POLTAVA STATE MEDICAL UNIVERSITY
Department of Anesthesiology and Intensive Care

Intensive care of acute respiratory failure

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Lecture plan

1. Hypoxia classification, clinic, differential diagnosis of different types of hypoxia.
2. Hypercapnia.
3. Hypocapnia.
4. Classification of respiratory failure.
5. Basic principles of respiratory failure intensive care.
6. Oxygen therapy: methods, indications, toxic effect of oxygen.

Lecture plan

7. Respyratory support: indications, methods, efficiency criteria.
8. Methods of restoration of airway patency and improvement of lung drainage function.
9. Adults respiratory distress syndrome: etiology, pathogenesis, clinical signs, intensive care.
10. Status asthmaticus: etiology, pathogenesis, clinical signs, intensive care.

Definition

Acute impairment in gas exchange between the lungs and the blood causing hypoxia with or without hypercapnia.

The inability of the lungs to meet the body's metabolic-needs for the transport of oxygen (O_2) into the blood and/or removal of carbon dioxide (CO_2) from the blood.

Classification of hypoxia

Hypoxic hypoxia

a) Defciency of oxygen in inspired air (high altitude, suffocation)

b) Hypoactive hypoventilation (central nervous system, neuromuscular or skeletal disorders)

c) Upper airway obstruction (foreign body, trauma or angioedema)

Classification of hypoxia

Pulmonary hypoxia

a) Increased airway resistance (chronic obstructive pulmonary disease and asthma)

b) Abnormal alveolar ventilation-perfusion ratio (pulmonary embolism, pneumonia, aspiration)

Classification of hypoxia

Pulmonary hypoxia

c) Diminished diffusing capacity via the alveolar-capillary membrane (interstitial lung disease and pulmonary vascular disease)

d) Pulmonary shunting (atelectasis, pneumonia, hepatopulmonary syndrome, and arteriovenous malformations)

Classification of hypoxia

Cardiac right-to-left shunts;
(atrial septal defect)

Anemic hypoxia
a) Anemia
b) Hemoglobinopathies
(methemoglobinemia and carbon monoxide poisoning)
5. Inadequate oxygen transport due to a circulatory defect (static hypoxia)

Classification of hypoxia

Cardiac right-to-left shunt

(atrial septal defect)

Anemic hypoxia

a) Anemia

b) Hemoglobinopathies (methemoglobinemia and carbon monoxide poisoning)

Classification of hypoxia

Static hypoxia

a) General circulatory defciency or collapse (shock or cardiac failure)
b) Localized circulatory defciency (peripheral, cerebral, or coronary vessels)

Classification of hypoxia

Histotoxic hypoxia

a) Late-stage irreversible shock

b) Poisoning of cellular oxidation enzymes (cyanide or arsenic toxicity and heavy ethanol intoxication)

c) Diminished cellular metabolic capacity for using oxygen (beri-beri, hyperthyroidism)

Classification ARF

Hypoxemic Respiratory Failure	Hypercapnic Respiratory Failure
Known as: Type I ARF, Lung Failure, Oxygenation Failure, Respiratory Insufficiency	***Known as:*** Type II ARF, Pump Failure, Ventilatory Failure
Definition: The failure of lungs and heart to provide adequate O_2 to meet metabolic needs	***Definition:*** The failure of the lungs to eliminate adequate CO_2
Criteria: $PaO_2 < 60$ mmHg on $F_IO_2 \geq .50$ or $PaO_2 < 40$ mmHg on any F_IO_2 $SaO_2 < 90$	***Criteria:*** Acute ↑ in $PaCO_2 > 50$ mmHg or Acutely above normal baseline in COPD with concurrent ↓ in pH < 7.30
Basic Causes: R-L shunt V/Q mismatch Alveolar hypoventilation Diffusion defect Inadequate FIO_2	***Basic Causes:*** Pump failure (drive, muscles, WOB) ↑ CO_2 production R-L shunt ↑ Deadspace

