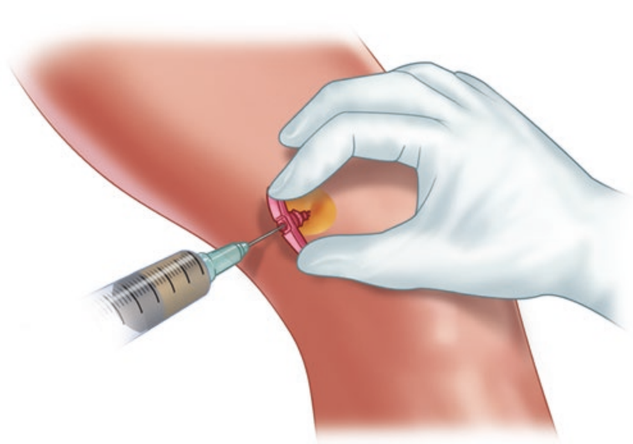

Fig. 116.1 Use hemostat or hand to stabilize needle within the joint space

6. Place a Band-Aid or other dressing over the site.
7. Inspect the fluid for color and clarity. Send the synovial fluid to the laboratory for analysis:
   (a) Generally, laboratory analyses should include:
      (i) Cell count and differential
      (ii) Gram stain and culture
      (iii) Crystal analysis
8. Postinjection care:
   (a) Advise patient to avoid strenuous activity for 1–2 days after injection. Apply ice to the injection site as needed.

Complications

- Local postinjection flare:
- Irritation of the synovium by steroid microcrystals.
- Can be confused for infection.
- Occurs and resolves within 48 hours after injection.
- Treat with ice and appropriate analgesics.
- Iatrogenic joint infection:
- Suspect if it begins later than, or lasts longer than, flare.
- Increasing pattern of pain.
- Fever, malaise, redness, or drainage around injection site.
- *Staphylococcus aureus* most common.
- Subcutaneous atrophy and depigmentation:
- Secondary to leakage of corticosteroids into soft tissues
- Aspiration of blood:
- Indicative of trauma or bleeding disorder (hemophilia)
- Systemic absorption

Pearls

- Mixing lidocaine with glucocorticoids:
  – Reduces pain caused by injection of steroids into joint space.
  – Less likely to cause soft tissue atrophy and tendon rupture.
  – Immediate relief from anesthetic indicates proper injection.
- Limiting intra-articular glucocorticoid injections per joint
  – OA
    Four injections per lifetime of the joint.
    Injections reduce the rate of accelerated degeneration in joints.
  – RA
    Limit of one injection per month
    No evidence of glucocorticoid-induced cartilage loss

Suggested Reading

Aponte EM, Schraga ED. Joint reduction, shoulder dislocation, anterior. Available at: http://emedicine.medscape.com/article/109130-overview#a08.

Cianflocco AJ. Intra-articular injections of the knee: a step-by-step guide. J Fam Pract. 2011;60(Suppl):S48–9. Available at: http://www.jfponline.com/pages.asp?id=10062.

Lavelle W, Lavelle ED, Lavelle L. Intra-articular injections. Anesthesiol Clin. 2007;25:835–62.

Molis MA, Young CC. Ankle impingement syndrome. Available at: http://emedicine.medscape.com/article/85311-overview.

Neustadt DH. Intra-articular injections for osteoarthritis of the knee. Cleve Clin J Med. 2006;73:897–911.

Roberts WN. Intraarticular and soft tissue injections: what agents(s) to inject and how frequently? Available at: www.uptodate.com.

Roberts WN. Joint aspiration or injection in adults: techniques and indications. Available at: www.uptodate.com.

Measurement of Compartment Pressure

117

Cherian Plamoottil

Indications

- The chief diagnostic tool outside of the clinical examination to establish the diagnosis of acute compartment syndrome.
- Have a low threshold to check compartment pressures in patients who present with the 5 Ps (pain out of proportion, pallor, paresthesias, pulselessness, and poikilothermia).
- Pain and paresthesias are the earliest findings in a patient with a proper clinical history which includes both traumatic and atraumatic causes of increased pressure in an enclosed space.

Contraindications

- Absolute
- No absolute contraindications
- Relative contraindication
- Avoid areas of cellulitis if possible to avoid introducing infection.

Materials and Medications

- Skin marker
- Betadine
- Lidocaine 1%
- 10 cc syringe
- 18 gauge needle to draw anesthetic
- 27 gauge needle to deliver anesthetic
- Sterile drapes
- Sterile gloves
- Stryker pressure monitor:
  - 3 cc prefilled saline syringe
  - Sideport needle
  - Diaphragm chamber
  - Stryker pressure monitor (Fig. 117.1)

Procedure

1. Mark the area of insertion, taking care to avoid any area of cellulitis.
2. Clean the marked area with Betadine and place drapes to create a sterile field.
3. Use the lidocaine to numb the insertion site, taking care to anesthetize the skin and subcutaneous tissue.
4. Assemble the Stryker pressure monitor system (Fig. 117.2):
   - Attach the 3 cc prefilled saline syringe to the diaphragm chamber.
   - Attach the sideport needle to the other side of the diaphragm chamber.
   - Place the needle, diaphragm, and syringe into the monitor system by aligning the diaphragm into the monitor system.
   - Ensure that the door of the monitor will appropriately close.
   - With the pressure monitor setup at a 45-degree angle, clear out all of the air bubbles in the system by gently depressing the plunger.
5. Calibrate the system by holding the monitor system at the angle you intend to enter the skin (typically perpendicular to the skin at the site of the entry), and press the "zero" button.
6. Once the system has been calibrated, you can check the compartment pressure by inserting the needle into site approximately 1–3 cm below the surface of the skin at the marked site.
7. Once the system has been calibrated, the compartment pressure can be measured by inserting the needle into site approximately 1–3 cm below the surface of the skin.

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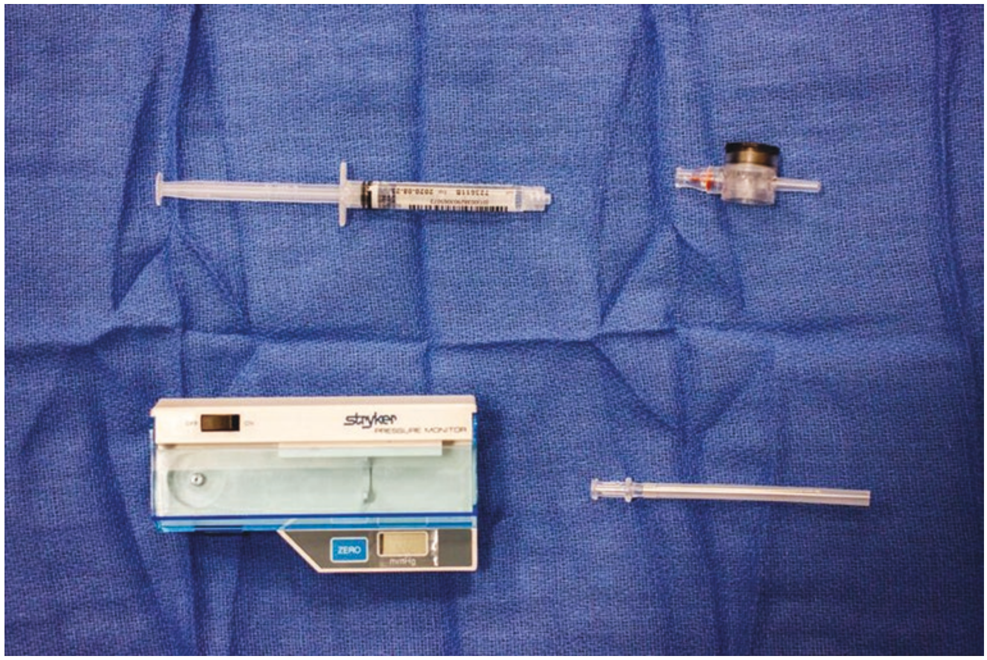

Fig. 117.1 Components of the Stryker pressure monitor system

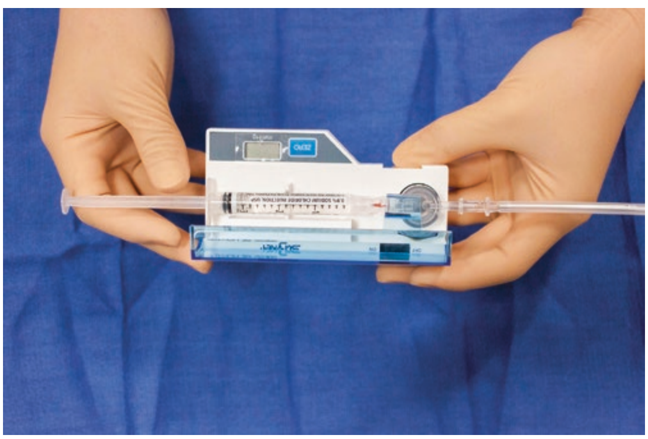

Fig. 117.2 The Stryker pressure monitor system set up for use

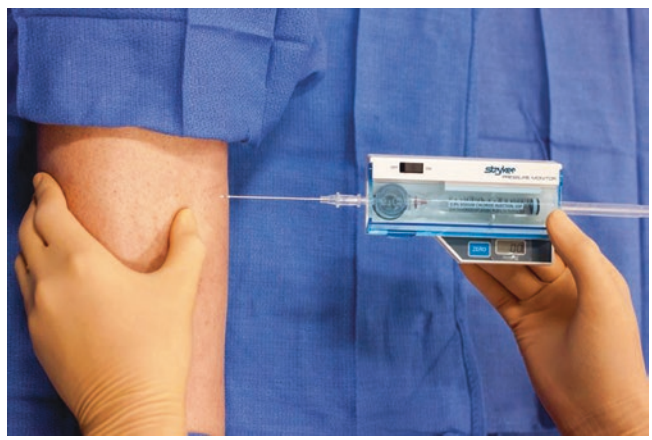

Fig. 117.3 The Stryker pressure monitor system being used to measure the compartment pressure of the lower extremity

8. Inject 0.3 cc of the sterile saline into compartment by depressing the plunger.
9. The display will read the pressure of the compartment.

Anatomic Considerations

- Upper extremity:
  – Upper arm: Insert the needle into the middle 1/3 of the upper arm. For the anterior compartment, insert the needle anterolaterally, and for the posterior compartment, insert the needle posterolaterally:
- Anterior: Biceps/brachialis/ulnar N./median N.
- Posterior: Triceps/ radial N.
  – Forearm: Insert the needle between the proximal and middle third of the forearm into the volar or dorsal compartment:
    - Volar: Wrist/finger flexors
    - Dorsal: Wrist/finger extension
    - Lateral (rarely involved): Brachioradialis/extensor carpi radialis longus and brevis
- Lower extremity (Fig. 117.3):
  – Thigh: Insert the needle into the middle 1/3 of the thigh into the anterior or posterior compartment:
    - Anterior: Quadriceps
    - Posterior: Hamstrings/sciatic nerves

- Lower leg: All needle insertions should be done just between the proximal 1/3 and the middle 1/3 of the lower leg:
  - Anterior: Tibialis anterior/extensor muscles of the toes:
    - 1 cm lateral to the tibia at 1–3 cm depth
  - Peroneal: Foot evertors (peroneus longus and brevis) and peroneal nerve:
    - 1 cm anterior to the posterior aspect of the fibula
    - Deep: Tibialis posterior/toe flexors:
    - Insert the needle at the medial border of the tibia aiming toward the fibula at a 2–4 cm depth.
  - Superficial posterior: Gastrocnemius/soleus/sural nerve:
    - Insert the needle posteriorly between the proximal 1/3 and the middle 1/3 of the lower leg off of the midline.

Complications

- Introduction of infection either from poor sterile technique or from inserting Stryker needle system through an area of cellulitis
- Iatrogenic increase in pressure from excessive treatment with anesthetic or over-injection of sterile saline
- Inaccurate pressure recordings by inappropriate needle placement, i.e., through tendon or ligament

Pearls and Pitfalls

- Compartment syndrome is a clinical diagnosis.
- Normal compartment pressure should always be under 10 mm Hg.
- A positive test/indication for fasciotomy is a pressure reading greater than 30 mm Hg or a delta pressure less than 30 mm Hg.
- Delta pressure is equal to the difference between diastolic blood pressure and the measure compartment pressure.
- For patients with compartment pressures above 10 mm Hg and the appropriate clinical picture, consider admission for continued compartment checks. Blood flow begins to diminish as compartment pressures approach 20 mm Hg. Ischemic necrosis will develop as pressure exceeds 30 mm Hg.
- The most commonly affected upper extremity compartment is the volar forearm compartment, and the most commonly affected lower extremity compartment is the anterior compartment of the lower leg.
- Have a high index of suspicion in pediatric supracondylar fractures.

Suggested Reading

Simon RR. Cook county manual of emergency procedures. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2012. p. 370–2.

Elliott KGB, Johnstone AJ. Diagnosing acute compartment syndrome. J Bone Joint Surg. British Volume. 2003;85-B(5):625–32. https://doi.org/10.1302/0301-620x.85b5.14352.

Frink, Michael (04/2010). Compartment syndrome of the lower leg and foot. Clin Orthopaed Related Res (0009-921X), 468(4), 940.

Hanandeh A, Mani VR, Bauer P, Ramcharan A, Donaldson B. Identification and surgical management of upper arm and forearm compartment syndrome. Cureus. 2019;11(10):e5862. Published 2019 Oct 8. https://doi.org/10.7759/cureus.5862.

Walls RM, et al. Chapter 42,General principles of orthopedic injuries. In: Rosen's emergency medicine: concepts and clinical practice. 9th ed. Philadelphia: Elsevier; 2018. p. 453–6.

Fetal Heart Rate Monitoring

118

Ilya Aleksandrovskiy, Nathaniel Lisenbee, and Joseph A. Tyndall

Indications

- Fetal heart rate (FHR) monitoring is important because it provides basic patterns that can be correlated to the acid-base status, circulatory volume, and oxygenation status of the fetus through brainstem detection and subsequent cardiac response. It has numerous uses during the antepartum and intrapartum stages [1].
- Antepartum indications include:
  - Nonstress test (consists of monitoring FHR in conjunction with fetal movements)
  - Contraction stress test (consists of monitoring FHR during contractions, which are induced pharmacologically)
  - Biophysical profile (BPP; consists of a nonstress test with an additional ultrasound)
- Intrapartum indications include monitoring FHR during:
  - Uterine contractions
  - Pain medications/anesthetic administration to the mother during labor
  - Procedures performed during labor
  - Second stage of labor
  - High-risk pregnancies, which can be defined by a number of conditions including [2, 3]:
    - Maternal diabetes, asthma, and preeclampsia/eclampsia
    - Multiple gestations
    - Intrauterine growth restriction
    - Premature rupture of membranes
    - Lack of prenatal care

Contraindications

- Contraindications for internal FHR monitoring:
  - Presence of placenta previa
  - Lack of ability to identify the portion of the fetal body where device application is being considered
  - Active herpes, active hepatitis, or human immunodeficiency virus (HIV) in the mother
- Contraindications for external FHR monitoring:
  - None

Methods

- Two methods for FHR monitoring:
  - Auscultation monitoring:
    - Defined as auscultating FHR every 15 minutes in the first stage of labor and auscultating every 5 minutes in the second stage
    - Does not provide strips with information on FHR variability or the shape of FHR accelerations and decelerations
  - Electronic FHR monitoring:
    - Allows for real-time continuous monitoring of FHR activity.
    - Provides strips with information on FHR variability or the shape of FHR accelerations and decelerations.
    - Can be performed by Doppler ultrasound or internal fetal electrocardiography (ECG).
    - When comparing the two methods for electronic FHR monitoring, both are equally reliable in most settings. Thus, external monitoring is the preferred method because it is noninvasive. However, in instances in which external monitoring becomes difficult owing to poor quality or technical difficulties, invasive monitoring is indicated.

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Equipment and Procedures

Multiple methods exist for electronic FHR monitoring. The most commonly used are external monitoring by Doppler ultrasound and internal monitoring by fetal ECG.

Doppler Ultrasound Is a Noninvasive Method to Monitor FHR (Fig. 118.1)

- Equipment
  - Electronic FHR monitor
  - Contraction monitor sensor with belt
  - FHR sensor with belt (consists of ultrasound transducer and ultrasound sensor)
  - Ultrasound coupling gel
- Procedure
  1. Place the patient in a supine position.
  2. Palpate the fetal anatomy through the maternal abdomen to find the approximate location of the fetal heart.
  3. Place ultrasound coupling gel on the maternal abdomen at the sight of suspected fetal cardiac activity.
  4. Place the transducer probe on gel and locate the fetal heart tones.
  5. Once the fetal heart tones are located, secure the FHR sensor to the maternal abdomen with the attached belt.
  6. Place the contraction monitor sensor near the fundus in order to monitor uterine contractions.
  7. Attach the FHR sensor and contraction monitor to the electronic FHR monitor to obtain printouts of FHR and uterine contractions.

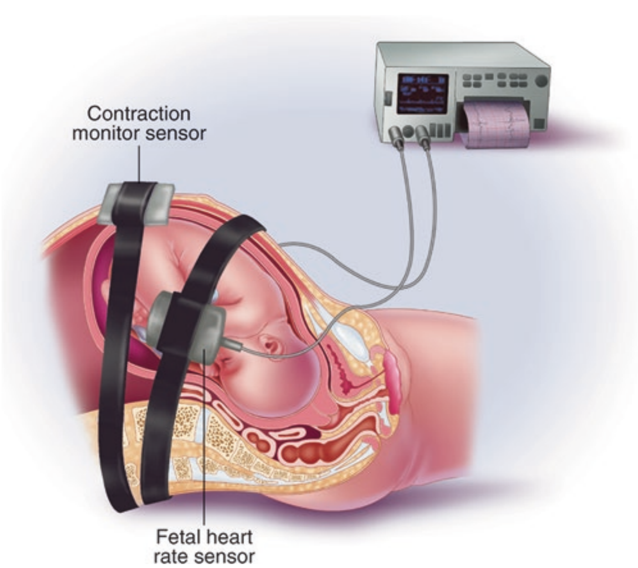

Fig. 118.1 External fetal heart rate monitoring

Internal Fetal ECG Is an Invasive Method to Monitor FHR and Is Used Only in the Intrapartum Period (Fig. 118.2)

- Equipment
  - Fetal scalp monitoring electrode
  - Leg plate electrode
  - Sterile vaginal lubricant
  - Electronic FHR monitor
- Procedure (Fig. 118.3)
  1. Place the patient in a dorsal lithotomy position.
  2. Sterilize the perineal area.
  3. Perform a bimanual vaginal examination to identify the presenting fetal head. (Note: rupture of membranes must occur before scalp electrode placement.)
  4. Place the spiral electrode guide tube on the fetal scalp, and advance the electrode until it contacts the scalp.

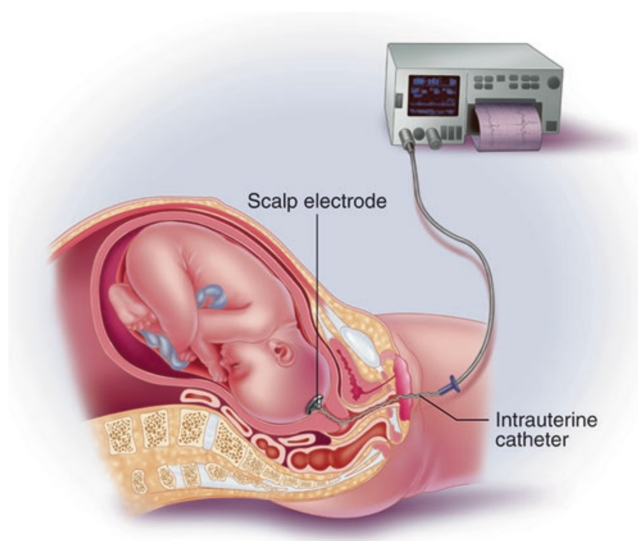

Fig. 118.2 Internal fetal heart rate monitoring

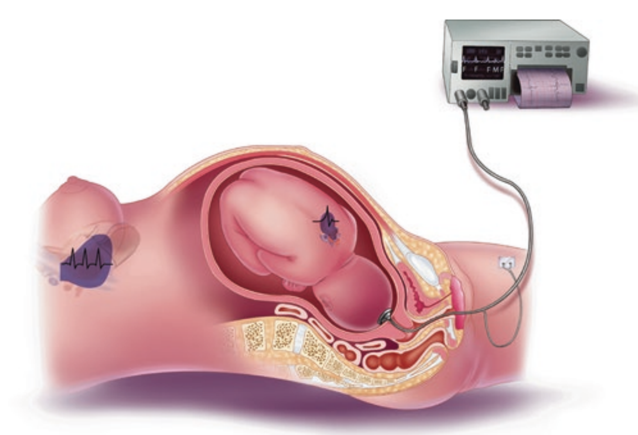

Fig. 118.3 Internal fetal heart rate monitoring

5. Rotate the drive tube clockwise approximately one rotation while maintaining pressure on the guide tube and drive tube.
6. Release the electrode locking device by pressing together the arms on the drive tube grip.
7. Carefully slide the drive and guide tubes off the electrode wires while holding the locking device open.
8. Attach the leg plate to the inner thigh of the mother as a means to eliminate electrical interference.
9. Attach the spiral electrode wires to the color-coded leg plate, which is then connected to the electronic fetal monitor.
10. Do not forget to sterilize the area of electrode placement after delivery is completed and the scalp electrode is removed.

When comparing the two methods, both are equally reliable in most settings. Thus, external monitoring is the preferred method because it is noninvasive. However, in instances in which external monitoring becomes difficult owing to poor quality or technical difficulties, invasive monitoring is indicated.

Complications

- Complications of external FHR monitoring:
  – Confusing maternal aortic pulsations with FHR
  – Inability to locate FHR
- Complications of internal FHR monitoring:
  – Fetal or maternal hemorrhage and fetal infection (usually scalp abscess at the site of insertion)
  – Uterine perforation
  – Subsequent fetal infection due to the invasive nature of the procedure

References

1. Hobel CJ. Intrapartum clinical assessment of fetal distress. Am J Obstet Gynecol. 1971;110:336–42.
2. Byrd JE. Intrapartum electronic fetal heart rate monitoring (EFM) and amnioinfusion. In: Advanced life support in obstetrics course syllabus. Kansas City: American Academy of Family Physicians; 1996. p. 97–106.
3. Queenan JT, Hobbins JC, Spong CY. Protocols for high-risk pregnancies. New York, John Wiley; 2010. Retrieved Jan. 16, 2012, from http://lib.myilibrary.com?ID=268955.
4. External and internal heart rate monitoring of the fetus. New Haven, Yale Medical Group; 2012. Retrieved from http://www.yalemedicalgroup.org/stw/.

Suggested Reading

Alfirevic Z, Devane D, Gyte GM. Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. Cochrane Database Syst Rev. 2006;3:CD006066.

American College of Obstetricians and Gynecologists. Fetal heart rate patterns: monitoring, interpretation, and management. ACOG Technical Bulletin 207. Washington, DC: ACOG; 1995.

Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Rouse DJ, Spong CY. Chapter 18, Intrapartum assessment. In: Williams Obstetrics. 23e. New York: McGraw Hill; 2010.

Freeman RK. Problems with intrapartum fetal heart rate monitoring interpretation and patient management. Obstet Gynecol. 2002;100:813.

Gomella LG, Haist SA. Chapter 13, Bedside procedures. In: Clinician's pocket reference. 11th ed. Columbus: McGraw-Hill; 2007.

Pinas A, Chandraharan E. Continuous cardiotocography during labour: Analysis, classification and management. Best Pract Res Clin Obstet Gynaecol. 2016;30:33–47. https://doi.org/10.1016/j.bpobgyn.2015.03.022. Epub 2015 Jun 25. PMID: 26165747.

Sweha A, Hacker TW, Nuovo J. Interpretation of the electronic fetal heart rate during labor. Am Fam Physician. 1999;59:2487–500.

Ultrasonography for Ectopic Pregnancy

119

Edgar J. Miranda, Alfredo Tirado, and L. Connor Nickels

An ectopic pregnancy is a pregnancy occurring outside of the uterine cavity (fundus) (Fig. 119.1). Ectopic pregnancy should be ruled out in any women of childbearing age who complains of abdominal or pelvic pain. Meta-analysis has shown that the use of POCUS in the emergency department to diagnose ectopic pregnancy has high sensitivity and negative predictive value [1]. This chapter looks to provide the reader with high yield information about the indications, contraindications, technique, and images of pathology.

Indications

- Patient in the first trimester of pregnancy with any combination of the following:
  - Vaginal bleeding.
  - Acute pelvic pain.
  - Hypotension or shock.
  - Dizziness or syncope.
  - Positive pregnancy test.
  - Adnexal mass.
  - Cervical tenderness.
  - Abnormal rise in the serum human chorionic gonadotropin (hCG).
  - No specific sign or symptom is absolute; therefore, the index of suspicion must be high.

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Contraindications

- Treating ectopic pregnancy medically when there is a fetal pole with fetal cardiac activity present
- Failing to consult obstetrics/gynecology when the patient has a serum hCG above the discriminatory zone and no sonographic findings to diagnose intrauterine pregnancy

Risk Factors for Ectopic Pregnancy

- Pelvic inflammatory disease (PID)
- Previous or current intrauterine device
- Infertility treatment
- Previous tubal surgery
- Tubal ligation
- Advanced maternal age
- Previous ectopic pregnancy
  - Usually a sonographic diagnosis
  - Sonographic signs of an ectopic can include any of the following:

    Gestational sac seen in one of the following:
    - Adnexa with any of the following:
      - Yolk sac (Figs. 119.2 and 119.3; see Fig. 119.7)
      - Fetal pole with or without cardiac activity
      - Both of these
    - Low position in the cervix (cervical ectopic)
    - Seemingly in the uterus, but off to one side and with minimal surrounding myometrium (interstitial ectopic)
    - Within the peritoneal cavity and outside of the tubes (abdominal ectopic)

    Pseudogestational sac seen in the uterus:
    - Uterine enlargement or decidual reaction (single outline only) in the endometrium without a gestational sac

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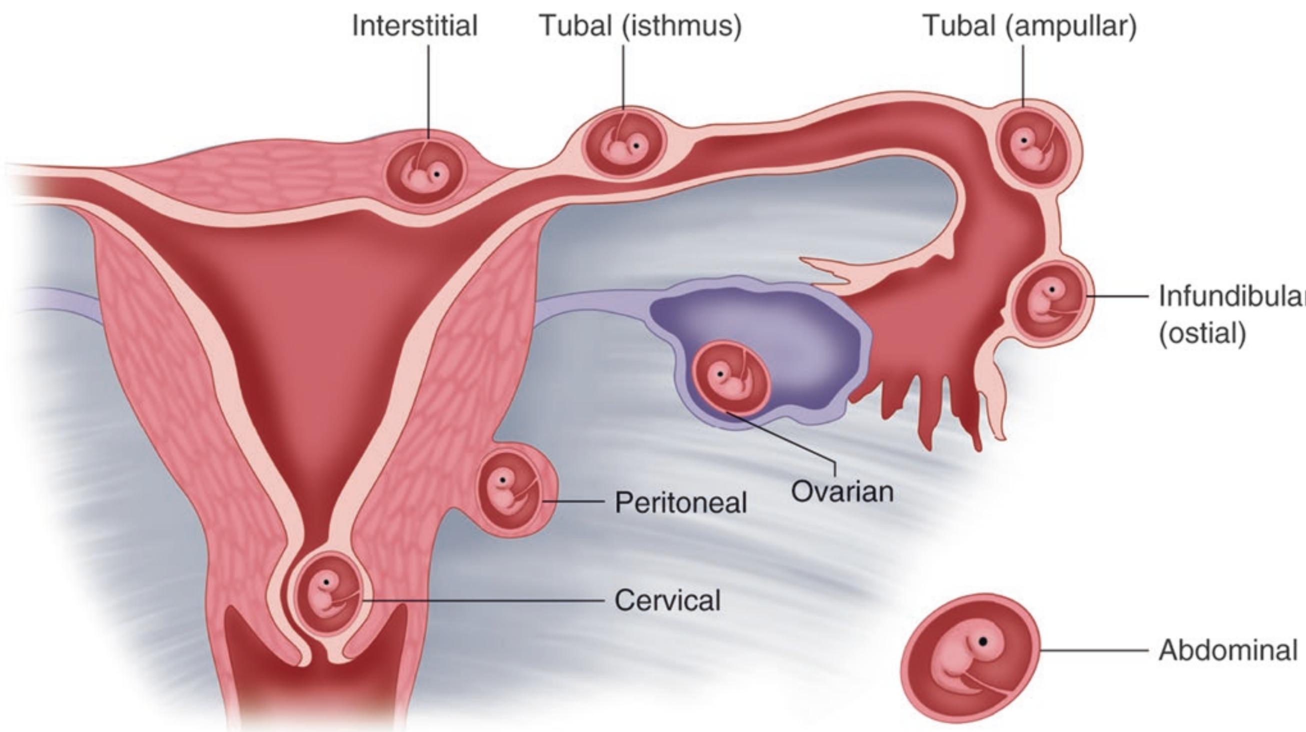

Fig. 119.1 Ectopic pregnancy diagram: pregnancy occurring outside of the uterine cavity

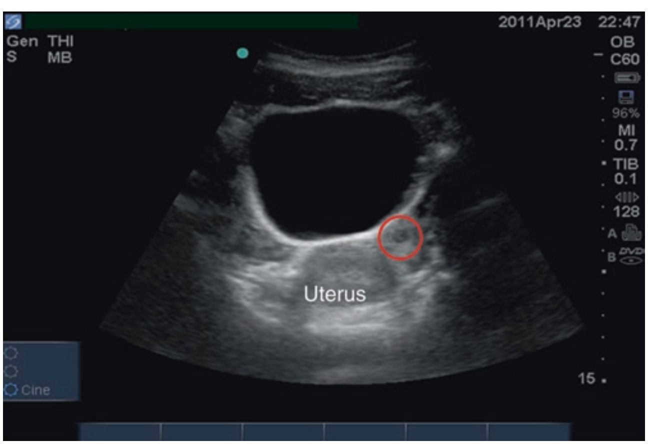

Fig. 119.2 Transabdominal transverse image of the uterus shows an ectopic pregnancy in the left adnexa (red circle) with the yolk sac present. (Photo courtesy of L. Connor Nickels, MD, RDMS)

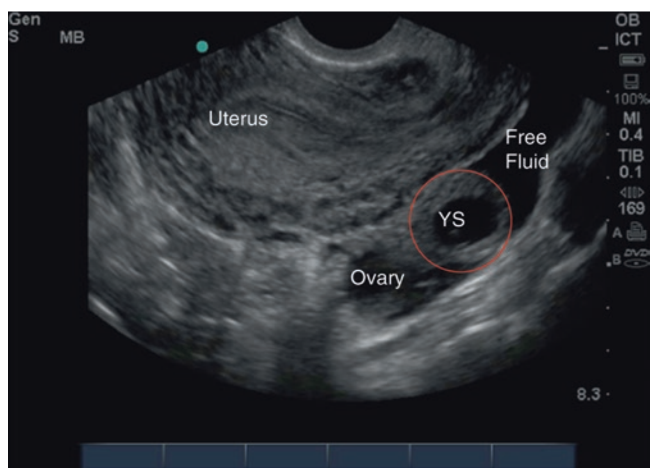

Fig. 119.3 Transvaginal sagittal image of an empty uterus with an ectopic pregnancy (in red circle) noted just posterior in the adnexa, adjacent to the ovary. The gestational sac contains a yolk sac, and there is free fluid surrounding the ectopic, concerning for rupture. (Photo courtesy of L. Connor Nickels, MD, RDMS). YS – yolk sac

Other unidentifiable adnexa mass
Free fluid in the pelvis or other gravity-dependent area (i.e., Morison's pouch in the right upper quadrant in a supine or reverse Trendelenburg patient) (Fig. 119.4):

- Small free fluid: tracks less than one third of the posterior cul-de-sac
- Moderate free fluid: tracks less than two thirds of the posterior cul-de-sac
- Large free fluid: tracks greater than two thirds of the posterior cul-de-sac

Fig. 119.4 Transvaginal sagittal image of an empty uterus and large free fluid in the posterior cul-de-sac in a patient with a presumed ectopic pregnancy. (Photo courtesy of L. Connor Nickels, MD, RDMS)

- Right upper quadrant free fluid: 100% predictability for ectopic

Empty uterus with serum hCG >1000 mIU/mL

– Patient in the first trimester of pregnancy with a serum hCG at or above the discriminatory zone (i.e., 1000 mIU/mL) without a sonographically normal gestational sac visualized within the uterus has an ectopic pregnancy until proven otherwise and should have an obstetrics consult in the emergency department:

Discriminatory zone may differ depending on the reference, but typically serum hCG is between 1000 and 2000 mIU/mL.

For this chapter, we have used serum hCG greater than 1000 mIU/mL [2, 3].

The discriminatory zone for transabdominal ultrasound is usually believed to be between 4,000 and 6,500 IU/mL.

– Yolk sac should be the first sign of definitive intrauterine pregnancy for emergency physicians because the decidual reaction and gestational sac are not 100% accurate.

