POLTAVA STATE MEDICAL UNIVERSITY
Department of Anesthesiology and Intensive Care

General principles of the anesthesia

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assistant professor

Lecture plan

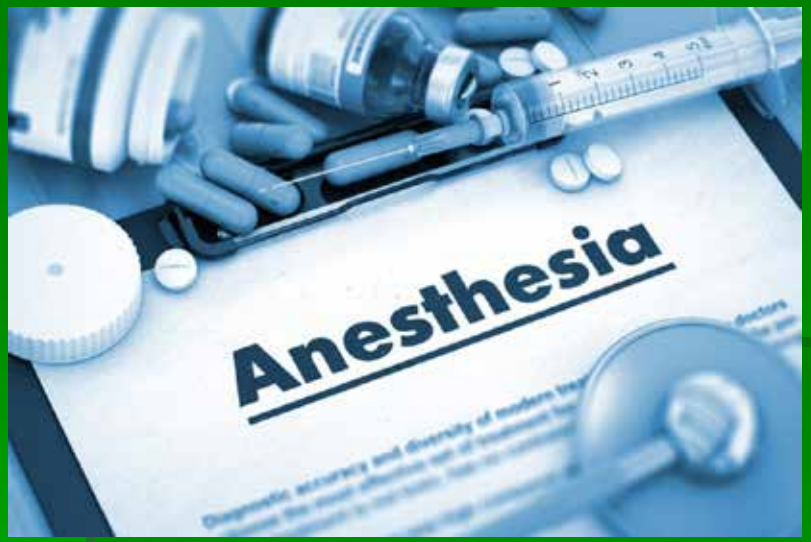
1. Legal provision of medical assistance to the population
2. Determine the required volume of medical care for different segments of the population according to the stage of providing medical care;
3. Determine the necessary logistical equipment for the various stages of medical care
4. Tasks and types of premedication.

Lecture plan

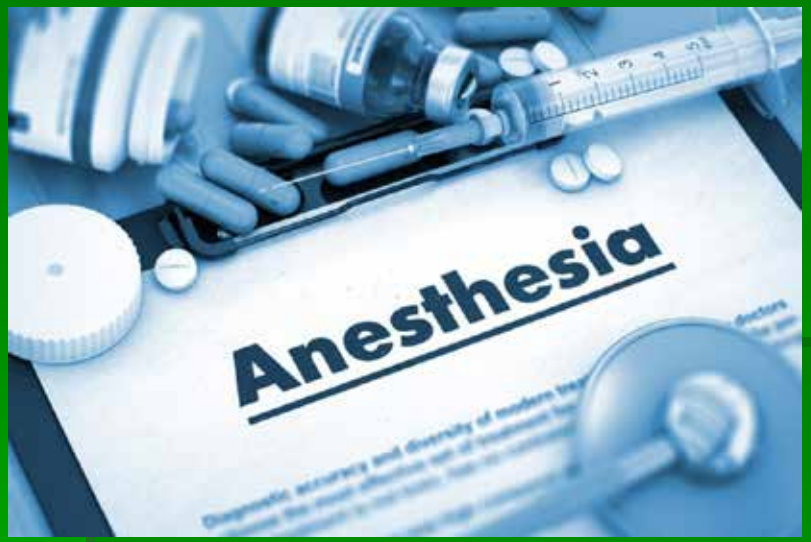
5. Assessment of anesthesiology and surgery risk.
6. Classification and physiological substantiation of the main types of anesthesiology.
7. Organization of postoperative management in patients of different age groups.
8. Recommendations on the structure of the anesthesiology and IT service in health care establishments in Ukraine.

Lecture plan

9. Classification of methods of inhalation anesthesia.
10. Respiratory circuits.
11. Inhalation anesthesia.
12. Non-inhalation anesthesia.
13. Possible complications of anesthesia drugs, their prevention, diagnosis and therapy.



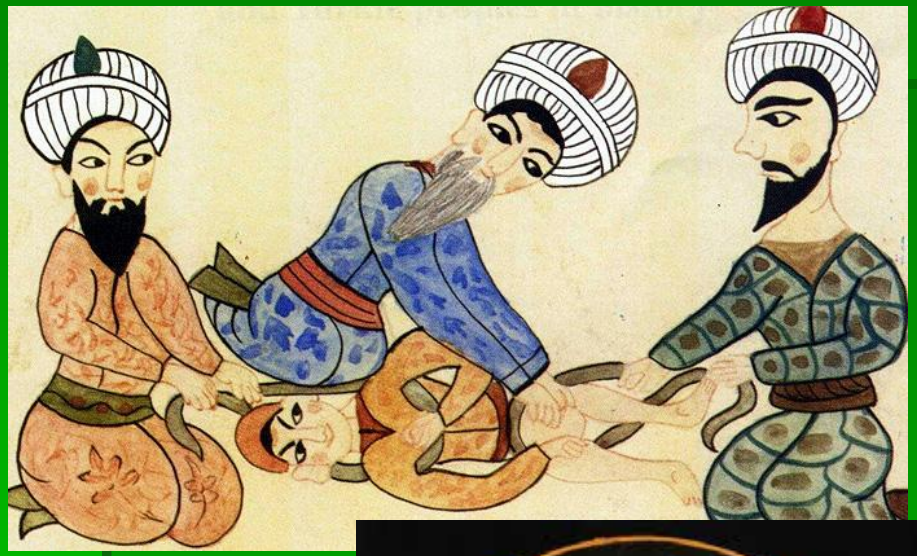
a state of controlled, temporary loss of sensation or awareness that is induced for medical purposes

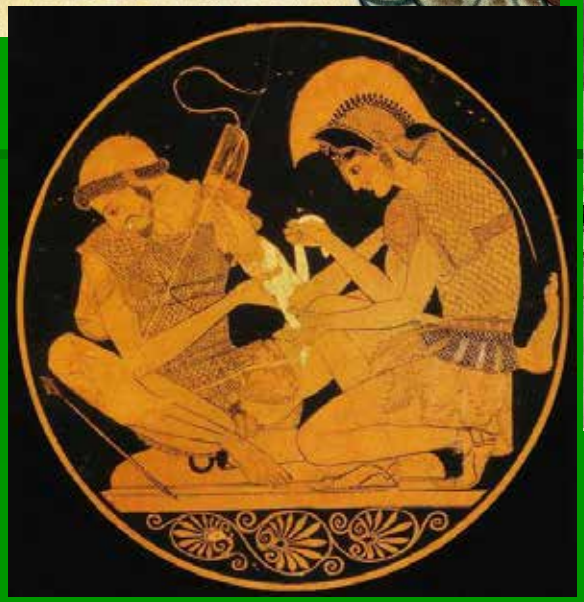


General anesthesia is a drug-induced reversible state defined by five end points:

- **Unconsciousness**, lack of awareness of sensory input
- **Analgesia**, lack of pain
- **Akinesia**, lack of movement
- **Amnesia**, lack of recall
- **Physiological** stability, the preservation of normal levels of all vital physiological functions, such as respiration, heart rate, blood pressure, and temperature