Signs

- tachypnea
- dyspnea
- the use of accessory respiratory muscles
-

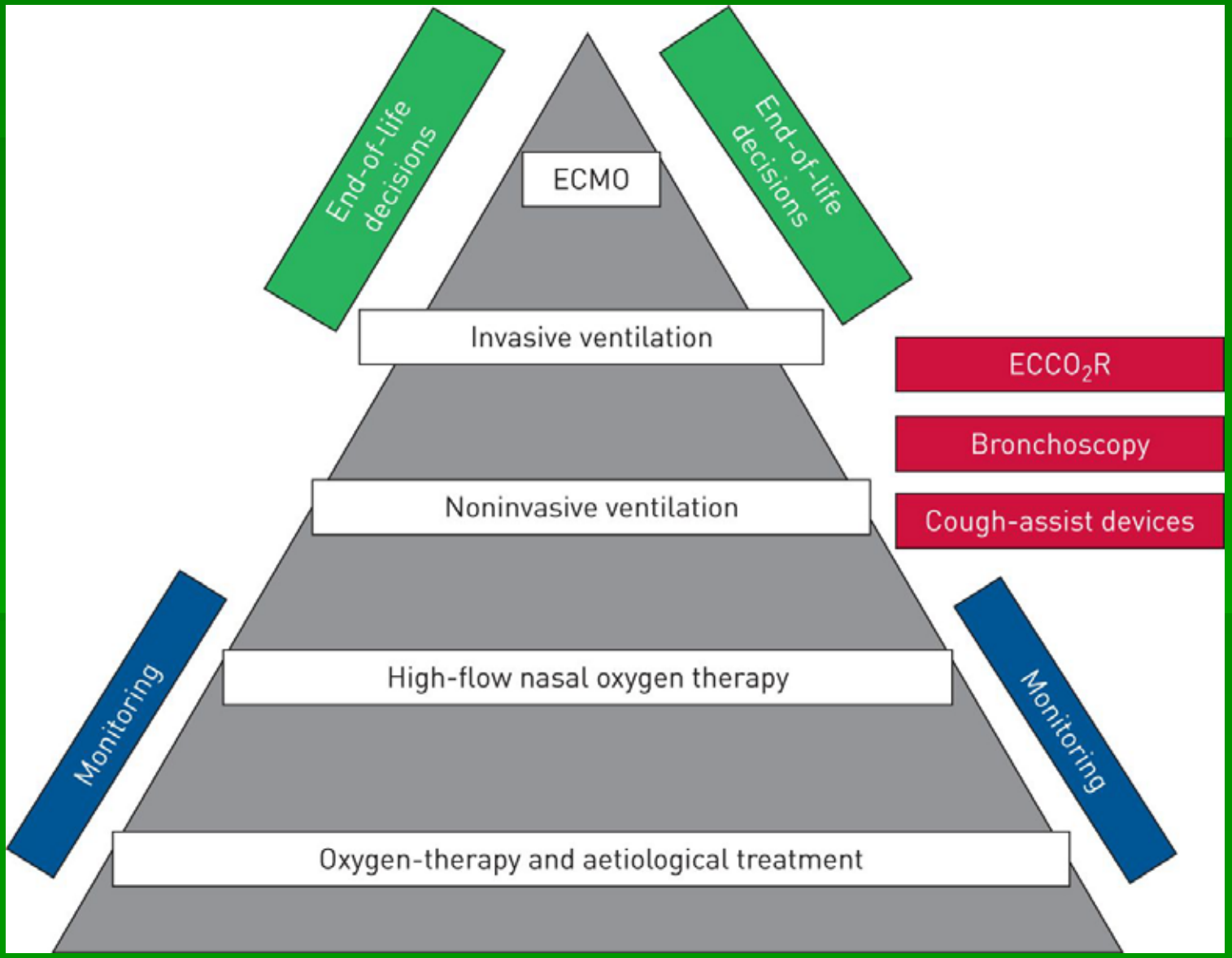
Diagnostic work-up basic

- pulsoxymetry
- chest X-Ray
- bedside ultrasound (BLUE)
- complete blood count
- arterial blood gases
- electrolites