– May be treated surgically or medically depending on findings:

Decision to be made by obstetrics consultant

Materials and Medications

- Ultrasound machine
- Probes: transabdominal and transvaginal
- Gel
- Skilled ultrasound operator
- Endocavitary probe covers
- Pelvic setup (speculum and cultures)
- Cardiac monitor and two large-bore intravenous needles
- Laboratory work: serum quantitative hCG, hemoglobin, group and Rh, type, and screen:
- May add additional laboratory tests depending on the stability and symptoms of the patient

Procedure

- Ultrasound machine in obstetrics preset
- Transabdominal:

1. Place the patient in the supine position.
2. Ideally, the bladder will be full for a good acoustic window.
3. Using a curvilinear probe, 3.5–5.0 MHz.
4. Begin scanning the patient in a sagittal position to identify the uterus as it lies in position with the bladder. Scan through the uterus completely in this plane, looking for signs of intrauterine pregnancy.
5. Imaging in the transverse plane should be done in the same fashion.
6. Any signs of an intrauterine pregnancy should be clearly identified and measured:
   - Gestational sac diameter:
     – Mean sac diameter of more than 25 mm suggests anembryonic pregnancy.
   - Yolk sac diameter:
     – Should be seen on transabdominal scanning when the mean sac diameter is 20 mm or at a gestational age of 7 weeks and is usually seen endovaginally with an MSD of 8–10 mm or gestational age of 5.5 weeks.
   - Fetal pole with crown rump diameter:
     – If present, fetal cardiac activity should be recorded by using M mode to obtain a tracing and measure the fetal heart rate. By the end of the 7th menstrual week, the embryo should measure 5–10 mm and should show cardiac activity.
7. Although sometimes limited transabdominally, an attempt to identify the adnexa should be performed in both planes bilaterally.
8. Any abnormalities identified should be noted:
   - Free fluid surrounding the uterus (anterior or posterior cul-de-sac) or ovaries
   - On pelvic imaging or FAST examination
   - Intrauterine contents not consistent with an intrauterine pregnancy and/or not clearly, centrally visualized within the fundus of the uterus

- Masses or contained fluid collections outside the uterus (Fig. 119.5)
- Yolk sac or fetal pole with or without fetal cardiac activity seen outside the uterus

9. Transvaginal scanning should be performed if a definitive intrauterine pregnancy is not identified on transabdominal imaging.
   - Transvaginal:
     1. Place the patient in the lithotomy position.
     2. The bladder is preferably empty.
     3. Use a transvaginal probe, 5–7.5 MHz.
     4. Repeat same steps as transabdominal imaging previously.
   - The procedure is the same for all pelvic ultrasounds including transabdominal and transvaginal imaging because this should be performed in a systematic fashion to not miss pertinent findings. Therefore, the findings may change, but the examination remains the same.
   - Yolk sac should be the first sign of definitive intrauterine pregnancy for emergency physicians because the decidual reaction and gestational sac are not 100% accurate.

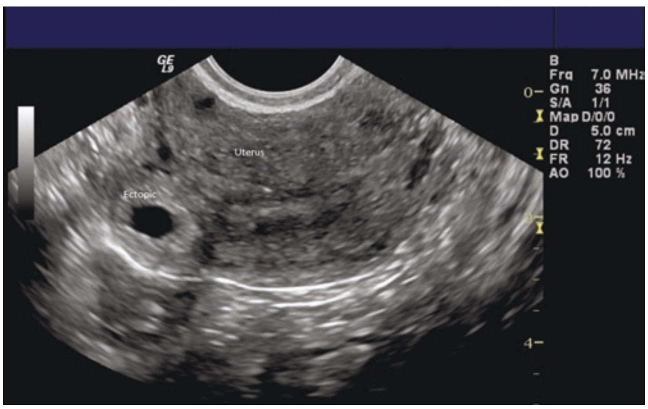

Fig. 119.5 Transvaginal transverse image of the uterus showing an empty endometrium with a fluid-filled mass outside of the uterus concerning for ectopic. (Photo courtesy of Alfredo Tirado, MD)

Complications

- Bleeding: internal and/or external
- Maternal death if ectopic ruptures:
  - Nine percent of pregnancy-related deaths
  - Leading cause of maternal death in the first trimester
- Sterility if tubes are damaged or surgically removed

Pearls and Pitfalls

- Pearls
  - **The** presence of an adnexal mass with free fluid in the abdomen or pelvis, an empty uterus, with a positive hCG has high specificity for ectopic pregnancy (Fig. 119.6 A&B).
  - Cervical ectopic pregnancy can be difficult to distinguish from a spontaneous abortion. If the patient is aborting, the ultrasound findings should change quickly, and the patient should have vaginal bleeding.
  - Double decidual reaction (Fig. 119.7) versus pseudogestational sac can be a very subtle distinction and should not be made by emergency physicians, hence

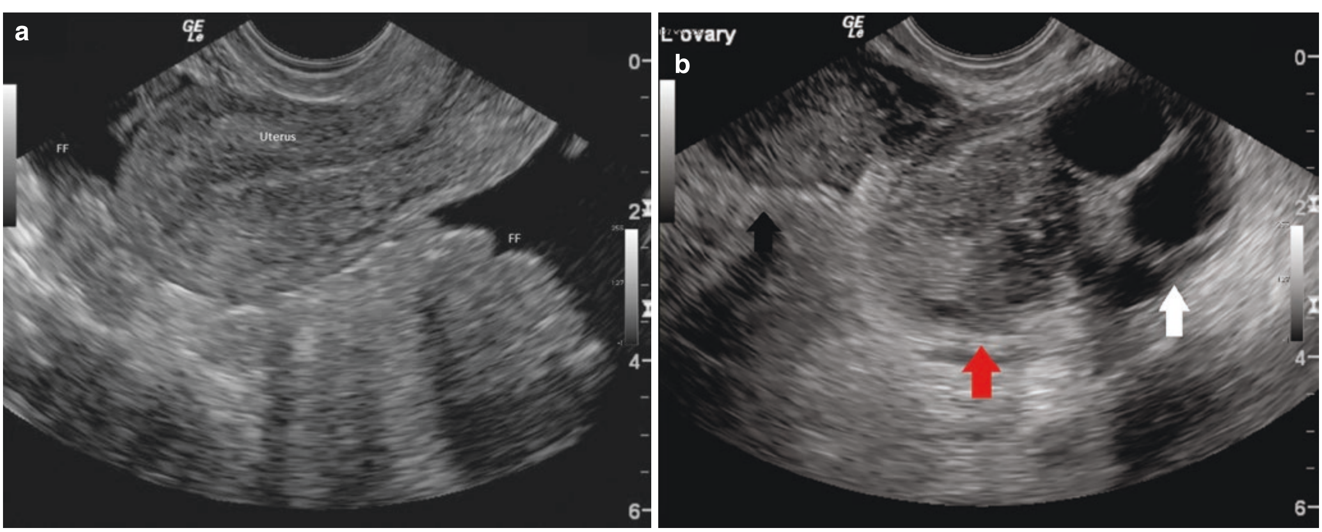

Fig. 119.6 (**a**) Transvaginal sagittal image of the uterus showing an empty uterus with large amounts of free fluid in the cul-de-sac and surrounding the fundus. (**b**) Transvaginal transverse view of the L adnexa of the same patient showing the uterus (black arrow), left adnexa (white arrow), and adnexal mass concerning for ruptured ectopic (red arrow). (Photo courtesy of Alfredo Tirado, MD)

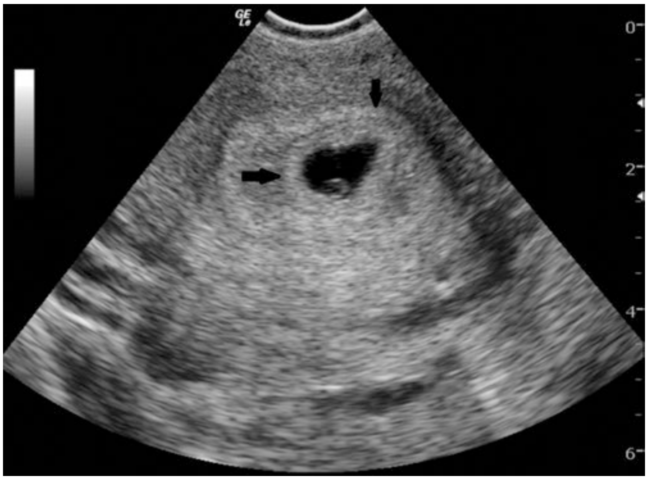

Fig. 119.7 Transabdominal transverse images of the uterus showing the concept of double decidual reaction (black arrows). Note the subtle presence of two well-demarcated "rings." Note the presence of the yolk sac. This is highly suggestive of early IUP. (Photo courtesy of Alfredo Tirado, MD)

the statement made earlier, requiring a yolk sac as the earliest definitive sign of an intrauterine pregnancy.

– Fibroids, bicornuate uterus, and eccentrically located normal pregnancy can all appear like a cornual pregnancy. The thinnest stripe of the myometrium seen surrounding the gestation should be measured "myometrial mantle." Anything less than 8 mm concerns for interstitial ectopic pregnancy.
– Most times when the patient is pregnant, has an empty uterus on sonographic imaging, and has vaginal bleeding, the final diagnosis is still unknown because it could still be an early normal pregnancy or an ectopic pregnancy.

- Pitfalls
  – Failing to obtain a pregnancy test in all reproductive-age women who have not undergone a hysterectomy
  – Failing to identify subtle signs of ectopic pregnancies

References

1. Ma OJ, Mateer JR, Blaivas M, editors. Emergency ultrasound. 2nd ed. New York: McGraw-Hill Professional; 2007.
2. Stein, John C, et al. "Emergency Physician Ultrasonography for Evaluating Patients at Risk for Ectopic Pregnancy: a Meta-Analysis." Ann Emerg Med, U.S. National Library of Medicine, Dec. 2010, www.ncbi.nlm.nih.gov/pubmed/20828874.
3. Hahn SA, Promes SB, Brown MD. Clinical policy: Critical issues in the initial evaluation and management of patients presenting to the emergency department in early pregnancy. Ann Emerg Med. 2017;69(2):241–50.

Suggested Reading

Gabbe SG, Niebyl JR, Galan HL, et al., editors. Obstetrics: normal and problem pregnancies. 5th ed. Philadelphia: Churchill Livingstone; 2007.

Marx J, Hockberger R, Walls R, editors. Rosen's emergency medicine: concepts and clinical practice. 7th ed. Philadelphia: Mosby; 2010.

Sanders RC, Winter T, editors. Clinical sonography: a practical guide. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2007.

Stead LG, Behera SR. Ectopic pregnancy. J Emerg Med. 2007;32(2):205–6.

120 Ultrasonography for Hydatidiform Mole

L. Connor Nickels and Leoh Léon

Definition: molar pregnancy = hydatidiform mole = anomalous growth of trophoblastic tissue which originates from the placenta and can metastasize

- Types
  - Complete (diploid and androgenic on origin): 46,XX (more common) or 46,XY:
    - Most common
    - Contains no fetal tissue
    - Most recognizable by clinical symptoms
    - Completely paternal in origin
  - Incomplete (aka partial mole; triploid): 69,XXX or 69,XXY:
    - Maternal and paternal in origin.
    - Contains fetal tissue, deformed, nonviable.
    - More subtle clinical presentation, the fetus usually dies within a few weeks of conception.

Indications

- Clinical presentation of any combination of the following:
  - Vaginal bleeding (most common presentation)
  - Uterus large for dates
  - With or without vomiting and persistent hyperemesis gravidarum
  - High blood pressure
- Serum human chorionic gonadotropin (hCG) very elevated in complete moles (more than would be consistent for dates): Usually greater than 100,000 mIU/mL.
- Partial mole hCG levels may be within normal range or lower than expected.

Contraindication

- Conservative management

Materials and Medications

- Ultrasound machine
- Probes: curvilinear (abdominal) and endocavitary (transvaginal)
- Gel
- Skilled ultrasound operator
- Endocavitary probe covers
- Pelvic setup (speculum and cultures)
- Lab work: serum quantitative hCG, hemoglobin, and group and Rh:
  - May add additional laboratory tests depending on the stability and symptoms of the patient

Procedure

- Ultrasound machine in obstetrics preset
- Transabdominal imaging:
  1. Place the patient in the supine position.
  2. Full bladder preferred as it will provide a good acoustic window.
  3. Using a curvilinear probe, 3.5–5.0 MHz (low frequency), begin scanning the patient in a sagittal position (probe indicator cephalic) to identify the uterus as it lies in position with the bladder. In this view, scan through the uterus to identify any signs of intrauterine pregnancy.
  4. Rotate the probe to a transverse position (counterclockwise, indicator toward patient right). Scan

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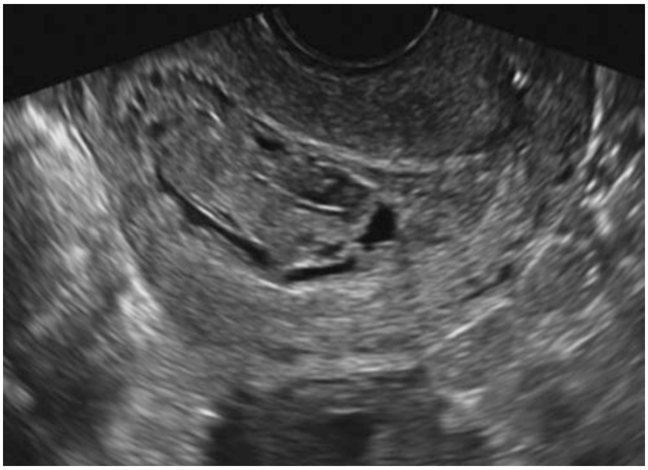

Fig. 120.1 First-trimester complete hydatidiform molar pregnancy with limited vesicular changes that are less prominent and best seen on transvaginal ultrasound images. Figure provided by Dr. Carol B. Benson, Director of Ultrasound, Department of Radiology, Brigham and Women's Hospital and Professor of Radiology, Harvard Medical School, Boston, MA. (*From* Esselen et al. [1]; *with permission*)

through the uterus completely in this plane, looking for any signs of intrauterine pregnancy.

5. Measure any signs of intrauterine pregnancy.
6. Sonographic findings of a molar pregnancy include:
   - Uterus filled with heterogeneous material:
     – Echogenic material interspersed with anechoic areas known as the "snowstorm" is the most common appearance of a mole (Fig. 120.1).

   Imaging can be easily confused with a missed abortion or fibroid; however, this highlights the importance of having the serum hCG levels as markedly elevated levels provide alternative diagnoses less likely.
7. Although sometimes limited transabdominally, an attempt to identify the adnexa should be performed in both planes bilaterally.
8. Any abnormalities should be noted.
9. Transvaginal scanning should be performed if a definitive intrauterine pregnancy is not identified on transabdominal imaging.

- Transvaginal imaging:
  1. Place the patient in the lithotomy position.
  2. The bladder is preferably empty.
  3. Use an endocavitary probe, 5–7.5 MHz.
  4. Repeat the same steps as for transabdominal imaging previously discussed.
  5. After scanning through the uterus in sagittal and transverse planes, the adnexa should be scanned in the same format bilaterally, looking for any abnormalities, as mentioned previously.
  6. Again, any abnormalities should be noted:
     – Free fluid surrounding the uterus (anterior or posterior cul-de-sac) and/or ovaries
     – Masses or contained fluid collections outside the uterus
     – Yolk sac or fetal pole with or without fetal cardiac activity seen outside the uterus
- The procedure for all pelvic ultrasounds (transabdominal and transvaginal imaging) is the same and performed in a systematic fashion so as to not miss pertinent findings. Therefore, the findings may change, but the examination remains the same.
- Yolk sac should be the first sign of definitive intrauterine pregnancy for emergency physicians because the decidual reaction and gestational sac are not 100% accurate.

Complications

- There are multiple complications which can occur including:
  – Invasive mole: after dilation and curettage, if a hydatidiform mole recurs, it can invade the muscle of the uterus. Color flow is needed to visualize any residual invasive tissue.
  – Molar tissue can develop into an aggressive malignancy, choriocarcinoma, which can metastasize early throughout the body:

    In this scenario, the tumor takes on a very cystic appearance with an echogenic rim. When this is seen, one should attempt to view the liver as well for heterogeneous appearance consistent with metastasis or consider other imaging tests (more comprehensive ultrasound, computed tomography, or magnetic resonance imaging) as indicated to further assess concerns for malignancy.

    Extremely sensitive to chemotherapy, but most favorable results are seen when diagnosed and treated early.

Pearls and Pitfalls

- Pearls
  – hCG levels above 100,000 mIU/mL in early pregnancy should raise concerns for molar pregnancy. Ultrasound and OB/Gyn consult must be obtained in the emergency department.

  - If diagnosed, patient must have a dilation and curettage to evacuate the mole:

    Follow serum hCG must to less than detectable levels because they have a high rate of recurrence (invasive mole) and potential for malignancy (choriocarcinoma).
  - May occur with intrauterine or ectopic pregnancies or after spontaneous abortions or full-term pregnancies.
  - Qualitative and quantitative β-hCG results may be falsely negative in the setting of a molar pregnancy secondary to the “high-dose hook effect” found in sandwich immunoassays in which there is an overabundance of antigen. This error can be corrected by diluting the urine or serum sample and repeating the test.
- Pitfalls
  - If undiagnosed, potentially life-threatening consequences surround this diagnosis. Close observation of the entire picture, including clinical presentation, laboratory results, and ultrasound findings, will help to avoid these outcomes.

Reference

1. Esselen KM, Goldstein DP, Horowitz N, Berkowitz RS. First-trimester ultrasound in gestational trophoblastic disease. In: Abramowicz JS, editor. First-trimester ultrasound: a comprehensive guide. Cham: Springer International Publishing; 2016. p. 327–37.

Suggested Reading

Bly S, Van den Hof MC. Diagnostic imaging committee, society of obstetricians and gynaecologists of Canada. Obstetric ultrasound biological effects and safety. J Obstet Gynaecol Can. 2005;27(6):572–80. English, French. https://doi.org/10.1016/s1701-2163(16)30716-2.

Cavaliere A, Ermito S, Dinatale A, Pedata R. Management of molar pregnancy. J Prenat Med. 2009;3(1):15–7.

Hunter CL, Ladde J. Molar pregnancy with false negative â-hCG urine in the emergency department. West J Emerg Med. 2011;12:213–5.

Lentz GM, Lobo RA, Gershenson DM, et al., editors. Comprehensive gynecology. 6th ed. Philadelphia: Mosby; 2012.

Ma OJ, Mateer JR, Blaivas M. Emergency ultrasound. 2nd ed. New York: McGraw Hill Professional; 2008.

Sanders RC, Winter T, editors. Clinical sonography: a practical guide. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2007.

Ultrasonography for Threatened, Incomplete, or Compete Abortion

121

Javier Rosario

Key Points Threatened abortion: closed os and no passage of products of conception (POC).

Inevitable abortion: open os and no POC.

Incomplete abortion: open os and passage of POC.

Complete abortion: closed os and empty uterus (all POC passed).

Missed abortion: fetus has died and the uterus has failed to enlarge any further.

Retained products: partial or incomplete passage of POC.

Indication

- Vaginal bleeding in the setting of early intrauterine pregnancy (IUP) with or without pain and/or cramps

Contraindications

- There are no contraindications to ultrasonography.

Materials and Medications

- Ultrasound (US) machine
- Probes: curvilinear (transabdominal) and endocavitary (transvaginal)
- Gel
- Endocavitary probe covers
- Towels
- Skilled ultrasound operator
- Pelvic examination setup
- Cardiac monitor and intravenous access if bleeding is significant
- Laboratory tests: serum human chorionic gonadotropin (hCG), hemoglobin, group and Rh, type, and screen

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Procedure

The procedure is the same for all pelvic ultrasounds including transabdominal and transvaginal imaging because this should be performed in a systematic fashion so as to not miss pertinent findings. Performing transabdominal imaging before endocavitary imaging is a common protocol:

1. Place the patient in the supine position.
2. Ultrasound machine in *obstetrics* preset with abdominal and/or endocavitary probe and gel.
3. Begin scanning the patient in a transabdominal sagittal plane to identify the uterus as it lies in position with the bladder. Scan through the uterus completely in this plane looking for signs of intrauterine pregnancy (gestational sac, yolk sac, fetal pole, fetal cardiac activity):
   - For our purposes as emergency physicians, a yolk sac seen within the uterus may suggest evidence of an intrauterine pregnancy (Fig. 121.1). The decidual reaction and/or presence of gestational sac is not 100% accurate to identify IUP.

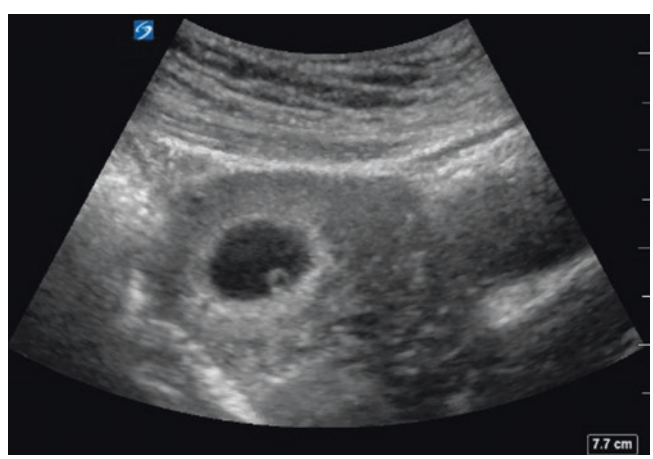

Fig. 121.1 Yolk sac present within the gestational sac with double decidual reaction. (Photo courtesy of Javier Rosario, MD)

L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0_121

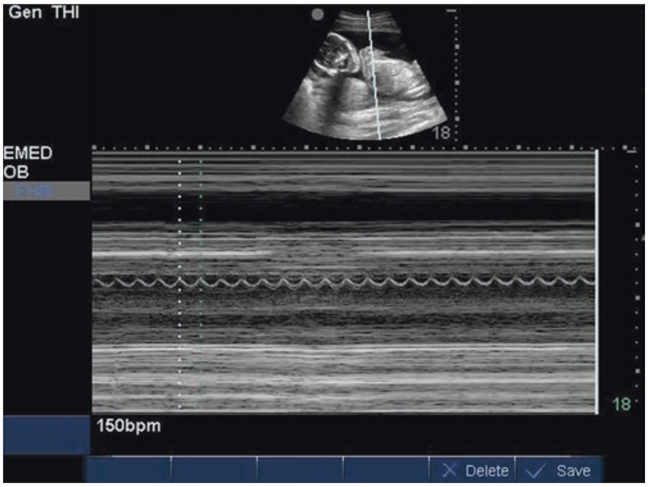

Fig. 121.2 Fetal cardiac activity recorded using M mode to obtain a tracing and measure the fetal heart rate. (Photo courtesy of Javier Rosario, MD)

4. Transabdominal imaging in the transverse plane should be done in the same fashion.
5. If an intrauterine pregnancy is clearly identified on transabdominal scanning, appropriate measurements can be taken to estimate dates:
   - Gestational sac diameter.
   - Yolk sac diameter or crown-rump length (CRL).
   - If present, fetal cardiac activity should be recorded by using M mode to obtain a tracing and measure the fetal heart rate (Fig. 121.2). The use of Doppler functions is not recommended for this evaluation.
6. For a complete examination, the adnexa should be scanned in an attempt to identify the ovaries bilaterally.
7. There should be an effort to identify the following abnormalities:
   - Free fluid surrounding the uterus (anterior or posterior cul-de-sac) or ovaries:
     – In appropriate scenarios where ectopic or other bleeding source is considered a focused assessment with sonography in trauma (FAST) examination may be included
   - Intrauterine contents not consistent with an intrauterine pregnancy and/or not clearly, centrally visualized within the fundus of the uterus
   - Any masses or contained fluid collections noted outside the uterus
   - A gestational sac, yolk sac, or fetal pole with or without fetal cardiac activity seen outside the uterus
8. Transvaginal scanning with the endocavitary probe should be performed if a definitive IUP is not identified on transabdominal imaging or when any of the other abnormalities mentioned above are found.
9. Transvaginal imaging is performed in the sagittal and transverse planes to identify an intrauterine pregnancy, with the bladder preferably empty.
10. Measurements should be taken of any intrauterine findings:
    - Same as #5.
11. Each adnexa should be scanned in the sagittal and transverse planes.
12. Any abnormalities identified should be noted:
    - Same as #7.
13. The uterus will be empty in the case of a complete abortion (Figs. 121.3 and 121.4).
14. Some diagnostic *evidence* of pregnancy failure include:
    - CRL >7 mm on transvaginal ultrasound with no fetal heart rate
    - Mean sac diameter >25 mm with no embryo
    - Absence of an embryo with a heart rate at >2 weeks' gestational age and a prior US that showed gestational sac with no yolk sac

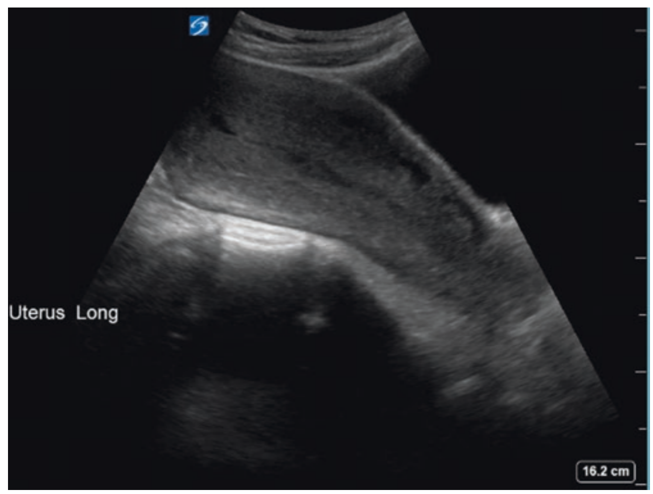

Fig. 121.3 Transabdominal sagittal image of an empty uterus. (Photo courtesy of Javier Rosario, MD)

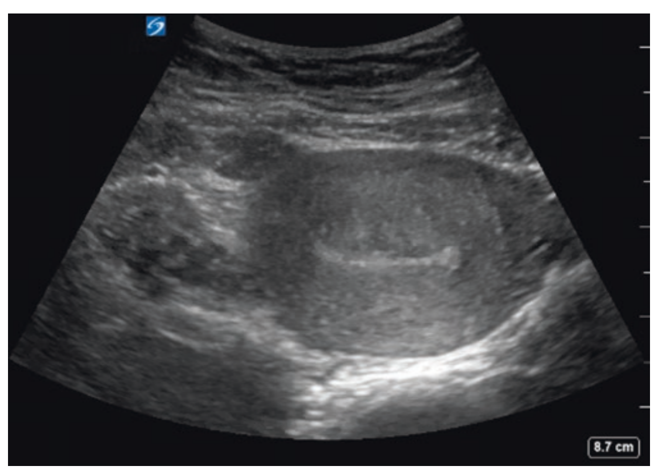

Fig. 121.4 Transabdominal transverse image of an empty uterus. (Photo courtesy of Javier Rosario, MD)

Complications

- Vaginal bleeding
- Miscarriage
- Rh isoimmunization

Pearls and Pitfalls

- Pearls
  - Threatened abortion:
    Threatened abortion is not visible sonographically. It is the presumed diagnosis when a patient presents with vaginal bleeding in the first 20 weeks of pregnancy, an intrauterine pregnancy is found with dates corresponding to the patient's dates, and the cervix is closed.
    Fetal cardiac activity suggests a better prognosis than those without.
    Fetal heart rate less than 120 bpm suggests impending fetal death (only 6% survival).
    Absence of expected structures or findings (yolk sac, fetal pole, fetal heart rate) by documented gestational age should raise suspicion for threatened or impending abortion.
  - Completed abortion:
    There are only three scenarios in which this diagnosis can confidently be made in the emergency department:
    1. Intact gestation is passed and identified in the emergency room or when the pelvic examination is performed.
    2. Ultrasound shows evidence of an empty uterus in the setting of a prior known and documented IUP:
       - Small internal echoes within the uterus may represent blood rather than retained products of conception and may require expert consultation.
    3. Negative pregnancy test result in the setting of a prior known intrauterine pregnancy:
       - In all other cases, the quantitative β-hCG must be followed until it is less than 2 mIU/mL.
- Pitfalls
  - Misinterpretation of the quantitative β-hCG may lead to treating threatened abortion as fetal demise or abortion – many of these pregnancies actually go on to completion with a normal fetus.
  - If there is any concern for alternative diagnoses in any of the abortion types (i.e., ectopic gestation), obstetrics consult should be obtained.
  - Failing to order a quantitative serum hCG to rule out other possibilities (e.g., molar pregnancy) and to ensure that it is trending downward (if others to compare).
  - Failing to establish follow-up for an incomplete abortion to ensure appropriate management. The patient may eventually require a dilation and curettage if products do not pass naturally.

Suggested Reading

Abramowicz J. First-Trimester Ultrasound: A Comprehensive Guide. Cham: Springer International Publishing; 2016.

Doubilet PM, Benson CB, Bourne T, Blaivas M. Diagnostic criteria for nonviable pregnancy early in the first trimester. N Engl J Med. 2013;369(15):1443–51.

Gabbe SG, Niebyl JR, Galan HL, et al., editors. Obstetrics: normal and problem pregnancies. 5th ed. Orlando: Churchill Livingstone; 2007.

Ultrasonography for Placenta Previa

122

L. Connor Nickels and Giuliano De Portu

Placenta previa is a condition in which the placenta covers the internal cervical os. It is the leading cause of antepartum hemorrhage. There are four grades of the condition:

- Complete: The placenta completely covers the internal os.
- Partial: The placenta partially covers the internal os.
- Marginal: Lower margin of the placenta reaches the internal os but does not cover it (within 3 cm).
- Low lying: Lower margin of the placenta is located in the lower uterine segment but does not reach the internal os (Fig. 122.1).

Indications

- A patient in the second half of pregnancy who presents to the emergency room with bright red, painless vaginal bleeding, OR premature labor should be evaluated for this condition.

Contraindications

- Absolute:
  – There are no absolute contraindications to transabdominal ultrasonography.
- Relative:
  – Transvaginal ultrasound should be carried out with caution, so as to avoid hemorrhage.

Materials and Medications

- Ultrasound machine
- Probes: curvilinear or phased array, endocavitary
- Sterile gel
- Endocavitary probe covers
- Towels
- Sterile speculum (see previously)
- Cardiac monitor, two large-bore intravenous needles, and laboratory tests

Procedure

1. Place the patient in the supine position.
2. Ultrasound machine with abdominal probe and gel.
3. Begin scanning the patient in a transabdominal sagittal position (Fig. 122.2) to determine the placental position and whether it is lying in the lower uterine segment.
4. The patient should then be scanned in a transverse fashion to further evaluate the exact position of the placenta.
5. If the placenta appears to lie in the lower uterine segment, the patient should be scanned in the oblique plane as well.
6. The bladder should initially be full for best visualization. However, if the placenta appears to reside low or lie over the internal os, the scanning should be repeated after the patient has voided:
   - An overdistended bladder may create the appearance of a placenta previa. The anterior wall of the uterus is compressed against the posterior wall by the distended bladder, shortening the distance between the placenta and the internal os (Fig. 122.3).
7. The following ultrasonographic findings exclude placenta previa [1]:
   - Direct apposition of the presenting part of the fetus and the cervix without space for interposed tissue
   - Presence of amniotic fluid between the presenting part of the fetus and the cervix, without the presence of placental tissue
   - Distance of greater than 2 cm between the inferior aspect of the placenta

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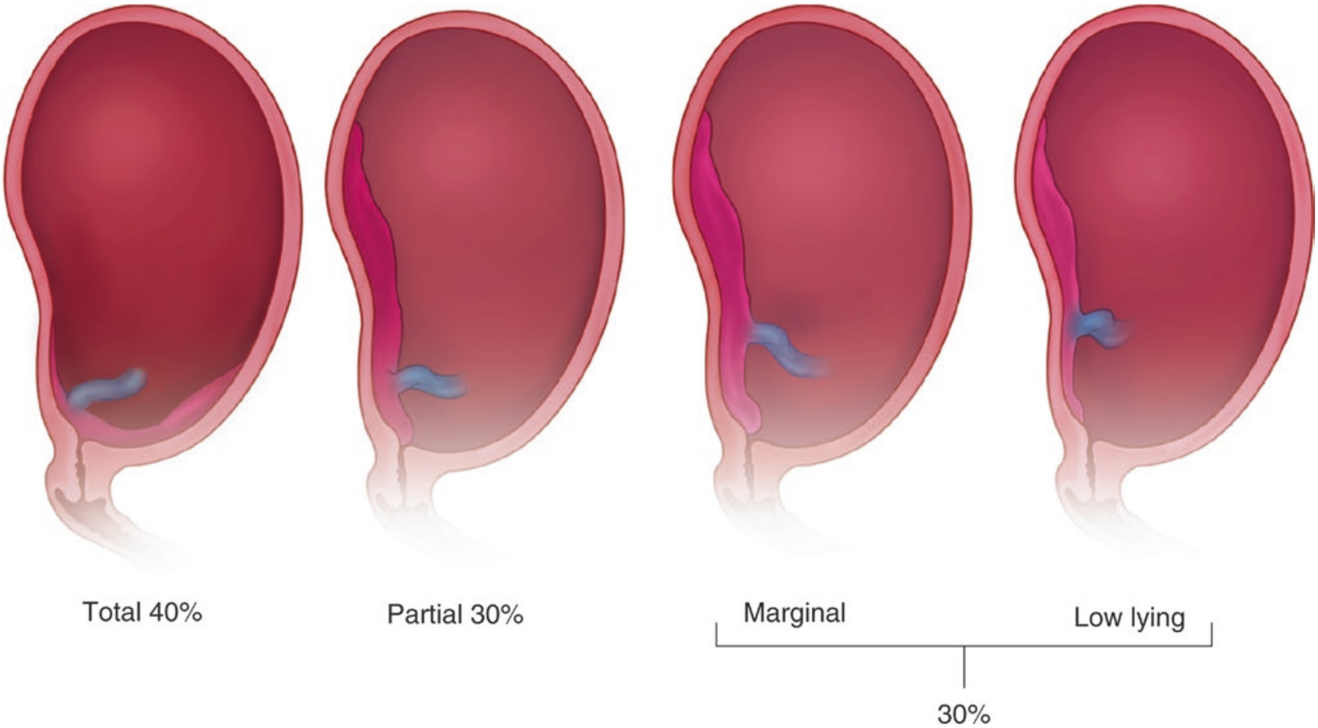

Fig. 122.1 Varying degrees of placenta previa

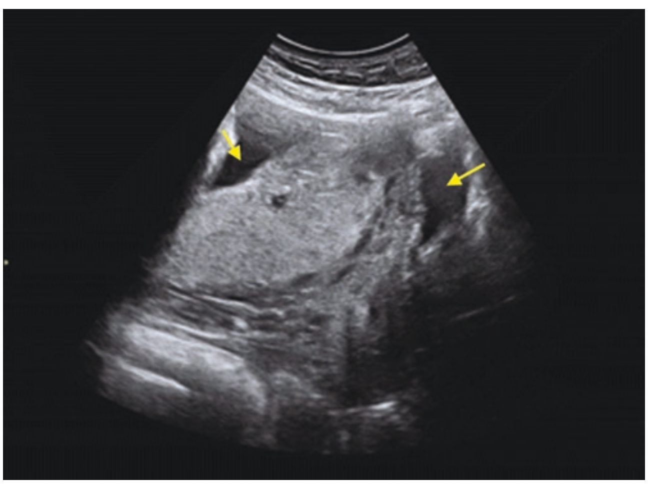

Fig. 122.2 Transabdominal ultrasound of placenta previa. Note loss of the decidual interface between the placenta and the myometrium on the lower part of the uterus and multiple intraplacental lacunae (*arrows*). (*Adapted from* Severi et al. [2]; *with permission*)

- Indirect visualization of the internal cervical os

8. If placenta previa cannot be ruled out with transabdominal ultrasound, the patient should then be scanned transvaginally with the endocavitary probe because this is more sensitive for diagnosing placenta previa.
9. A sterile speculum examination should be performed before transvaginal scanning to assess the cervix and ensure there are no presenting parts or bulging membranes. Transvaginal imaging is contraindicated if the patient has ruptured or bulging membranes.
10. The probes should be swapped out and a sterile cover placed on the endocavitary probe with gel inside the cover and sterile gel on the outside of the cover.
11. The endocavitary probe should be inserted into the vaginal canal, ensuring that caution is taken to stay off the cervix and distal to it, keeping the cervix in view on the screen.
12. The patient should be scanned in both the sagittal and the transverse planes to assess the inferior margin of the placenta.
13. If the inferior margin appears to be located near the internal os, then the distance should be measured:
    - Steps 8 through 13 should only be performed by the emergency physician if he or she feels confident in this ultrasound skill and there is no obstetrics available. If obstetrics is available, these steps should be performed in conjunction with them or by them to ensure the best outcome for the patient.