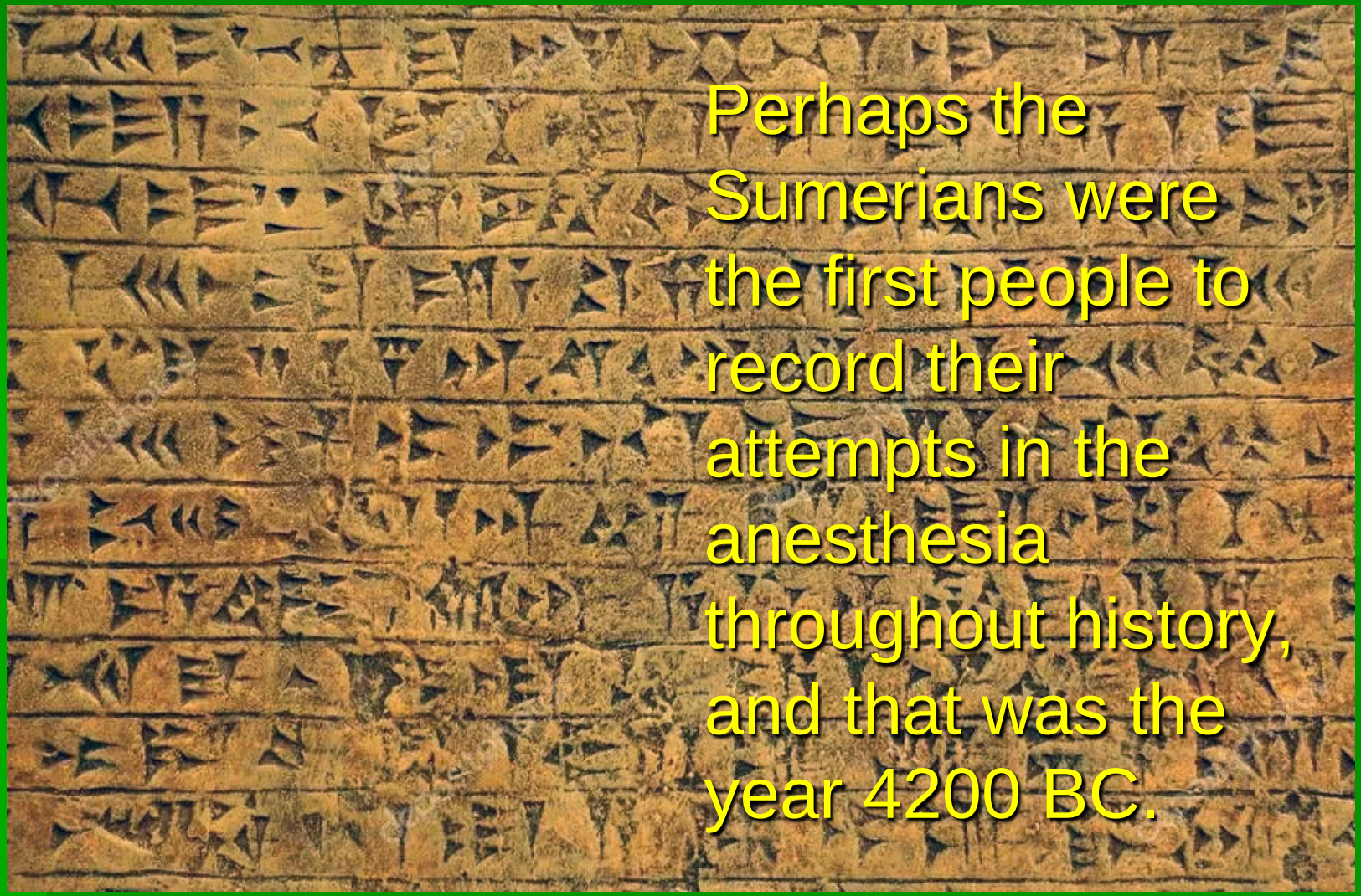
History





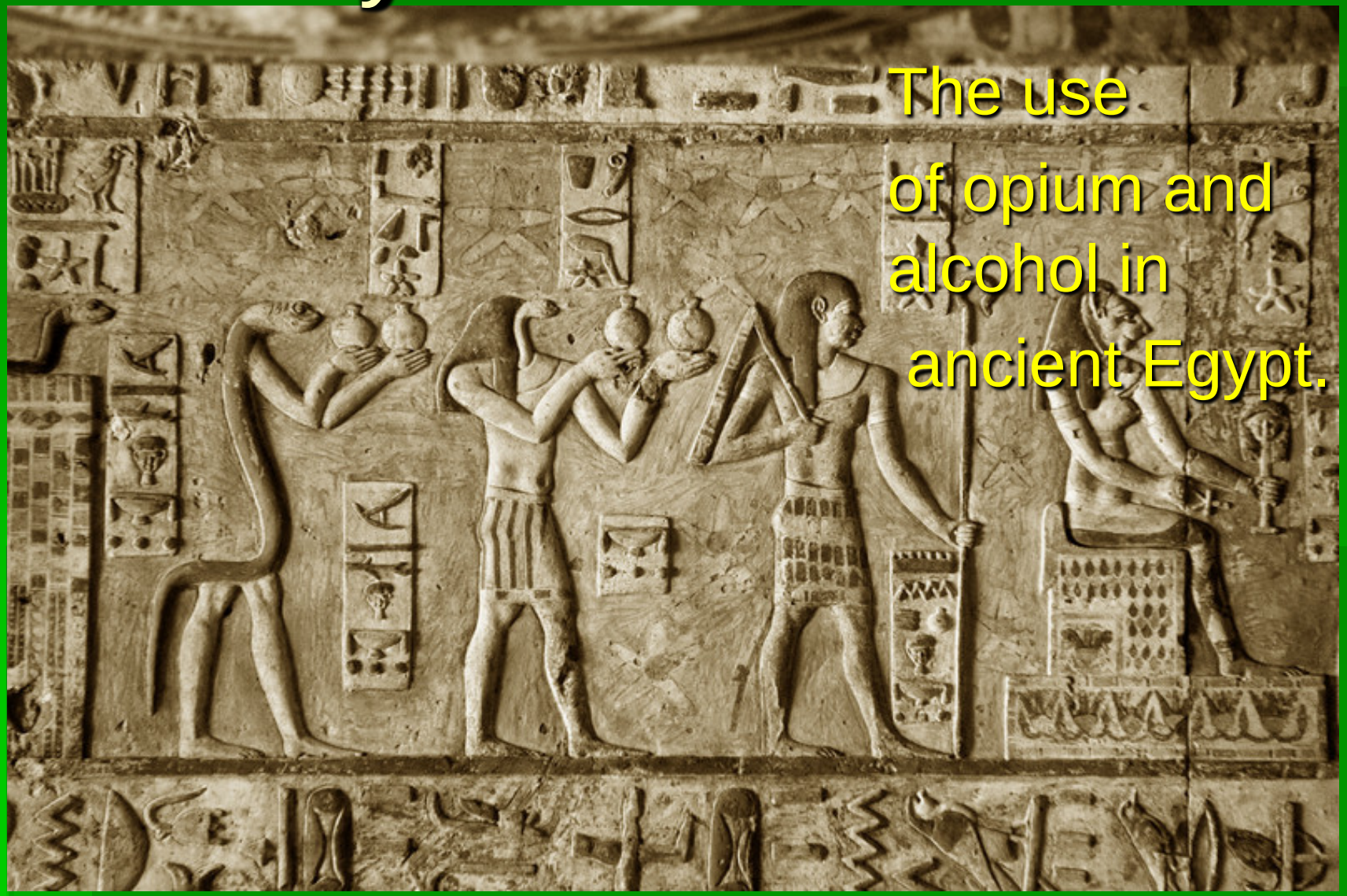
The use
of manual fixation.

History



Perhaps the Sumerians were the first people to record their attempts in the anesthesia throughout history, and that was the year 4200 BC.

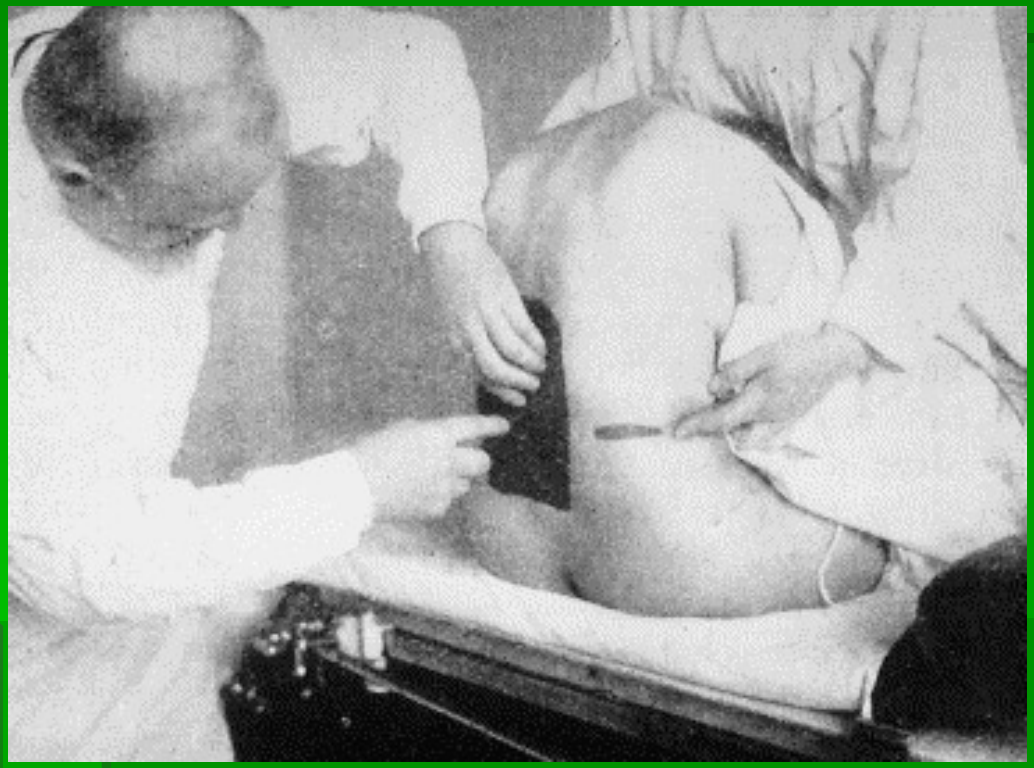
History



History

16 october 1846 William Thomas Green Morton, American dental surgeon, gave the first successful public demonstration of ether anesthesia during surgery.

History



August 16, 1898, August Bier performed the first successful "cocainization“ of the spinal cord (spinal anesthesia) as an alternative to general anesthesia.

Types of anesthesia

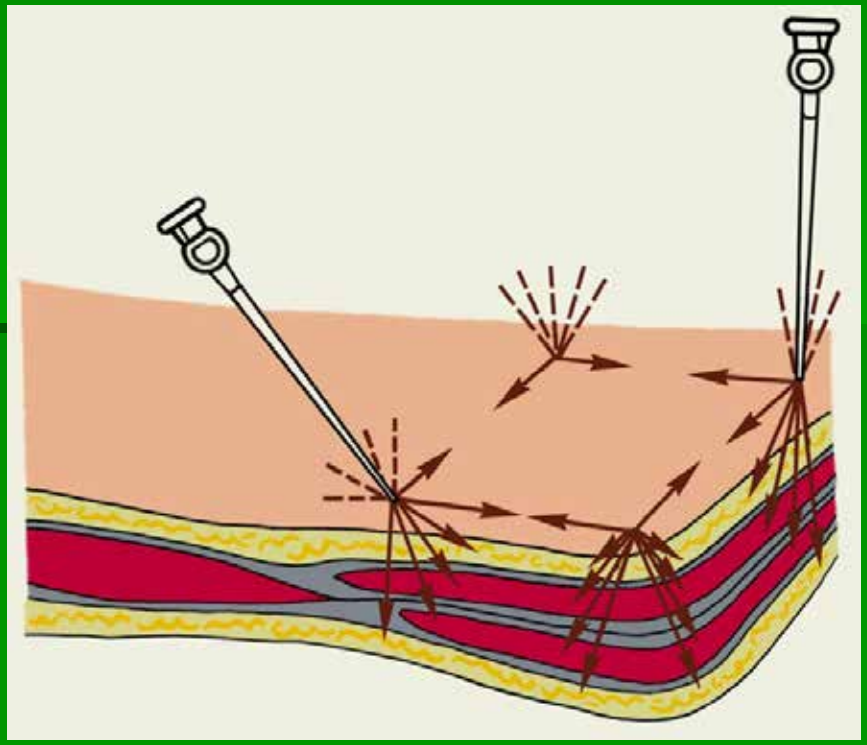
- Local
  - §topical anesthesia
  - §infiltration anesthesia
- Regional
  - §nerv block
  - §spinal anesthesia
  - §epidural anesthesia
- General anesthesia
  - §inhalation
  - §TIVA