Diagnostic work-up advanced

- computerized tomography (CT)
- spirometry
- capnography
- bronchoscopy
- microbiological evaluation
- cardiac enzymes

Treatment


End-of-life decisions
End-of-life decisions
ECMO
Invasive ventilation
Noninvasive ventilation
High-flow nasal oxygen therapy
Oxygen-therapy and aetiological treatment
Monitoring
Monitoring
$ECCO_2R$
Bronchoscopy
Cough-assist devices

Oxygen Therapy

a treatment that provides you with extra oxygen to reduce / correct arterial hypoxemia

Oxygen Therapy

Indication:

- peri and post cardiac or respiratory arrest
- hypoxia - diminished blood oxygen levels (oxygen saturation levels of <92%)
- acute and chronic hypoxemia (PaO_2 < 65mmHg)
- shock
- low cardiac output and metabolic acidosis (HCO_3 < 18mmol/l)
- chronic type two respiratory failure

Oxygen Therapy

Nasal Cannula

Concentration O_2: 22 - 40%
Delivery O_2:1 - 6 L/min

Advantages:
- patient can talk and eat while receiving oxygen
- easy to use
- low cost

Limitations:
- easily dislodged
- not as effective is a patient is a mouth breather or has blocked nostrils or a deviated septum or polyps
- drying to nares if level is above 4 L/min.

Oxygen Therapy

Simple face mask

Concentration O_2: 25 - 60%
Delivery O_2:4 - 10 L/min

Advantages:
- q moderate oxygen concentrations
- q easy to use
- q low cost

Limitations:
- q difficult to eat with mask on
- q patient may feel claustrophobic with the mask on

Oxygen Therapy

Non rebreather mask

Concentration O_2: 40 - 80%
Delivery O_2: 6 - 15 L/min

Advantages:
- high oxygen concentrations
- easy to use

Limitations:
- the risk of suffocation
- the chance of hyper-oxygenation
- possiblity lack of humidity

Oxygen Therapy

Venturi mask

Concentration O_2: 24 - 60%
Delivery O_2: 4 - 15 L/min

- set oxygen concentrations
- does not dry mucous membranes

Limitations:

- difficult to using

Oxygen Therapy

High-flow nasal cannula

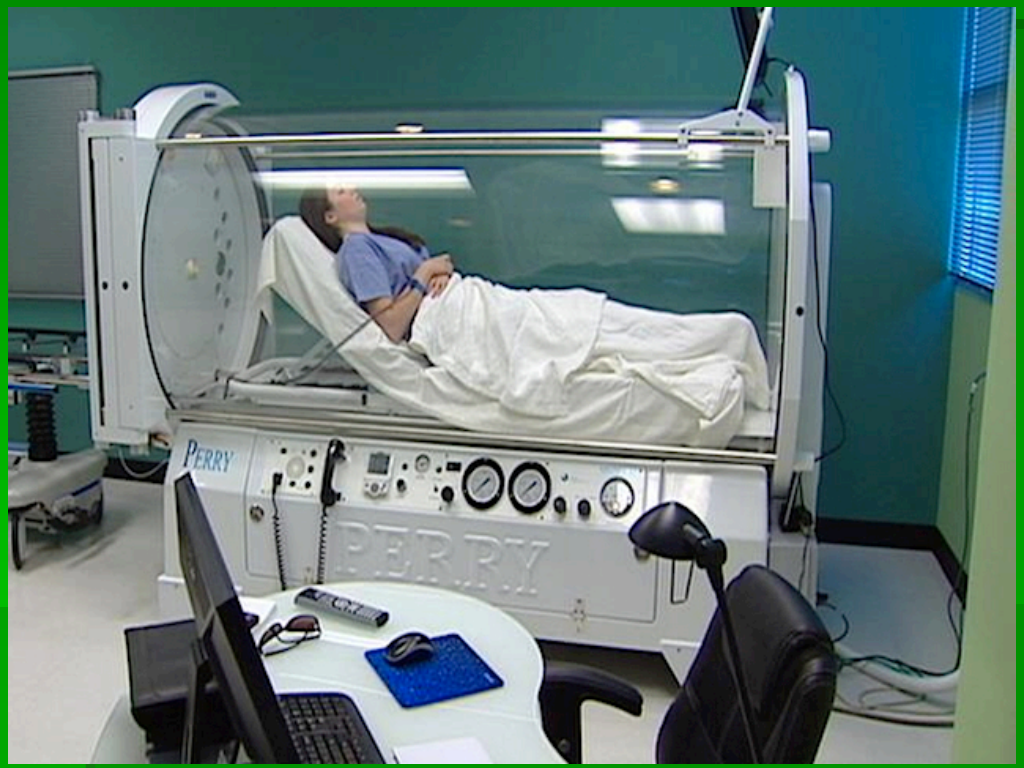
Concentration O_2: 21 - 100%
Delivery O_2:5 - 60 L/min