Complications

- Bleeding:
  – May range from self-limited to life-threatening hemorrhage
- Maternal and/or fetal distress or death

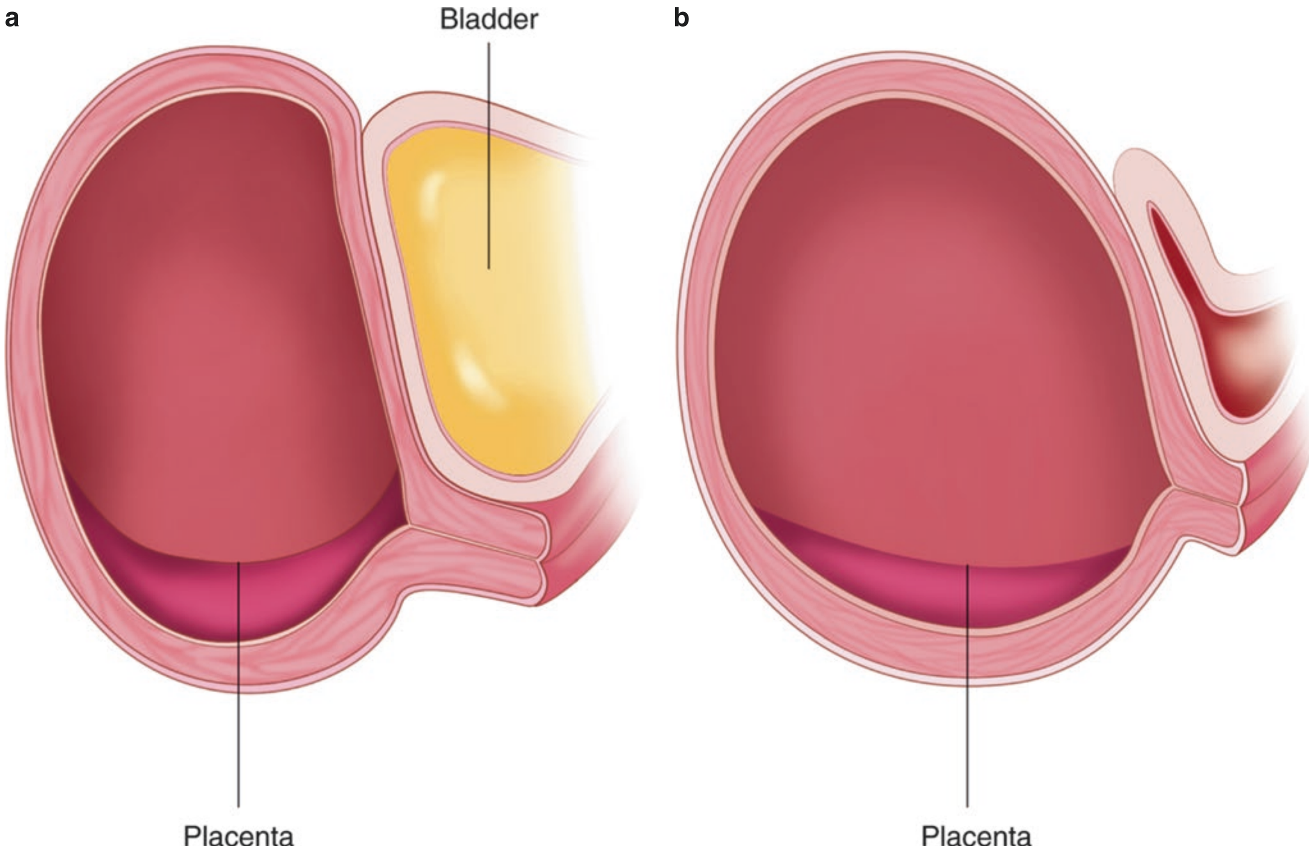

Fig. 122.3 (**a**) Overdistended bladder creating the appearance of placenta previa, (**b**) empty bladder showing the more accurate position of the placenta

Pearls and Pitfalls

- Pearls
  - Risk factors include:
    - Multiparity
    - Multiple pregnancy
    - Advanced maternal age
    - Previous placenta previa
    - Cigarette smoking
    - Cocaine abuse
    - Hypertension
    - Previous cesarean delivery/uterine surgeries
  - Myometrium contraction: can mimic placenta previa by temporarily displacing the placenta in the lower uterine segment.
  - If ultrasound capabilities are not available, but the patient is in the second half of pregnancy and having vaginal bleeding, do not perform a digital cervical examination.
- Pitfalls
  - Digital examination should be avoided because this may precipitate life-threatening hemorrhage and/or death.
  - Always consult obstetrics as soon as possible if this is suspected or known and the patient is symptomatic. Not consulting obstetrics could be detrimental to the mother and fetus.
  - Gentle sterile speculum examination should be done only if an obstetrician is not available. This is to ensure the bleeding is coming from the cervix. If placenta previa is suspected or known and obstetrics are available, then abdominal ultrasound evaluation alone should be sufficient for the examination of the patient.

References

1. American College of Radiology. Role of imaging in second and third trimester bleeding. In: ACR appropriateness Criteri. Reston: American College of Radiology; 2001.
2. Severi FM, Bocchi C, Vannuccini S, Petraglia F. Placenta previa. In: Malvasi A, Tinelli A, Di Renzo G, editors. Management and ther-

apy of late pregnancy complications. Cham, Switzerland: Springer; 2017. https://doi.org/10.1007/978-3-319-48732-8_12.

Selected Reading

Gabbe SG, Niebyl JR, Galan HL, et al., editors. Obstetrics: normal and problem pregnancies. 5th ed. Orlando: Churchill Livingstone; 2007.

Ma OJ, Mateer J, Blaivas M, editors. Emergency ultrasound. 2nd ed. New York: McGraw Hill Professional; 2007.

Marx J, Hockberger R, Walls R, editors. Rosen's emergency medicine: concepts and clinical practice. 7th ed. Philadelphia: Mosby; 2010.

Sanders RC, Winter T, editors. Clinical sonography: a practical guide. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2007.

Ultrasonography for Placental Abruption

123

Nicholas F. Fusco

Placental abruption is a condition in which the placenta detaches from the myometrium of the uterus prior to normal delivery. This condition starts to increase after the 16th week in pregnancy with peak incidence around weeks 24–26.

There are four types of placental abruption based upon the location of the hematoma (Fig. 123.1):

1. Retroplacental
   - Hematoma is behind the basal plate and causes elevation of the placenta from the myometrium.
2. Marginal subchorionic
   - Hematoma is located peripherally behind the placenta extending to the chorion.
3. Preplacental
   - Hematoma is anterior to the placenta above the chorionic plate and behind the amnion.
4. Intraplacental
   - Hematoma is within the placenta.

Indication

- A patient beyond 16 weeks who is having abdominal pain or painful vaginal bleeding

Contraindications

- Absolute:
  – There are no absolute contraindications to transabdominal ultrasonography or transvaginal ultrasonography.
- Relative:
  – There are no relative contraindications to transabdominal ultrasonography or transvaginal ultrasonography.

Materials and Medications

- Ultrasound machine
- Probes: curvilinear or phased array, endocavitary
- Sterile gel
- Endocavitary probe covers
- Towels
- Cardiac monitor, two large-bore intravenous needles, and laboratory tests

Procedure

1. Place the patient in the supine position.
2. Ultrasound machine with abdominal probe and gel.
3. Ideally the patient will have a full bladder prior to transabdominal evaluation.
4. Begin scanning the patient in a transabdominal sagittal position with sweeping of the uterus looking for the placenta and any hyperechoic or hypoechoic areas around or within the placenta. Blood will tend to be hyperechoic if detected soon after abruption occurred or hypoechoic if the hematoma has been present for a long period of time.
5. The patient should then be scanned in a transverse fashion to further evaluate the placenta for any abnormal echogenicity associated with the placenta (Fig. 123.2).
6. If no abnormalities are found with transabdominal evaluation, the exam can be repeated transvaginally.
7. The probes should be swapped out and a sterile cover placed on the endocavitary probe with gel inside the cover and sterile gel on the outside of the cover.
8. Probe is then inserted into the vaginal canal and scanned in both the sagittal and transverse planes looking for any hyperechoic or hypoechoic structures within or surrounding the placenta.

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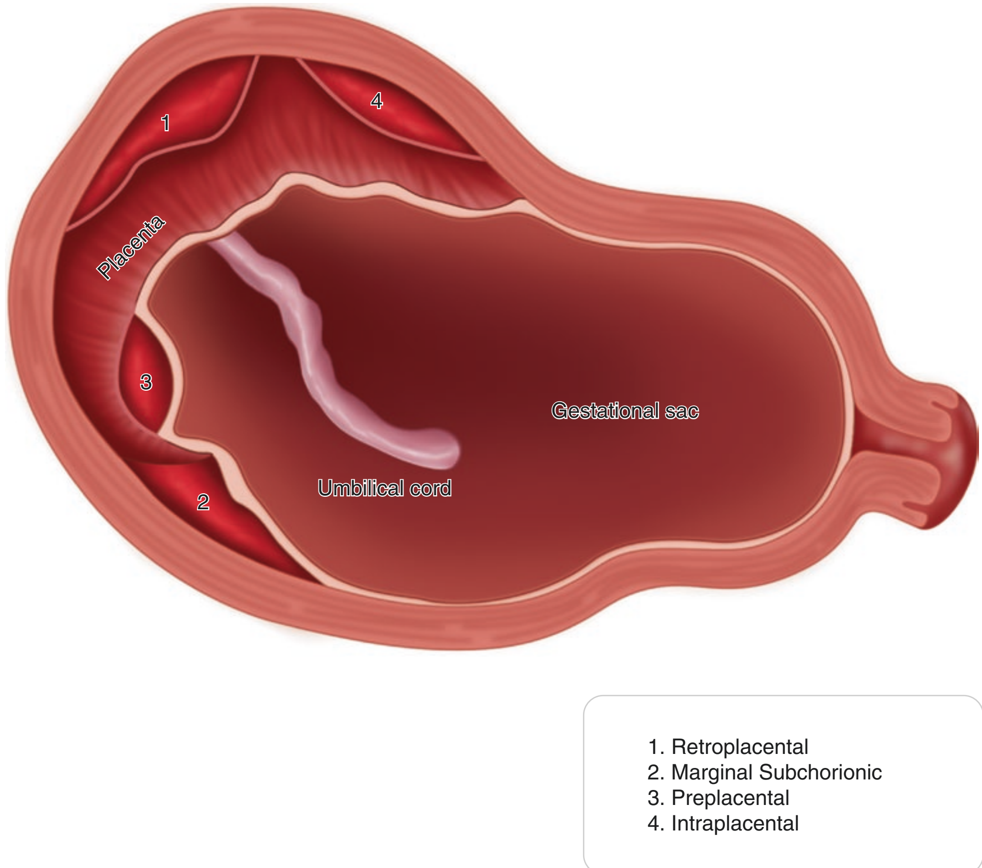

Fig. 123.1 Four types of placental abruption based upon the location of the hematoma

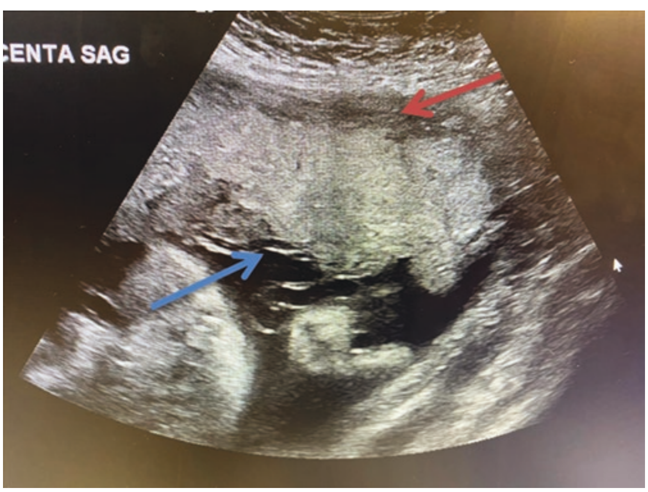

Fig. 123.2 Abruptio placenta (red arrow) with hematoma (blue arrow)

Complications

- Failure to identify abruption on ultrasonography is extremely common due to the changing echogenicity of blood with time. A high clinical suspicion is needed to identify the patients with placental abruption and a negative ultrasound. These patients should be further evaluated in an obstetrics setting to monitor for non-reassuring fetal heart tones.
- Large abruptions can lead to intrauterine growth restriction, fetal demise, premature delivery, and disseminated intravascular coagulopathy

Pearls and Pitfalls

- Pearls
  - Ultrasonography has a high specificity for placental abruption. It is the initial imaging modality for evaluation of this condition.
  - Can use color flow Doppler to try and identify hematoma as this should have no active flow in comparison with the placenta.
  - Risk factors include:
    - Smoking
    - Trauma
    - Multiparty
    - Thrombophilia
    - Hypertension (chronic and gestational)
    - Premature rupture of membranes
    - Prior placental abruption
    - In vitro fertilization

  - Alcohol use during pregnancy
  - Drug use during pregnancy (cocaine, etc.)
- Pitfalls
  - Ultrasonography has very poor sensitivity for identification of placental abruption. This is because the hematoma tends to be isoechoic to the surrounding placental tissue. Blood may also have drained through the vagina, and a hematoma may not be present to see on ultrasound or the hematoma may be too small to identify.
  - Myometrial contractions and placental chorioangiomas can mimic placental abruption.

References

1. American College of Radiology. Role of imaging in second and third trimester bleeding. In: ACR appropriateness criteri. Reston: American College of Radiology; 2001.
2. Fadl SA, Linnau KF, Dighe MK. Placental abruption and hemorrhage—review of imaging appearance. Emerg Radiol. 2019;26:87–97. https://doi.org/10.1007/s10140-018-1638-3.

Suggested Reading

https://www.pocus101.com/obstetric-ob-ultrasound-made-easy-step-by-step-guide/

Emergency Vaginal Delivery

124

Umarfarook Mirza, Christopher Shields, and Muhammad Waseem

Indications

- Inevitable delivery of the fetus (no time to transfer).
  - Cervix fully dilated at 10 cm and fully effaced 1 mm.
  - Presenting part visible at introitus (“crowning”).
  - Contractions <2 minutes apart.

Contraindications

Absolute

- Indications for emergent Caesarean section (C-section).
- Prolapsed cord.
- Prior C-section with classic vertical incision.
- Placenta previa – complete/partial.
- Breech presentation – footling.

Relative

- Placenta previa – marginal/low lying.
- Breech presentation – complete/incomplete/frank.

Materials and Medications (Fig. 124.1)

- 4 Crile clamps or Kelly clamps
- 1 Mayo scissor curved and 1 Mayo scissor straight
- 2 sponge forceps
- 2 towel clamps
- 1 Mayo-Hegar needle holder
- 1 mouse-tooth forceps
- Laceration repair kit with absorbable suture.
- Warmed towels and blankets.
- Neonatal resuscitation equipment.
- Suction bulb.
- Betadine (povidone-iodine).
- Umbilical cord clamp (Fig. 124.2).
- Incubator warmer (Fig. 124.3).
- Most importantly, help (obstetrics consultant).

Procedure

1. Determine the fetal presentation (breech or cephalic) with bedside ultrasound.
2. If breech, follow the breech algorithm.
3. Perform a vaginal examination.
4. Check for cord prolapse.
5. Check effacement.
6. Check dilation.
7. Prepare the site.
8. Position the mother in the extreme lithotomy position.
9. Deliver the head in a controlled manner.
10. Check to see if the cord is wrapped around the neck (if present follow cord presentation pathway).
11. Deliver the anterior shoulder with downward traction of the head.
12. Check for shoulder dystocia (if present follow McRobert-Rubin maneuvers; see shoulder dystocia chapter).

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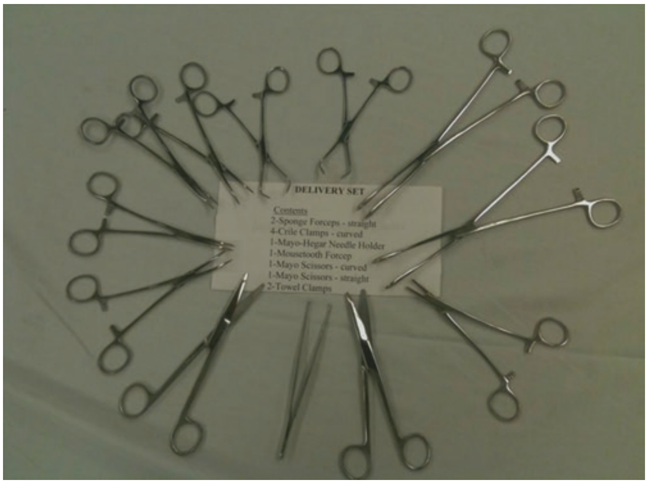

Fig. 124.1 Equipment: delivery set

13. Deliver the posterior shoulder by gently pulling the trunk upward.
14. Suction the airway.
15. Clamp the cord 5 cm from the umbilicus in two places and cut.
16. Obtain Apgar score of the baby. Initiate resuscitation if required.
17. Keep the baby warm in the incubator.
18. Clamp the cord again closer to the vaginal opening.
19. Use this clamp to help deliver the placenta. Use gentle controlled traction on the clamp with one hand while placing the other hand suprapubically to push the uterus upward.
20. If the placenta does not deliver easily, stop and wait for a few minutes to allow it to detach from the uterine wall naturally and then try again. Watch for a gush of blood that signals that the placenta has detached. Usually the placenta delivers within 5 minutes, but can take up to 30 minutes.
21. Examine the integrity of the placenta. Consider retained intrauterine placental products if the placenta appears to be missing tissue, and manually remove them; retained placenta may cause postpartum hemorrhage.
22. Massage the fundus externally to prevent uterine atony, but only after all products have been removed.
23. Repair any vaginal or cervical lacerations.

Fig. 124.2 Equipment: umbilical clamp

Fig. 124.3 Equipment: incubator warmer

Complications

- Postpartum hemorrhage due to uterine atony or retained products.
- Uterine inversion.
- Rectal or urethral injuries.
- Shoulder dystocia.
- Meconium aspiration.

Pearls and Pitfalls

Pearls

- Postpartum hemorrhage has a high incidence during the first hour postpartum.
- Be aware of possible second delivery.
- Oxytocin, Methergine (methylergonovine maleate), or misoprostol may be used after delivery of the placenta; all help to increase uterine contractions and decrease postpartum hemorrhage. Avoid methylergonovine in hypertension and misoprostol in asthmatics.

Pitfalls

- Rushing delivery of the head/shoulders can lead to trauma to mother/baby.
- Rushing delivery of the placenta, when the placenta is not ready to detach, may cause placental or cord tearing or uterine inversion. Remember that it may take up to 20 minutes for the placenta to detach from the uterus.

Suggested Reading

Liao JB, Buhimschi CS, Norwitz ER. Normal labor: mechanism and duration. Obstet Gynecol Clin N Am. 2005;32:145–64, vii.
Norwitz ER, Robinson JN, Repke JT. Labor and delivery. In: Gabbe SG, Niebyl JR, Simpson JL, editors. Obstetrics: normal and problem pregnancies. 4th ed. Philadelphia: Saunders; 2001. p. 353–94.
Vasquez V, Desai S. Labor and delivery and their complications. In: Walls R, Hockberger R, Gausche-Hill, editors. Rosen's emergency medicine: concepts and clinical practice. 9th ed. Philadelphia: Mosby; 2018.

Episiotomy

125

Samyr Elbadri, Bobby K. Desai, and Alpa Desai

Indications (Relative)

- Fetal macrosomia
- Shoulder dystocia
- Breech delivery
- Occiput posterior position
- Risk of major perineal laceration
- Non-reassuring fetal heart rate tracing

Relative Contraindications

- Abnormalities of the perineum
- Inflammatory bowel disease
- Severe perineal scarring

Materials and Medications

- Betadine or other skin antiseptic
- Sterile gloves
- Sterile towels
- Lidocaine 1% or 2% (10 cc)
- 18–22 gauge needle, 25 gauge needle
- Syringe (10 cc)
- Sterile gauze (4″ × 4″)
- Bandage scissors
- Laceration repair kit
- 2-0 or 3-0 absorbable suture

Procedure

1. Informed consent may be required.
2. Position the patient appropriately. The patient's feet should be placed in table stirrups in the dorsal lithotomy position to allow for proper view of the vaginal, perineal, and anal anatomy.
3. Time the episiotomy so that it precedes injury to the fetus or maternal tissues, but also avoids excessive maternal blood loss.
4. Using lidocaine (drawn up in 10 cc syringe), anesthetize the perineum with the 25 gauge needle.
5. For a median episiotomy, insert two fingers under the posterior fourchette to protect the presenting fetal part from the scissors. Make a vertical incision extending posteriorly from the fourchette and stopping at the perineal body.
6. For a mediolateral episiotomy, insert two fingers under the posterior fourchette to protect the presenting fetal part from the scissors. Make an incision 30–60° toward the lateral aspect of the anal sphincter, extending from the posterior fourchette to the lowermost fibers of the puborectalis portion of the levator ani muscles. Aim for the 5 or 7 o'clock position.
7. Deliver the infant and the placenta. Inspect the cervix and upper vaginal canal, and repair if necessary prior to repairing the episiotomy incision. Assess the degree and extent of the episiotomy. Perform a rectovaginal exam using the thumb in a pill-rolling motion to assess the integrity of the anal sphincter and rectal mucosa. First-

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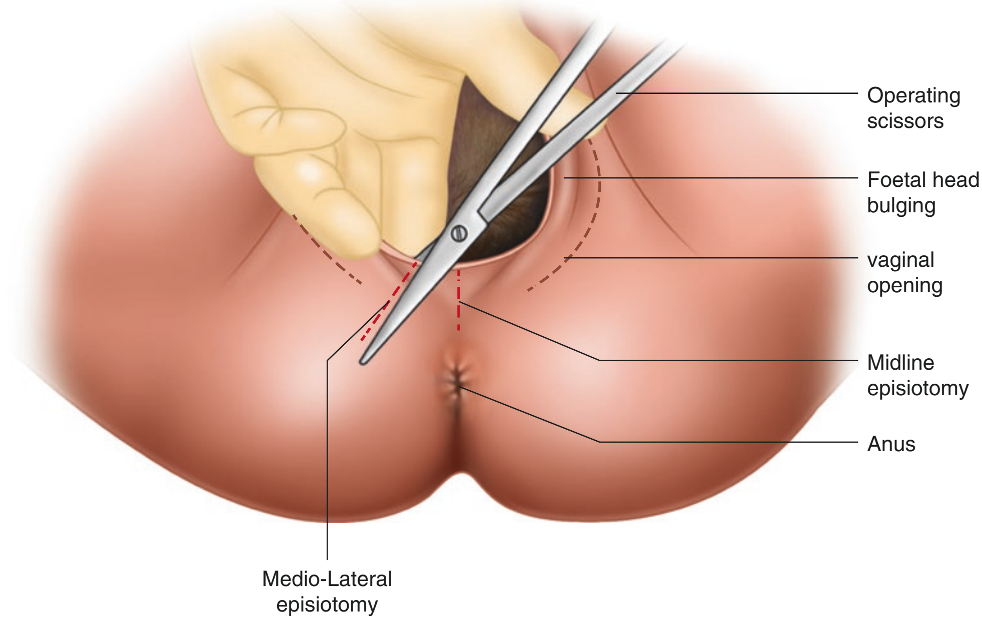
Fig. 125.1 Procedure



degree tears extend only into the skin. Second-degree tears extend into the muscular layer. This is the usual extent of an episiotomy. Third-degree tears involve the anal sphincter. Fourth-degree tears extend into the rectum. Third- and fourth-degree tears should be repaired by experienced providers.

8. Goals of episiotomy repair are to restore hemostasis using the least amount of suture. To close the vaginal mucosa, place an anchoring suture 1 cm above the apex of the incision, and run a continuous suture to the mucocutaneous junction.
9. Next, use 3–5 simple interrupted sutures to reapproximate the perineal musculature.
10. Closure of the superficial layers should be made using loosely tied interrupted sutures. Alternatively, a cephalad continuous subcuticular suture can be used starting and then returning to the mucocutaneous junction (Fig. 125.2).

Complications

- Hematoma formation
- Infection
- Rectovaginal fistula
- Dyspareunia
- Stool incontinence

Pearls and Pitfalls

- The routine use of episiotomy is not recommended.
- The median episiotomy is easier to perform and repair. It often has less blood loss, heals rapidly, and provides less discomfort when compared to the mediolateral episiotomy. It is the preferred approach in the United States.
- The disadvantage of median episiotomy is the potential for creating a third- or fourth-degree tear.

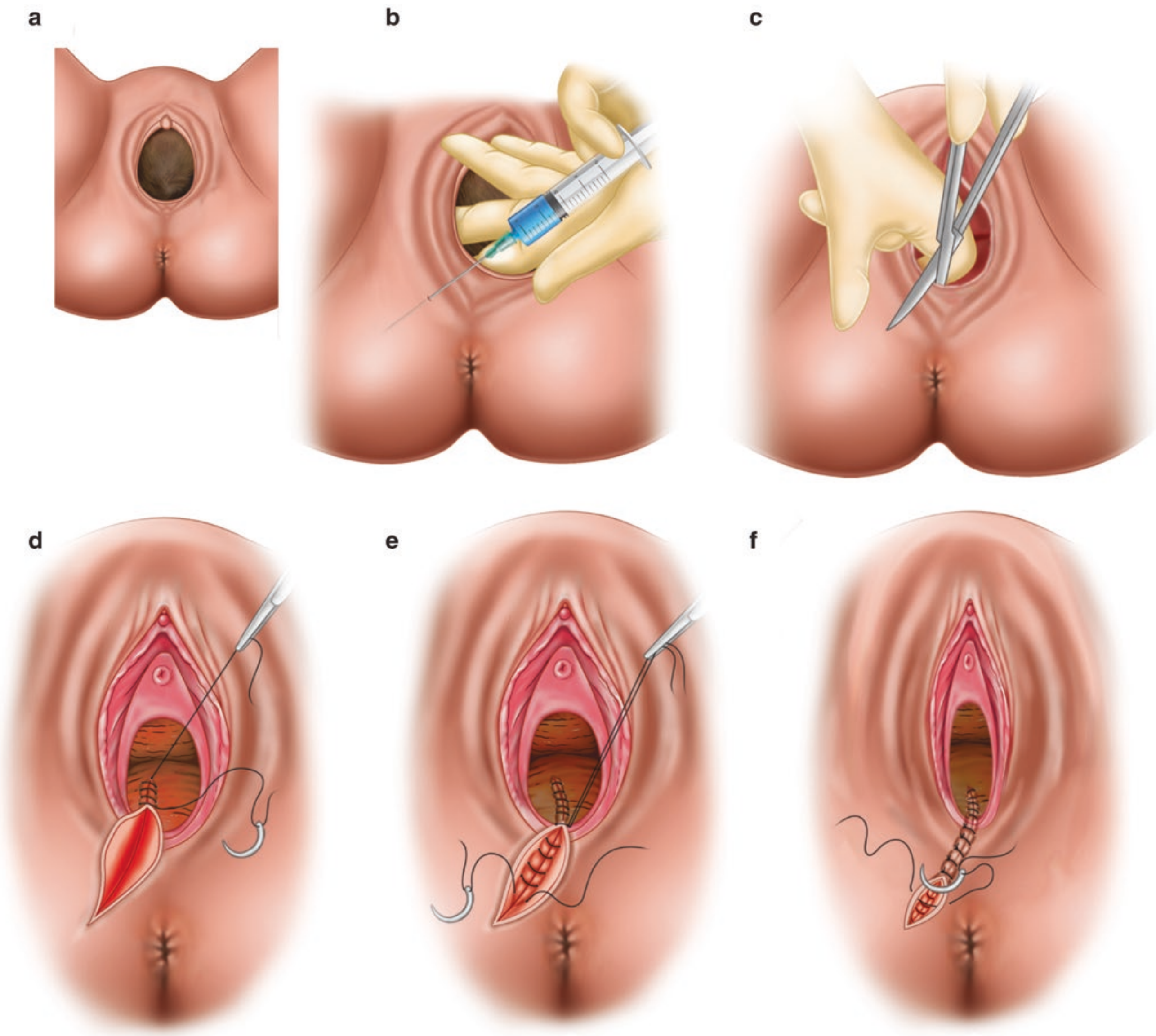


Fig. 125.2 Procedure

Suggested Reading

How To Do and Repair an Episiotomy | Merck Manual Professional Version

https://www.acog.org/Clinical-Guidance-and-Publications/Episiotomy/Episiotomy-Procedure-and-Repair-Techniques

Merck Manuals - https://www.youtube.com/watch?v=39frZ9lQ4f0

Roberts JR, Abella BS. Clinical procedures in emergency medicine. Philadelphia: Saunders/Elsevier; 2010.

Shoulder Dystocia Reduction

126

Jessica Houck

Shoulder dystocia is an obstetric emergency and occurs when the fetal shoulder (usually anterior) gets caught in the maternal pelvis, and does not deliver after delivery of the fetal head. Risk factors include fetal macrosomia, maternal diabetes, a prior history of shoulder dystocia or macrosomia, prolonged second stage of labor, post-term pregnancy, multiparity, and obesity. Fetal complications include brachial plexus injury and clavicle fracture. Maternal complications include vaginal or perineal tears and postpartum bleeding.

Indications

- When gentle traction is insufficient to deliver the fetal shoulders after delivery of the fetal head.
- This may be evident when the fetal head has been successfully delivered and then retracts against the perineum between contractions, also known as the turtle sign.

Contraindications

- The only absolute contraindication is if the procedure would endanger mother's life.
- Relative contraindication includes any situation where C-section is indicated.

Materials and Medications

- Oxygen
- Non-rebreather mask
- Foley catheter and insertion kit
- Neonatal warmer and crash cart
- Analgesics
- Timer or stopwatch

Procedure

- Once shoulder dystocia is recognized, instruct the mother to stop pushing.
- Have the nurse get additional help by recruiting help to the bedside and having someone consult obstetrics, pediatrics, and anesthesia to the bedside STAT.
- Have the nurse start a timer and call out time every 60 seconds.
- Obtain peripheral IV access and place on cardiac monitor.
- Apply oxygen to the mother via 100% non-rebreather.
- Have the mother positioned with her buttocks flush with the end of the bed.
- Have a team prepare to perform neonatal resuscitation upon delivery of the fetus.
- Follow the below procedures in a sequential order until the fetus is delivered.

Foley Catheter Placement

- Decompress the bladder with the insertion of a Foley catheter.

McRoberts Maneuver (Also Known as the Extreme Lithotomy Position)

- Have two assistants hyperflex and abduct the mother's legs against the abdomen, holding the knees as widely apart as possible (Fig. 126.1).

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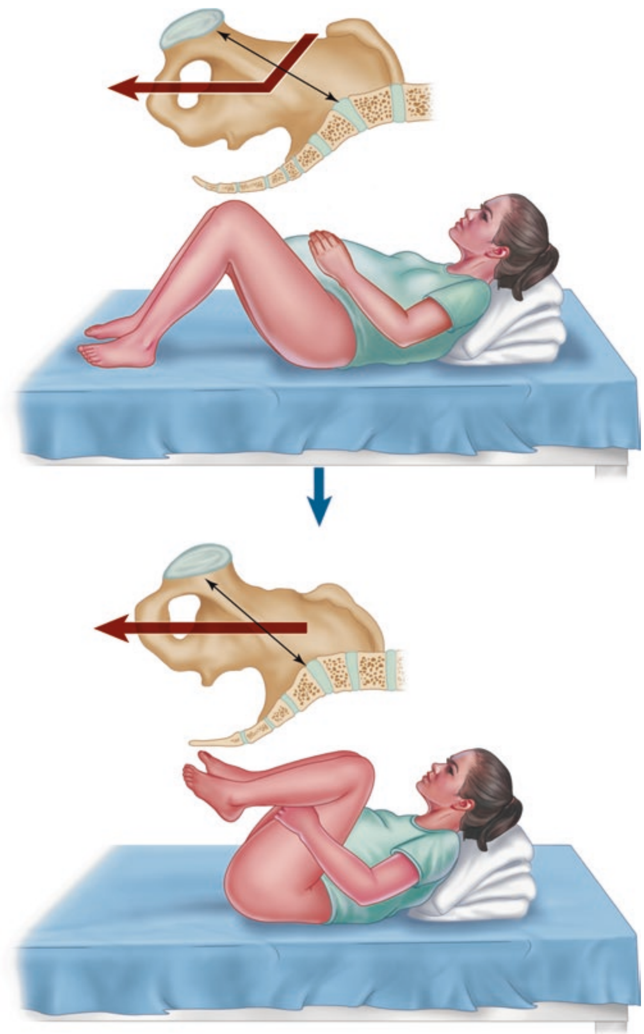

Fig. 126.1 McRoberts maneuver: hyperflexion of the maternal thighs against the abdomen

Suprapubic Pressure

- While the knees are hyperflexed and abducted, have someone apply suprapubic pressure (not fundal) with a palm or fist directing the anterior shoulder downward.
- Apply pressure continuously for 1–2 minutes.
- A stool may be helpful to stand on for better positioning.