Types of anesthesia

topical anesthesia

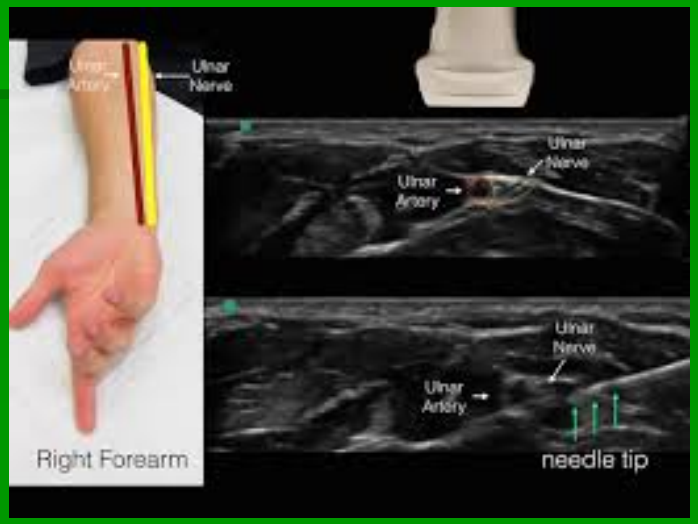
Types of anesthesia

infiltration anesthesia



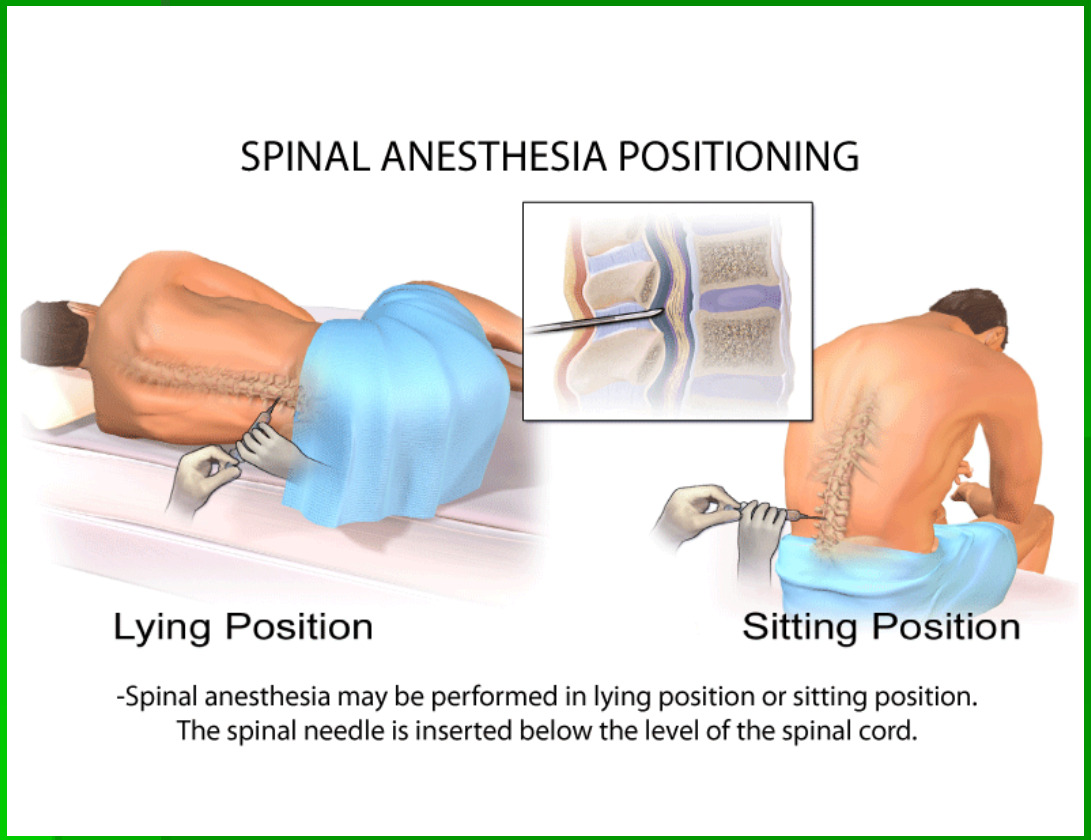
Types of anesthesia

nerv block



Types of anesthesia

spinal anesthesia



Types of anesthesia

spinal anesthesia needles

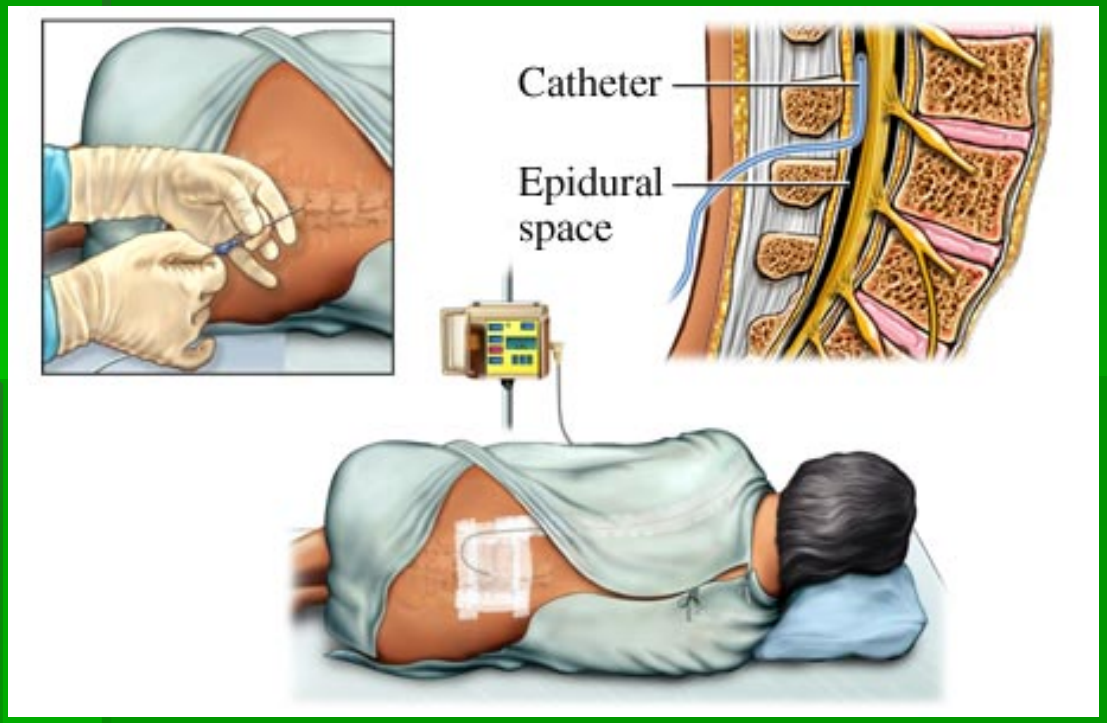
Quincke

Sprotte

Greene

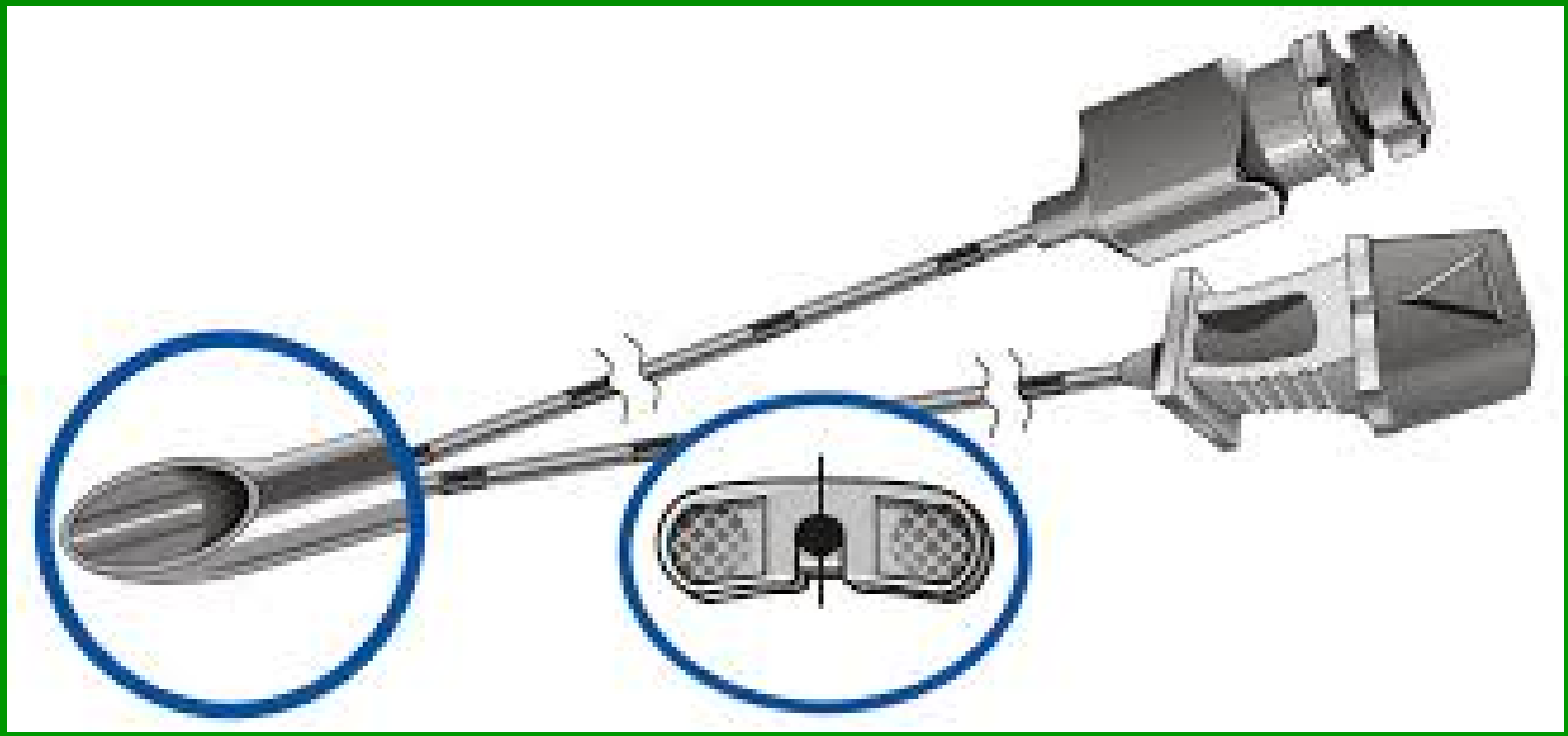
Types of anesthesia

epidural anesthesia



Types of anesthesia

epidural anesthesia needle

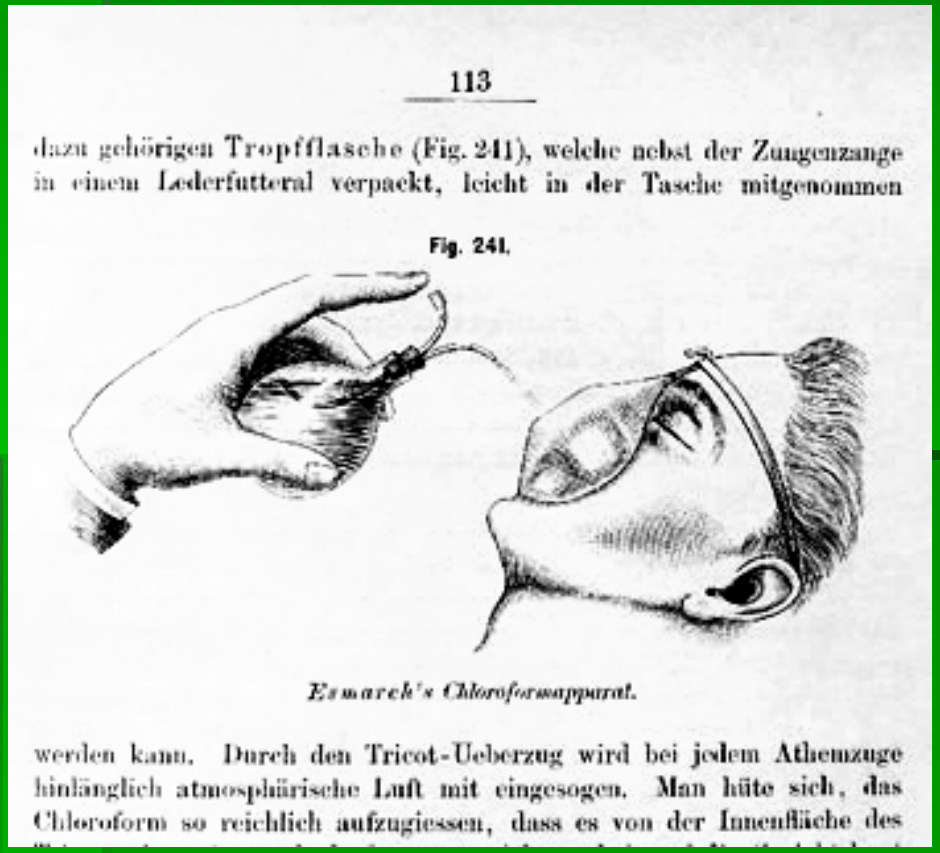


Local anesthetics

Agent	Lipid Solubility	Relative Potency	Protein Binding (%)	Duration	pK_a	Onset Time
Procaine	<1	1	5	Short	8.9	Slow
2-Chloroprocaine	>1	3	—	Short	8.7	Very quick
Mepivacaine	1	1.5	75	Medium	7.7	Quick
Lidocaine	3	2	65	Medium	7.9	Quick
Bupivacaine	28	8	95	Long	8.1	Moderate
Tetracaine	80	8	85	Long	8.5	Slow
Etidocaine	140	8	95	Long	7.9	Quick
Ropivacaine	14	8	94	Long	8.1	Moderate