Advantages:

- maintenance of constant FiO_2
- generation of a positive end-expiratory pressure
- decrease in anatomical dead space
- improved mucociliary clearance
- decreased work of breathing

Oxygen Therapy

Hyperbaric oxygen therapy

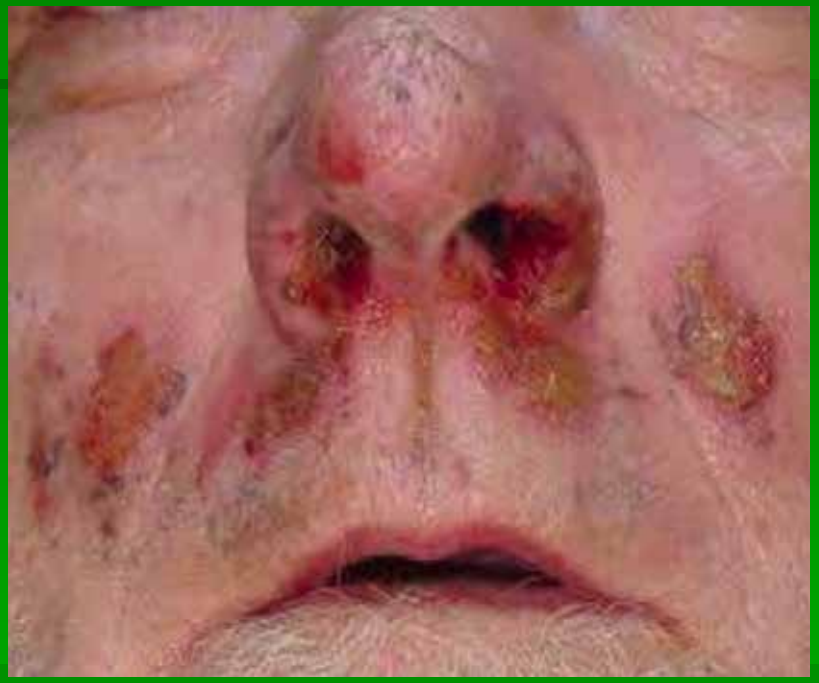


Indications:

- Air or gas embolism;
- Carbon monoxide poisoning;
- Decompression sickness;
- Clostridal myositis.