Gaskin All-Fours Maneuver

- If the mom is able, place her on her hands and knees. If anesthesia or mother's condition prohibits this, advance to the Rubin maneuver.
- Apply gentle downward traction on the infant's head or posterior shoulder.

Fig. 126.2 Gaskin all-fours maneuver

- Alternatively, if the anterior shoulder is easier to manipulate and access, you may apply upward traction on the anterior shoulder (Fig. 126.2).

Rubin Maneuver

- Place fingers behind the posterior shoulder and attempt to rotate the shoulder in the direction of the fetal face and chest, approximately 30° (Fig. 126.3).
- Alternatively, the anterior shoulder may be used as well, rotating the shoulder in the direction of the fetal face and chest (Fig. 126.4).

Woods Corkscrew Maneuver

- Literally manipulating the fetus as a corkscrew, apply pressure to the anterior and posterior shoulders allowing for 180-degree rotation of the shoulder girdle either clockwise or counterclockwise into an oblique position, allowing for delivery of the shoulder (Fig. 126.5).
- Maintain McRoberts position and suprapubic pressure guided toward the anterior shoulders' direction of rotation during this procedure.

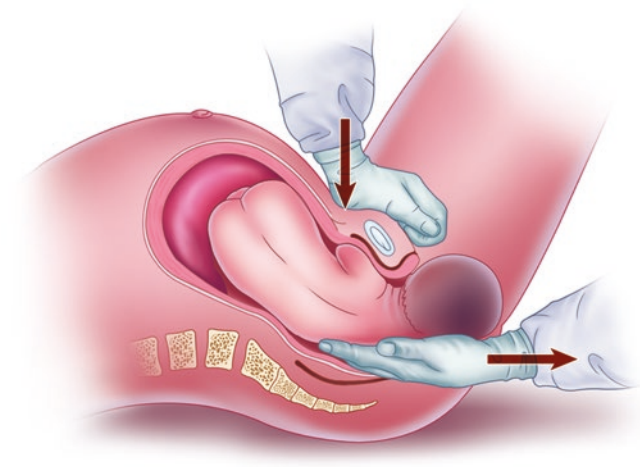

Fig. 126.3 Ruben I maneuver: suprapubic pressure is directed at the anterior shoulder

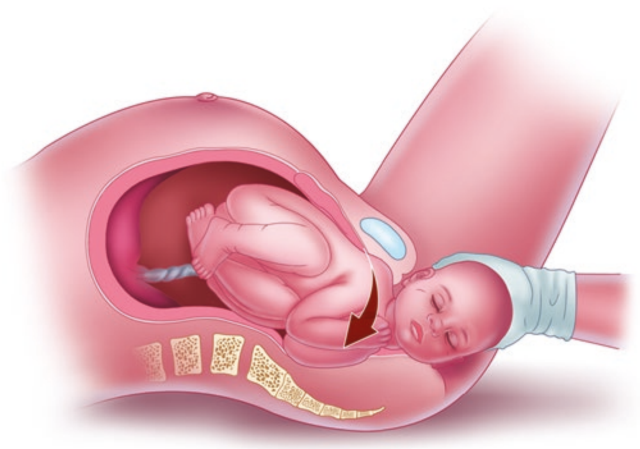

Fig. 126.4 Ruben II maneuver: pressure is applied to the most accessible part of the fetal shoulder and rotated toward the chest

Barnum Maneuver

- Attempt to deliver the posterior arm by inserting hand into the vagina along the chest wall until the posterior forearm can be grasped.
- If the posterior forearm cannot be reached, apply traction under the posterior axilla with either the provider's hand or a soft catheter looped in the axilla, and attempt to deliver the posterior shoulder.
- If this is unsuccessful, attempt the corkscrew maneuver to reposition the posterior shoulder, and reattempt the Barnum maneuver.

Fetal Clavicular Fracture

- Attempt to break the fetal clavicle by applying rapid pressure to the midpoint of the fetal clavicle.

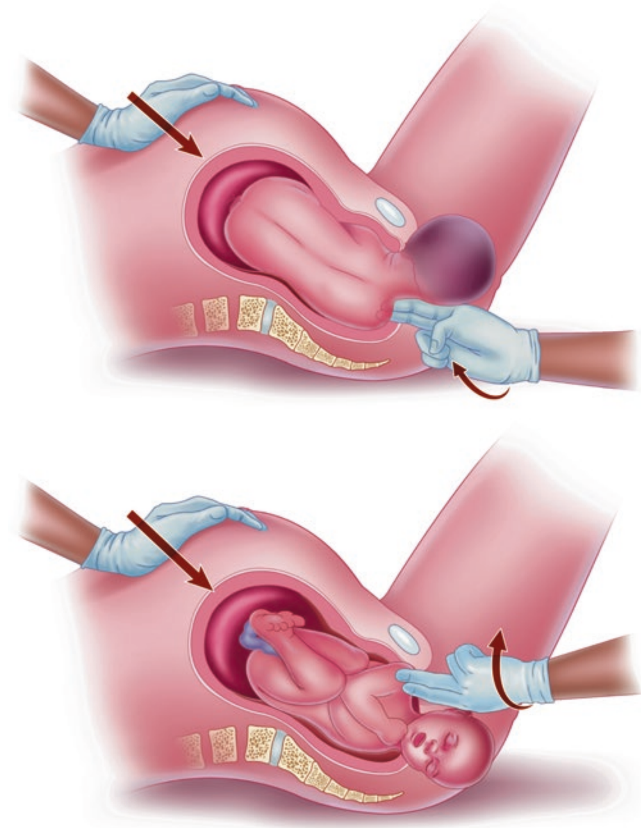

Fig. 126.5 Woods corkscrew maneuver: pressure is applied to the clavicle of the posterior arm, enabling rotation and dislodgment of the anterior shoulder

- Alternatively, place fingers on inferior border of the midpoint of the fetal clavicle, and apply rapid pressure superiorly toward the fetal head.

Zavanelli Maneuver

- As a last resort and ONLY if OB and anesthesiology are immediately available to take over
- Push the fetal head back into the pelvis and perform a cesarean section.

Complications

- Fetal brachial plexus injury
- Fetal hypoxia and subsequent brain injury secondary to insufficient blood flow through a compressed umbilical cord
- Fetal clavicular fractures
- Maternal postpartum hemorrhage
- Maternal perineal lacerations

Pearls and Pitfalls

- Fetus needs to be delivered within 5 minutes to prevent brain damage secondary to asphyxia and acidemia.
- The “HELPERR” mnemonic, from the Advanced Life Support in Obstetrics course, can be a useful tool for addressing this emergency [3]:
  - *H*elp – Call OB, neonatology, and anesthesia.
  - *E*mpty bladder – Catheterize to increase AP diameter.
  - *L*egs flexed – McRoberts maneuver.
  - *P*ressure – Suprapubic to dislodge anterior shoulder.
  - *E*nter vagina – Rubin or Woods corkscrew maneuver.
  - *R*emove posterior arm – Barnum maneuver.
  - *R*oll – Gaskin maneuver.
- McRoberts maneuver with suprapubic pressure relieves shoulder dystocia about 50% of the time.
- Even if the above procedures are done correctly, there is still significant risk of morbidity to the child given the difficult nature of shoulder dystocia.
- Avoid excessive neck rotation and traction as these can increase the likelihood of the above complications.
- Spend no longer than 2 minutes on the rotational maneuvers (Ruben and Woods corkscrew maneuvers).
- Zavanelli maneuver and cesarean delivery should not be attempted if obstetrics and anesthesiology are not immediately available.
- The Barnum maneuver carries the highest risk for brachial plexus injuries.
- Fundal (as opposed to suprapubic pressure) pressure is NOT a maneuver for shoulder dystocia; it increases the risk of further impaction, brachial plexus injury, factures of the humerus and clavicle, perineal lacerations, and uterine rupture.

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References

1. Rodis JF. Shoulder dystocia: Intrapartum diagnosis, management, and outcome. UpToDate. 2016 June 21. https://www.uptodate.com/contents/shoulder-dystocia-intrapartum-diagnosis-management-and-outcome

Suggested Reading

ACOG Committee on Practice Bulletins-Gynecology, The American College of Obstetrician and Gynecologists. ACOG practice bulletin clinical management guidelines for obstetrician-gynecologists. Number 40, November 2002. Obstet Gynecol. 2002;100:1045.

Baxley EG, Gobbo RW. Shoulder dystocia. Am Fam Physician. 2004 Apr 1;69(7):1707–14.

Breech Delivery in the Emergency Department

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Kristin Hughes, Sapnalaxmi Amin, Anton A. Wray, and Joseph A. Tyndall

Breech presentation: the buttocks enter the pelvis before the head (Fig. 127.1):

- Frank (extended):
  - Hips flexed and knees extended, buttocks presenting
  - Most common
- Incomplete/complete (flexed):
  - One or both hips and knees flexed, buttocks presenting
- Footling:
  - One or both hips and knees extended, foot presenting

The emergent delivery of a breech baby is one of the most challenging situations for an emergency physician.

Indications

- Inevitable delivery of fetus with complete or frank breech presentation
- Absence of vertex presentation

Contraindications

- Footling presentation (increased risk of cord prolapse and entrapment of the after-coming head).

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- There is adequate time to transfer the mother safely to labor and delivery in the knee/chest position (administer subcutaneous terbutaline before transfer).

Materials and Medications

- Supplemental oxygen for mother
- Ultrasound machine
- Piper forceps
- Sterile towels/gloves
- Betadine (povidone-iodine) or another antiseptic preparing solution
- Sterile lubricant (Surgilube)
- Instruments to cut the umbilical cord/perform episiotomy/resuscitate baby (Kelly clamps/scissors/#10 scalpel/bulb suction)
- Available emergency department staff
- Pediatric, obstetrics, and anesthesia practitioners

Procedure

1. Assess the health of the mother and the baby (vitals/physical examination/history).
2. Listen to the fetal heart with stethoscope or Doppler ultrasound:
   - Should be 120–160 beats/min.
3. Identify the type of presentation by bedside ultrasound or by digital exam.
4. Perform a sterile digital examination to confirm the position of the baby and the stage of labor:
   - Membranes should not be artificially ruptured. The amniotic sac will help to dilate the cervix, lubricate the canal, and protect the umbilical cord from compression.
5. If footling presentation: await OB/general surgery for emergency C-section.

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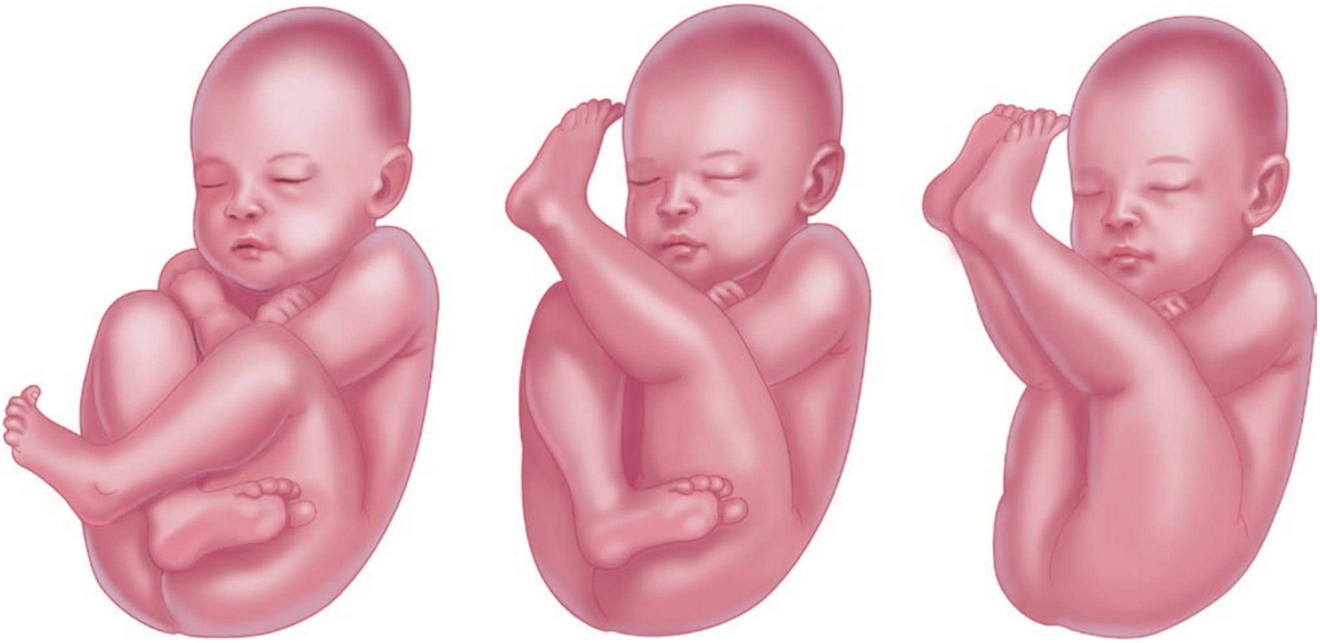

Fig. 127.1 Variations of the breech presentation

6. If frank/complete/incomplete: instruct the patient to push when the cervix is completely dilated.
7. When the breech has descended to the perineum, consider performing an episiotomy if more space is needed. Cleanse the perineum with antiseptic and sterile lubricant beforehand.
8. Allow the baby to extrude to the umbilicus with maternal efforts alone. Do not exert traction before this time.
9. If frank: deliver the posterior leg by gently guiding the sacrum anteriorly, grasping the thigh and flexing the leg at the knee.
10. Deliver the anterior leg in a similar manner while guiding the sacrum posteriorly.
11. If incomplete: deliver the extended leg as #8 or #9 as appropriate.
12. Delivery continues as it would for a complete presentation.
13. Wrap the legs/buttocks in a clean towel to decrease trauma (create grip).
14. Grasp the upper legs with the index fingers holding the anterior iliac crests. Place the thumbs on the sacrum (Fig. 127.2).
15. Apply gentle traction as the mother pushes until the scapulae and axillae are visible.
16. If there is difficulty delivering the shoulders, deliver the posterior shoulder by rotating the trunk 90° and applying gentle downward traction to rotate the shoulder anteriorly.
17. Rotate the baby 180° so as to deliver the anterior arm in a similar manner.

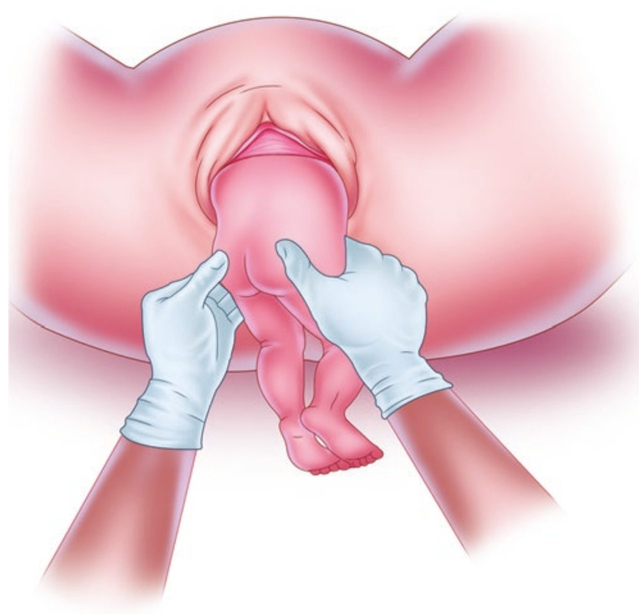

Fig. 127.2 Correct placement of hands on the sacrum

18. If the arms do not spontaneously deliver, a finger can be hooked over the shoulders to bring the arm down while rotating the trunk as above (Fig. 127.3).
19. Use the McRoberts position to increase the diameter of the pelvis (Fig. 127.4).
20. Maintain the baby in the same plane as the vagina (support the body with the forearm), and place the second

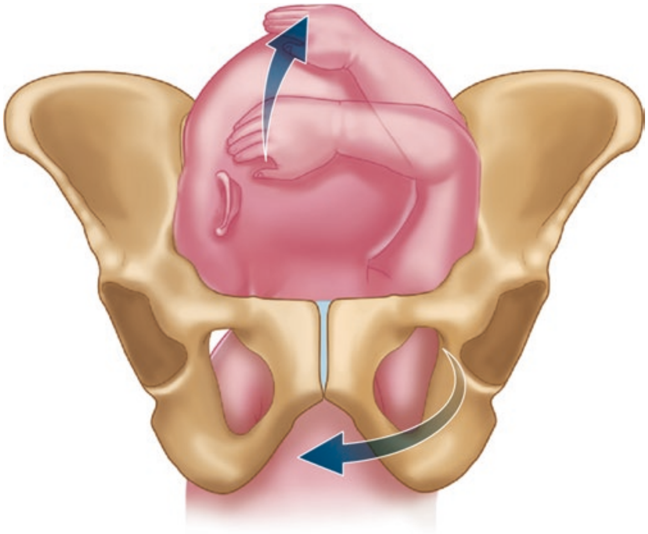

Fig. 127.3 Rotation toward maternal symphysis pubis to avoid nuchal arm

and fourth fingers over the maxilla of the baby. Place the middle finger in the mouth or on the chin and the other hand on the upper back/occiput (Fig. 127.5):

- Avoid extreme elevation of the fetus to prevent hyper-extension and cervical spine injury. Piper forceps may also be used to promote flexion.

21. Deliver the head in the flexed position:
    - If the baby descends with the neck and abdomen facing anteriorly: Grasp the shoulders posteriorly with two fingers of one hand while the other hand flexes the abdomen and the baby's feet are brought upward (Fig. 127.6).
    - If the baby's neck remains extended: Leave the baby hanging (weight = traction). When the hairline appears under the symphysis, grab the baby by the feet and elevate upward (Fig. 127.7).
22. Clamp and cut the umbilical cord (collect arterial and venous samples for pH).

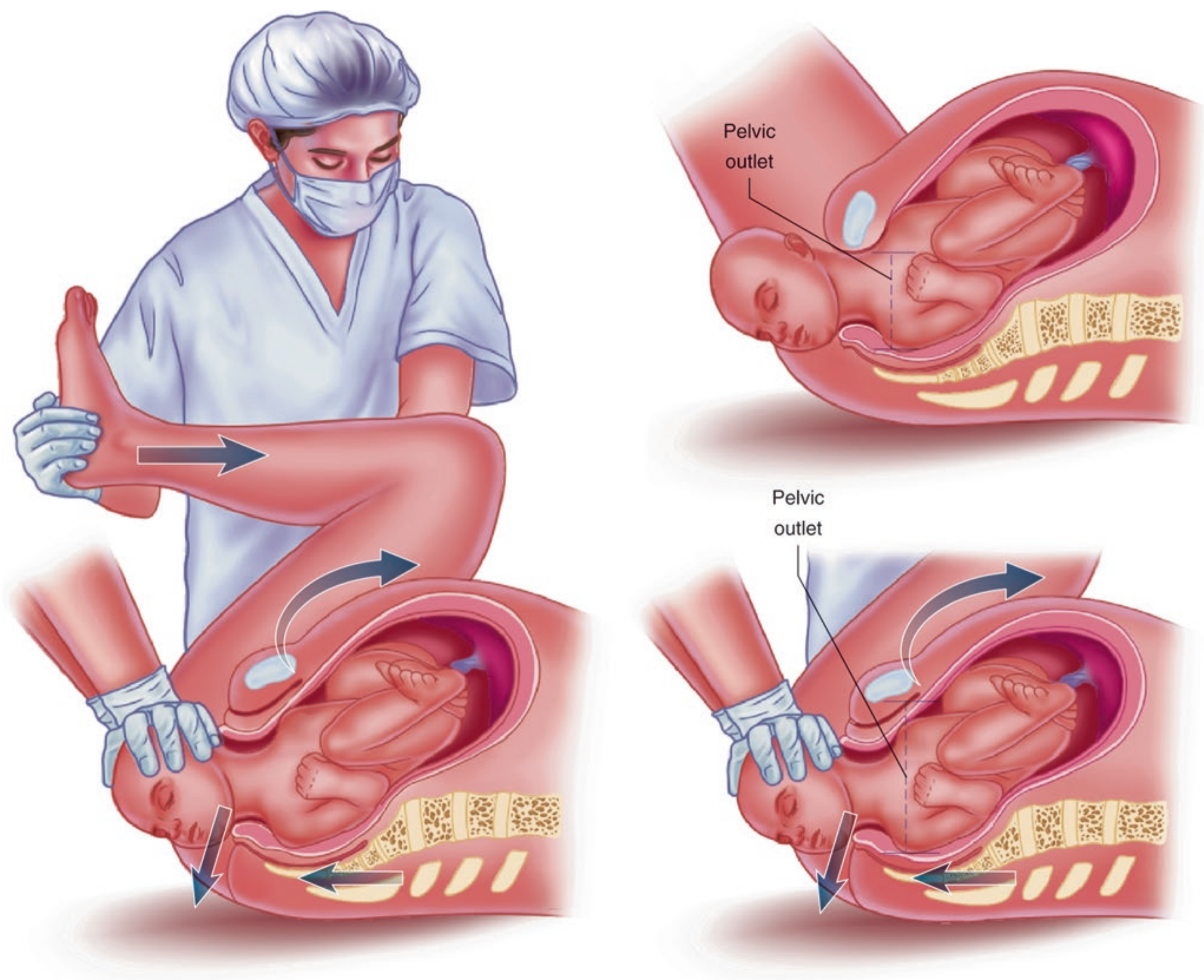

Fig. 127.4 The McRoberts maneuver in vertex (head-first) presentation

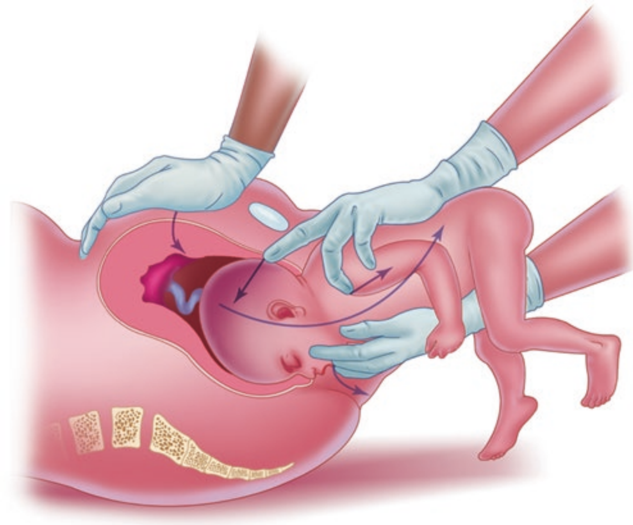

Fig. 127.5 Delivery of the head in flexed position

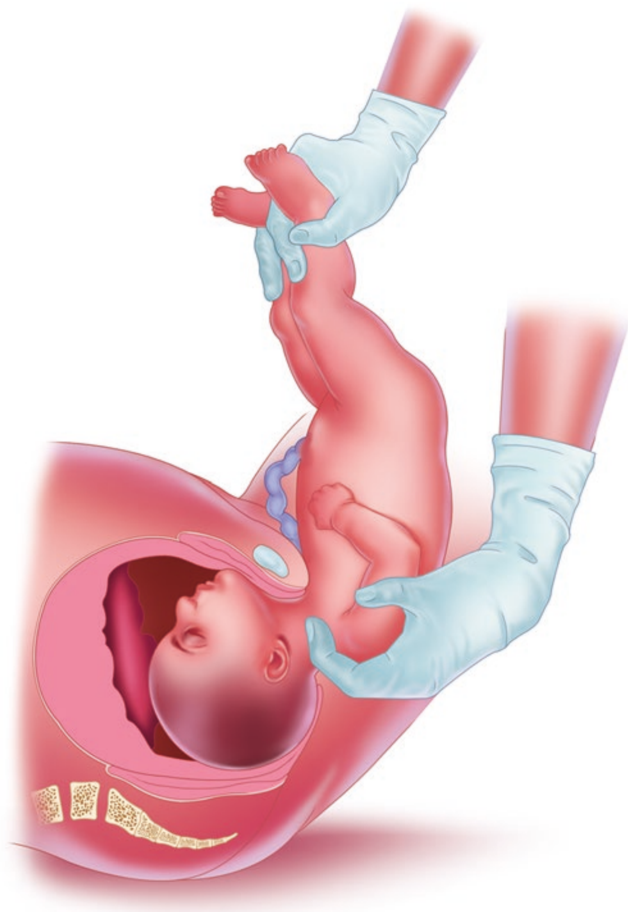

Fig. 127.6 Correct hand placement if the abdomen facing anterior

23. Suction the baby's mouth and nose, and resuscitate as indicated.
24. Deliver the maternal placenta.
25. Repair tears or episiotomy made during delivery.

Complications

- Umbilical cord prolapse
- Brachial plexus injury (from the nuchal arm)
- Fetal head entrapment
- Cervical spine injury (from hyperextension of the neck)
- Birth asphyxia

Pearls and Pitfalls

- Pearls
  – Allow the uterine contractions to help deliver the baby.
- Pitfalls
  – Do not rush the delivery or use too much force. This can increase the risk of trauma to the baby and mother.
  – Beware of nuchal arm. To avoid brachial plexus injury: Rotate the face of baby toward the maternal symphysis pubis. This will reduce the tension keeping the arm around the back of the fetal head (*see* Fig. 127.3).

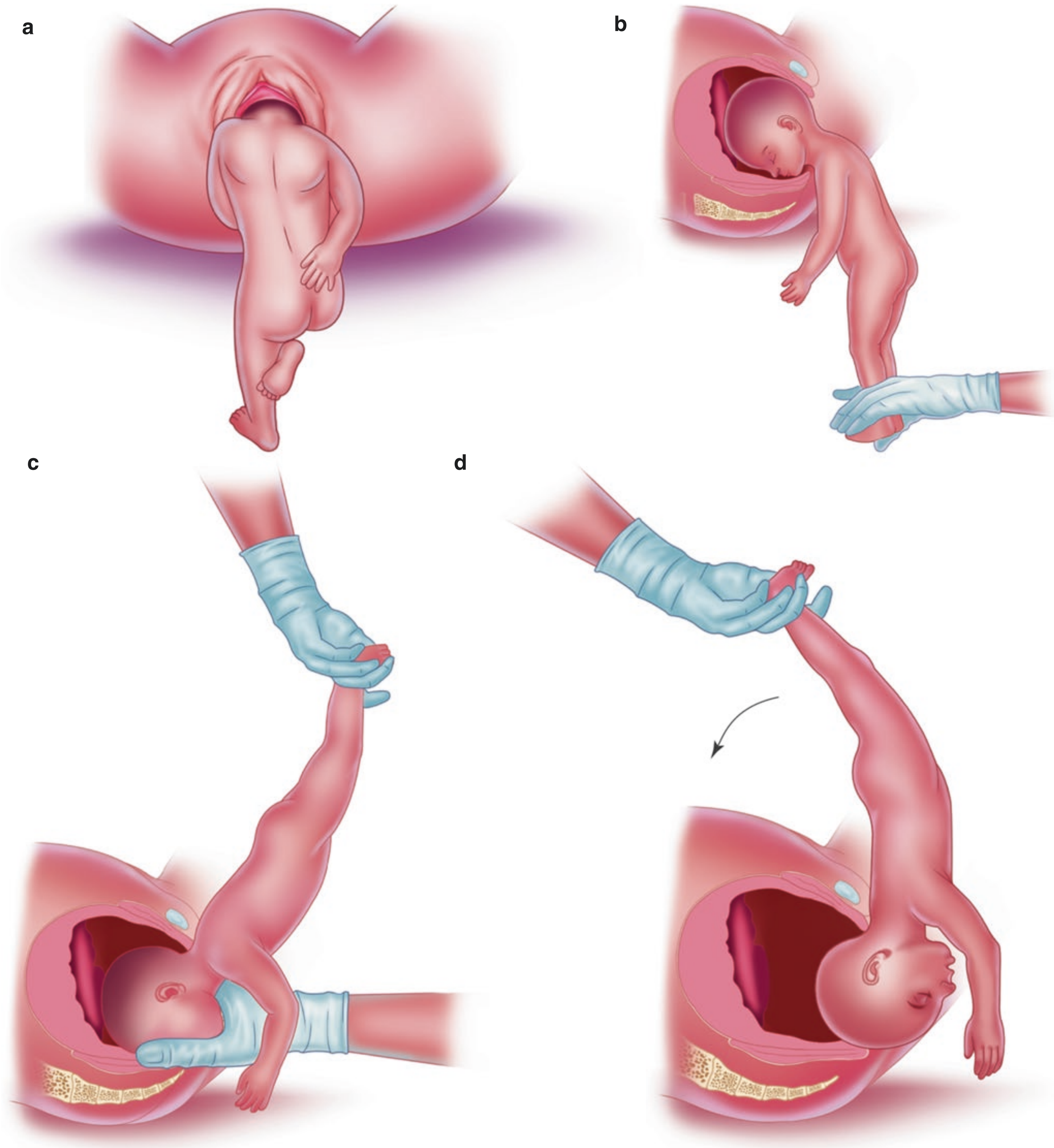

Fig. 127.7 The Burns-Marshall maneuver. (**a**) Allow baby to hang until you can see the hair at the nape of his neck; (**b**) swing the baby's head clear of the birth canal; (**c**) left hand guards and slips the perineum over fetal mouth; suction baby's air passage to clear mucus; (**d**) hold baby's feet

Suggested Reading

Auerbach PS. Gynecologic and obstetric emergencies. In: Wilderness medicine. 6th ed. Philadelphia: Elsevier; 2012.

Buckley RG, Knoop KJ. Gynecologic and obstetric conditions. In: Knoop KJ, Stack LB, Storrow AB, Thurman RJ, editors. The atlas of emergency medicine. 3rd ed. New York: McGraw Hill; 2010.

Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Rouse DJ, Spong CY. Breech presentation and delivery. In: Williams obstetrics. 23rd ed. New York: McGraw Hill; 2010.

Kish K, Collea JV. Chapter 21. Malpresentation & cord prolapse. In: DeCherney AH, Nathan L, editors. Current diagnosis & treatment: obstetrics & gynecology. 10th ed. New York: McGraw Hill; 2007.

Kotaska A, Menticoglou S, Gagnon R. Vaginal delivery of breech presentation. Int J Gynecol Obstet. 2009;107:169–76.

Probst BD. Emergency childbirth. In: Roberts JR, Hedges JR, editors. Clinical procedures in emergency medicine. 5th ed. Philadelphia: Elsevier; 2010.

128 Management of Primary Postpartum Hemorrhage

Jessica Houck

Early postpartum hemorrhage is an obstetric emergency and defined as symptomatic blood loss within 24 hours of delivery, or ongoing blood loss of more than 1000 mL within 24 hours of delivery. The number one cause is due to uterine atony. Other causes include birth canal trauma, retained placental products, and uterine inversion. Early recognition and intervention is required to prevent maternal death and complications from hemorrhagic shock.

Indications

- Symptomatic blood loss within 24 hours of delivery
- Ongoing blood loss of more than 1000 mL within 24 hours of delivery

Materials and Medications

- Speculum with light source
- Suture material with laceration tray (forceps, hemostats, scissors, gauze, absorbable suture)
- Normal saline or lactated Ringers
- Oxytocin (first line)
- Methylergonovine, misoprostol, or 15-methyl-prostaglandin (second line)
- Blood products (PRBCs, FFP, platelets, cryoprecipitate)
- Two 18 gauge IVs

Procedure

1. Start with ABCs (airway, breathing, circulation):
   - Establish two large-bore peripheral IVs.
   - Obtain vitals to estimate volume of blood loss.
   - If there are signs of hemorrhagic shock, bolus IV crystalloids and initiate massive transfusion protocol with packed RBCs, platelets, and FFP.
   - Send coagulopathy panel, CBC, and type and screen (crossmatch if necessary).
2. Perform uterine massage (Fig. 128.1):
   - Palpate the abdomen for an enlarged boggy uterus.
   - Place one hand on the abdomen and the other inside the introitus and manually massage the uterus.
3. Simultaneously, give medications to increase uterine tone:
   - First line is oxytocin:
     – Give 10 units IM.
     – Alternatively, mix 20 units of oxytocin in 500 mL NS. Bolus 250 mL (10 U) followed by an infusion at a rate of 250 mL/hr (10 U/hr) IV (run for a maximum of 5 hours).
     – Rapid IV pushes of oxytocin cause cardiovascular collapse.
   - Second-line medications can be given if oxytocin is not available or ineffective:
     – Methylergonovine
       Give 0.2 mg IM q2–4hrs.
       Contraindicated in patients with hypertensive disorder, preeclampsia or eclampsia, or cardiovascular disease.
     – Misoprostol
       600–1000 mcg per rectum, sublingual, or oral given once
       May cause fever
     – 15-methyl-prostaglandin
       Give 0.25 mg IM q15–90 min; max 8 doses.
       Contraindicated in asthma patients; may cause diarrhea or transient fever.
4. If bleeding persists, inspect the birth canal and cervix for trauma and retained placental products:
   - Use a speculum and light source.
   - If a laceration is visualized, repair with absorbable suture (such as chromic or Polyglactin) (Fig. 128.2).