Types of anesthesia

inhalation anesthesia



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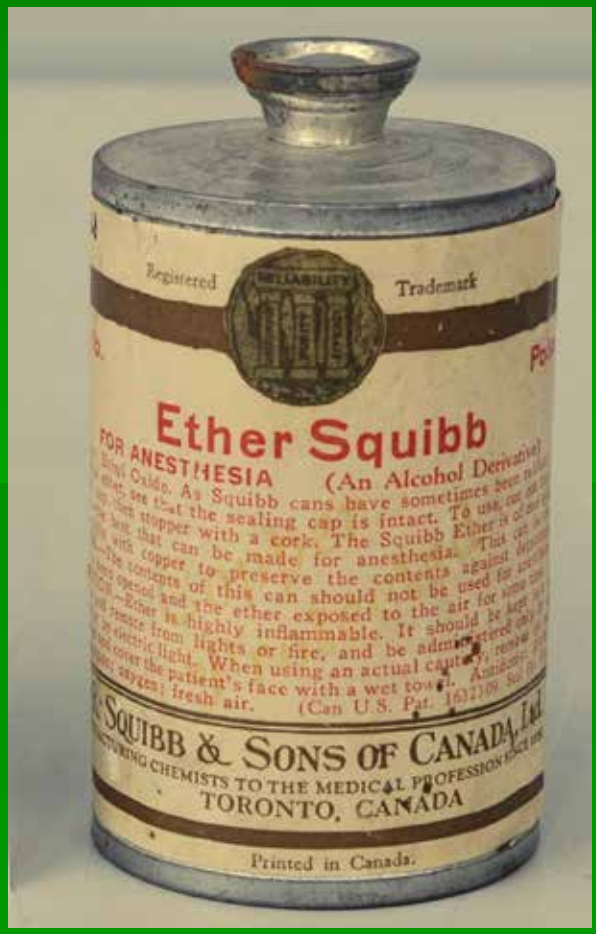
dazu gehörigen Tropfflasche (Fig. 241), welche nebst der Zungenzange in einem Lederfutteral verpackt, leicht in der Tasche mitgenommen

Fig. 241.

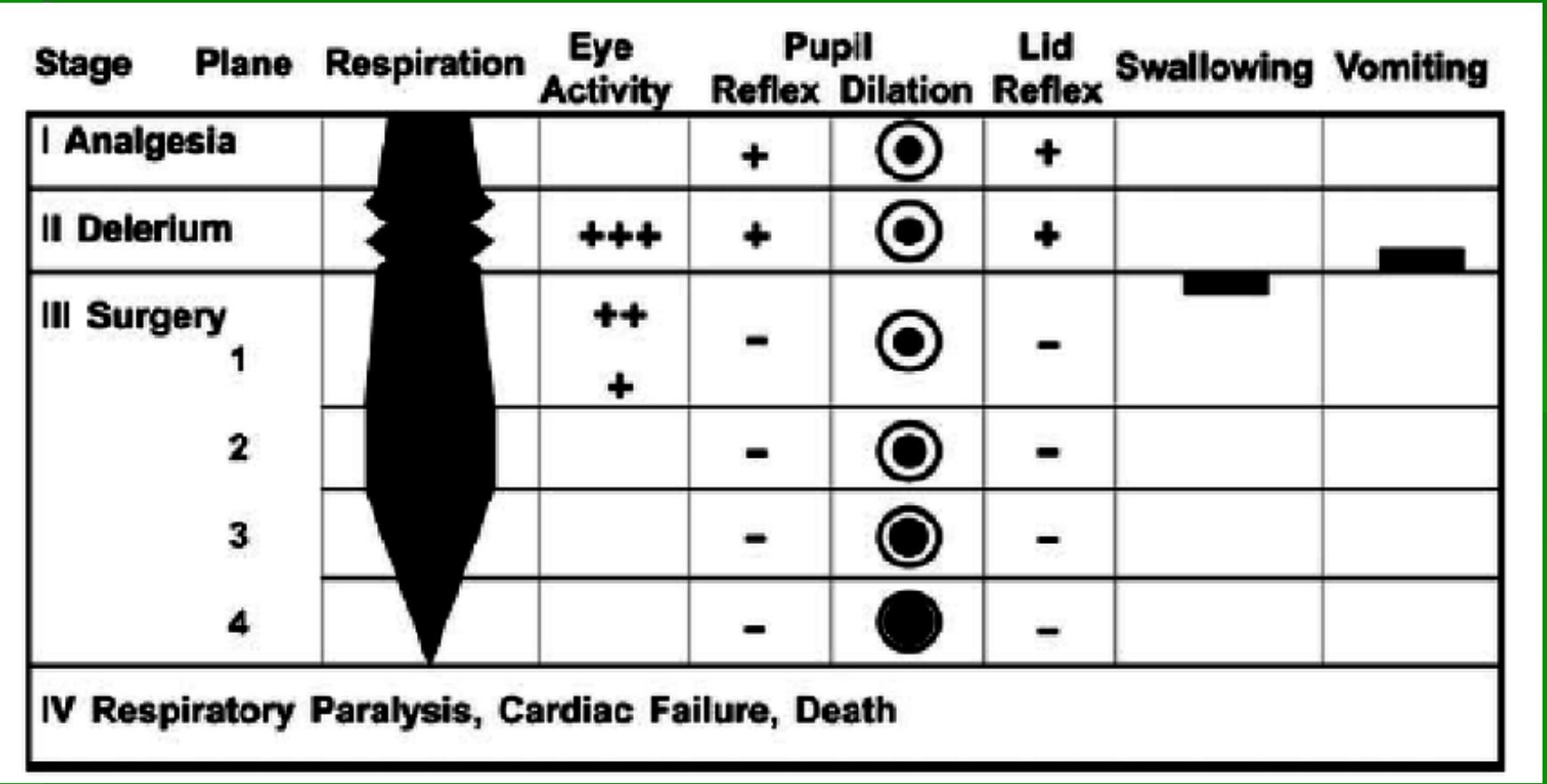
Esmarch's Chloroformapparat.

werden kann. Durch den Tricot-Ueberzug wird bei jedem Athemzuge hinlänglich atmosphärische Luft mit eingesogen. Man hüte sich, das Chloroform so reichlich aufzugiessen, dass es von der Innenfläche des



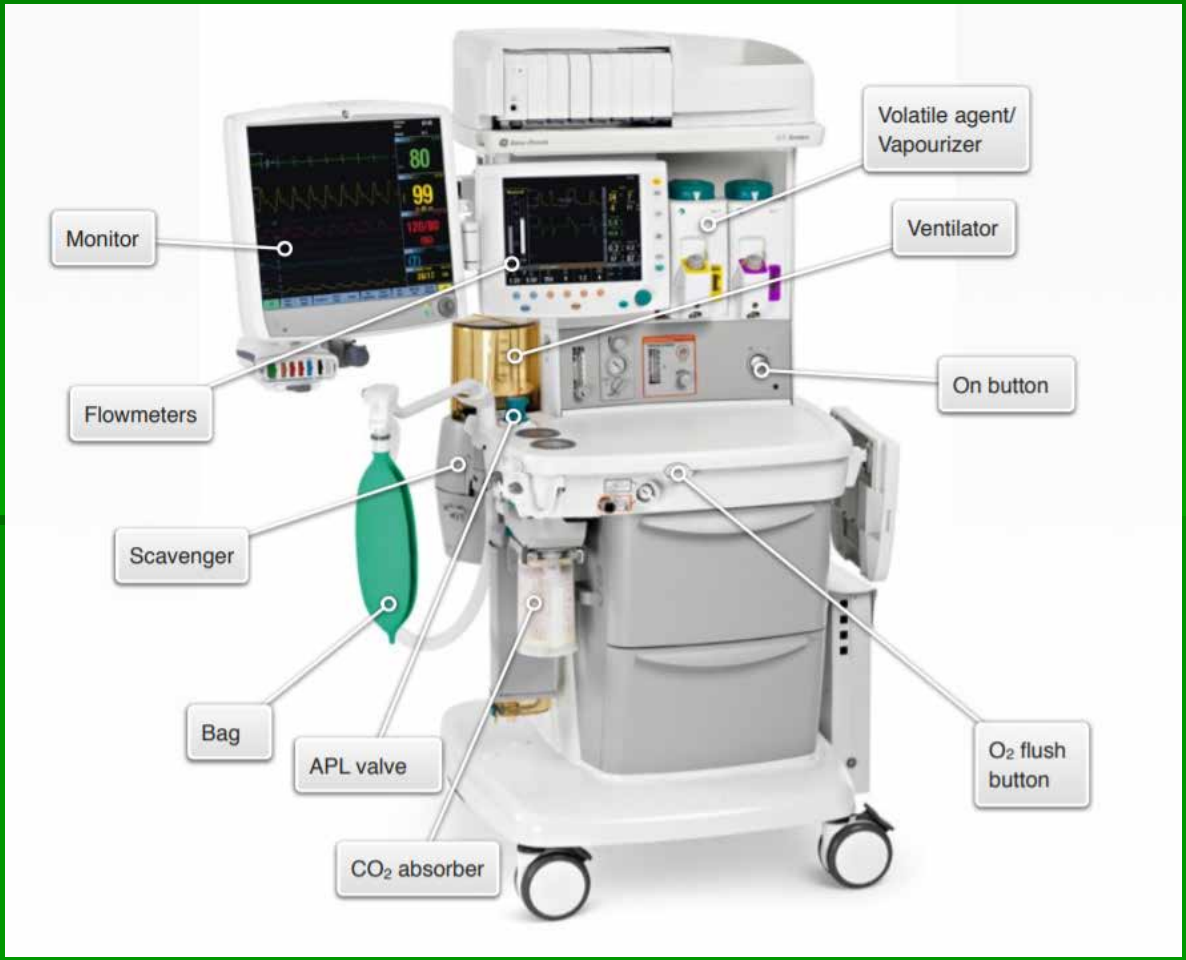
Types of anesthesia

Ether anesthesia stages



Types of anesthesia

inhalation anesthesia

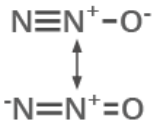


A BRIEF SUMMARY OF INHALATIONAL ANAESTHETICS

A RANGE OF SIMPLE BUT DIVERSE CHEMICAL COMPOUNDS WITH GENERAL ANAESTHETIC PROPERTIES. **Key:** C CURRENTLY CLINICALLY UTILISED R RARELY OR NO LONGER IN USE

NITROUS OXIDE (C)

ALSO KNOWN AS LAUGHING GAS

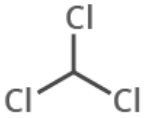


Colourless gas with a slightly sweet odour and taste

Like other inhalational anaesthetics, it also induces a degree of analgesia. It is a weak general anaesthetic, so is often used as a carrier gas for other, more powerful anaesthetics.

CHLOROFORM (R)

PRODUCED BY MANY KINDS OF SEAWEED

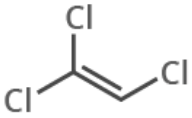


Colourless, sweet-smelling and dense liquid

Common in the 1800s, its use was abandoned due to toxicity & fatalities. Contrary to popular belief, it's hard to incapacitate someone quickly with a chloroform-soaked rag.

TRICHLOROETHENE (R)

DYED BLUE TO AVOID CONFUSION WITH CHLOROFORM

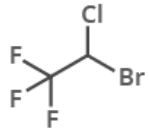


Colourless, non-flammable liquid, with a sweet smell

When used as an anaesthetic it was almost always combined with nitrous oxide. It smells similar to chloroform, which it replaced, but was itself replaced by faster acting agents.