Oxygen Therapy

Side effects

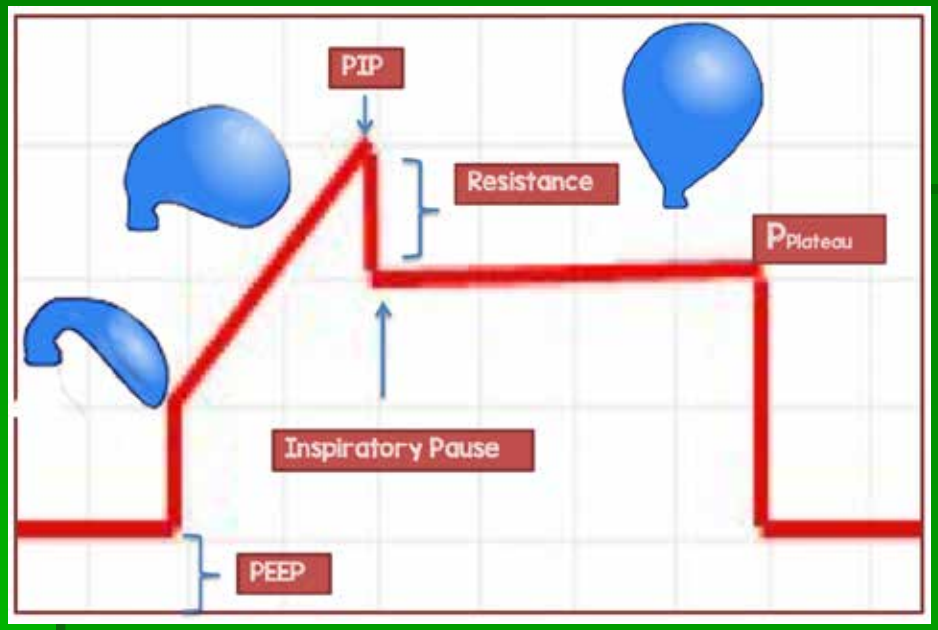


- dry of bloody nose
- skin irritation
- risk of fire
- suppression of breathing
- oxygen toxicity
- retinopathy of prematurity

Mechanical Ventilation Indications

- Cardiorespiratory arrest or impending arrest
- Respiratory distress/tachypnea with increased ventilatory demand and breathing effort leading to respiratory muscle fatigue
- Severe hypercapnic respiratory failure with either poor candidacy for nasal intermittent positive pressure ventilation (NIPPV) or failure of NIPPV
- Severe refractory hypoxemia with failure of noninvasive oxygen delivery devices
- Severe refractory metabolic acid-base disorder
- Need for therapeutic hyperventilation or hypoventilation
- Decreased respiratory drive with bradypnea

Mechanical Ventilation



Peak Inspiratory Pressure (PIP): dynamic pressure needed to fully inflate the lung

Airway Resistance: PIP – Plateau Pressure (normally <5cmH20 unless excessive airway resistance)

Inspiratory Pause: ventilator maneuver to measure plateau pressure

Plateau Pressure (PPlat): alveolar distending pressure

Mechanical Ventilation

Invasive

Non-invasive

Mechanical Ventilation

Modes of Mechanical Ventilation	Types of Breaths	Independent Variable	Dependent Variable	Notes
Volume Assist/Control	Assisted or Controlled	Preset Tidal Volume	PIP & Plateau Pressures	Control tidal volume (lung protective) Control of minute ventilation (RR & Vt)
Pressure Assist/Control	Assisted or Controlled	Preset Pressure	Adequate Tidal Volumes (not too high or low)	Patient comfort (decelerating flow), Control over delivered pressures (avoid barotrauma)
Pressure Support (PS)	Supported	Preset Pressure	Adequate Tidal Volumes (not too high or low)	Patient comfort Allows patient to maintain respiratory work effort
Synchronized Intermittent Mandatory Ventilation (SIMV) • PS	Assisted, Controlled or Supported	PC-SIMV=Preset Pressure VC-SIMV=Preset Tidal Volume	PC-SIMV=Adequate Tidal Volumes (not too high or low) VC-SIMV=PIP & Plateau Pressures	Can get benefits of supported breaths (PS), but still ensure minimum number of mandatory breaths (controlled or assisted)
Pressure Regulated Volume Control (PRVC)	Assisted or Controlled	Preset Tidal Volume	PIP & Plateau Pressures	Control Minute Ventilation Control Vt, Patient comfort (decelerating flow), Can limit high pressures (avoid barotrauma)