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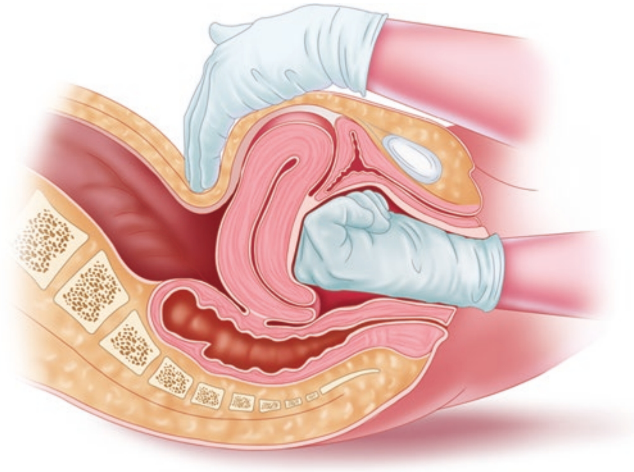

Fig. 128.1 Intrauterine massage for uterine atony

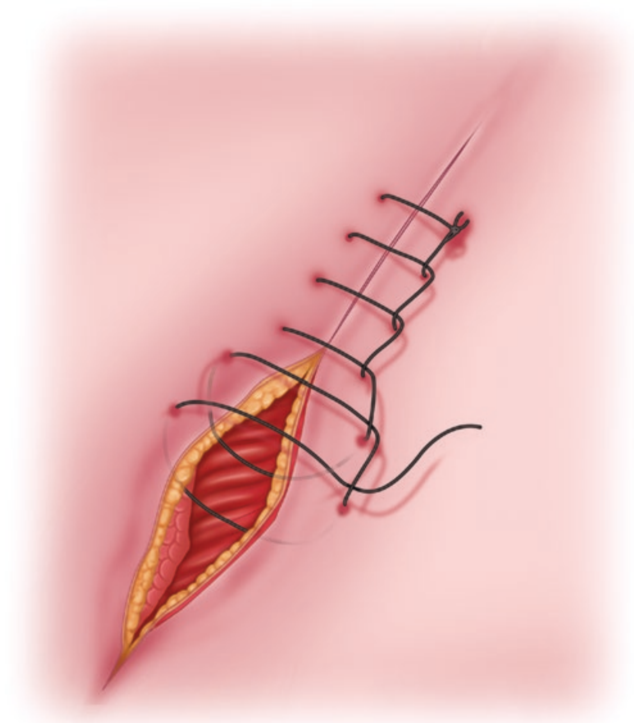

Fig. 128.2 Repair laceration with absorbable suture

- If placental products are visualized, remove manually or with forceps:
  - May evaluate further with ultrasound if patient is stable
- If uterine inversion is seen, manually reduce the uterus back to anatomical position:
  - Provide analgesia.
  - You may need to provide terbutaline, magnesium sulfate, halogenated general anesthetic, or IV nitroglycerin to relax the uterus.

5. Obtain early obstetrical and surgical consultation:
   - Patients with refractory bleeding despite interventions may need emergent surgical intervention or arterial embolization by interventional radiology.
   - Consultation should be done simultaneously with the above procedures.

Pearls and Pitfalls

- Failure to recognize hemorrhagic shock.
- Uterine atony accounts for up to 90% of postpartum hemorrhage.
- Failure to give oxytocin in conjunction with manual uterine massage, which may lead to a delayed recurrence of bleeding.
- Lacerations are the second most common cause of postpartum hemorrhage.

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Suggested Reading

ACOG Committee on Practice Bulletins-Obstetrics, The American College of Obstetrician and Gynecologists, ACOG Practice Bulletin Clinical Management Guidelines for Postpartum Hemorrhage; https://www.acog.org/Clinical-Guidance-and-Publications/Practice-Bulletins/Committee-on-Practice-Bulletins-Obstetrics/Postpartum-Hemorrhage

California Maternal Quality Care Collaborative, Obstetric Hemorrhage 2.0 Toolkit; 2015 March 24. https://www.cmqcc.org/resource/obstetric-hemorrhage-20-toolkit

Perimortem Cesarean Section

129

Jordana J. Haber, Elaine B. Josephson, and Muhammad Waseem

Indication

- Maternal arrest with a viable fetus (gestation ≥24 week) within 4 minutes of cardiopulmonary arrest

Contraindications

- Stable mother
- Fetus less than 24 weeks' gestation
- Extreme fetal prematurity
- Maternal hypoxia longer than 15 minutes

Materials and Medications

- Cesarean section instrument tray if available:
  - #10 or #11 scalpel blade, scissors, bladder retractor, two large retractors, gauze sponges, hemostats, suction, forceps, and straight and curved clamps
- Skin antiseptic preparing solution, such as Betadine (povidone-iodine)
- Silk suture with needle driver or skin stapler
- Sterile drapes
- Sterile gloves
- Obstetrical pack (see Chap. 126):
  - Bulb syringe and umbilical cord clamp
- Clean blanket or towels for delivery
- Neonatal resuscitation equipment

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Owing to the rarity of this procedure in the emergency department, it is unlikely to have a prepared cesarean section tray available. In this case, a thoracotomy or thoracostomy tray combined with an obstetrical pack would contain all the supplies needed. At a minimum, a scalpel and an obstetrical pack are necessary.

Procedure

1. Continue cardiopulmonary resuscitation until delivery.
2. Prepare the skin with antiseptic solution and a sterile drape.
3. Insert a Foley catheter to empty the bladder.
4. Obtain emergent obstetrician and neonatologist consult if available, but do not delay procedure.
5. Using a #10 or #11 blade, make a vertical midline incision beginning 4–5 cm below the xiphoid process, and extend the incision to the pubic symphysis (Fig. 129.1).
6. Incise through the subcutaneous fat no further than the rectus sheath.
7. Lift the rectus sheath with a toothed forceps, and make an incision with scissors to expose the uterus (Fig. 129.2).
8. With forceps and scissors, lift and incise the peritoneal membrane in the midline.
9. Identify and lift the bowel and cover it with saline-soaked gauze.
10. Retract the rectus sheath and bladder with a bladder retractor, or, if not available, use saline-soaked gauze or a towel.
11. Create a 2- to 4-cm midline vertical opening in the uterus.
12. Place a finger in the opening directed caudally to protect the fetus while making a superior incision through the uterine wall. Once complete, repeat this step in the inferior direction.
13. Use a clamp to rupture the amniotic membranes. Immediately deliver the fetus and clamp the umbilical cord.

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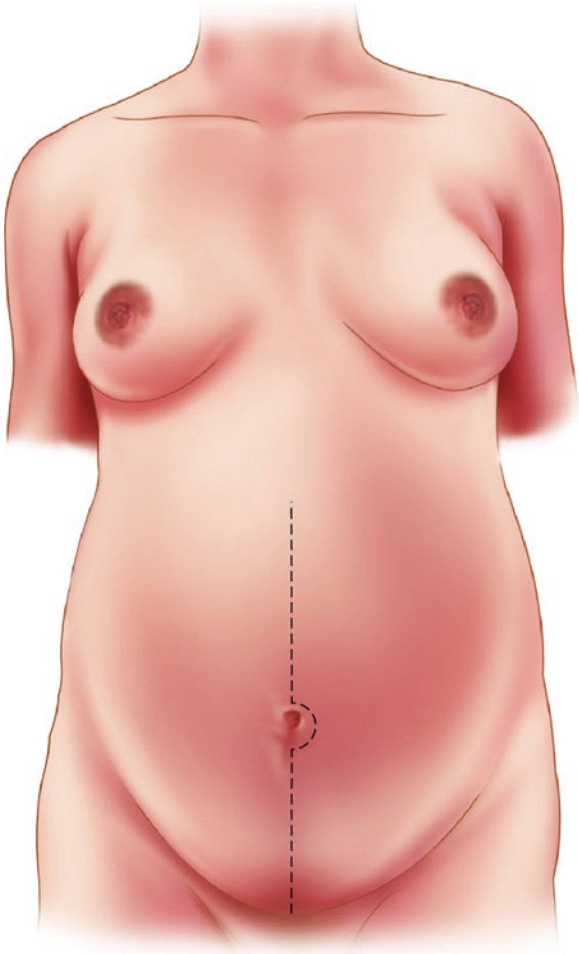


Fig. 129.1 Vertical incision

14. Expulse the head by placing a hand between the pubic symphysis landmark and the fetal occiput. Then, gently flex the fetus while simultaneously moving the head superiorly and anteriorly until delivery (Fig. 129.3).
15. Suction the mouth and nose with a bulb syringe immediately.
16. Deliver the shoulders, followed by the torso and extremities. Secure the umbilical cord with a hemostat or umbilical cord clamp 10 cm distal to the fetus and a second clamp 2 cm distal to this clamp. With scissors, incise the umbilical cord between the two clamps.
17. Immediately begin resuscitation of the infant (Fig. 129.4).
18. If the patient is still alive or regains vital signs, prepare to deliver the placenta. Begin with an OxyContin infusion at 20 U in 1 L at 10 mL/h. Apply cautious traction to the umbilical cord until the placenta separates from the uterus (Fig. 129.5).
19. Following delivery the uterus should be closed using two layers with either 2–0 or 1–0 suture. In the case of maternal death, skin staples or a running stitch is an acceptable method of skin closure.

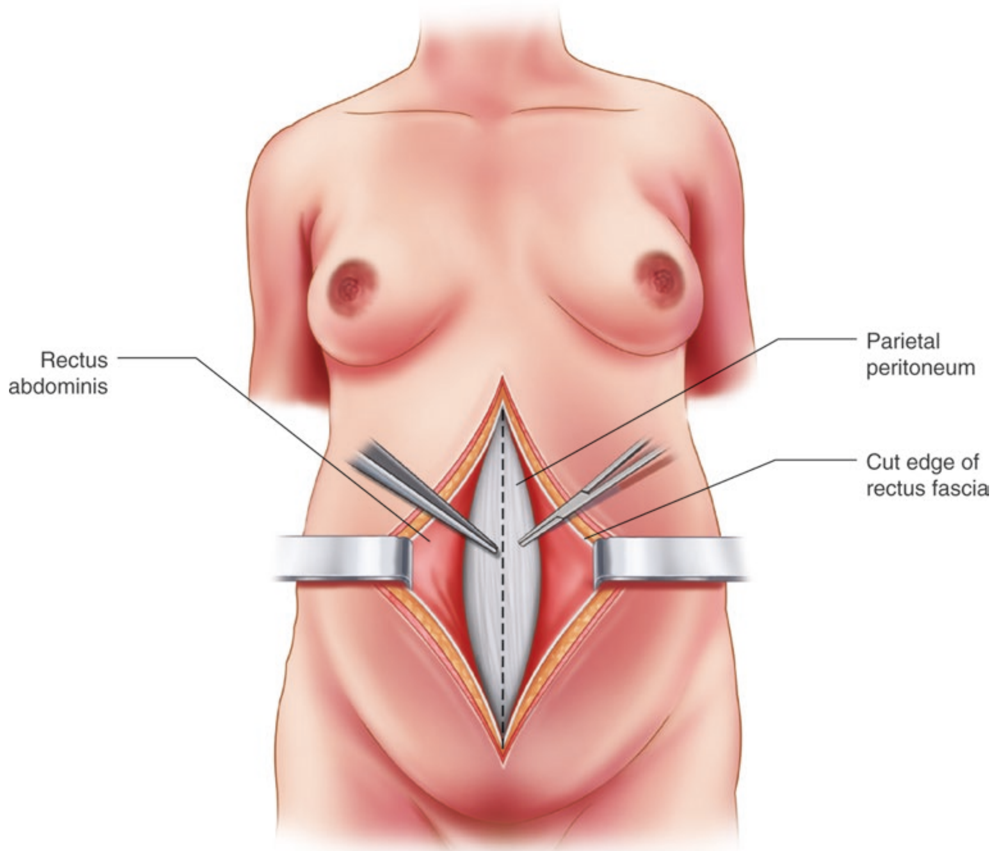
Complications

- Maternal sepsis
- Maternal visceral injury
- Maternal hemorrhage
- Maternal death
- Fetal injuries and laceration
- Fetal sepsis

Pearls and Pitfalls

- Pearls
  - Perimortem cesarean section, although rarely performed, should be considered in any maternal arrest when the fetus is 24 weeks' or greater gestation.
  - In addition to saving the life of the fetus, this procedure may aid in resuscitation of the mother. Emptying of the uterus may improve thoracic compliance and, therefore, improve maternal ventilation.
- Pitfalls
  - The decision to perform an emergency cesarean section must be made early. There is a higher chance of survival if performed no more than 4 minutes after the onset of maternal cardiac arrest and much worse

Fig. 129.2 Exposing rectus sheath



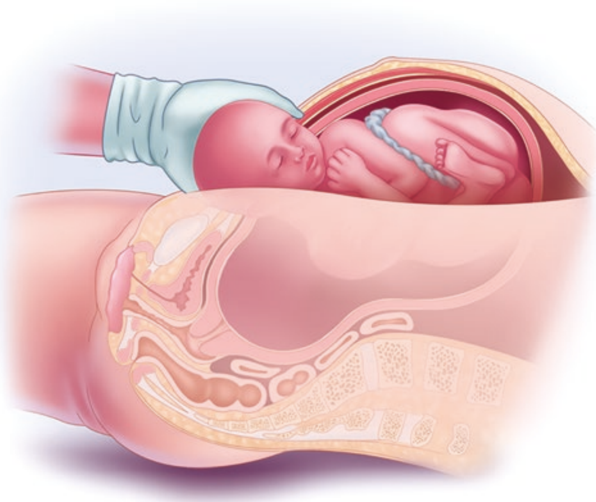


Fig. 129.3 Delivery of the fetus

Fig. 129.4 Suctioning newborn as part of resuscitation

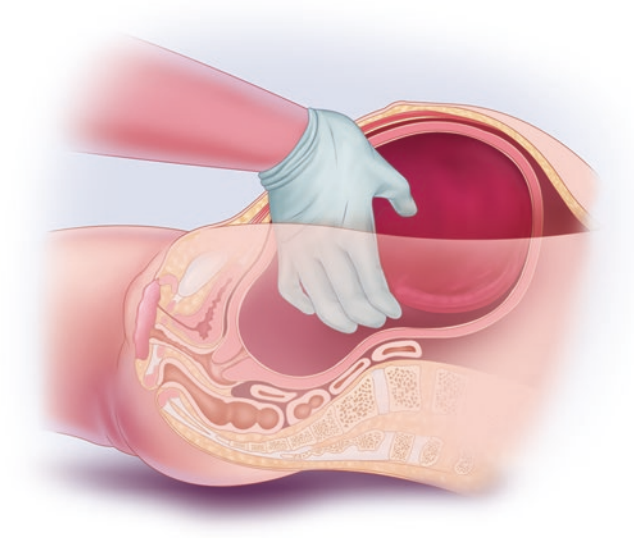


Fig. 129.5 Delivery of the placenta

change of survival if performed greater than 20 minutes after the onset of maternal cardiac arrest.

Suggested Reading

Drukker L, Hants Y, Sharon E, Sela HY, Grisaru-Granovsky S. Perimortem cesarean section for maternal and fetal salvage: concise review and protocol. Acta Obstet Gynecol Scand. 2014;93(10):965–72. https://doi.org/10.1111/aogs.12464. Epub 2014 Aug 27. PMID: 25060654.

Jeejeebhoy FM, Zelop CM, Windrim R, Carvalho JC, Dorian P, Morrison LJ. Management of cardiac arrest in pregnancy: a systematic review. Resuscitation. 2011;82:801–19.

Parry R, Asmussen T, Smith JE. Perimortem caesarean section. Emerg Med J. 2016;33(3):224–9. https://doi.org/10.1136/emermed-2014-204466. Epub 2015 Feb 24. PMID: 25714106.

Whitten M, Irvine LM. Postmortem and perimortem caesarean section: what are the indications? J R Soc Med. 2000;93:6–9.

Part XV

Common Pediatric Procedures

Peripheral Venous Catheterization

130

David N. Smith and Judith K. Lucas

Indications (*see also* Chap. 2)

- Fluid resuscitation
- Medication administration
- Blood draws

Contraindications

- Relative
  - Avoid catheterizing areas of trauma in which extravasation of fluid is possible (e.g., burns, open wounds, or severe edema in tissue).
  - Avoid catheterizing in an area of local infection (e.g., cellulitis), to avoid risk of inoculating the circulation with bacteria.
- Absolute
  - None

Materials and Medications

- Gloves
- Skin disinfectant (isopropyl alcohol, chlorhexidine, or Betadine [povidone-iodine])
- Appropriate-sized catheter (18- to 24-gauge [IV]) (Fig. 130.1):
  - Large child: 18–20 gauge
  - Infant or small child: 22–24 gauge

Fig. 130.1 24-Gauge angiocatheter (*yellow*), 18-gauge angiocatheter (*red*), 20-gauge angiocatheter (*blue*)

- Tourniquet
- Sterile 2 × 2 gauze
- Appropriate-sized Tegaderm transparent dressing
- Adhesive tape

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- IV bag with solution set (tubing flushed and ready) or saline lock
- Sharps container

Procedure

1. Comfortably position the patient with the site exposed.
2. Assemble the equipment and don a pair of (nonlatex) examination gloves.
3. Apply the tourniquet to the extremity above the site to be catheterized (Fig. 130.2).
4. Visualize and palpate the vein.
5. Cleanse the site with a disinfectant swab, using an expanding circular motion.
6. Prepare and inspect the catheter and flush the tubing; be certain that the stylet and catheter separate easily; then fit again into the notch, aligning the bevel with the hub.
7. Stabilize the vein and apply countertension to the skin, being careful not to touch the cleansed area.
8. Insert the stylet through the skin and then reduce the angle while advancing through the vein (Fig. 130.3).
9. Observe for "flashback" as blood slowly fills the flashback chamber.
10. Advance the needle approximately 1–2 mm further into the vein, depending on the gauge and age of the patient, to ensure that the catheter is within the vein.

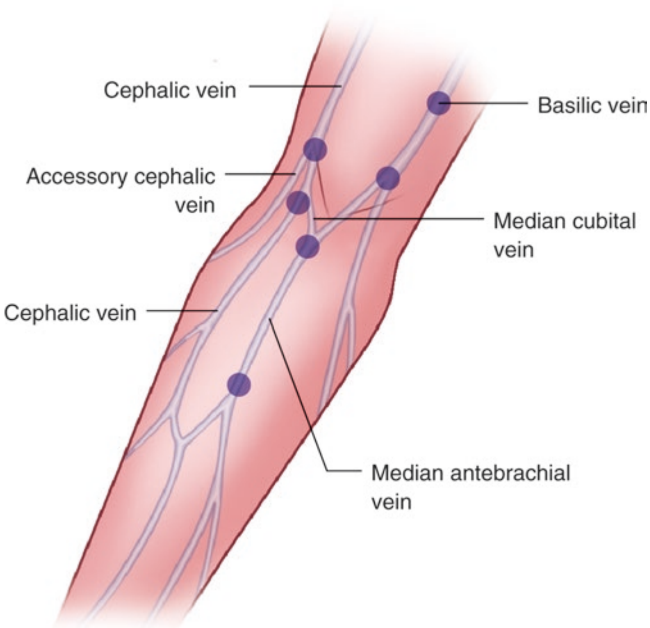

Fig. 130.2 Anatomy of the volar surface antecubital fossa and forearm

11. Slowly advance the catheter into the vein while keeping tension on the vein and skin (Fig. 130.4).
12. While advancing the catheter, be certain to hold the stylet portion with the thumb and forefinger, so as to avoid advancing the needle portion into and through the opposite side of the vessel, thus "blowing" the vein.
13. When the catheter is advanced about halfway, slowly withdraw and remove the stylet while simultaneously continuing to advance the catheter to its hub.
14. Attach a 3-mL non-Luer-Lock syringe to the hub.
15. Remove the tourniquet.
16. Gently attempt to aspirate blood. The blood should be free-flowing.
17. Secure the catheter by either placing a transparent occlusive dressing (e.g., Tegaderm) over the lower half of the catheter hub or taping over the catheter hub in a cruciate fashion, taking care not to cover the IV tubing connection (Fig. 130.5).
18. Remove the cover from the end of the IV tubing and insert the IV tubing into the hub of the catheter. (The tubing must have been flushed with IV solution before connecting with the catheter hub; the unit from the solution bag/bottle through the catheter must be air-free.)
19. Open up the IV roller clamp and observe for drips forming in the drip chamber.
20. Place a piece of tape over the catheter hub, then make a small (kink-free) loop in the IV tubing, and place a second piece of tape over the first piece to secure the loop (Fig. 130.6).
21. Place a third piece of tape over the IV tubing above the site.
22. Ensure that the IV is properly secured and infusing properly.
23. Ensure that all "sharps" are placed in the sharps container.

Pearls and Pitfalls

- Pearls
  - Start catheter attempts distal in the extremities and move proximally with each subsequent attempt.
  - In infants, the use of ultrasound or a light source can aid in location of the vessel and placement of the line.
  - In an emergent situation, in which fluids or medications are needed quickly, intraosseous access (*see* Chap. 132) can be obtained if venous catheterization fails.
- Pitfalls
  - The use of lidocaine subcutaneously can improve patient comfort, but it does disrupt anatomical landmarks.

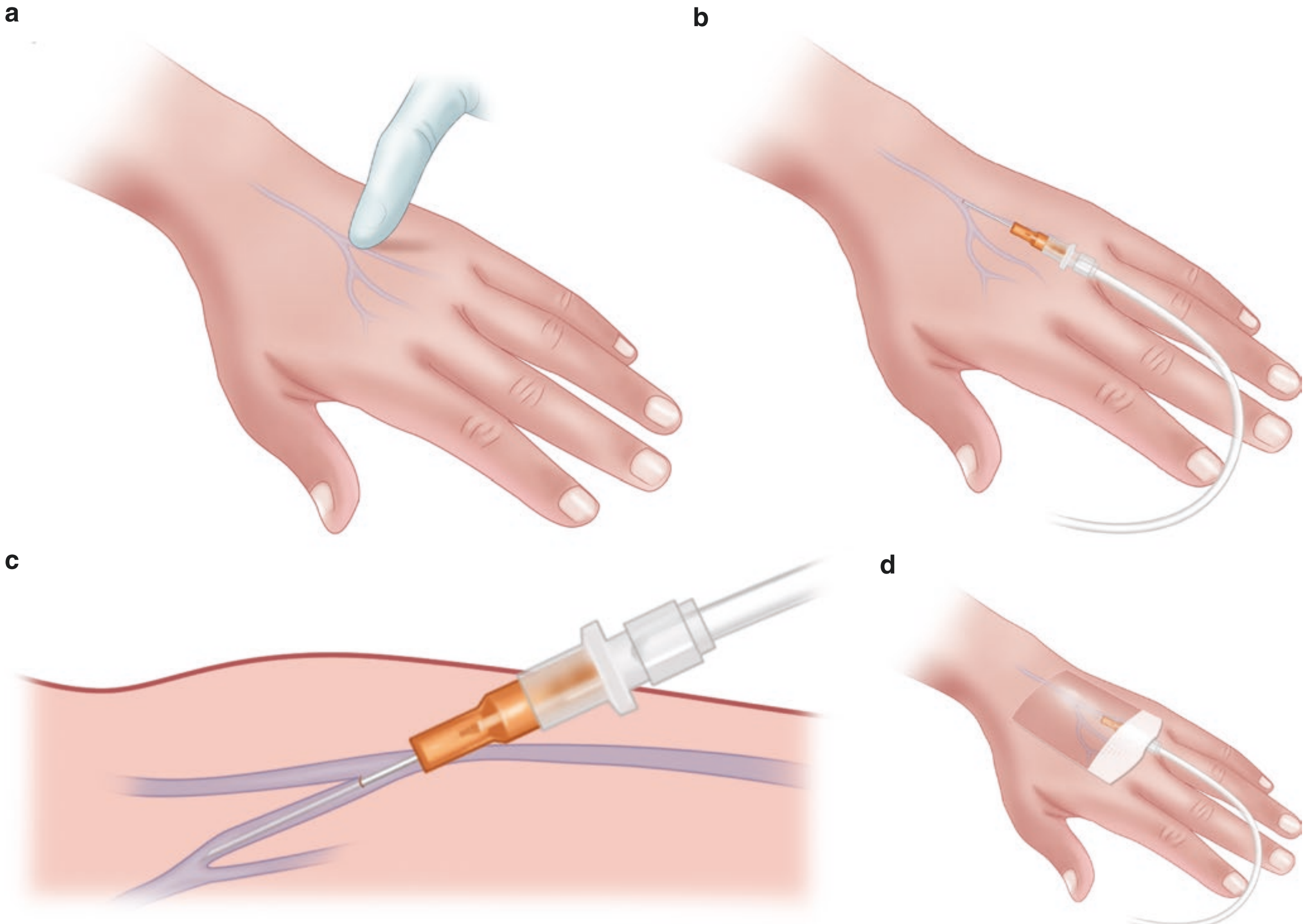

Fig. 130.3 (**a**–**d**) After applying the tourniquet, palpate a vein, as straight as possible, and ideally without many “knots” (i.e., valves).

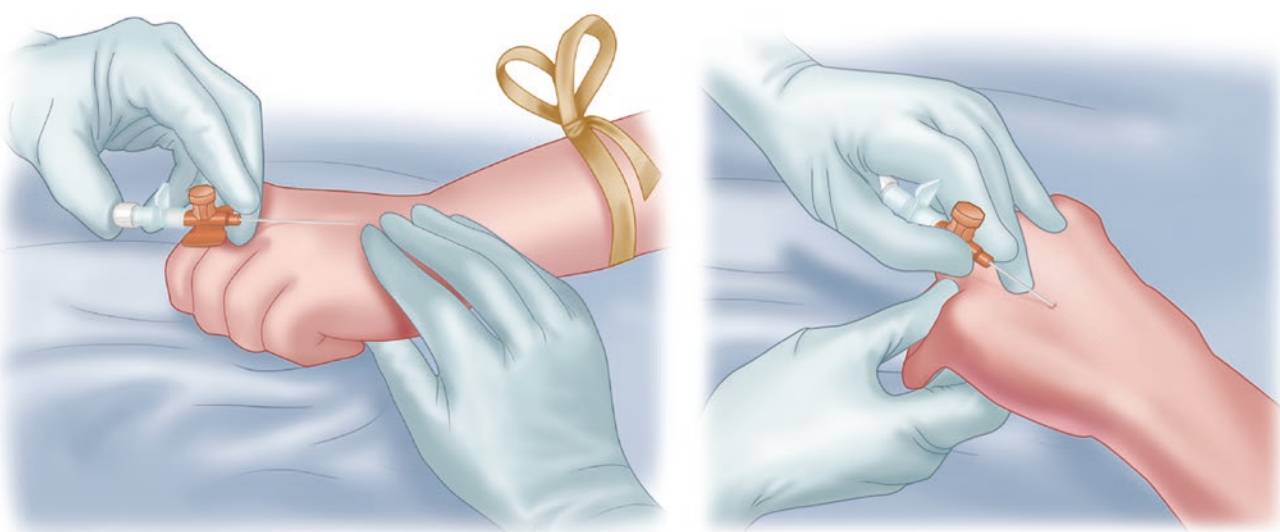

Fig. 130.4 With the tourniquet “up” and the vein distended, apply traction to the skin, pierce the skin, and pass the catheter tip into the vein until blood return is noted in the catheter hub

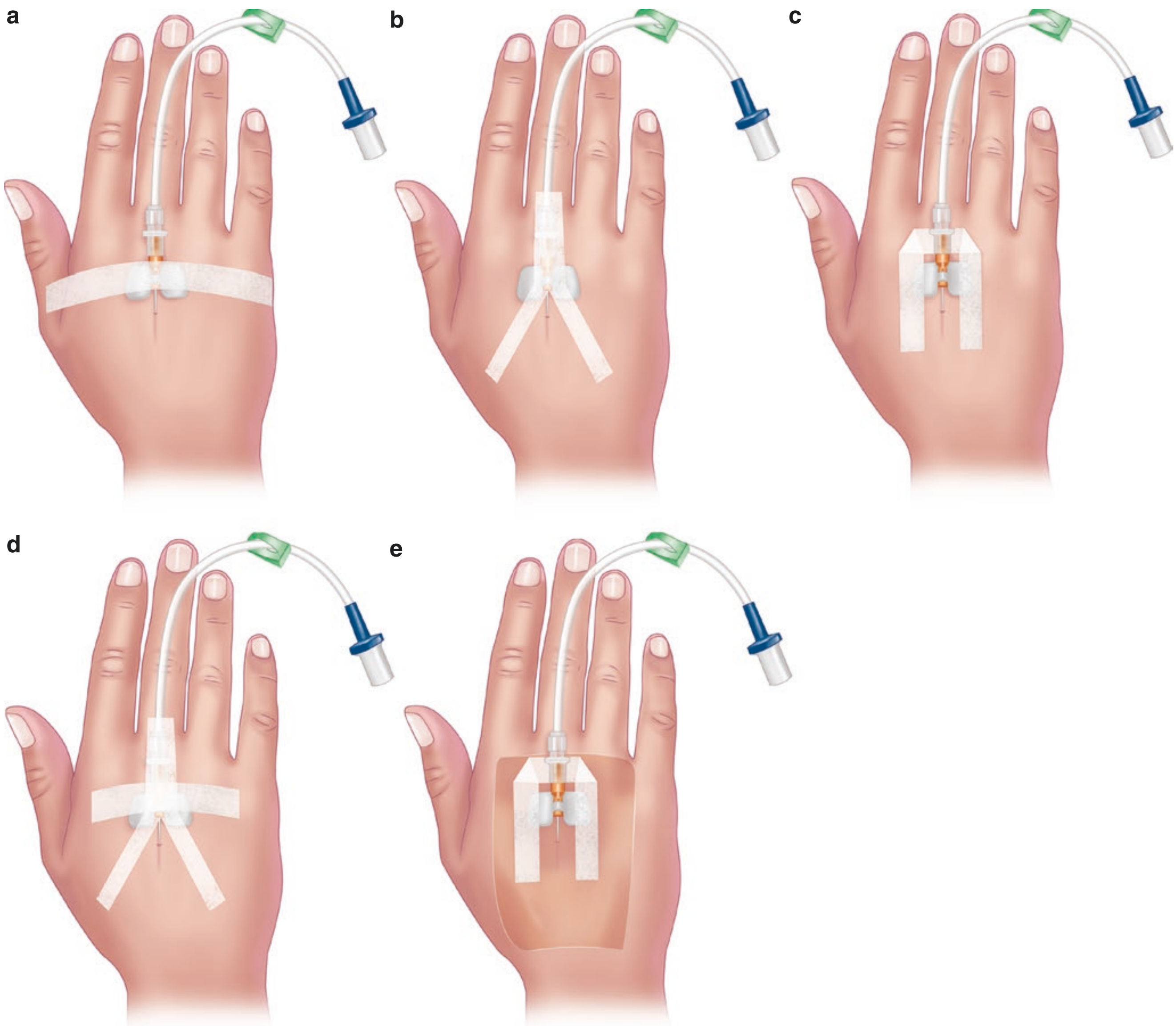

Fig. 130.5 (**a**–**d**) Securing the intravenous line utilizing the cruciate taping style

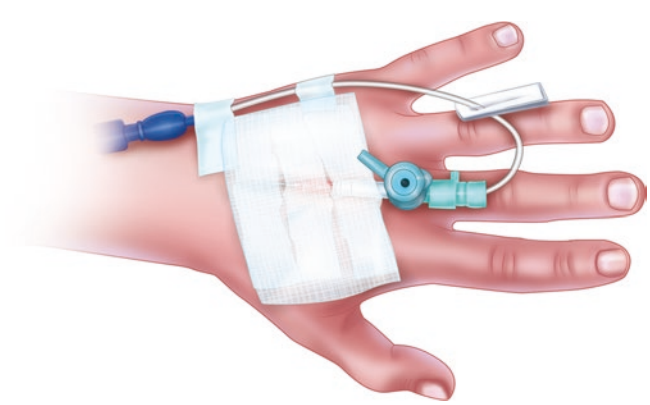

Fig. 130.6 Commercially available hub stabilizer, minimizing the need for excessive tape

Suggested Reading

Department of Emergency Medicine, University of Ottawa. Peripheral intravenous access. 2003. http://www.med.uottawa.ca/procedures/iv

Nursing Resource Administration. Medical procedure: insertion of peripheral IV line. http://nursing-resource.com/iv-insertion

Sabado JJ, Pittiruti M. Principles of ultrasound-guided venous access. UpToDate. http://www.uptodate.com/contents/principles-of-ultrasound-guided-venous-access.

Torrey SB. Vascular (venous) access for pediatric resuscitation and other pediatric emergencies. UpToDate. http://www.uptodate.com/contents/vascular-venous-access-for-pediatric-resuscitation-and-other-pediatric-emergencies.

131 Umbilical Venous Catheters (Insertion and Removal)

Emily Drone, Ariel E. Vera, and Judith K. Lucas

Indications

- Temporary vascular access for infants up to roughly 10 days of life (between 7 and 14 days) with shock or cardiopulmonary failure
- Emergency vascular access in this age group, when peripheral intravenous (IV) access cannot be rapidly obtained
- Preferred vascular access in infants less than 1000 g

Contraindications

- Omphalitis
- Anatomical wall defects (e.g., omphalocele, gastroschisis)
- Necrotizing enterocolitis
- Peritonitis

Materials and Medications

- Anesthetic: not necessary; procedure is painless.
- Soft ties to restrain infant's extremities.
- Sterile gloves/gowns.
- Antiseptic solution (Betadine or alcohol swabs).
- Sterile towels/drapes
- 3.5-French (infants <1500 g) or 5-French (>1500 g) umbilical venous catheter.
- 5-French feeding tube.
- Three-way stopcock.
- 10-mL syringe with heparinized saline flush (1 U/mL).
- Umbilical tape or 3-0 silk on a cutting needle.
- Non-toothed forceps.
- Small hemostats (2).
- #11 scalpel and blade.
- Scissors.
- Graph depicting length of catheter insertion, if placing umbilical venous catheter (UVC) above the diaphragm in either very small infants or infants for whom measurement of central venous pressure (CVP) is indicated (Fig. 131.1).

Procedure (Insertion)

1. Place the infant under a radiant warmer.
2. Using soft ties, restrain the infant's extremities.
3. Scrub the umbilicus and surrounding abdomen with antiseptic solution.
4. Drape the umbilicus and area in a sterile manner (leave the infant's head exposed).
5. Tie a loose loop with the umbilical tape around the base of the cord OR run the 3-0 silk through the skin *of the cord* in a purse-string fashion:
   - This will be used later to anchor the line after placement and to provide hemostasis should the line accidentally be pulled out and bleeding ensue.
6. Using the scalpel blade, cut the umbilical cord horizontally approximately 2 cm above the junction between the cord and the skin.
7. Identify the umbilical vessels:
   - The vein is thinner-walled, larger in diameter, and somewhat floppy-appearing relative to the umbilical arteries; it is typically located at the 12 o'clock position.