HALOTHANE (R)

ONLY INHALATIONAL ANAESTHETIC CONTAINING A BROMINE ATOM

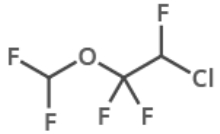


Colourless liquid with a sweet odour resembling that of chloroform

Unstable in light. A potent anaesthetic, though it is a weak analgesic. Hepatitis links resulted in a dramatic reduction in use, & replacement with newer agents.

ENFLURANE (C)

RAPID INDUCTION & RECOVERY FROM ANAESTHESIA

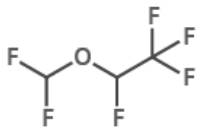


Volatile, colourless liquid, with a sweet smell; light-sensitive

Used increasingly in the 1970s and 80s, but no longer as common. It lowers the threshold for seizures in epilepsy sufferers, and can also be toxic to the kidneys.

DESFLURANE (C)

BOILS AT ROOM TEMPERATURE; LOW POTENCY



Colourless, non-flammable liquid, with an unpleasant, pungent odour

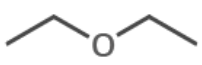
Highest onset and offset of action of the volatile anaesthetic drugs. However, it has a low potency, and its high cost prohibits its use in less developed countries.

YEAR AVAILABLE FOR CLINICAL USE

1844 · 1846 · 1847 · 1925 · 1930 · 1951 · 1956 · 1960 · 1973 · 1981 · 1992 · 1994

DIETHYL ETHER (R)

COMMONLY USED AS A SOLVENT



Colourless, volatile and highly flammable liquid

Also known simply as 'ether', it was commonly used with chloroform or alcohol. It was found to have undesirable side-effects, such as nausea and vomiting.

CYCLOPROPANE (R)

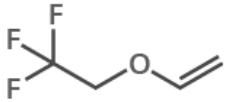
EXTREMELY REACTIVE UNDER NORMAL CONDITIONS

Colourless and highly flammable gas with a sweet, petrol-like odour

Often combined with oxygen, and gave a rapid onset of anaesthesia. However, its high cost and explosive nature limited its use, leading to it being largely phased out.

FLUOROXENE (R)

THE FIRST VOLATILE ANAESTHETIC CONTAINING FLUORINE

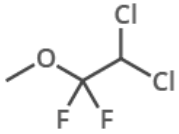


Colourless liquid, with a less pungent smell than diethyl ether

Compared to other agents available at the time, fluoroxene, whilst of use, did not provide any distinct advantages, although it did appear to minimise respiratory irritation.

METHOXYFLURANE (C)

SIGNIFICANT RESPIRATORY DEPRESSANT

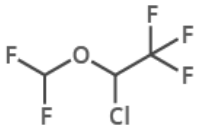


A colourless liquid with a strong, fruity aroma and high boiling point

Extremely potent, but with slow onset and offset times, and also a powerful analgesic. Abandoned in 1970s due to kidney toxicity, but still used in emergencies in Australia.

ISOFLURANE (C)

STRUCTURAL ISOMER OF ENFLURANE

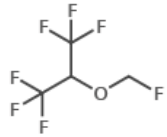


Colourless, non-flammable liquid, with a pungent, musty odour

Always administered with oxygen; nitrous oxide can also be used. Often used to maintain anaesthesia induced with another drug. Its use is beginning to decline.

SEVOFLURANE (C)

NAME DERIVES FROM THE SEVEN FLUORINE ATOMS IT CONTAINS



Colourless, non-flammable liquid, with a mildly unpleasant sweet odour

Most commonly used volatile anaesthetic, often administered with nitrous oxide & oxygen. Its onset & offset are slower than desflurane, but it irritates mucous membranes less.

Properties of inhaled anesthetics

Anesthetic	Blood : gas partition coeffecient	Brain:Blood Partion coefficient	Minimal Alveoler conc(mac) (%)	metabolism	Comments
Nitrous Oxide	0.47	1.1	>100%	None	Incomplete, rapid onset and recovery
Desflurane	0.42	1.3	6-7	<0.05%	Low volatility , fast induction, rapid recovery
Sevoflurane	0.69	1.7	2.0	2-5% (fluoride)	Rapid onset & recovery, unstable in soda lime
Isoflurane	1.40	2.6	1.40	<2%	Medium rate of onset and recovery
Enflurane	1.80	1.4	1.7	8%	Medium rate of onset and recovery
Halothane	2.30	2.9	0.75	>40%	Nedium rate of onset and recovery
Methoxyflurane	12	2.0	0.16	>70% (fluoride)	Slow onset and recovery,

Types of anesthesia

Total Intravenous Anesthesia (TIVA)

Types of anesthesia

Sedation

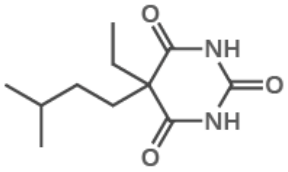
	VERBAL RESPONSE	COGNITIVE FUNCTION	AIRWAY PATENCY	RESPIRATORY FUNCTION	CARDIOVASCULAR FUNCTION
Light Sedation	Normal	Conscious, but cognitive function and coordination would be impaired	Normal	Normal	Normal
Moderate Sedation	Would respond purposefully to verbal commands	Depressed consciousness	Normal	Normal	Normal
Deep Sedation	Not easily aroused; verbal response only to painful or repeated physical stimuli	Depressed consciousness	Airway might require support to remain patent	Spontaneous ventilation may be inadequate	Usually maintained

A BRIEF SUMMARY OF INTRAVENOUS ANAESTHETICS

Key: (B) BARBITURATE (BD) BENZODIAZEPINE (A) ARYLCYCLOHEXAMINE (I) IMIDAZOLE (P) ALKYL PHENOL ● RAPID-ACTING AGENTS ● SLOWER-ACTING AGENTS

AMOBARBITAL (B)

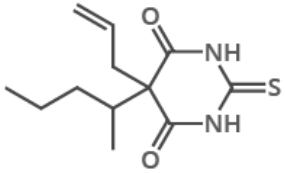
ALONG WITH OTHER BARBITURATES, PREVIOUSLY USED AS A 'TRUTH SERUM'



Intermediate duration of action. It is a hypnotic agent, and can be used to treat insomnia. It was also used by the US army in WWII as an attempted treatment for shell shock, but proved largely ineffective.

THIAMYLAL (B)

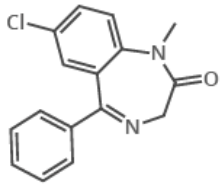
LIKE OTHER BARBITURATES, STRONG BUT SHORT-ACTING



Very short duration of action. Thiamylal is still in current use as an induction agent, and is also used as an anti-convulsant to limit the side effects experienced from the use of other anaeasthetics.

DIAZEPAM (BD)

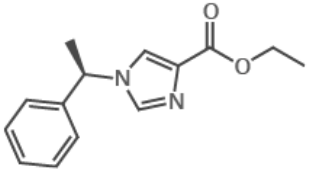
MORE COMMONLY KNOWN BY ITS BRAND NAME, VALIUM



Long duration of action. In its use as an anti-anxiety medication it has been nicknamed 'Mother's Little Helper'. In anaesthesia, it is often used to induce moderate sedation. Also used for benzodiazapine dependence.

ETOMIDATE (I)

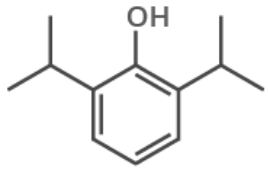
FREQUENTLY USED FOR ANAESTHESIA FOR EMERGENCY INTUBATION



Fairly short duration of action. Used as an induction agent for short surgical procedures; the chances of a large drop in blood pressure are lower than for other anaesthetics. No longer used very widely.

PROPOFOL (P)

HAS LARGELY REPLACED THIOPENTAL FOR INDUCTION OF ANAESTHESIA



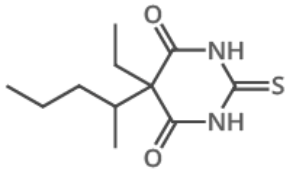
Short duration of action. Widely used for both induction and maintenance of anaesthesia, and often given with opioids to help ease pain. Awakening is rapid and can also be accompanied by mild euphoria.

YEAR AVAILABLE FOR CLINICAL USE

1929 1934 1950 1957 1966 1973 1977 1978

THIOPENTAL (B)

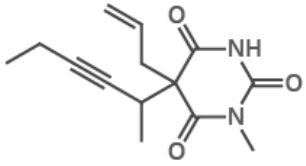
PREVIOUSLY USED FOR LETHAL INJECTIONS IN THE USA



Very short duration of action. Its use in lethal injections was ceased after the EU banned its export for this purpose. Used as an induction agent to induce loss of consciousness, but largely replaced by propofol.

METHOHEXITAL (B)

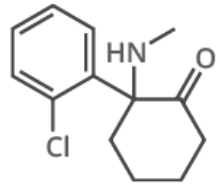
LOWERS SEIZURE THRESHOLD; USEFUL FOR ELECTROCONVULSIVE SHOCK THERAPY



Very short duration of action, and faster recovery rate than with some other barbiturates. Also cheaper than propofol. Commonly used for outpatient surgical and dental procedures.

KETAMINE (A)

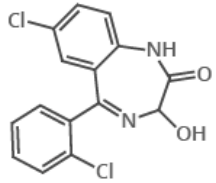
ALSO USED AS A RECREATIONAL DRUG



Short duration of action. Doesn't suppress breathing as much as other anaesthetics, but can also cause hallucinations. Often used to induce and maintain anaesthesia in severely injured patients.

LORAZEPAM (BD)

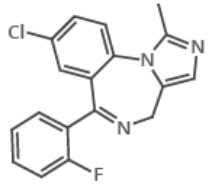
ALSO USED FOR SHORT-TERM TREATMENT OF ANXIETY



Long duration of action. Often used to treat anxiety disorders under the brand name 'Ativan'. Sometimes given before awake procedures as it can also prevent the formation of new memories.