Mechanical Ventilation

Choosing a Ventilatory Mode

Advantages for volume-targeted modes

- ease of monitoring pulmonary mechanics
- simple to limit tidal volume

Advantages for pressure-targeted modes

- protection against dynamic hyperinflation
- enhanced patient comfort

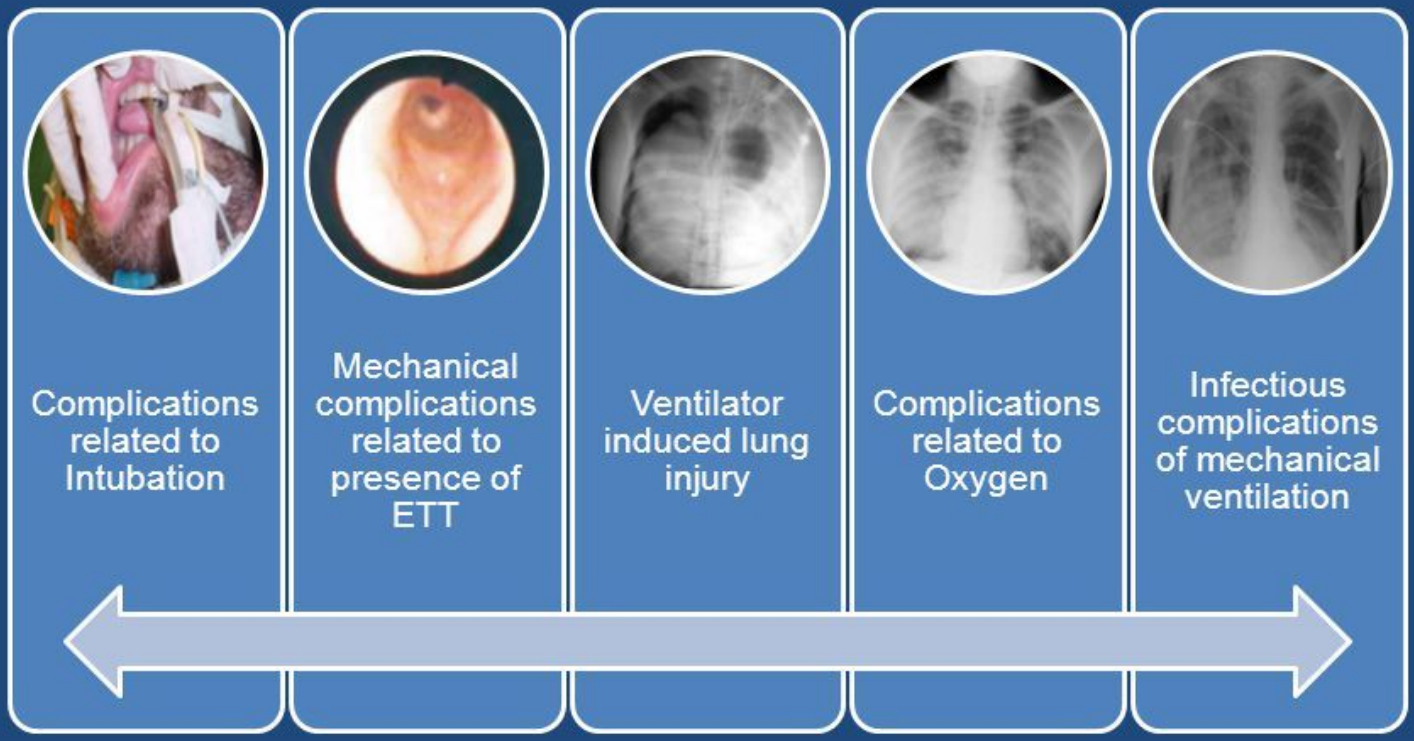
Mechanical Ventilation **intelectual modes**