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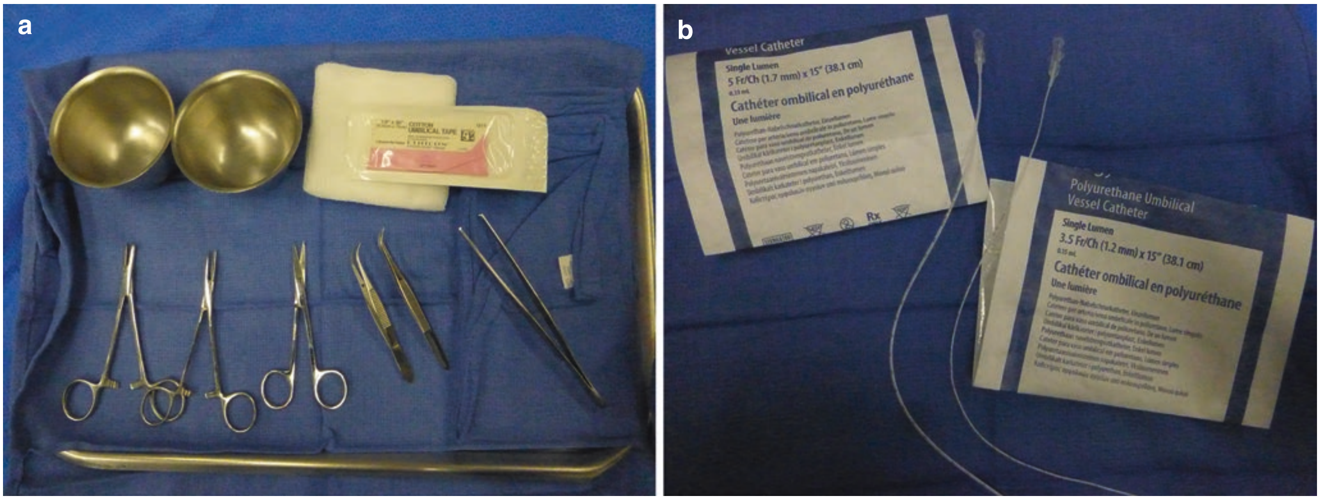
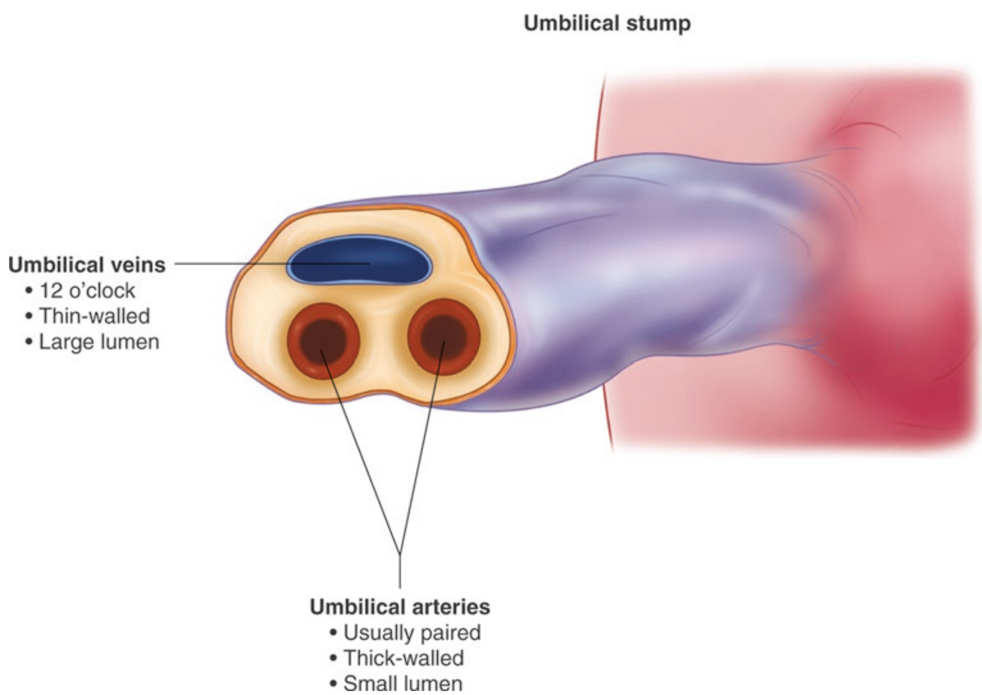


Fig. 131.1 (**a**) Instrumentation suggested for umbilical venous catheter placement. (**b**) Umbilical venous catheters. (In an emergency, a 5-F feeding tube is an acceptable alternative)

Fig. 131.2 Anatomy of the umbilical cord when cut transversely approximately 2 cm from abdominal wall



- The arteries are smaller, thick-walled, and paired (a single umbilical artery often signifies the presence of a congenital malformation/syndrome); they are located at the 4 and 8 o'clock positions (Fig. 131.2).

8. Place the stopcock on the receiving end of the umbilical catheter or the 5-French feeding tube, and flush with heparinized saline solution; then close the stopcock:
   - It is imperative that there is no air in the catheter.
9. Introduce a closed smooth-surfaced forceps into the lumen of the umbilical vein, and allow the forceps to separate, dilating the vein (Fig. 131.3).
10. Insert the catheter (or feeding tube) into the lumen and gently advance, directing the catheter toward the right shoulder (Fig. 131.4).
11. Advance the catheter only until good blood flow is noted and then another 1–2 cm (a total of only 4–5 cm in a term infant):
    - *Do not force the advancement.*
    - At this level, the tip of the catheter should still be inferior to the liver (Fig. 131.5).
12. Tighten the umbilical tie or the purse-string suture.
13. Secure the catheter with a tape bridge (Figs. 131.6, 131.7, and 131.8).

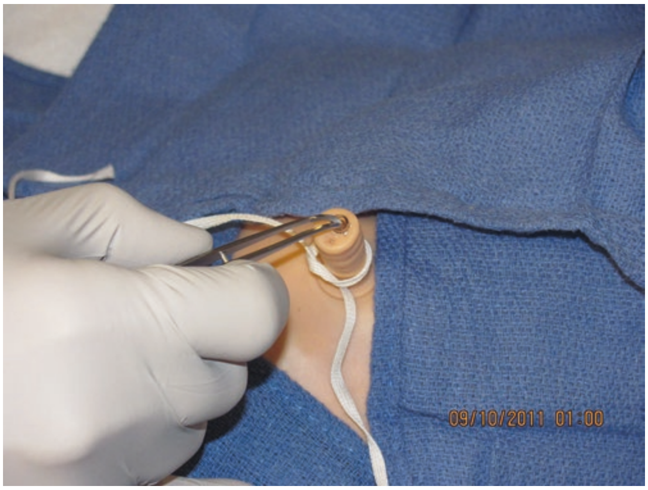


Fig. 131.3 Sterilely draped umbilicus, with umbilical tape loosely tied at the base of the umbilical cord. This tie will be cinched and secured once the catheter is placed, but meanwhile, can assist with homeostasis should the catheter be inadvertently dislodged during placement. Gently dilate the umbilical vein with a smooth-toothed forceps, by inserting the most distal couple of millimeters of the closed forceps into the umbilical vein and relaxing so that the forceps tips smoothly separate

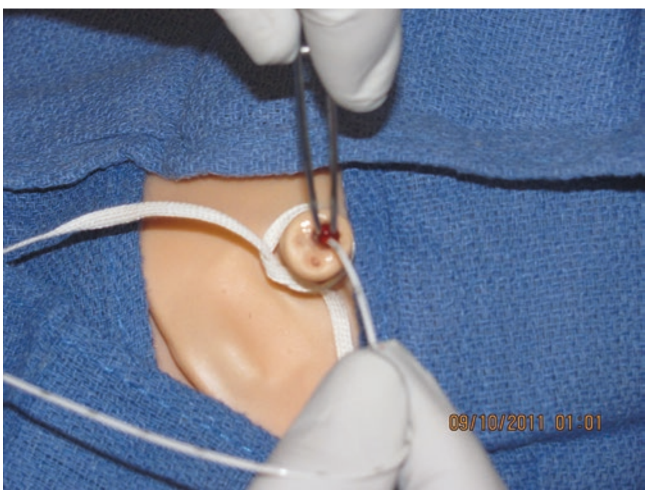


Fig. 131.4 Gently pass the umbilical venous catheter (or 5-F feeding tube) until there is easy blood return

14. The preferred and safest method during emergent resuscitation is to place the catheter about 1–2 cm after the point of blood return (known as a "low-lying UVC"), but in less emergent situations, it is best to get an abdominal X-ray to confirm positioning; many solutions are caustic to the liver and can result in complications. When confirming with X-ray, the tip should be at the junction of the inferior vena cava just below the right atrium.

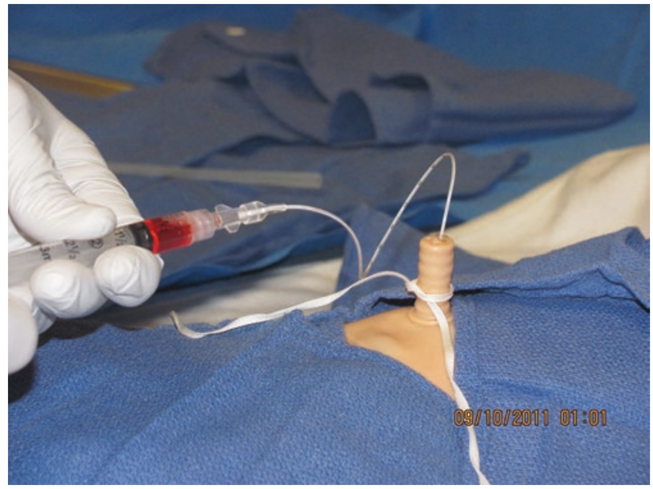


Fig. 131.5 Once there is easy blood return, pass the catheter an additional 1–2 cm. The catheter should still be inferior to the liver at this point

Fig. 131.6 Creating an umbilical catheter tape bridge: the uprights

Procedure (Removal)

1. The UVC should be removed as soon as adequate peripheral venous access is obtained (except in an infant estimated to weigh <1000 g).
2. Turn infusions off.
3. Be certain the stopcock is closed to the infant.
4. It is imperative that there be no air in the catheter before withdrawal. (If air is present and the infant takes inspiration, the negative pressure generated can pull a significant amount of air into the central vasculature.)
5. Remove the securing tape from the infant.
6. Withdraw the catheter gradually as a single maneuver.

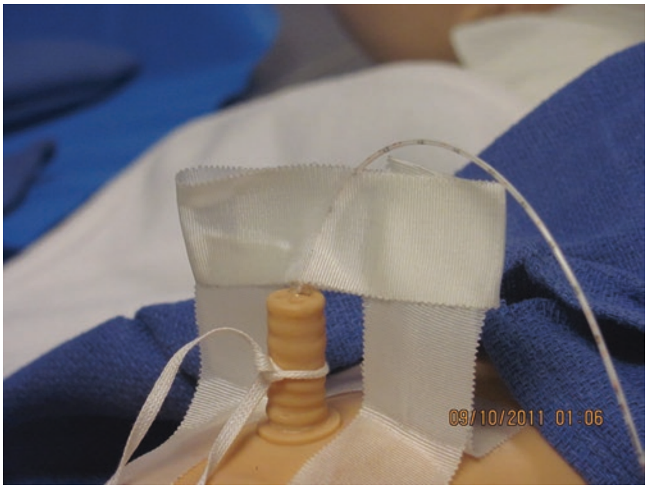


Fig. 131.7 Umbilical tape catheter bridge: The "crossbar" secures the catheter without applying tape to the umbilical stump

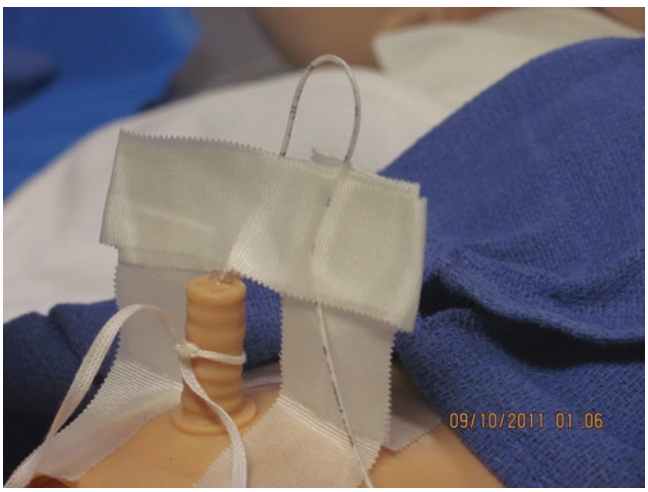


Fig. 131.8 Fold the catheter over to create a "U." Be careful not to kink the catheter, and secure with a second taped crossbar to lend additional security to the catheter and prevent displacement

Complications

- Infection
- Bleeding due to disconnection of tubing (*always use Luer-Lock connections*) or perforation of vessels
- Arterial injury by accidental perforation
- False lumen
- Hepatic injury, abscess, or necrosis if the catheter sits within a portal vein
- Thrombosis (catheter tip or in the portal venous system)
- Air embolus
- Dysrhythmia or pericardial tamponade or perforation if catheter is advanced too far

Pearls and Pitfalls

- Pearls
  - The umbilical vein is 2–3 cm long before it widens into the umbilical recess, just before intersecting with the left portal vein and the ductus venosus.
  - Be certain to include the length of the umbilical stump in any calculations for placement.
  - If using the calculating graph, measure from the right shoulder to the umbilicus (Fig. 131.9).
  - If choosing the above-diaphragm site for placement, corkscrewing the catheter clockwise while passing the catheter will encourage it to pass through the ductus venosus.
  - A kidney, ureter, and bladder study is mandatory in high UVC placement.
- Pitfalls
  - When preparing with Betadine (povidone-iodine), be certain to wipe away and remove any pooled Betadine along the infant's side because this will cool the infant initially; as the Betadine is warmed, it becomes highly irritating to newborn skin.

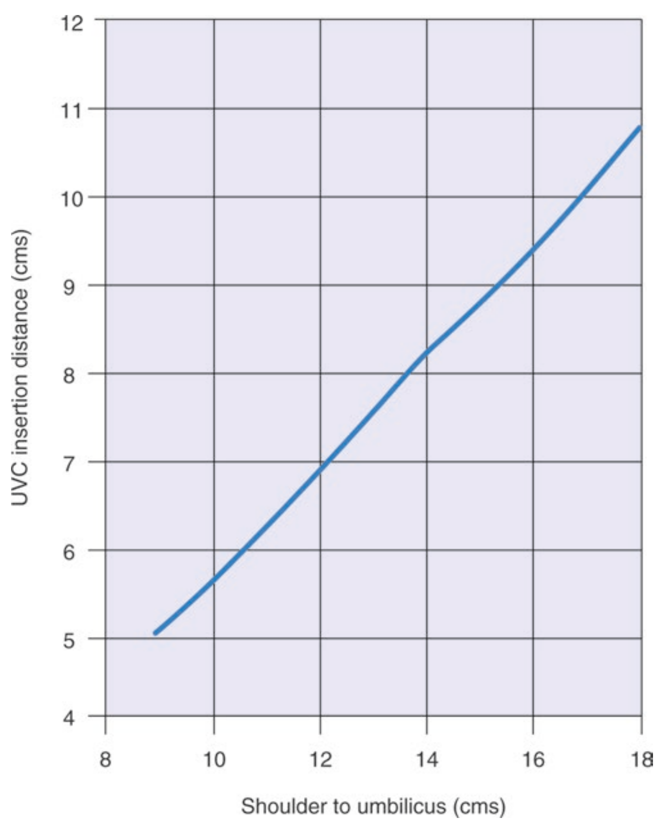


Fig. 131.9 Graph for estimation of insertion distance of the catheter; be certain to add the length (cm) of the umbilical stump to the insertion distance

Suggested Reading

Magnan JP. Umbilical vein catheterization. Medscape. http://emedicine.medscape.com/article/80469-overview. Accessed 25 June 2019.

Schlesinger AE, Braverman RM, DiPietro MA. Pictorial essay. Neonates and umbilical venous catheters: normal appearance, anomalous positions, complications, and potential aid to diagnosis. AJR Am J Roentgenol. 2003;180:1147–53. https://doi.org/10.2214/ajr.180.4.1801147.

Sudbury, Jones, Bartlett. Emergency vascular access. In: American Academy of Pediatrics. APLS: The pediatric emergency medicine resource. 5th ed. p. 741.

Intraosseous Access

132

Judith K. Lucas and Ariel E. Vera

Indications

- During cardiac arrest: Failure to attain vascular access after three peripheral intravenous attempts or 90 seconds, whichever comes first.
- Inability to gain vascular access in pediatric patients presenting in shock due to hemorrhage (trauma), sepsis, profound dehydration, or cardiac failure.

Contraindications

- Absolute.
  - Fracture of the long bone considered for intraosseous (IO) access.
- Relative.
  - Previous IO access attempt in the same long bone.
  - Presence of cellulitis, burns, or osteomyelitis at insertion site.
  - Inferior vena cava injury (circulatory access proximal to the injury site is preferred).
  - Osteogenesis imperfecta.

Materials and Medications

- Preparation materials, such as an antiseptic solution and sterile drapes, *if* the patient's stability offers the time.

Fig. 132.1 Jamshidi disposable sternal/iliac aspiration needle (Jamshidi, Cardinal Health; Dublin, OH)

- Lidocaine without epinephrine: If it becomes necessary to place an IO in a conscious patient, use lidocaine to anesthetize the skin to the bony cortex. Once accessed, infiltrate 2–3 mL into the marrow to alleviate some of the pain of medications infusing through the marrow.
- IO needle (Figs. 132.1, 132.2, and 132.3 show examples).

Procedure: Proximal Tibia (Most Common Site)

1. Patient should be supine, with the intended leg slightly externally rotated and flexed at the hip. Flex the knee about 90°.
2. Place a towel underneath the knee and the proximal lower leg.
3. Palpate the tibial tuberosity (Fig. 132.4). Then move fingers 2 cm distal to the tuberosity (1–2 fingerbreadths) and 1–2 cm medial (Fig. 132.5). This area is consistently flat and is distal to the growth plate.

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Fig. 132.2 Cook intraosseous needle (Cook Critical Care; Bloomington, IN)

Fig. 132.3 EZ-IO (Vida-Care; San Antonio, TX)

Fig. 132.4 *Step 1.* Identify the tibial tuberosity

4. If the patient is stable, create a sterile field focused on the insertion site.
5. Insertion site should be cleaned with an antiseptic solution.
6. Pass the needle through the skin and subcutaneous tissue to the cortex.
7. Once the bone is reached, stabilize the IO with the thumb and first fingers adjacent to where the needle penetrates the skin.
8. Apply steady and firm pressure downward and with a twisting motion (back and forth) with the palm on the end of the device. Inserting the needle perpendicular to the bone is totally acceptable, but it is ideal to angle the needle caudally slightly (about 15°) to avoid the growth plate (Fig. 132.6).

Fig. 132.5 *Step 2.* Move fingers one to two fingerbreadths below the tuberosity and medially, to the flat aspect of the proximal tibia

Fig. 132.6 *Step 3.* Angle the device slightly caudal to avoid growth plate

Fig. 132.7 *Step 4.* Uncap the top of the device and remove the trocar

Fig. 132.8 *Step 5.* Stabilize the intraosseous cannula

9. As the cortex is fully penetrated, indicating entrance into the marrow space, one may feel an ease in resistance. Do not advance the needle further. The needle should be able to stand up without support.
10. Remove the inner trocar (Fig. 132.7).
11. Attempt to aspirate marrow/blood. Not being able to do so *does not* mean inadequate or inaccurate placement. Instead, if marrow cannot be aspirated, affix a 10-mL syringe with normal saline and attempt to infiltrate. Resistance to flow should be minimal, and one should not appreciate either extravasation around the insertion site, coolness, or tissue expansion posterior to the site (indicating the fluid is passing through the IO).
12. Once placement is confirmed, connect an intravenous line, using a three-way stopcock.
13. Secure the needle with tape and gauze (Fig. 132.8).

Procedure: Alternative Sites

- Distal tibia:
  - The landmarks are the medial aspect of the tibia (the flat portion), two fingerbreadths proximal to the medial malleolus.
  - Again, externally rotate and abduct the hips, with the knee flexed about 60° (as with the proximal tibia).
  - Angle the needle toward the knee (cephalad) about 10–15° to avoid the distal tibia growth plate.
  - The remainder of the IO insertion is identical to the procedure for proximal tibia placement.
- Distal femur:
  - Slightly flex and externally rotate the hip.
  - Flex the knee enough that the quadriceps muscle group is relaxed.
  - The landmarks for the distal femur are the anterior thigh, midline, about three fingerbreadths proximal to the medial and lateral condyles.
  - The IO is inserted perpendicular to the bone (because there is no growth plate in the distal femur other than the condyles).
  - The remainder of the procedure is identical to the procedure for placement in the proximal tibia.
- Proximal humerus:
  - The patient should be supine, with the shoulder, upper arm, and elbow as close to the body as possible, yet still on the bed. The elbow should be flexed at 90°, with the forearm and palm resting on the patient's abdomen.
  - The provider slides his or her thumb up the anterior shaft of the humerus toward the shoulder until the greater humerus tubercle is palpated, which identifies the surgical neck of the humerus.
  - The insertion site is perpendicular to the humerus, approximately one to two fingerbreadths proximal to the tubercle (Fig. 132.9).
  - The remainder of the insertion is identical to that for the proximal tibia.
- Sternum (not usually recommended for small children):
  - Requires a special IO needle and system.
  - Method of placement is specific to the insertion system chosen.
  - The manubrium is the desired site (as opposed to the body of the sternum, which would interfere with cardiopulmonary resuscitation).
  - Risks specific to sternal placement include pneumothorax, mediastinitis, and great vessel injury.

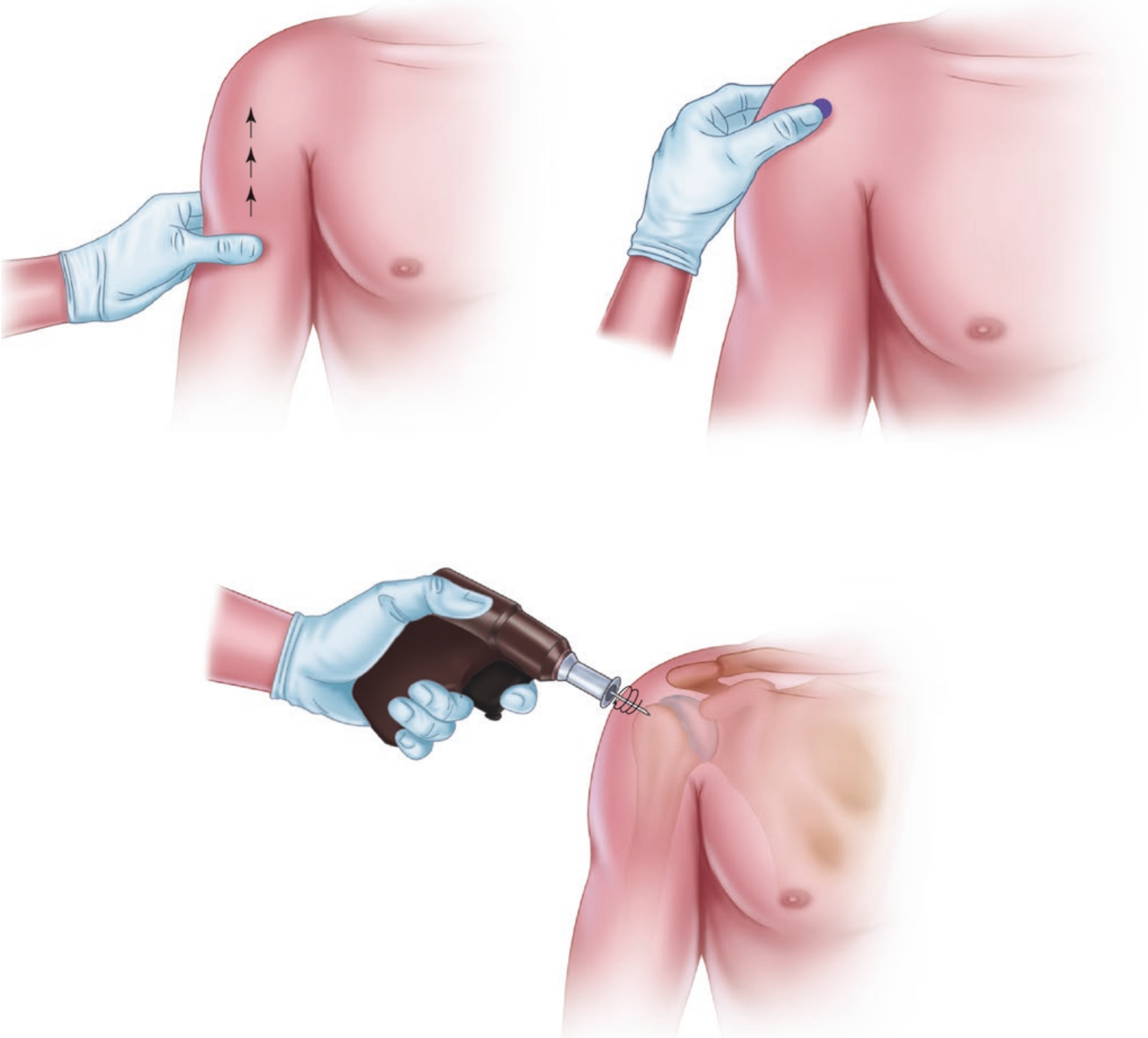

Fig. 132.9 IO insertion into proximal humerus site

Procedure: Removal

- For battery-powered devices like EZ-IO, attach a Luer-Lock syringe to the catheter, hold the extremity, and rotate the catheter with the syringe in a clockwise manner while gently pulling back. After removal, apply pressure and dress the site.
- For spring-loaded or manual devices, attach a Luer-Lock syringe or safety latch, hold the extremity, and gently pull with a slight rotary motion. After removal, apply pressure and dress the site.

Complications

- Extravasation of fluid:
  - Occurs as a result of a misplaced IO, either not completely in the marrow space anteriorly or through the cortex posteriorly.
  - Tissue necrosis.
- Compartment syndrome if extravasation is not recognized.
- Fracture and growth plate injury.
- Infection and osteomyelitis are rare complications if sterile technique is used.
- Fat embolism, considered rare and only in adult patients.

Pearls and Pitfalls

- Be certain to avoid placing a hand beneath the IO site during placement, in order to prevent possible IO penetration into the provider's tissue.
- Do not rely on the sensation of a "pop" to determine appropriate penetration into the cortex, especially in infants.
- Likewise, one may not be able to aspirate bone marrow or blood, even with an appropriately placed IO. *Do not* pull out the IO if marrow cannot be aspirated. Rather, gently but firmly infiltrate 10 mL of normal saline.
- Blood gases, body chemistries, and blood typing can be obtained from IO samples, but the sample *cannot* be used for hematocrit determination.
- Monitor the IO access and the extremity frequently for any signs of compromise (swelling, erythema).
- The IO line can be left in place and used for no longer than 24 hours, as it increases the risk of osteomyelitis.
- Attempt to replace the IO with a peripheral or central IV-line access as soon as possible.
- Basically, any drug (e.g., epinephrine, norepinephrine, lidocaine, rocuronium, antibiotics) or fluid (e.g., crystalloids, blood) that can be administered via an IV route can be safely administered via an IO route.
- Push-pull technique for rapid fluid administration (*see* Chap. 141) can be used safely with an IO access.

Suggested Reading

Bohn D. Intraosseous vascular access: from archives to the ABC. Crit Care Med. 1999;27:1053–4.

DeCaen AR, Reis A, Bhutta A. Vascular access and drug therapy in pediatric resuscitation. Pediatr Clin N Am. 2008;55:909–27.

Deitch K. Intraosseous infusion. In: Roberts JR, Hedges JR, editors. Clinical procedures in emergency medicine. fifth ed. Philadelphia: Saunders; 2009. Chap. 25.

EMS World. Intraosseous infusion: not just for kids anymore. Posted Jan. 12, 2011. Updated from Mar 2005. EMSWorld.com. Cygnus Business Media Site.

Halm B, Yamamoto LG. Comparing ease of intraosseous needle placement: Jamshidi versus cook. Am J Emerg Med. 1998;16:420–1.

Perron CE. Intraosseous Infusion. UpToDate. 9 Jan 2019. www.uptodate.com/contents/intraosseous-infusion

Lumbar Puncture in Pediatrics

133

Ariel E. Vera, Maritza A. Plaza-Verduin, and Judith K. Lucas

Indications

- Evaluation of cerebrospinal fluid (CSF) for infection, malignancy, subarachnoid hemorrhage, or demyelinating process (e.g., Guillain-Barré)
- Measurement of opening pressure
- Treatment of pseudotumor cerebri
- Diagnosis of central nervous system (CNS) metastases
- Instillation of intrathecal chemotherapy
- Injection of radiopaque dye for spinal cord imaging

Contraindications

- Increased intracranial pressure
- Bleeding diathesis (platelet count <50,000)
- Overlying skin infection near the area of puncture site
- Spinal cord trauma or spinal cord compression
- Signs of progressive cerebral herniation
- Condition of the patient (e.g., unstable airway, potentially dangerous breathing problem, severe circulatory instability, status epilepticus) that could cause an abrupt decompensation
- Known spinal cord deformity

Materials and Medications

- Lumbar puncture (LP) tray (Fig. 133.1):
  - Sterile drapes
  - Betadine (povidone-iodine) swabs or tray to pour Betadine
  - Sterile sponges for preparing the puncture site
  - Sterile 3-mL syringe with needle for lidocaine injection
  - Sterile collecting tubes (4)
  - Sterile spinal needle with stylet (size depending on age of patient):
    Premature infant: 22 gauge or smaller, 1.5 inch
    Neonate to 2 years: 22 gauge, 1.5 inch
    2–12 years: 22 gauge, 2.5 inch
    Older than 12 years: 20 or 22 gauge, 3.5 inch
  - Pressure manometer column with a three-way stopcock
- Betadine solution
- Sterile gloves
- Mask
- Lidocaine (1–2% without epinephrine)
- 4% lidocaine cream (LMX-4) or lidocaine and prilocaine mixture (EMLA)
- Oral sucrose (for newborns)

Procedure

1. Position the child in either the sitting or the lateral recumbent position with the hips, knees, and neck flexed (Figs. 133.2 and 133.3):
   - For small infants or any patient with any degree of cardiorespiratory compromise, keep close monitoring of heart rate, respirations, and oxygen saturation while in the flexed position.
2. Palpate the top of the iliac crest and draw an imaginary line connecting the two across the back, which should

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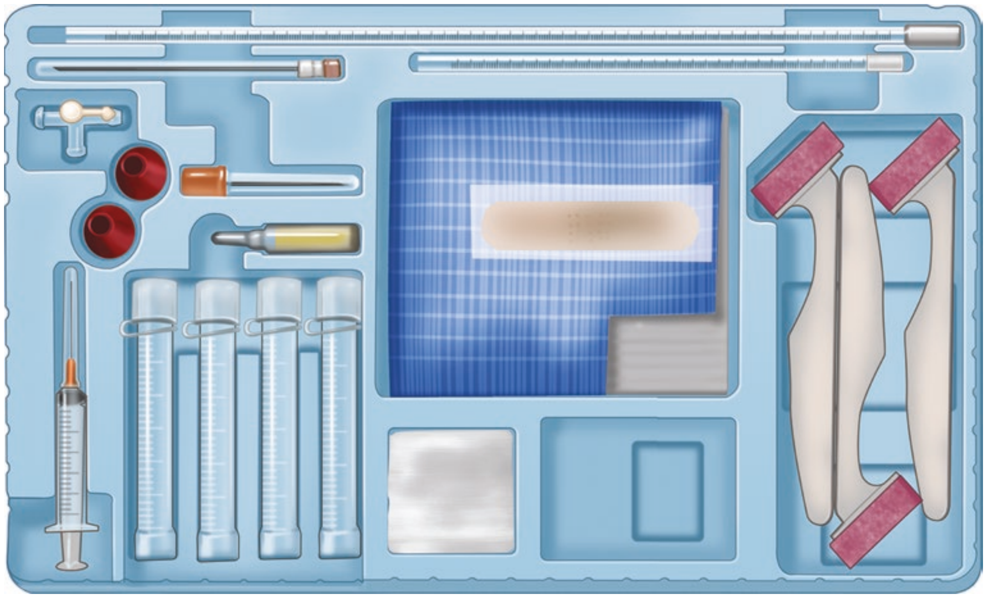

Fig. 133.1 Lumbar puncture (LP) tray

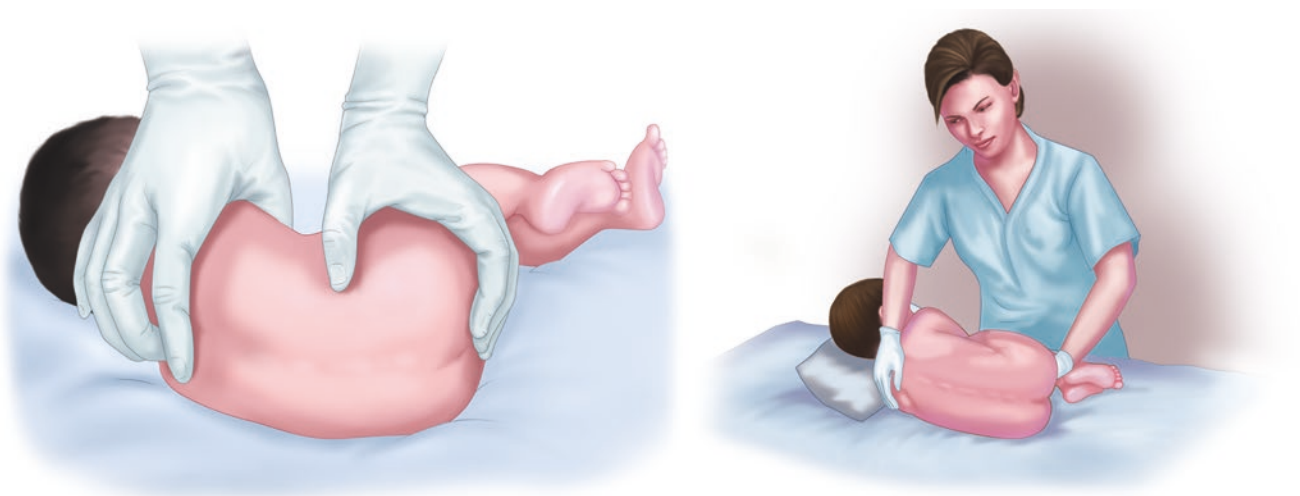

Fig. 133.2 Curling up for an LP

cross the midline just above the fourth lumbar spine (Fig. 133.4).