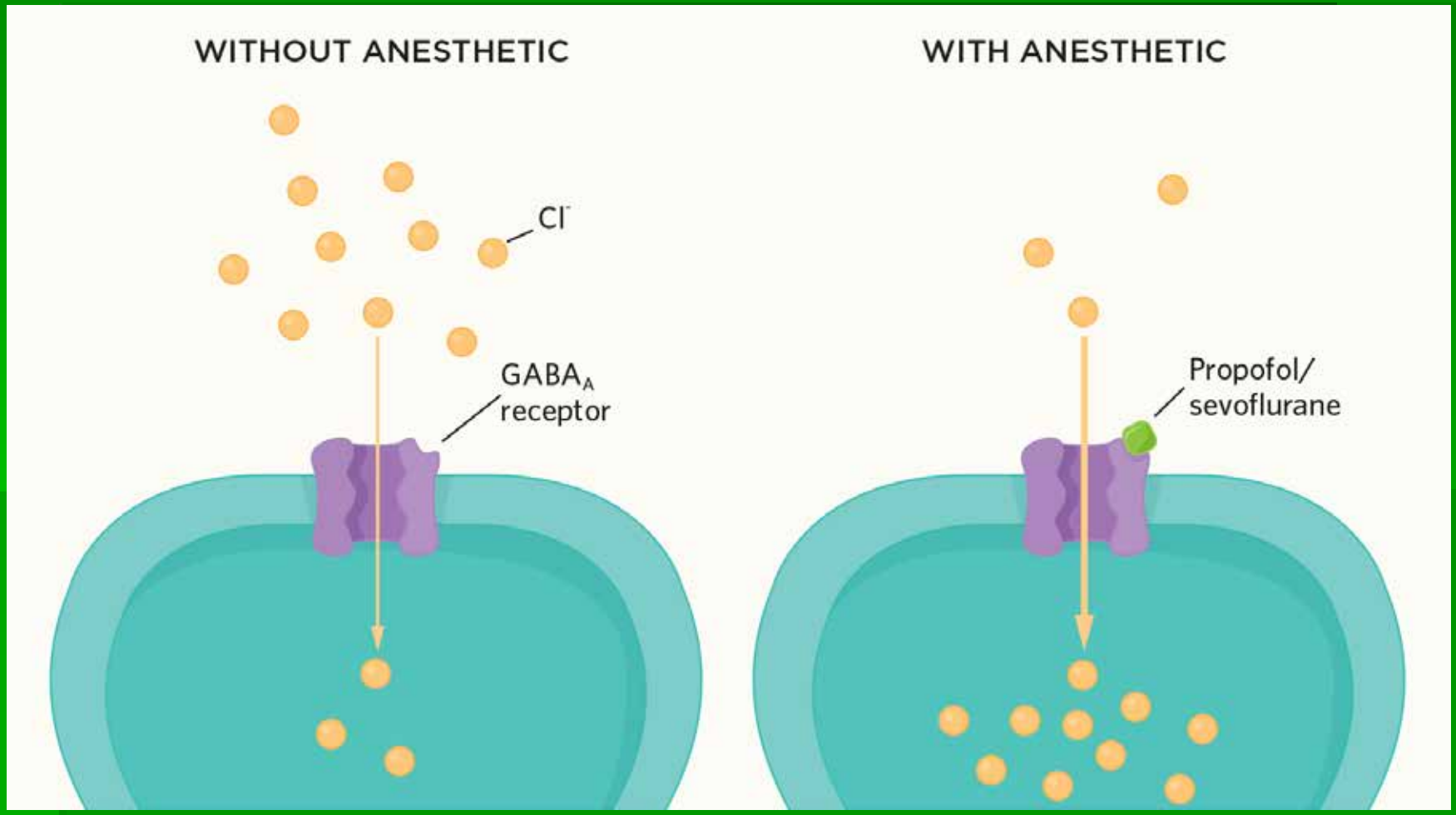
MIDAZOLAM (BD)

REPLACED THIOPENTAL FOR USE IN LETHAL INJECTIONS IN THE USA

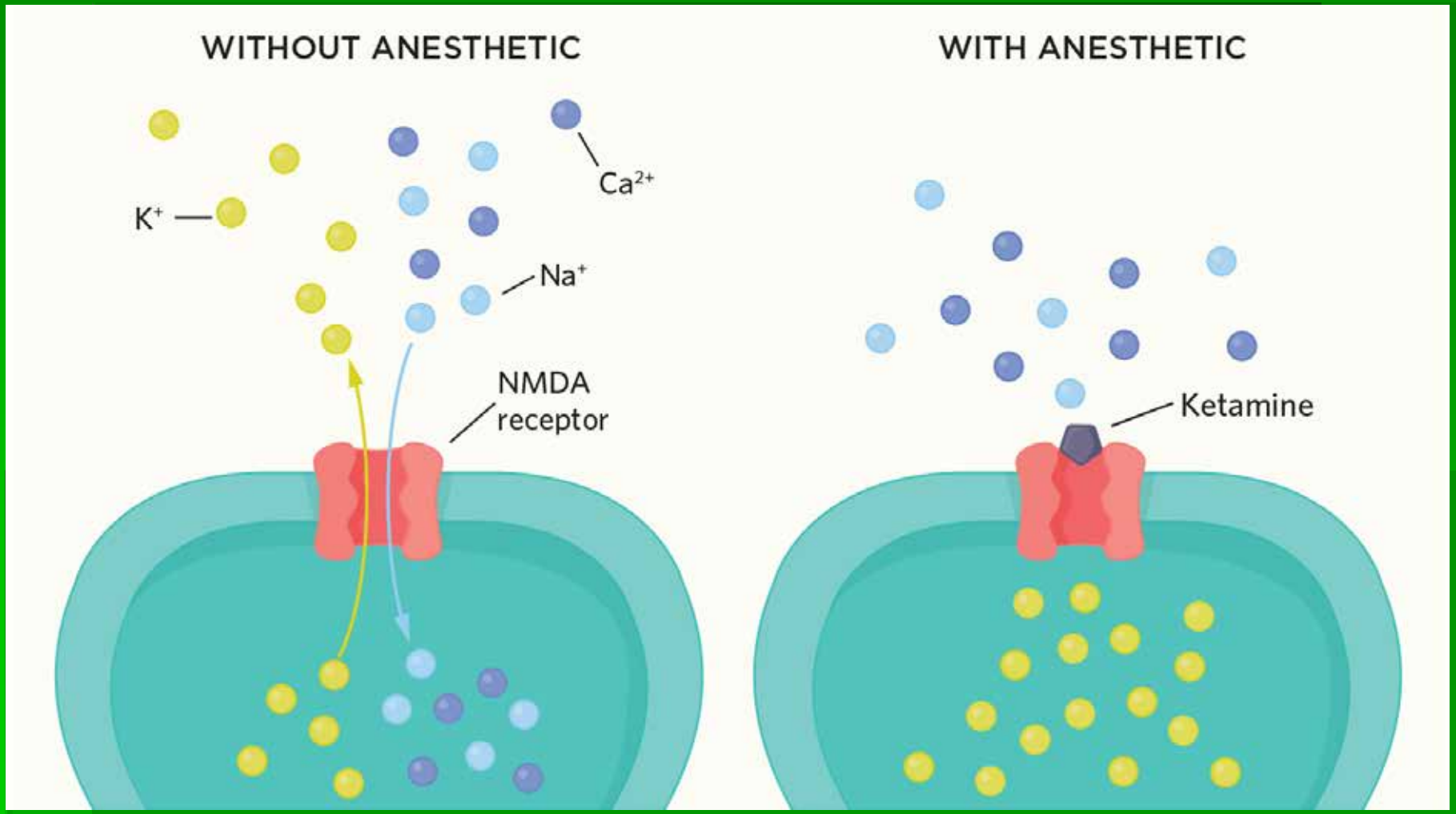


Short duration of action. Midazolam is two to three times as potent as diazepam, and has a faster onset. Also used in end-of-life care to help reduce agitation and anxiety, and in the management of seizures.

Hypnotics


WITHOUT ANESTHETIC
WITH ANESTHETIC
Cl-
GABAA receptor
Propofol/ sevoflurane

Hypnotics


WITHOUT ANESTHETIC
WITH ANESTHETIC
Ca^{2+}
K^+
Na^+
NMDA receptor
Ketamine

Hypnotics

Pharmacokinetic Data for Intravenous Anesthetics

Drug	Induction, Dose, mg/kg IV (70 kg Dose)	Infusion Dose (mcg/kg/min)	Sedation Dose (mcg/kg/min)	Duration of Action (min)	Vd (Steady State) L/kg	$t_{1/2}$ Distribution (min)	$t_{1/2}$ Elimination (hr)	Protein Binding (%)	Clearance (ml/kg/min)
Propofol	1–2.5 (70–125)	100–200	25–75	3–8	2–10	2–4	4–23	97	20–30
Thiopental	3–5 (210–350)	200–300 (1st 20 min) 30–70 (after 20 min)	30–80	5–10	2.5	2.4	11	83	3.4
Methohexital	1–1.5 (70–105)	50–150	10–50	4–7	2.2	5–6	4	73	4
Etomidate	0.2–0.3 (14–21)	10 (*)	2.5–7.5	3–8	2.5–4.5	2–4	2.9–5.3	77	18–25
Ketamine	1–2 (70–140)	10–100	5–20	5–10	3.1	11–16	2–4	12	12–17
Dexmedetomidine**	n/a	0.2–0.7 mcg/kg/h**	0.2–0.7 mcg/kg/h**	n/a	2–3	6	2–3	94	10–30
Midazolam	0.1–0.3 (7–21)	0.25–1	0.25–1	15–20	1.1–1.7	7–15	1.7–2.6	94	6.4–11

Opioids

Opioids

Opioid Receptors

	μ receptor	κ receptor	δ receptor
Location	μ1 – supraspinal μ2 - spinal	κ1 – spinal κ3 –supraspinal	Spinal Supra-spinal
Effects	Analgesia Respiratory depression Sedation Euphoria Miosis Bradycardia, Hypothermia Physical dependence	Spinal analgesia Dysphoria Sedation Psychomimetic	Spinal analgesia Affective behaviour (Supraspinal) Respiratory depression
Agonists	Morphine, Codeine, Fentanyl Pentazocine(weak) Endorphins	Pentazocine, Dynorphins	Enkephalins

Opioids

Pharmacokinetics of Intravenous Opiates

Drug	Onset	Elim $t_{1/2}$	Part. Coeff.	Context-Sensitive $t_{1/2}$	Vd (L/kg)	Protein-Bound (%)	Potency (compared with IV morphine)
Fentanyl	3–7 min	475 min	820	1–2 hr	4.1	84	100
Remifentanil	60–120 sec	3–10 min	17.8	3–6 min	0.3–0.4	80	250
Sufentanil	3–5 min	2.5–4.5 hr	1750	17 min	2.86	92	500–700
Alfentanil	1.5–2 min	90–111 min	130	12–18 min	0.86	92	10–25
Morphine	20–30 min	2–4 hr	1.4	—	2.8– 4.2	26–36	1
Hydromorphone	15 min	2.64	1.3	—	3.7	8–19	5–7
Meperidine	15 min	3–5 hr	21	—	2.8–4.2	70	0.1

Opioids

	Loading Dose	Maintenance Dose		Comments
		Bolus	Infusion	
Fentanyl	2-6 µg/kg	25-50 µg/kg	0.5-5.0 µg/kg/hr	Risk of significant depression of spontaneous ventilation
Alfentanil	25-50 µg/kg	5-10 µg/kg	0.5-2 µg/kg/min	Propofol decreases elimination clearance and distribution
Sufentanil	0.25 - 2µg/kg	0.1 - 0.25 µg/kg	0.5- 1.5 µg/kg/hr	
Remifentanil	1 - 2 µg/kg		0.1-1.0 µg/kg/min	During emergence and post-operatively alternative analgesia should be administered or low-dose infusion continued

Opioids

Anaesthetic Techniques Using Opioids

- Analgesia
- Sedation
- Balanced Anaesthesia
- Neuroleptanalgesia-Neuroleptanaesthesia
- TIVA
- High-Dose Opioid Anaesthesia for Cardiac Surgery
- Intrathecal Infusion