3. Palpate L3–4 or L4–5 space along this line.
4. Place EMLA or LMX-4 on the area and allow some time for anesthesia to occur (can take up to 30 min to be effective). Administration of sucrose solution (23% sucrose) orally during the procedure may be used for alleviation of pain in newborns.
5. Prepare the skin in a sterile fashion with Betadine solution using enlarging circles that begin at the puncture site.
6. Drape the patient with sterile towels, exposing the puncture site:
   - If an infant, do so conservatively to be able to monitor the infant during the procedure.
7. Locate the intervertebral space (L3–4 or L4–5) once again.
8. Make a small mark on the chosen intervertebral space with a fingernail depression or the plastic cap of the spinal needle.
9. If desired, or if anesthetic cream was not previously used or more is needed, apply a small wheal of lidocaine at the desired puncture site using a 25-gauge needle.
10. Insert the spinal needle in the intervertebral space. Especially in children less than 3 months of age, consider the early stylet removal technique (section "Early Stylet Removal Technique"):
    - Puncture the skin in the midline just caudal to the palpated spinous process.

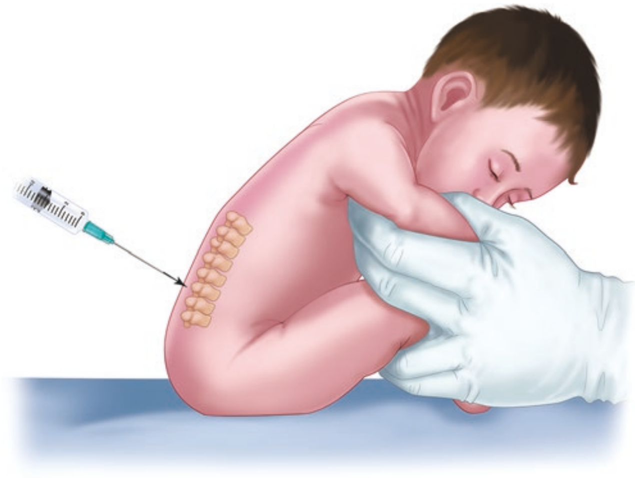

Fig. 133.3 Having the LP

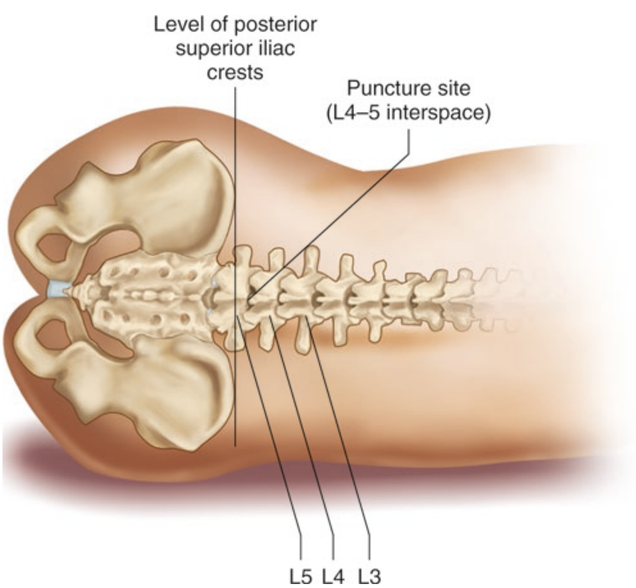

Fig. 133.4 Anatomy of the lumbar spine, showing the sites for dural puncture

- The bevel should be positioned so that the dura mater is pierced parallel to its fibers (to reduce the likelihood of CSF leakage):
  - If in the lateral recumbent position, the bevel of the needle should be positioned horizontally.
  - If in the sitting position, the bevel of the needle should be positioned vertically.
  - Angle the needle slightly cephalad toward the umbilicus and parallel to the bed if the patient is in the lateral recumbent position, or slightly caudal (perpendicular to the skin) if the patient is in the sitting position.

11. Advance the needle several millimeters at a time and withdraw the stylet frequently to check for CSF flow:
    - Advance the needle until a loss of resistance is felt, or approximately 1–2 cm:
      - In infants, the dura is not so thick and a "pop" or give may be unnoticeable, so after passing between the spiny processes and approximately 2 cm through the skin, remove the stylet frequently to check for CSF return. This will allow you to avoid passing through the subarachnoid space.
      - After the change in resistance occurs, if resistance is met again, pull back gently on the needle to reposition in the subarachnoid space and remove the stylet to check for CSF.
12. Once CSF is free-flowing, attach a pressure manometer to the needle hub via the three-way stopcock (Fig. 133.5):
    - To prevent movement of the needle, be sure to hold the spinal needle in place with one hand while attaching the manometer.
    - Measure the CSF pressure once the CSF reaches the highest level in the manometer column.
    - CSF pressures will be best obtained in the lateral recumbent position with the neck and legs extended.
    - Normal CSF pressure is 5–20 cm H_2O with the neck and legs extended, 10–28 cm H_2O with the neck and legs flexed.
    - Have an assistant hold the top of the pressure manometer while the spinal needle is supported at the connection of the manometer and stopcock.
13. Remove the manometer and collect the CSF into sterile tubes:

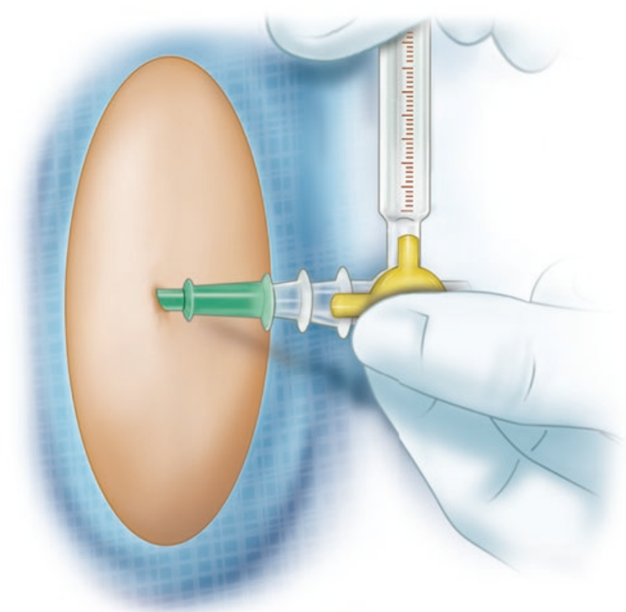

Fig. 133.5 Pressure manometer attached to the needle hub via the three-way stopcock

- Be sure to keep the needle in place when removing the manometer.
- Continue to drain fluid into the collecting tubes, approximately 1 mL per tube.
- The tubes should be labeled for specific studies, depending on the order of collection:
  - First tube for Gram stain and culture
  - Second tube for quantitative glucose and protein
  - Third or fourth tube for cell count and differential (When the LP is to assess for possible subarachnoid blood, the first and fourth tubes are sent for cell count.)
  - Leftover tube for any additional studies that may be needed

14. Replace the stylet and remove the spinal needle.
15. Cleanse the puncture area to avoid staining with the Betadine solution.
16. Apply a sterile dressing to the puncture site.
17. Patients 4 years and older should remain in the supine position, with the head elevated no more than the height of a pillow (for comfort), for at least an hour to avoid spinal tap headaches.
18. Likewise, after the LP, giving a fluid bolus of normal saline (10–20 mL/kg for children; 1 L for non-volume-sensitive adults) will also assist with avoidance of spinal tap headaches.

Early Stylet Removal Technique

- Some studies have demonstrated greater success rate, especially in children less than 3 months, by using this method.
- The stylet must be kept inside the needle while penetrating through the skin, to avoid long-term complications of intraspinal epidermoid tumors.
- Procedure
  - Initial approach and steps are the same as in steps 1–9 above.
  - Insert the needle with the stylet in, puncture through the epidermis and dermis (usually <1 cm), and then immediately remove the stylet.
  - Advance the needle through the rest of the layers (subcutaneous fat, muscle, ligaments) without a stylet until CSF flow is seen.
  - Continue with procedure as described in steps 11–17. (The stylet should be reinserted before needle removal from the spinal cavity.)

Complications

- Minor
  - Localized back pain
  - Transient paresthesia during procedure
  - Post-LP headache
- Major
  - Severe back pain associated with neurological signs (may be subdural or epidural spinal hematoma)
  - LP-induced meningitis
  - Cerebral herniation
  - Acquired epidermoid tumor
  - Damage to adjacent structures (disk herniation, retroperitoneal abscess, spinal cord hematoma)

Pearls and Pitfalls

- Pearls
  - Success of the LP depends on the positioning of the patient:
    - Goal of positioning is to stretch the ligamentum flavum and increase the interlaminar spaces.
    - In the recumbent position, the shoulder and hips should be perpendicular to the bed, keeping the spinal cord straight, with no rotation.
    - Sitting position is useful with older, cooperative patients or with very young infants who are unlikely to struggle and may have increased respiratory distress in the lateral recumbent position.
  - Consider early stylet removal technique, especially in children less than 3 months of age.
  - Administration of an anxiolytic (e.g., midazolam) can be used to facilitate the procedure in an older child. In some cases, procedural sedation may be required.
  - Placing the tip of the thumb on the spinous process just above the space being entered can ensure good alignment of the needle.
  - In older patients, a “pop” may often be felt as a change in resistance occurs once the dura is penetrated, but that “pop” may be exceedingly subtle or not palpable in infants and neonates.
  - If no CSF returns, attempt the following options:
    - Ensure the needle is in the appropriate position, withdrawing the needle slowly if necessary.
    - Rotate the needle 90°.
    - For an infant, have the assistant massage the anterior fontanel to help facilitate CSF flow.

If the procedure continues without CSF, withdraw the needle to just under the skin and redirect it.

If the procedure continues without CSF, withdraw the needle and insert a new needle with stylet at an alternative site.

If these steps do not yield CSF, the infant may be dehydrated, not allowing for adequate CSF flow:

- Give the patient a bolus and reattempt later.
- Try putting the infant in a sitting position to increase flow.

- Pitfalls
  - Traumatic LP:

    Bloody CSF fluid, which usually clears as the CSF drains if the needle is in the correct space.

    Occurs with improper technique (inserting the needle too far to one side, into an epidural venous plexus or through the subarachnoid space into or adjacent to the vertebral body).

    Also can occur with proper technique.

    If fluid does not clear and clots form in the tubes, LP should be reattempted at a different site.
  - Failed LP attempts despite proper procedure and positioning:

    Ultrasound can be used to visualize the area and determine the reason for failure or the likelihood of success with future attempts.

Suggested Reading

Baxter AL, Fisher RG, Burke BL, Goldblatt SS, Isaacman DJ, Lawson ML. Local anesthetic and stylet styles: factors associated with resident lumbar puncture success. Pediatrics. 2006;117:876–81.

Coley BD, Shiels WE, Hogan MJ. Diagnostic and interventional ultrasonography in neonatal and infant lumbar puncture. Pediatr Radiol. 2001;31:399–402.

Cronan KM, Wiley JF. Lumbar puncture. In: King C, Henretig FM, editors. Textbook of pediatric emergency procedures. 2nd ed. New York: Lippincott Williams & Wilkins; 2008.

Ebinger F, Kosel C, Pietz J, Rating D. Headache and backache after lumbar puncture in children and adolescents: a prospective study. Pediatrics. 2004;113:1588–92.

Friedman AG, Mulhern RK, Fairclough D, Ward PM, Baker D, Mirro J, Rivera GK. Midazolam premedication for pediatric bone marrow aspiration and lumbar puncture. Med Pediatr Oncol. 1991;19:499–504.

Partin WR. Emergency procedures. In: Stone CK, Humphries RL, editors. Current diagnosis & treatment: emergency medicine. 6th ed. New York: McGraw-Hill; 2007.

Suprapubic Bladder Aspiration

134

Maritza A. Plaza-Verduin and Judith K. Lucas

Indications

- Collection of sterile urine for urinalysis and culture (avoiding urethral contamination).
- Collection of sterile urine in a child with gastroenteritis and frequent diarrheal stools.
- Female child with labial adhesions or male child with minimally retractable foreskin.
- Urinary retention.

Contraindications

- Empty or nonpalpable bladder.
- Urination within 1 hour before the procedure.
- Anatomical abnormalities of the gut or genitourinary tract.
- Bleeding diathesis.
- Intestinal obstruction.
- Overlying cellulitis on abdominal wall.
- Lower abdominal scars or wounds.

Materials and Medications

- Sterile gloves.
- Lidocaine (1–2%) with syringe and needle.
- EMLA cream.
- Betadine (povidone-iodine) solution.
- Sterile syringe, 5–20 mL.
- Sterile needle, 22 or 23 gauge, 1.5 inch.
- Sterile specimen container.
- Sterile towels.
- Sterile gauze.
- Sterile dressing.
- Adhesive bandage.

Procedure

1. Place the infant in the supine, frog-leg position (Fig. 134.1).
2. Localize the bladder.
3. Palpate the midline between the umbilicus and the pubis symphysis to feel for bladder fullness:
   - Use a portable ultrasound device to localize the bladder and allow for approximation of bladder size (see later).
4. Localize the symphysis pubis and the imaginary line midline from the umbilicus to the pubic symphysis (Fig. 134.2).
5. Sterilize the area from the umbilicus to the urethra.
6. Drape the area with sterile towels, keeping the puncture site area exposed.
7. The area of insertion should be midline 1–2 cm above the symphysis pubis on the abdominal wall:
   - The suprapubic crease usually can be used as a guideline to the puncture site.
8. Place a small wheal of anesthetic at the intended puncture site, or apply EMLA cream:
   - If using EMLA cream, apply it before sterilization and allow some time for anesthesia to occur.
9. Occlude the urethral opening to avoid spontaneous loss of the urine specimen (Fig. 134.3):
   - In females, directly apply pressure to the urethral meatus.
   - In males, apply gentle pressure to the base of the penis against the pubic symphysis.

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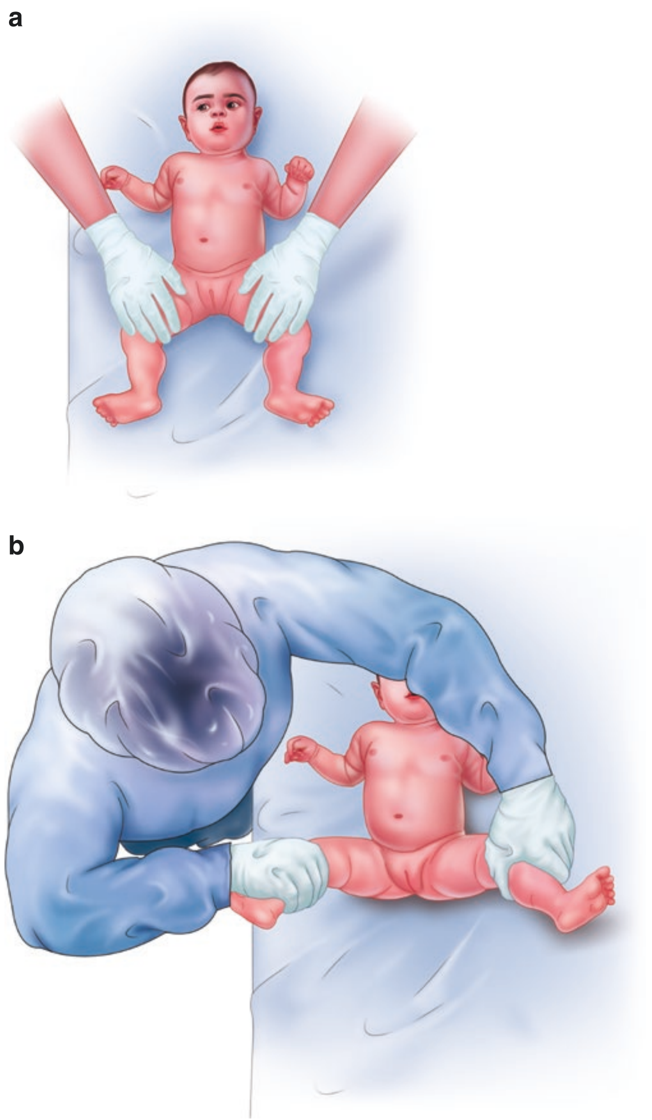

Fig. 134.1 (**a** and **b**) Frog-leg position

- Puncture the skin with the needle (attached to the syringe) at a 10–20° angle to the perpendicular, aiming slightly cephalad.

10. Apply negative pressure to the syringe as the needle is advanced, until urine enters the syringe; do not advance more than 1 inch:
    - If unsuccessful, draw back the needle until it rests in the subcutaneous fat and redirect 10° in either direction.
    - Do not attempt more than three times.
11. Cleanse the area of antiseptic solution and apply an adhesive dressing.

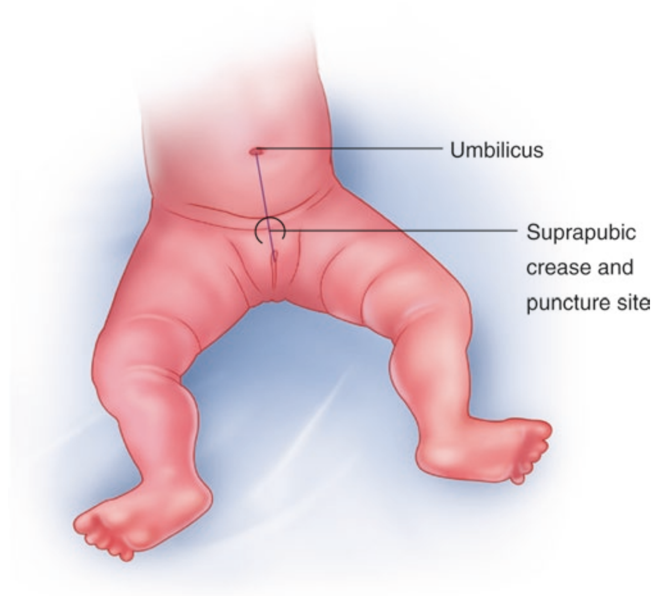

Fig. 134.2 Landmarks

Complications

- Peritoneal perforation with or without bowel perforation.
- Infection.
- Hematuria.
- Inability to aspirate urine.

Pearls and Pitfalls

- If no fluid is obtained, hydrate the child and reattempt in 1 hour.
- Ultrasound can be used to identify bladder size or for ultrasound-guided aspiration:
  – Use a portable ultrasound device with a standoff 7.5-MHz sector probe to allow for superficial scanning and measurement of the diameter of the bladder.
  – Bladder diameter measurement:
    1. Apply approximately 5 mL of ultrasound transmission gel to the infant's suprapubic region.
    2. Apply pressure to the ureteral meatus as previously described.
    3. Gently apply the probe to the suprapubic region in the midline, and scan the area in transverse plane, with the probe directed caudad or cephalad as needed to maximize the bladder image:

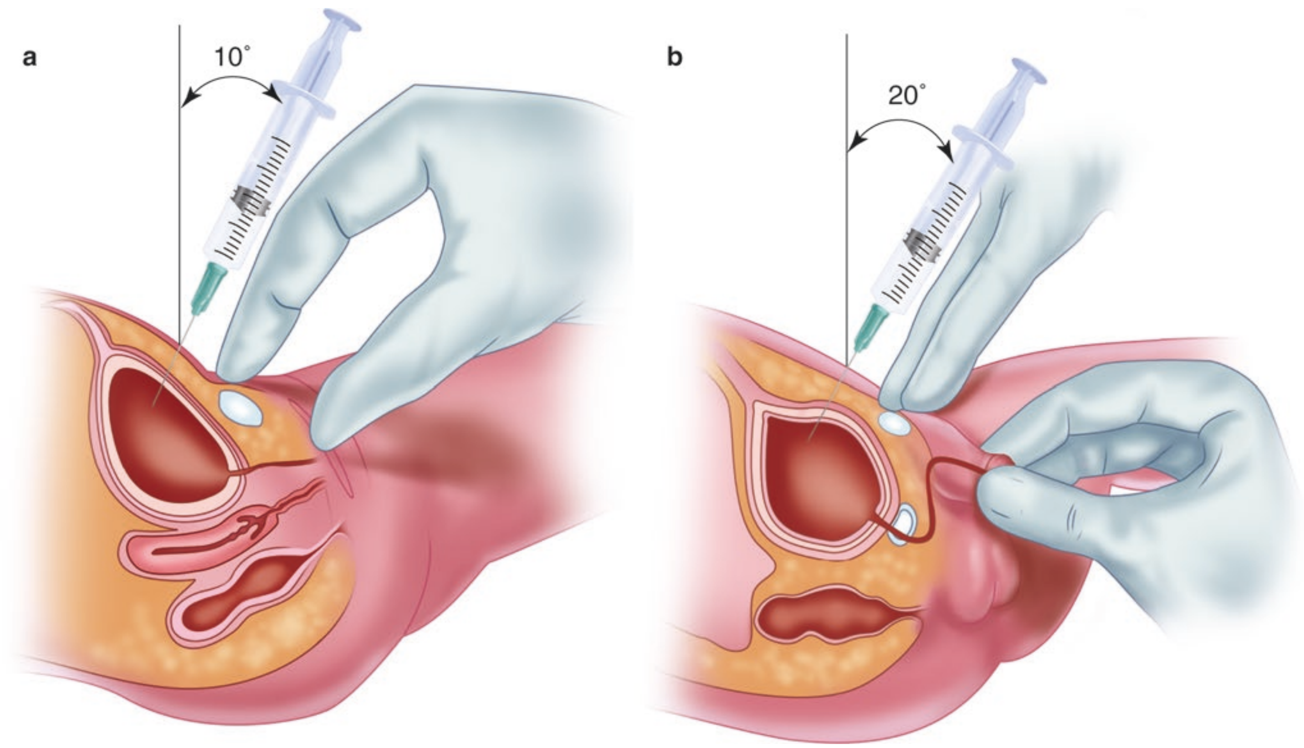

Fig. 134.3 Insert the needle 10–20° perpendicular to the skin, after occluding the urethral opening by direct pressure to the urethral meatus in a female (**a**) or gentle pressure (by squeezing) to the penile urethra in boys (**b**)

- The bladder will appear anechoic below the brighter reflections of the rectus muscle and bladder wall.

4. When the maximum bladder size is obtained, freeze the image:
   - Measure the anteroposterior and transverse internal bladder diameters.
   - Goal measurement is 2 cm or more of each diameter. If either diameter is less than 2 cm, the bladder is considered to be empty.

– Ultrasound-guided bladder aspiration:
1. After preparing the sterile field, place a sterile sheath over the ultrasound probe and proximal cable:
   - Gel should be placed within the sheath to eliminate the air interface between the probe and the sheath.
2. Apply gel to the abdomen above the symphysis pubis.
3. Locate the bladder and measure the maximum diameter as described previously.
4. Insert the needle midline at the location where the bladder wall is closest to the probe.
5. Continue steps for aspiration as described previously.

Suggested Reading

Kozer E, Rosenbloom E, Goldman D, Lavy G, Rosenfeld N, Goldman M. Pain in infants who are younger than 2 months during suprapubic aspiration and transurethral bladder catheterization: a randomized, controlled study. Pediatrics. 2006;118:e51–6.

Leong Y, Tang KW. Bladder aspiration for diagnosis of urinary tract infection in infants and young children. J Singapore Paediatr Soc. 1976;18:43–7.

Loiselle JM. Ultrasound-assisted suprapubic bladder aspiration. In: King C, Henretig FM, editors. Textbook of pediatric emergency procedures. 2nd ed. New York: Lippincott Williams & Wilkins; 2008.

Pollack CV, Pollack ES, Andrew ME. Suprapubic bladder aspiration versus urethral catheterization in ill infants: success, efficiency and complication rates. Ann Emerg Med. 1994;23:225–30.

Polnay L, Fraser AM, Lewis JM. Complication of suprapubic bladder aspiration. Arch Dis Child. 1975;50:80–1.

135 Removal of Hair/Thread Tourniquet

Judith K. Lucas

Indications

- Consider the diagnosis when presented with an appendage that has a well-demarcated, circumferential, painful, edematous distal segment, adjacent to a nonedematous, nonerythematous proximal portion (Fig. 135.1).
- Removal is imperative in all cases of tourniquet syndrome and should be undertaken without delay.
- The method of removal is determined by the degree of constriction:
  - Unwrapping: in situations with minimal or no edema and the ability to visualize the offending hair or thread
  - Blunt probe, cutting mild to moderate edema
  - Incision: severe swelling or inability to visualize the constricting band; epithelialization
  - Depilatory: for areas with mild to moderate edema, but without epithelialization

Fig. 135.1 Hair tourniquet

Contraindications

- Absolute
  - There are no absolute contraindications; the tourniquet must be removed.
- Relative
  - Based on the specific approach, such as avoiding incising the skin of a patient with hemophilia, or avoiding depilatory creams in a patient with known allergies to such substances

Materials and Medications

- Unraveling technique:
  - Fine-tipped, non-rat-tooth forceps or small, fine hemostats
- Blunt probe and tourniquet cutting:
  - Antiseptic solution of choice
  - Lidocaine 1% without epinephrine for local or regional anesthesia
  - Scalpel blade #11 or iris scissors
  - Blunt probe or metal earwax curette
- Incision technique:
  - Antiseptic solution of choice
  - Lidocaine 1% without epinephrine for local or regional anesthesia
  - Scalpel blade #11

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  - Fine-tipped, non-rat-tooth forceps or small, fine hemostats
- Depilatory technique:
  - Commercial depilatory cream

Procedures

- Unraveling method (Fig. 135.2):
  1. Place the appendage in an orientation that maximizes exposure.
  2. Apply skin traction so that the greatest amount of the tourniquet and base of the constriction can be seen.
  3. Look closely to identify a free end of the hair or thread. If no free end is visible, identify an area of bunching or a knot. Break the knot from the strand and grasp the end with the forceps or hemostat.
  4. Slowly and gently pull and unwind the hair.
  5. This procedure may take several attempts because the hair strand or thread may break repeatedly during removal. Sometimes more than one hair strand may be involved.
- Blunt probe and cutting method (Figs. 135.3 and 135.4):
  1. Apply gentle traction to the skin to maximally expose the involved area and to make the base of the wedge caused by the tourniquet as shallow as possible.
  2. Gently impose a blunt probe or a metal ear curette between the skin and the tourniquet, starting proximally to the band and sliding distally beneath the constriction.
  3. Cut the tourniquet by sliding the scalpel blade along the edge of the probe, placing the blunt edge of the scalpel against the skin and slicing the constricting material in a movement away from the skin, in order to avoid inadvertently cutting the skin.
  4. Once an end of the tourniquet has been created, the remainder of the offending strap can be removed via unraveling.
- Incision technique for digits (Fig. 135.5):
  1. Perform a digital nerve block to anesthetize the extremity proximal to the constriction.
  2. Sterilize the involved area with antiseptic solution of choice, and drape in typical protocol to allow as sterile a procedure as is possible outside a surgical suite.
  3. Incise the skin across the demarcation indicating the presence of the tourniquet at the 3 o'clock or 9 o'clock position or the midline dorsal area (12 o'clock), passing the scalpel blade proximally to distally and down to the bone (Fig. 135.6). Incision at these locations will avoid the laterally located neurovascular bundles of the digits.
- Incision technique for severe penile tourniquet:
  1. Begin with a dorsal nerve block (Fig. 135.7).
  2. Sterilize the involved area with antiseptic solution of choice, and drape in typical protocol to allow as sterile a procedure as is possible outside a surgical suite.
  3. A longitudinal incision is made at either the 4 o'clock or the 8 o'clock position, in order to avoid the penile neurovascular structures located dorsally.
  4. The incision should be made perpendicular to the tourniquet, but shallowly, in order to avoid penetration through the deep fascia. It will be necessary to repeat the incision, staying within the original incision, gently but repeatedly in order to cut through the whole tourniquet. In this way the constriction is relieved, but the integrity of the corpus cavernosum and the corpus spongiosum is maintained (Fig. 135.8).
  5. Once the layers of the tourniquet have been interrupted, grasp an end of the hair/thread, and remove the remainder of the tourniquet by utilizing the unraveling method.
- Depilatory method:
  1. Depilatories work only on hair and will not work on threads.
  2. Apply the depilatory cream directly to the hair tourniquet with a saturated cotton swab, so as to avoid applying this potential irritant to surrounding tissue.
  3. Wait the recommended amount of time, as dictated by whatever brand of depilatory is used (usually about 10 minutes).

Fig. 135.2 A good example for use of the unraveling technique. The edema is minimal, and the hair is easily identifiable

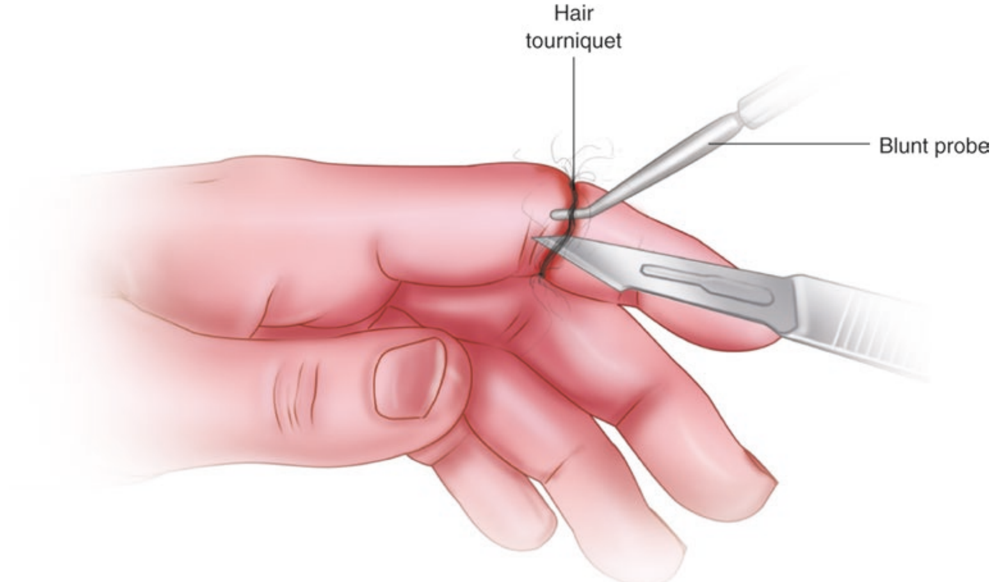

Fig. 135.3 Blunt and cut method. Notice that the cutting edge of the scalpel blade is away from the skin as it is placed adjacent to the probe and slips beneath the tourniquet

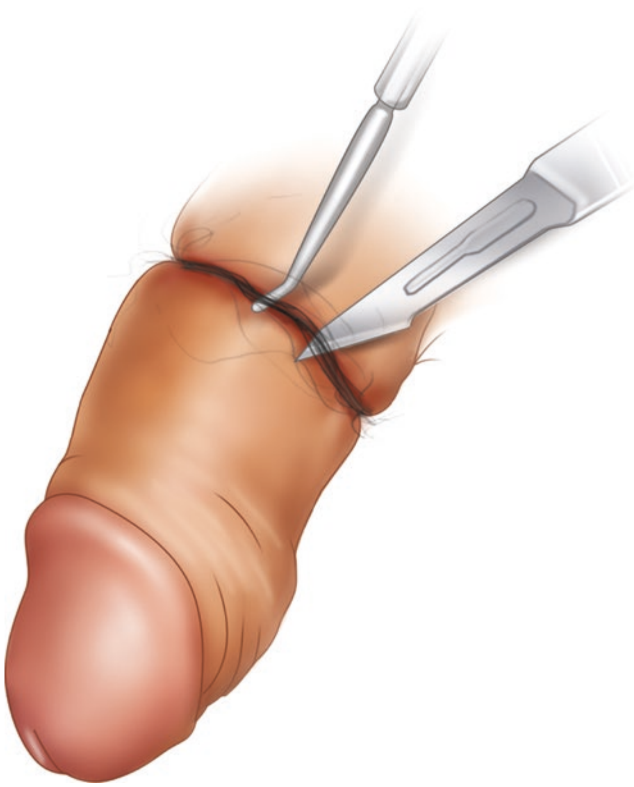

Fig. 135.4 Blunt and cut method

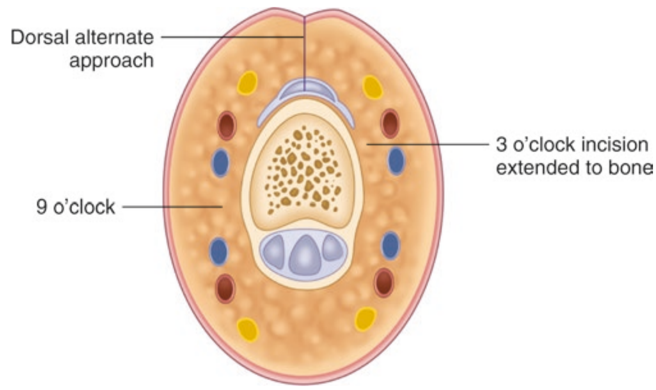

Fig. 135.5 Incision technique for digits

4. After the appropriate time has elapsed, wash off the cream thoroughly with soap and water.

Complications

- Necrosis of tissue distal to the tourniquet.
- Neurovascular damage secondary to prolonged ischemia.
- The incision technique can cut into the tendon insertions or neurovascular bundles of the digits or into the corpus

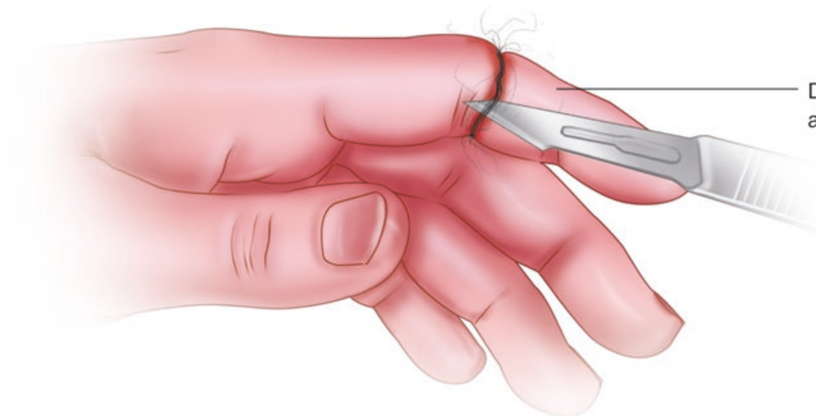

Fig. 135.6 Incision at 12 o'clock preferred

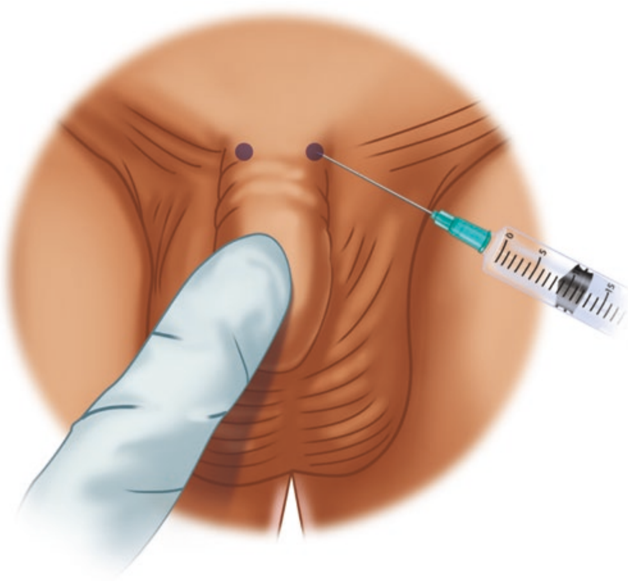

Fig. 135.7 Dorsal nerve block

callosum of the penis. Be certain to ascertain function after incision.
- Infection, especially after incision.

Pearls and Pitfalls

- Pearls
  - All tourniquets must come off.
  - The easiest way to get to the bottom of the tourniquet, regardless of method used, is to identify the knot or bunched area if possible.
  - When using the incision technique, keep the incision in the longitudinal plane of the appendage and perpendicular to the tourniquet. This may result in a longitudinal incision of the extensor tendon but will not transect it or affect its function.
  - Do not use a depilatory on an open wound, as it can be painful. Direct incision may be preferred.
  - 24-hour follow-up is mandatory. If the tourniquet has been present for an extended period, it may take several days for return of color and blood flow.
  - Be certain to document neurovascular status before and after tourniquet removal.
  - Consider surgical consult in cases of severe tissue edema or distorted anatomy.
  - Tourniquets have been described in the child abuse literature. Consider that possibility in the preverbal child.

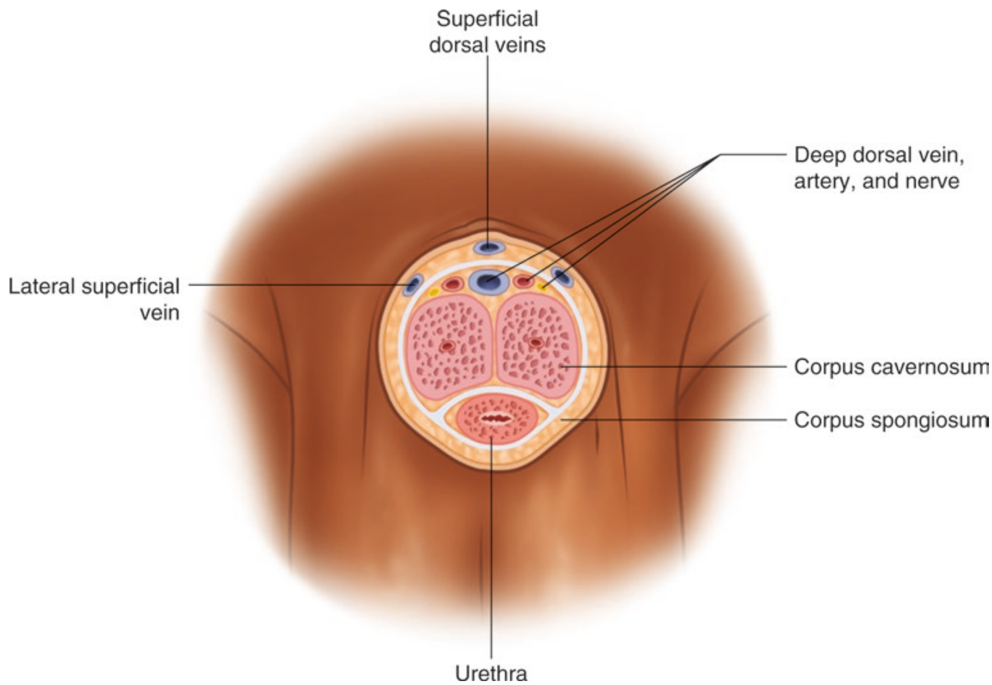

Fig. 135.8 Penile tourniquet schematic

- Consider topical antibiotic treatment if there is skin compromise.
- Pitfalls
  - Depilatories will not work on nonorganic tourniquets.

Suggested Reading

Bothner J. Hair entrapment removal techniques. UpToDate. Accessed 30 Nov 2010.

Hoppa E. Hair tourniquet and other narrow constricting bands: clinical manifestations, diagnosis, and treatment. UpToDate. Accessed 26 June 2019. https://www.uptodate.com/contents/hair-tourniquet-and-other-narrow-constricting-bands-clinical-manifestations-diagnosis-and-treatment#H18433820

Klusmann A. Tourniquet syndrome—accident or abuse? Eur J Pediatr. 2004;163:495–8.

Lundquist ST, Stack LB. Genitourinary emergencies: diseases of the foreskin, penis, and urethra. Emerg Med Clin North Am. 2001;19:529–46.

Muncy D. Hair tourniquet removal. Medscape. Available at: https://emedicine.medscape.com/article/1348969-overview. Accessed 26 June 2019.

Peleg D, Steiner A. The Gomco circumcision: common problems and solutions. Am Fam Physician. 1998;58:891–8.

Use of the Broselow Tape

136

Judith K. Lucas

Indications

- To determine the equipment size and the medication doses during a pediatric resuscitation, without having to take the time to perform calculations

Contraindications

- Premature infant or newborn whose heel, while the infant is fully extended, does not fall at least into the white area (corresponding to 3, 4, and 5 kg).
- The length of the child exceeds the distal end of the green area (36 kg).

Material

- Broselow Pediatric Emergency Tape (Armstrong Medical Industries, Wilshire, IL) (Figs. 136.1 and 136.2)

Procedure

- Place the infant or child on the bed in the supine position (Fig. 136.3).
- Extend the Broselow Pediatric Emergency Tape next to the patient, placing the red line at the top of the patient's head (Fig. 136.4).
- With the patient fully extended, especially through the hips and knees, align the bottom of the heel while the ankle is flexed and toes upward, with the color on the tape adjacent to the heel (Fig. 136.5).
- The color on the tape corresponds to the patient's weight.

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Fig. 136.1 Broselow tape, proximal end (at patient's head)

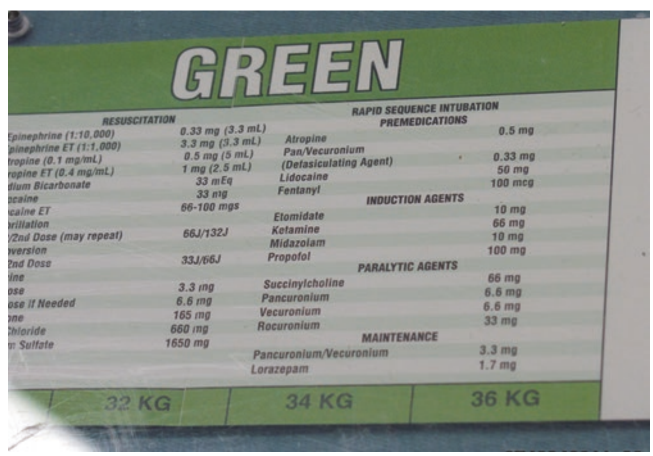

Fig. 136.2 Broselow tape, distal end (the tape will accommodate a 36-kg child, at most)

- The side of the tape with weights noted along the bottom has medication doses for resuscitation, rapid-sequence intubation (RSI), and paralytics (Fig. 136.6).
- The top half of the other side of the tape has the appropriate dosing for managing seizures, overdoses, elevating

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Fig. 136.3 Placement of the child on the tape

intracranial pressure, and fluids. The bottom half of this side has the appropriate equipment sizes, such as endotracheal (ET) tubes, nasogastric (NG) tubes, chest tubes, and other equipment, which correspond to the patient's weight (Fig. 136.7).

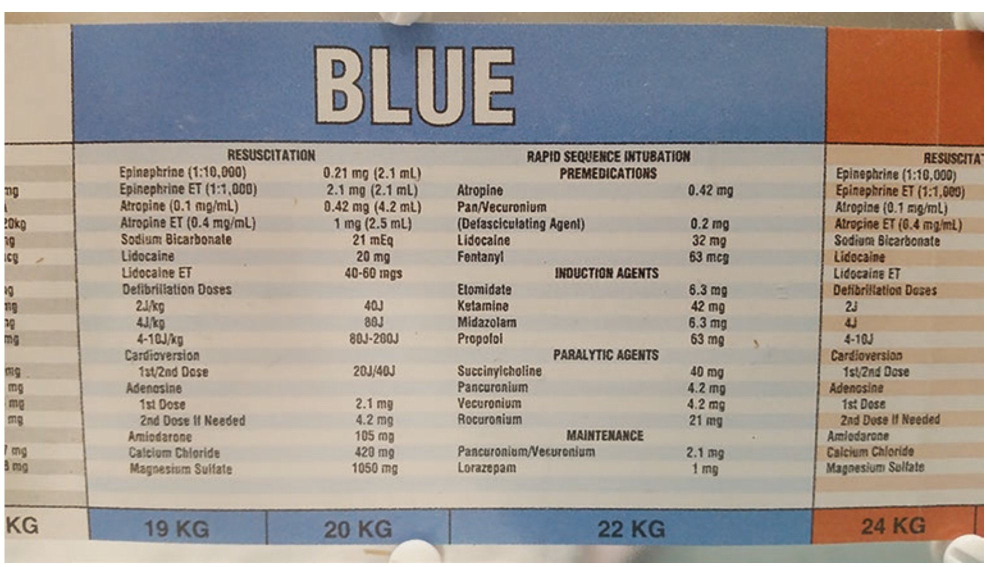
Pearls and Pitfalls

- Pearls
  - Be certain that the top of the head is at the red line and that the patient's body is fully extended. Infants tend to lie flexed at the hips and knees.
  - Determining the appropriate color code depends on noting the bottom of the heel while the ankle is flexed and the toes are pointing upward.

Fig. 136.4 Placement of the child on the tape

Fig. 136.5 Placement of the child on the tape

Fig. 136.6 Front of the tape. Weight groupings are noted at the bottom. This is the side with resuscitation and rapid-sequence intubation (RSI) medications



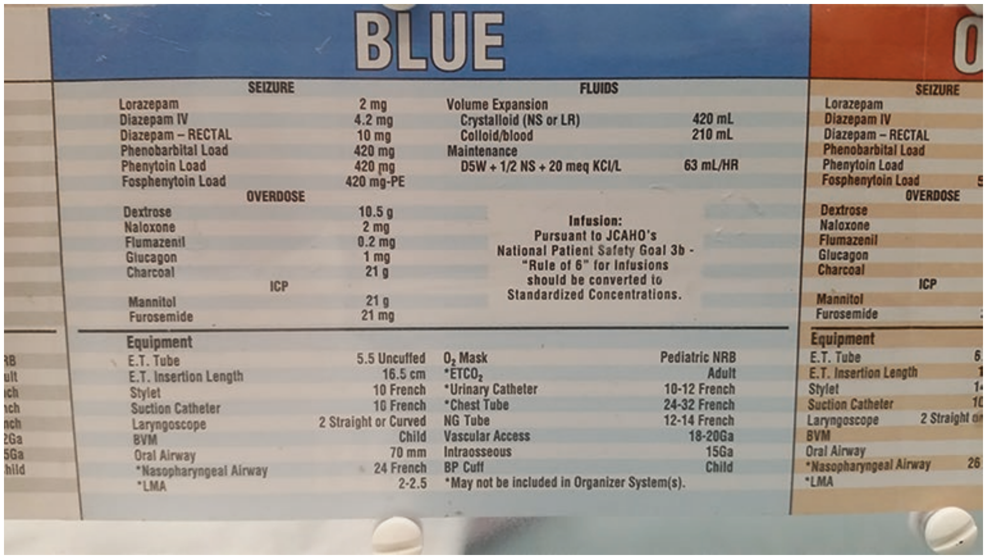


Fig. 136.7 Reverse side of the tape. This side has medications for critical interventions aside from the primary survey, as well as equipment sizes

- Pitfalls
  – Beware of the child who is unusually heavy compared with other children of the same height.

Suggested Reading

Luten R. Error and time delay in pediatric trauma resuscitation: addressing the problem with color-coded resuscitation aids. Surg Clin North Am. 2002;82:303–14, vi.

Luten R, Broselow J. Standardization of product concentration in emergency dosing: a response to Fineberg and Arendt. Ann Emerg Med. 2008;52:477–8.

Rosenberg M, Greenberger S, Rawal A, Latimer-Pierson J, Thundiyil J. Comparison of Broselow tape measurements versus estimations of pediatric weights. Am J Emerg Med. 2011;29:482–8.

Nursemaid's Elbow

137

Judith K. Lucas

Definition

- An injury commonly seen in children between 6 months and late preteens, although generally seen between 1 and 3 years
- A subluxation of the radial head, usually resulting from sudden, longitudinal traction on an extended arm with the wrist pronated
- Often occurs when a parent/caregiver is holding the child by the hand while walking and suddenly pulls the child away from a dangerous situation (Fig. 137.1)

Fig. 137.1 Note that the toddler prefers to hold her right arm pronated and somewhat flexed at the elbow. When asked where it hurts, she may as often point to her wrist as to her elbow. There will be no soft tissue swelling anywhere along the upper extremity

Clinical Diagnosis

- History of pulling-type injury.
- Child presents with arm adducted, held slightly flexed at the elbow and pronated (Fig. 137.1).
- The child may point to the elbow or wrist as the source of pain, but both areas are without any swelling and are non-tender on palpation.
- The elbow can be flexed and extended, but the forearm cannot be supinated.
- Radiography is not required if the patient presents with the classic story of arm pulling and no direct trauma to the extremity.

Indication

- Clinical presence of subluxed radial head

Contraindications

- Absolute
  - Radiographic evidence of elbow or forearm fracture
  - Swelling or pain about the elbow, forearm, or wrist
- Relative
  - Unknown history or witnessing of pulling-type injury

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Materials and Medications

- None

Procedure: Hyperpronation (Preferred Method) (Fig. 137.2)

1. Explain to the caretaker that the reduction will cause the child *very brief* discomfort.
2. Seat the child on the lap of a parent/caregiver or an assistant, facing the operator and holding the child in such a way as to hold the child's humerus against his or her side.
3. The physician performing the procedure holds the elbow at approximately 90° and grasps the elbow, with the thumb over the region of the radial head (in order to be able to palpate the reduction "clunk" or "click").
4. The physician then holds the patient's wrist firmly and rapidly hyperpronates the forearm. A palpable or audible "click" signifies successful reduction but may not be appreciable.
5. The child may cry for a few minutes after reduction. The provider should leave the bedside for 5–10 minutes and instruct the parent or caregiver to allow the child simply to play, without focusing on the affected arm.
6. After approximately 10 minutes, return to the bedside and reevaluate the child, who should have full use of the arm by then.

Alternative Procedure: Supination (Fig. 137.3)

1. Follow the first three steps for the hyperpronation method above.
2. While holding the patient's wrist firmly, the operator steadily supinates the patient's forearm completely, followed by flexing the elbow, bringing the patient's wrist up to the shoulder.
3. Follow steps 5 and 6 above.

Evaluation After Procedure

- If the child has complete use of the arm, no further intervention is required.
- If the child is still unable to supinate the forearm after 20–30 minutes, consider a repeat attempt at reduction.
- If there is still no return to full function after 30 minutes and/or repeated attempts at reduction, X-rays should be considered.

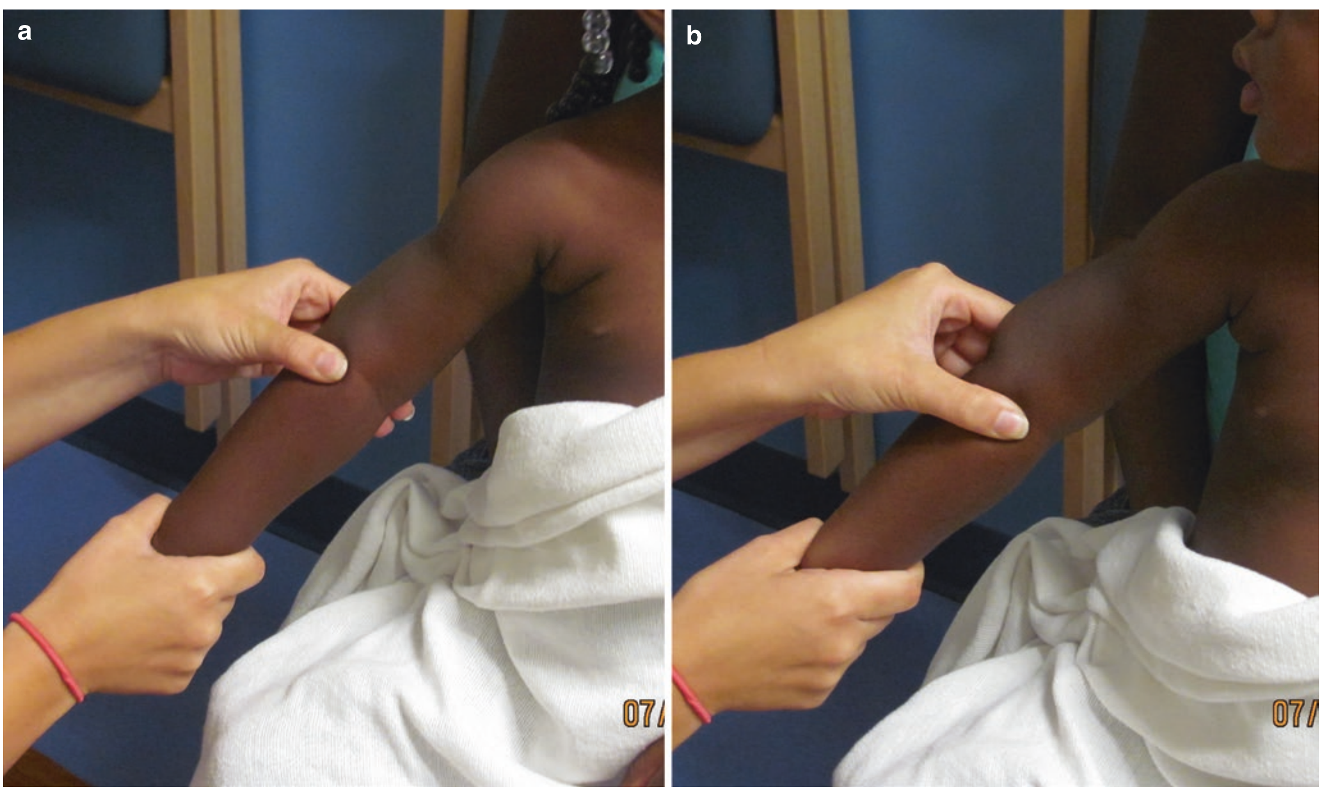

Fig. 137.2 Pronation: (**a**) The examiner's left hand holds the patient's radial head and medial condyle to better appreciate palpable reduction of the subluxation. (**b**) The examiner's right hand gently, but firmly, hyperpronates the patient's forearm from the level of the wrist. Within this maneuver, the examiner should feel or sense a "pop"

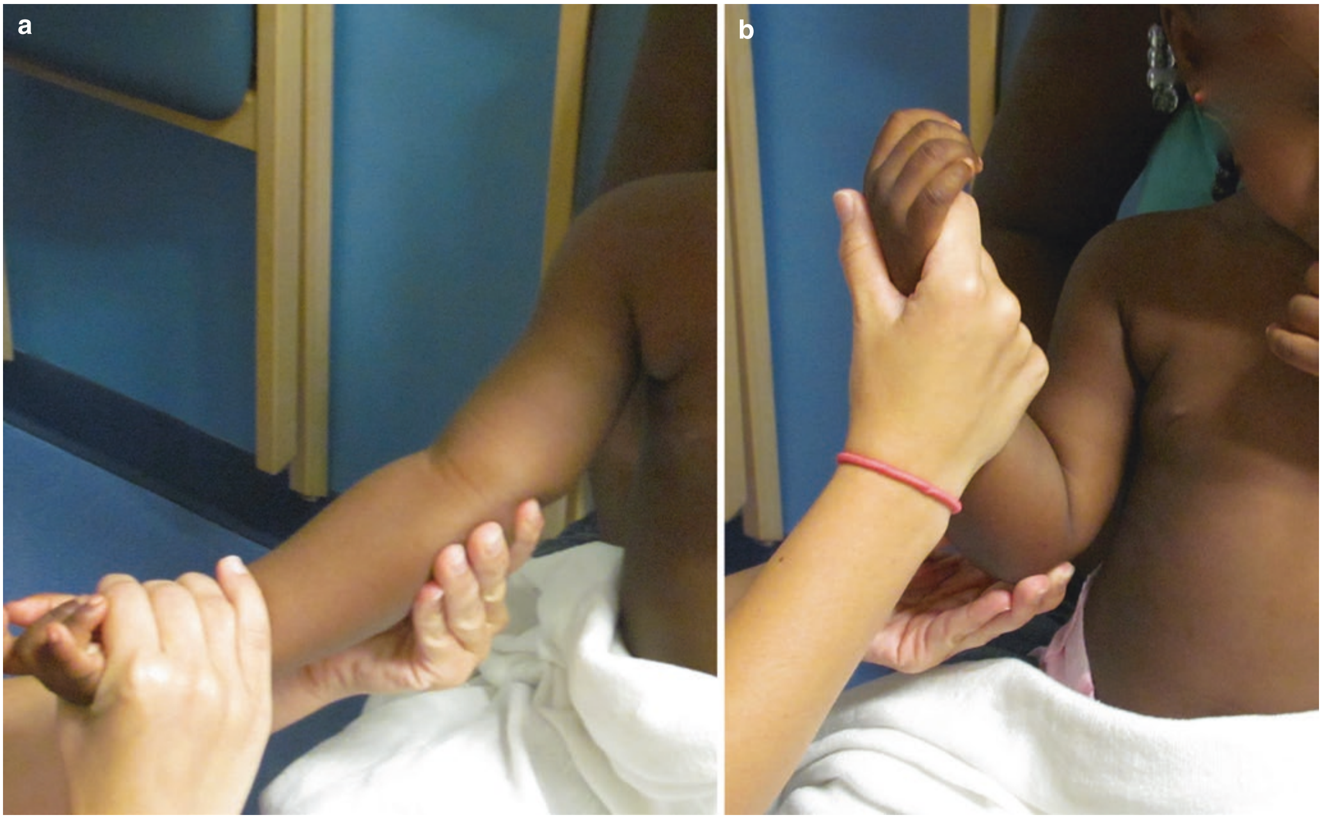

Fig. 137.3 Supination: (**a**) The examiner's left hand is in the same position as for the pronation technique. (**b**) The examiner supinates the forearm, from the level of the wrist, and fully flexes at the elbow. In either of these two maneuvers, the examiner should feel or sense a "pop"

- If X-rays are negative but the child still refuses to use the arm, the child should be reevaluated in 24 hours.

Pearls and Pitfalls

- Pearls
  - After reduction, analgesic medications are rarely needed. If the need arises, stay with ibuprofen because it is a proven anti-inflammatory.
  - Consider the use of distracting techniques such as offering a toy or a phone while holding/immobilizing the child's unaffected arm, as the child may be hesitant at first to start using the arm.
  - If no improvement is seen within 15 minutes of reduction, consider the injury to be a fracture, and obtain appropriate views of the elbow and forearm.
  - If there is a significant delay between injury and reduction (more than 12 hours) or recurrent episodes occur, consider placing a long-arm posterior splint with orthopedics follow-up.
- Pitfalls
  - The longer the radial head has been subluxed, the longer it will take the child to return to full use.

Suggested Reading

Krul M, van der Wouden JC, Koes BW, Schellevis FG, van Suijlekom-Smit LW. Nursemaid's elbow: its diagnostic clues and preferred means of reduction. J Fam Pract. 2010;59:e5–7.

Krul M, van der Wouden JC, van Suijledom-Smit LW, Koes BW. Manipulative interventions for reducing pulled elbow in young children. Cochrane Database Syst Rev. 2009;4:CD007759. https://doi.org/10.1002/14651858.CD007759.pub2.

Macias CG, Bothner J, Wiebe R. A comparison of supination/flexion to hyperpronation in the reduction of radial head subluxations. Pediatrics. 1998;102:e10–8.

Quan L, Marcuse EK. The epidemiology and treatment of radial head subluxation. Am J Dis Child. 1985;139:1194–7.

Switzer JA, Ellis T, Swiontkowski MF. Wilderness orthopaedics. In: Auerbach PS, editor. Wilderness medicine. 5th ed. Philadelphia: Elsevier; 2007. p. 573.

Push-Pull Technique for Fluid Administration During Pediatric Resuscitation

138

Ariel E. Vera, Emily Drone, and Judith K. Lucas

Indications

- Rapid fluid resuscitation is the backbone of treatment for most types of pediatric shock. Achieving the recommended fluid rates is not always easy. The push-pull technique is a simple method for delivering rapid fluid infusion rates by a single provider.
- Indications include any situation where the fluid infusion rate required is greater than what is achievable with IV pumps, rapid infuser devices, or pressure bags.
- During pediatric shock, fluid rates of up to 20 mL/kg over 5 minutes may be required.

Contraindications

- Absolute
  - None
- Relative
  - Small-gauge IV access, which may compromise the IV line
  - Circumstances in which a rapid fluid infusion rate may lead to cardiovascular deterioration

Materials (Fig. 138.1)

- IV-line tubing
- Three-way stopcock
- Extension tubing
- 20-mL syringe
- IV fluids

Procedure

1. Obtain intravenous (IV) or intraosseous (IO) access. Rapid fluid administration can be achieved on peripheral lines or intraosseous access. A peripheral large-bore IV offers less resistance than a central line, so higher fluid rates are achievable.
2. Attach a three-way stopcock to the end of the IV bag line.
3. Connect extension tubing to the three-way stopcock.
4. Connect the 20-mL syringe to the remaining three-way stopcock opening.
5. Prime the line with normal saline to remove air from the line.
6. Connect extension tubing to the patient's IV/IO line.
7. Turn the stopcock off to the patient and on to the IV tubing (Fig. 138.2).
8. Pull fluid into the syringe to fill 20 mL (or amount desired) of normal saline.
9. Turn the stopcock off to the IV line and on to the patient (Fig. 138.3).
10. Push fluids into the patient.
11. Turn the stopcock off to the patient and on to the IV tubing, and repeat cycles until the total amount of fluid desired is achieved.

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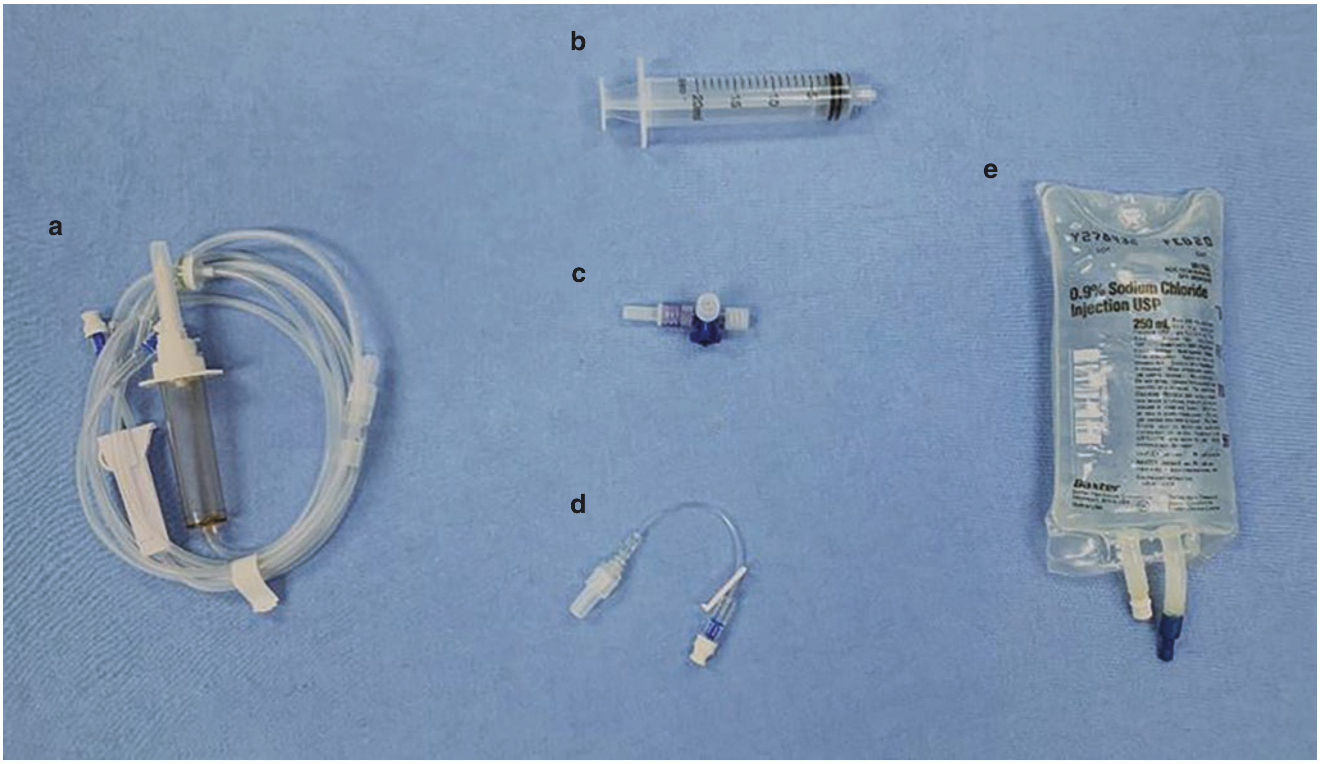

Fig. 138.1 (**a**) IV-line tubing. (**b**) 20-mL syringe. (**c**) Three-way stopcock. (**d**) Extension tubing. (**e**) IV fluids

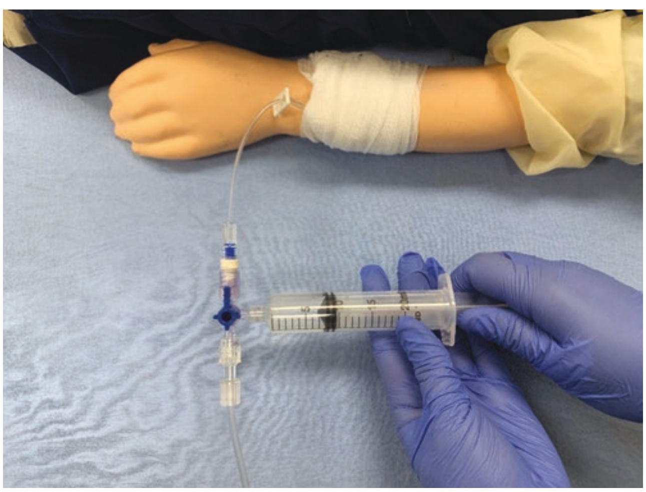

Fig. 138.2 Three-way stopcock off to the patient, to draw fluid from the syringe

Fig. 138.3 Three-way stopcock, off to the IV line and push for rapid fluid infusion to the patient

Pearls and Pitfalls

- Pearls
  - Any syringe size may be used, but using a 20-mL syringe may simplify the process, given that the recommended initial volume for most cases involving pediatric resuscitation is 20 mL/kg. By using a 20-mL syringe, the patient's weight in kilograms is equal to the number of push-pull cycles required.
  - A 20-mL syringe may be associated with less hand fatigue than using larger syringes.
- Pitfalls
  - Be careful of intravenous air injection during rapid infusion methods, as it can lead to pulmonary air embolism.
  - If blood is withdrawn during a pulling error, the integrity of the IV catheter may be compromised.

Suggested Reading

Cole ET, Harvey G, Foster G, Thabane L, Parker MJ. Study protocol for a randomised controlled trial comparing the efficiency of two provider-endorsed manual paediatric fluid resuscitation techniques. BMJ Open. 2013;3:pii: e002754. https://doi.org/10.1136/bmjopen-2013-002754.

Oliveira CF, Nogueira de Sá FR, Oliveira DS, Gottschald AF, Moura JD, Shibata AR, et al. Time- and fluid-sensitive resuscitation for hemodynamic support of children in septic shock: barriers to the implementation of the American College of Critical Care Medicine/Pediatric Advanced Life Support Guidelines in a pediatric intensive care unit in a developing world. Pediatr Emerg Care. 2008;24:810–5. https://doi.org/10.1097/PEC.0b013e31818e9f3a.

Toshniwal G, Ahmed Z, Sengstock D. Simulated fluid resuscitation for toddlers and young children: effect of syringe size and hand fatigue. Paediatr Anaesth. 2015;25:288–93. https://doi.org/10.1111/pan.12573.

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L. Ganti (ed.), *Atlas of Emergency Medicine Procedures*, https://doi.org/10.1007/978-3-030-85047-0