Neuromuscular blocking drugs

NMBDs	Intubating Dose (mg/kg) [RSI dose, mg/kg]	Maintenance Dose (mg/kg)	Onset (min)	Duration to Return ≥25% Twitch Height (min)	Duration to Return ≥0.9 TOF Ratio (minutes)	Continuous Infusion
Depolarizing						
Succinylcholine (Anectine)	1 [1–1.5]	—	0.5–1	5–10		
Nondepolarizing						
Pancuronium (Pavulon)	0.1	0.02	3– 5	60–90	130–220	
Rocuronium (Zemuron)	0.6–1.2 [0.6–1.2]	0.1	1–2	20–35	55–80	3–12
Vecuronium (Norcuron)	0.1 [0.3– 0.4]	0.02	3–5	20–35	50–80	1
Atracurium (Tracrium)	0.5	0.1	3–5	20–35	55–80	4–12
Cisatracurium (Nimbex)	0.1 [0.4]	0.02	3–5	20–35	60–90	0.4–4

Monitoring

History

§consciousness

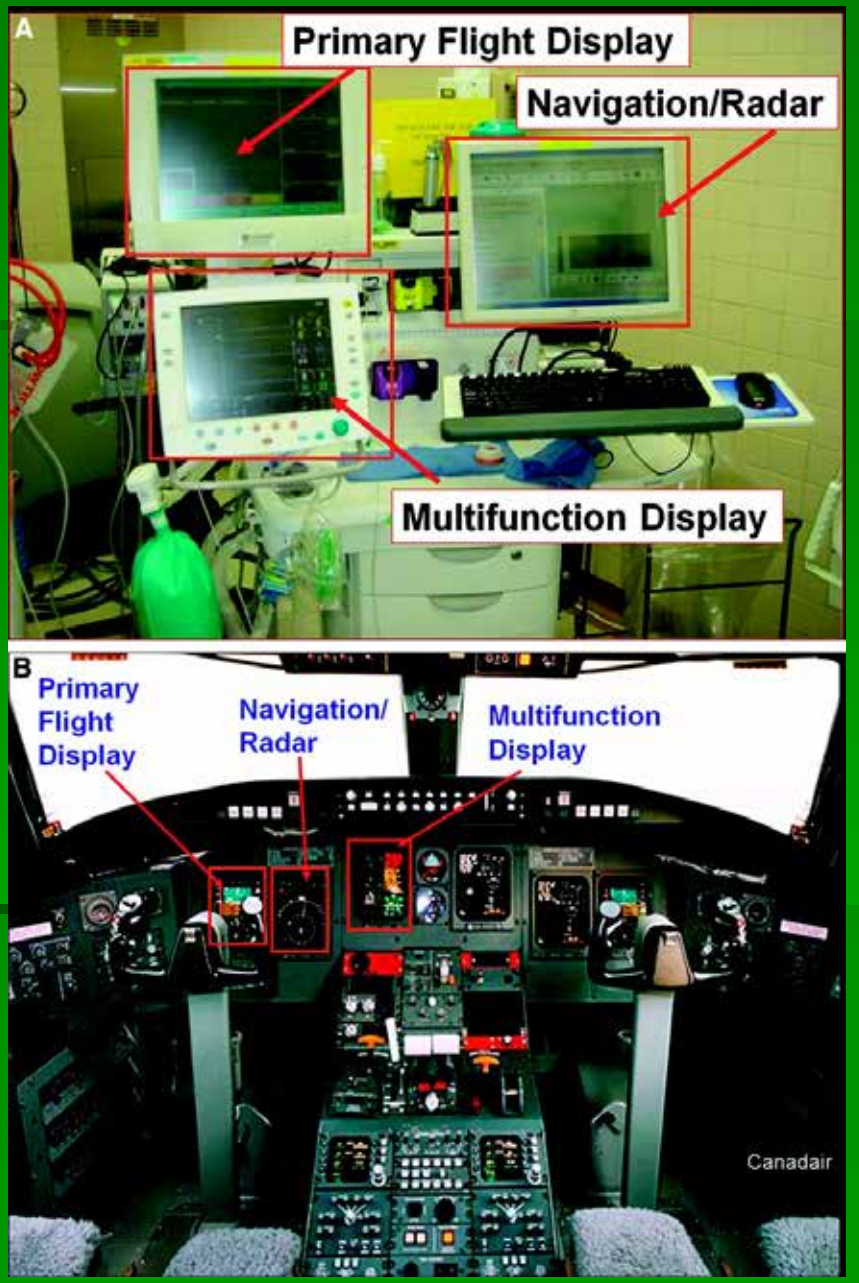
§pupil size

§pulse

§breath

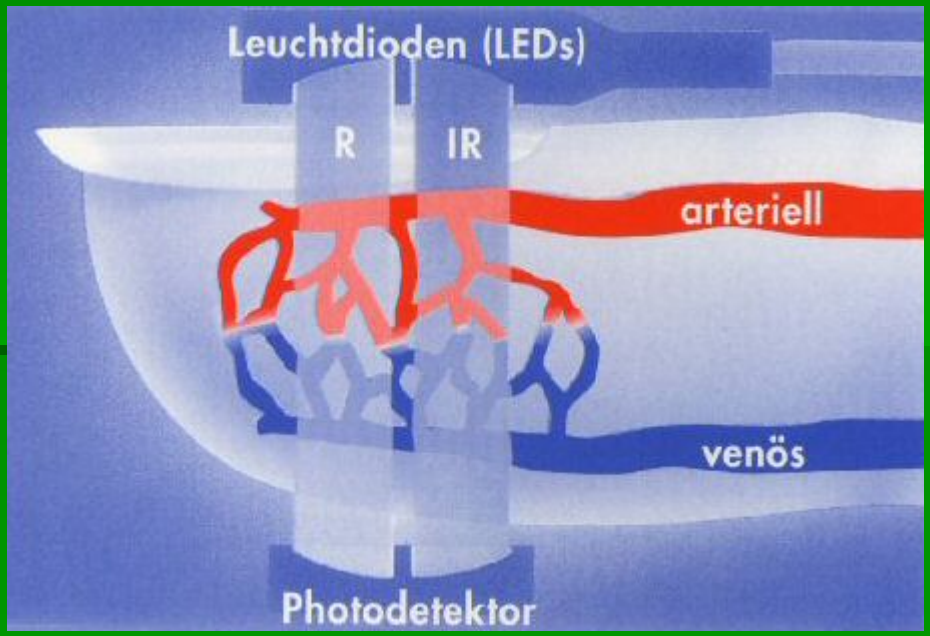
Monitoring

The anesthesiologist's modern workplace is like an airplane cockpit



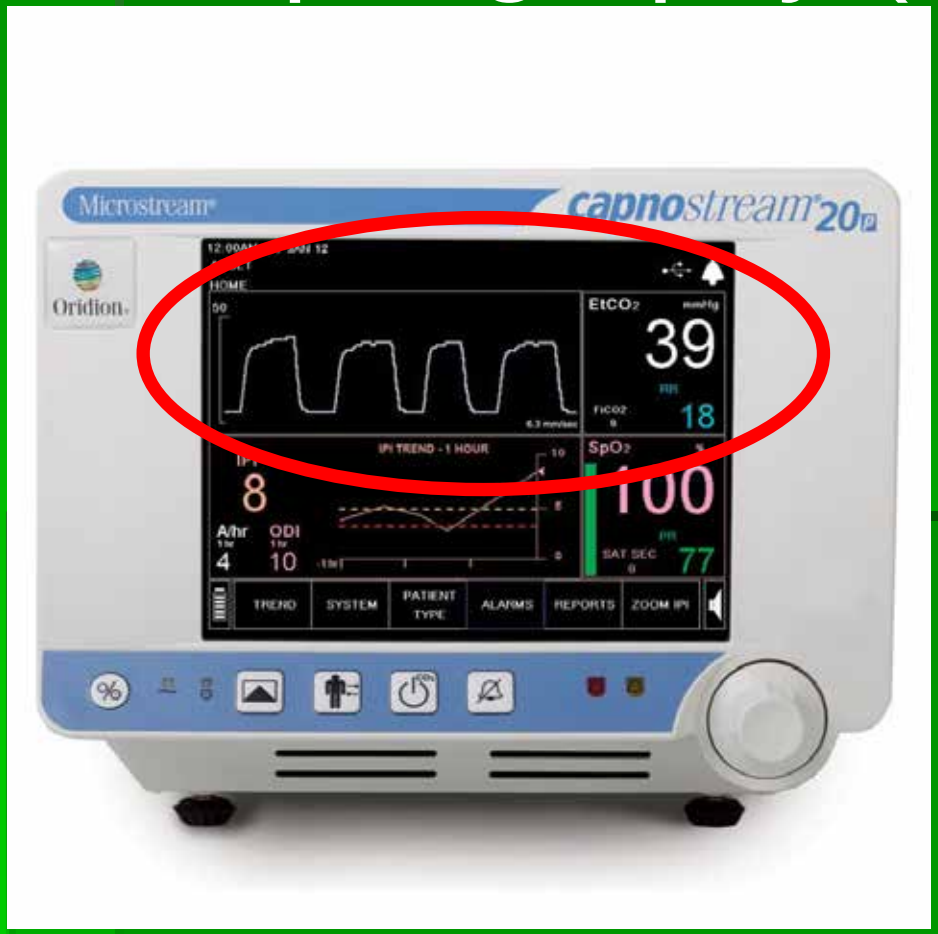
Monitoring

Pulsoxymetrie (SpO_2)



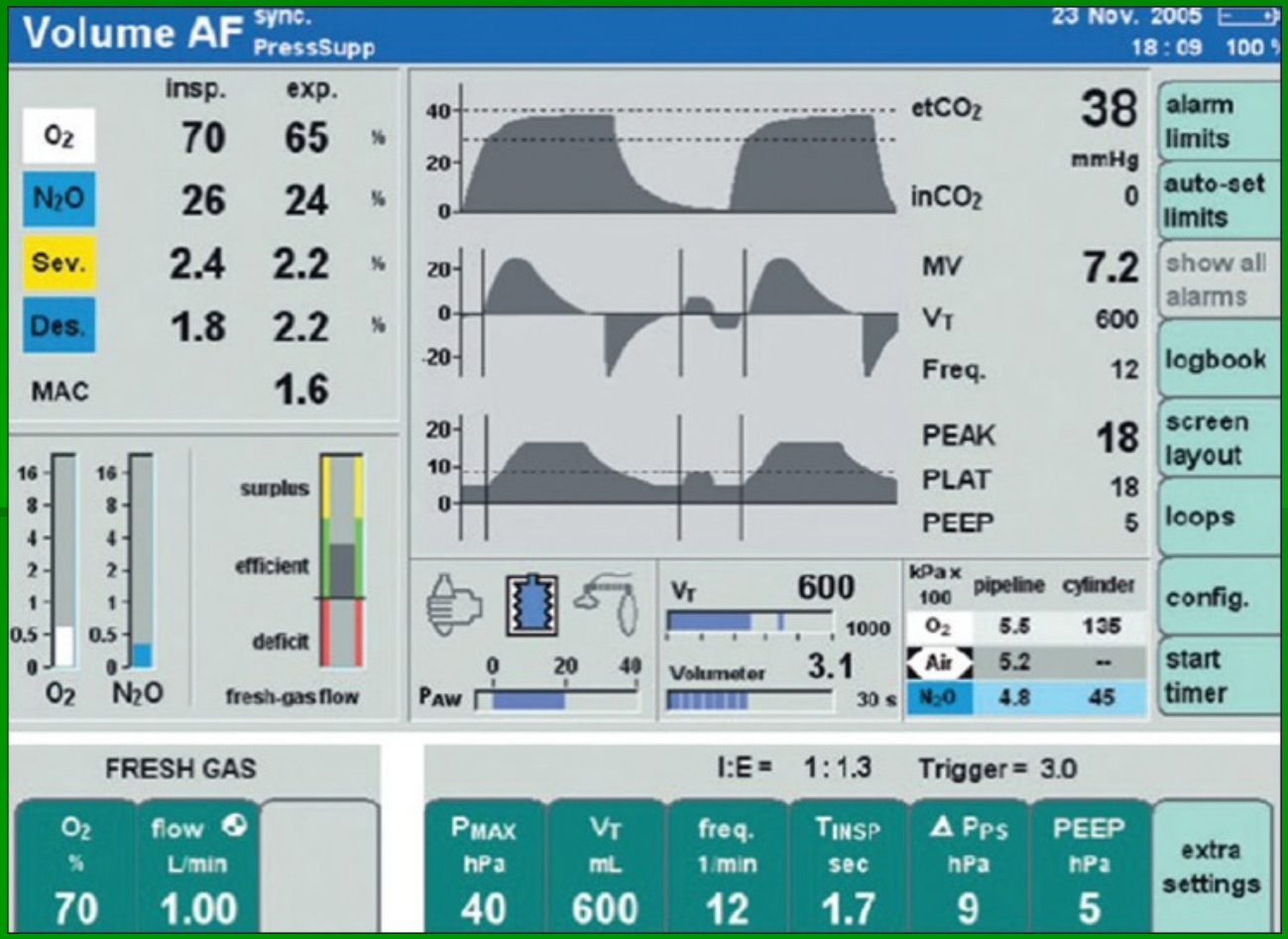
Monitoring

Capnography ($EtCO_2$)



Monitoring

Ventilation & gas monitoring



Monitoring

Electrocardiography

Monitoring

Blood pressure

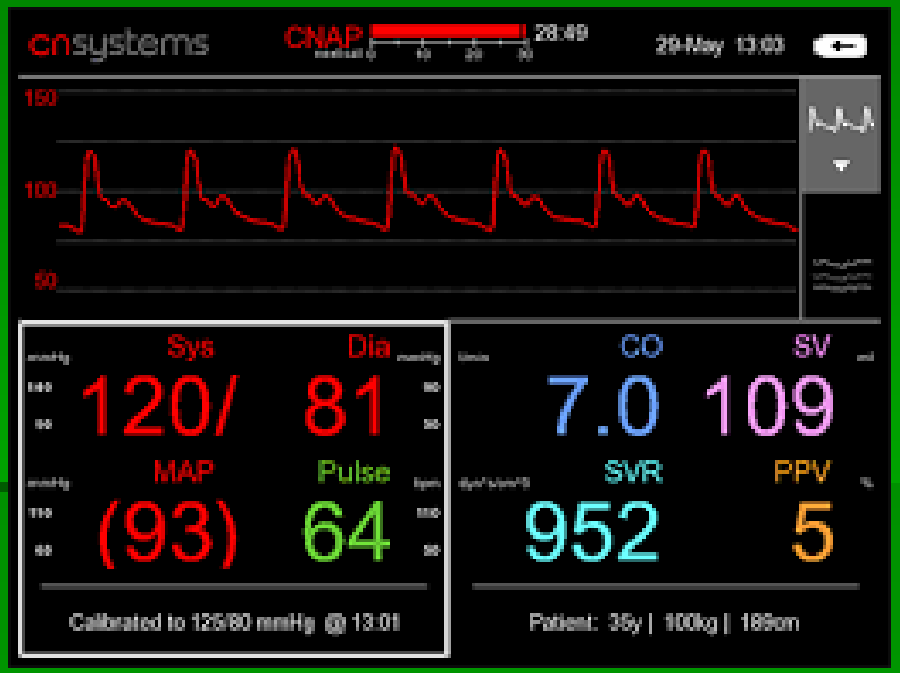
	Technique	Advantages	Limitations
	Oscillometric brachial cuff	Accurate non-invasive	Intermitent
	Arterial line	Gold-standard	Invasive
	Volume clamp	Non-invasive	Inaccurate expensive
	Physiological PWA	Non-invasive inexpensive deployed in OR	Under validation

Monitoring

Blood pressure (non invasive)

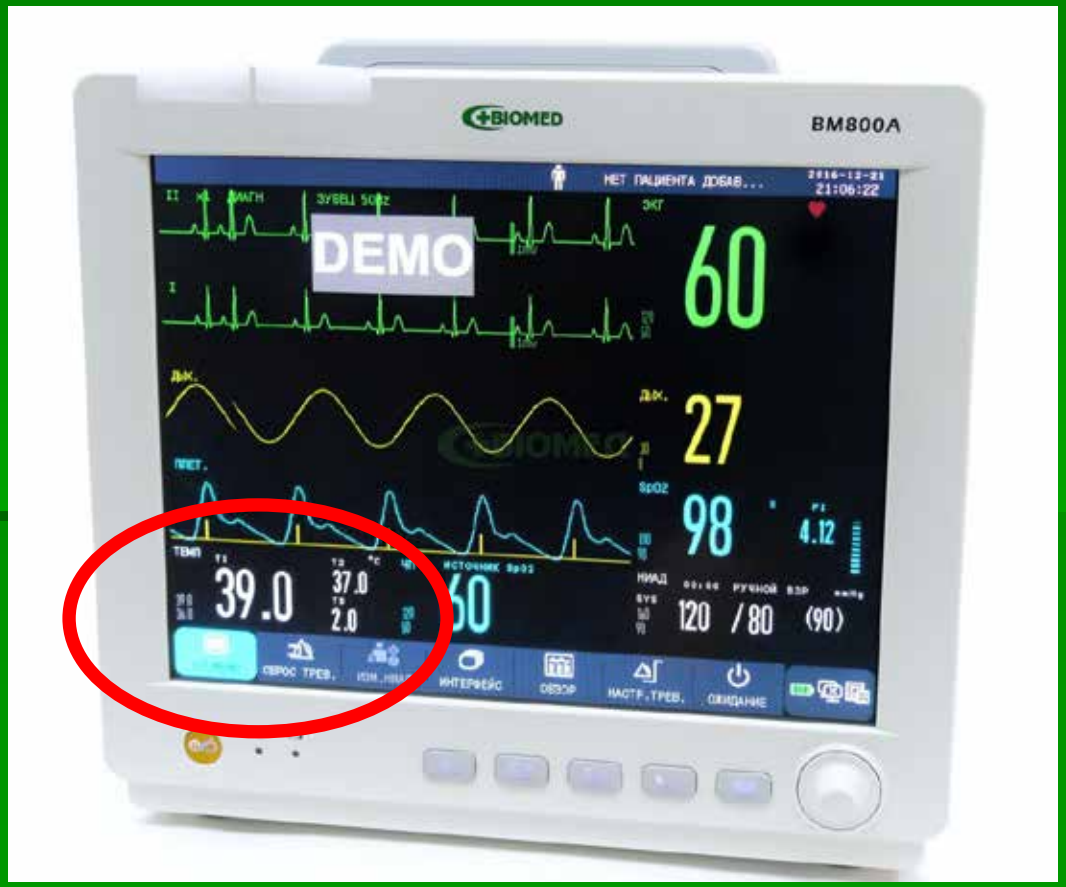
Monitoring

- Blood pressure (invasive)



Monitoring

Temperature



Monitoring

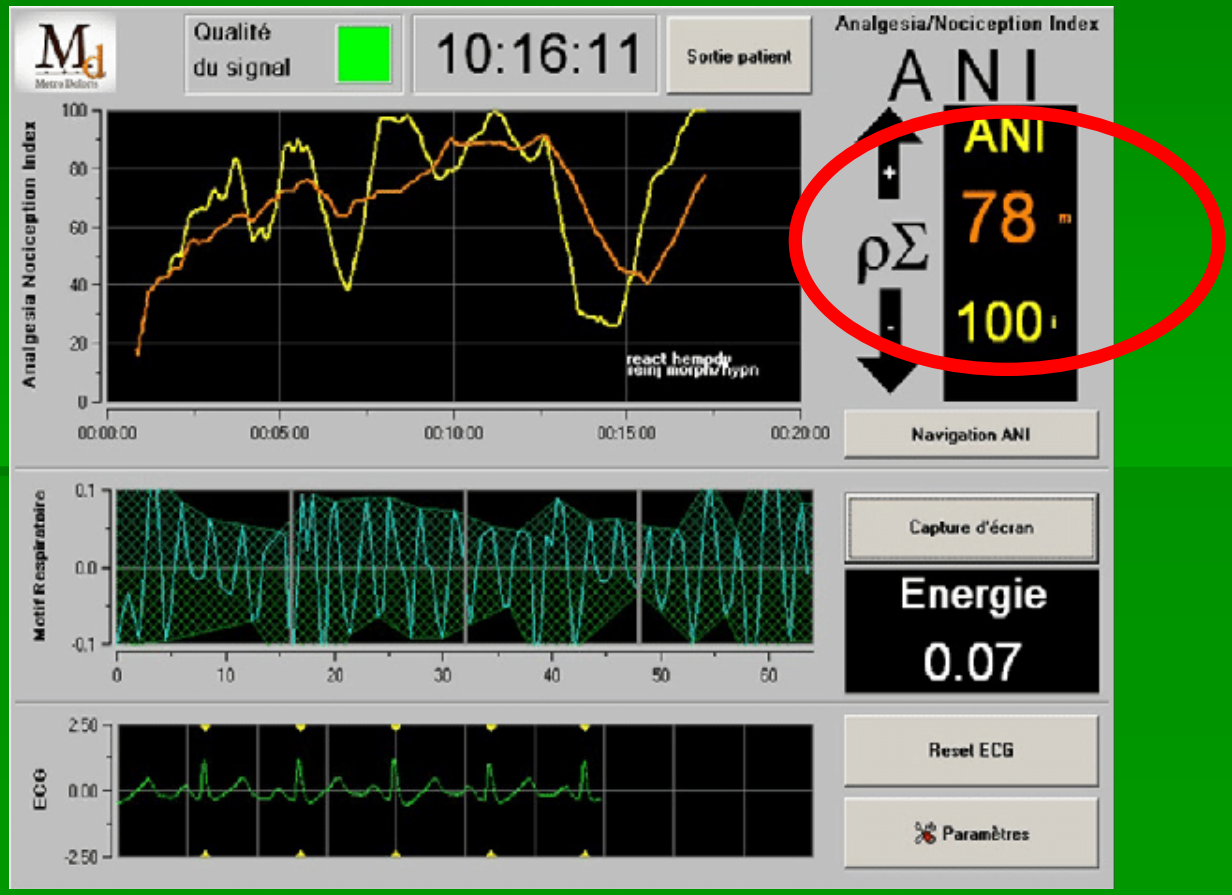
- Neuromuscular conduction (TOF)

Monitoring

- Depth of anesthesia (BIS)

Monitoring

Effectiveness of analgesia (ANI)



Literature

1. Liang Z, Ren N, Wen X, et al. Age-dependent cross frequency coupling features from children to adults during general anesthesia. Neuroimage. 2021;240:118372. doi:10.1016/j.neuroimage.2021.118372
2. John F. Butterworth IV, David C. Mackey, John D. Wasnick, Morgan & Mikhail's Clinical Anesthesiology. Sixth ed. 2018, - 1400

Questions for the next lecture

Respiratory failure and anesthesia: is there a connection?

Oxygen: is it always useful?