Neurally Adjusted Ventilatory Assist **(NAVA)**

INTELLiVENT

Mechanical Ventilation

Complications of Mechanical Ventilation



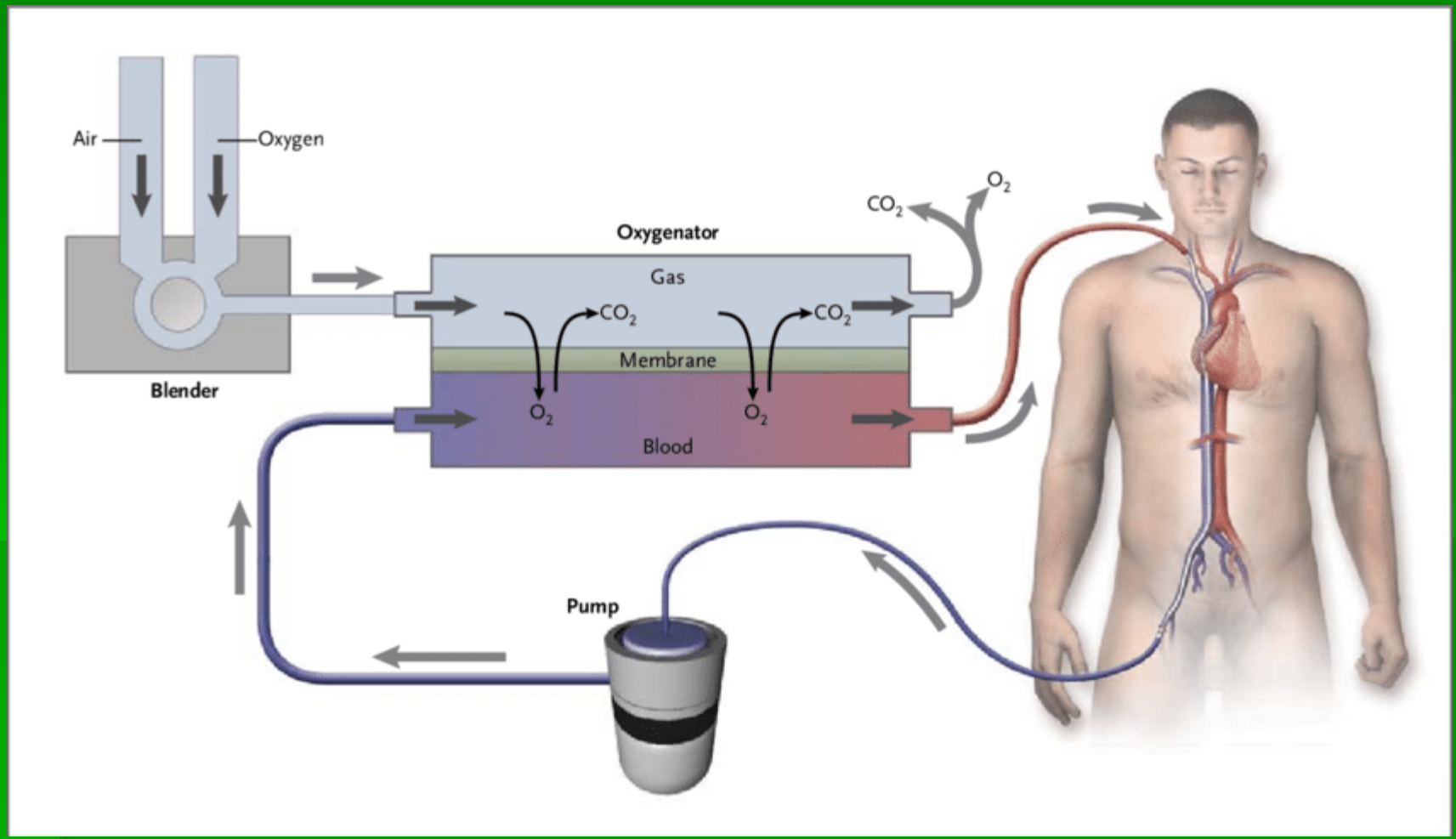
Mechanical Ventilation Complications

Volutrauma	• Overdistention
Atelectetrauma	• Repeated recruitment and collapse
Bio trauma	• Inflammatory mediators
Barotrauma	• High-pressure induced lung damage
Oxygen toxic effect	• FiO2

Extracorporeal membrane oxygenation

the using of mechanical devices to temporarily (days to months) support heart or lung function

Extracorporeal membrane oxygenation



Extracorporeal membrane oxygenation

Indications:

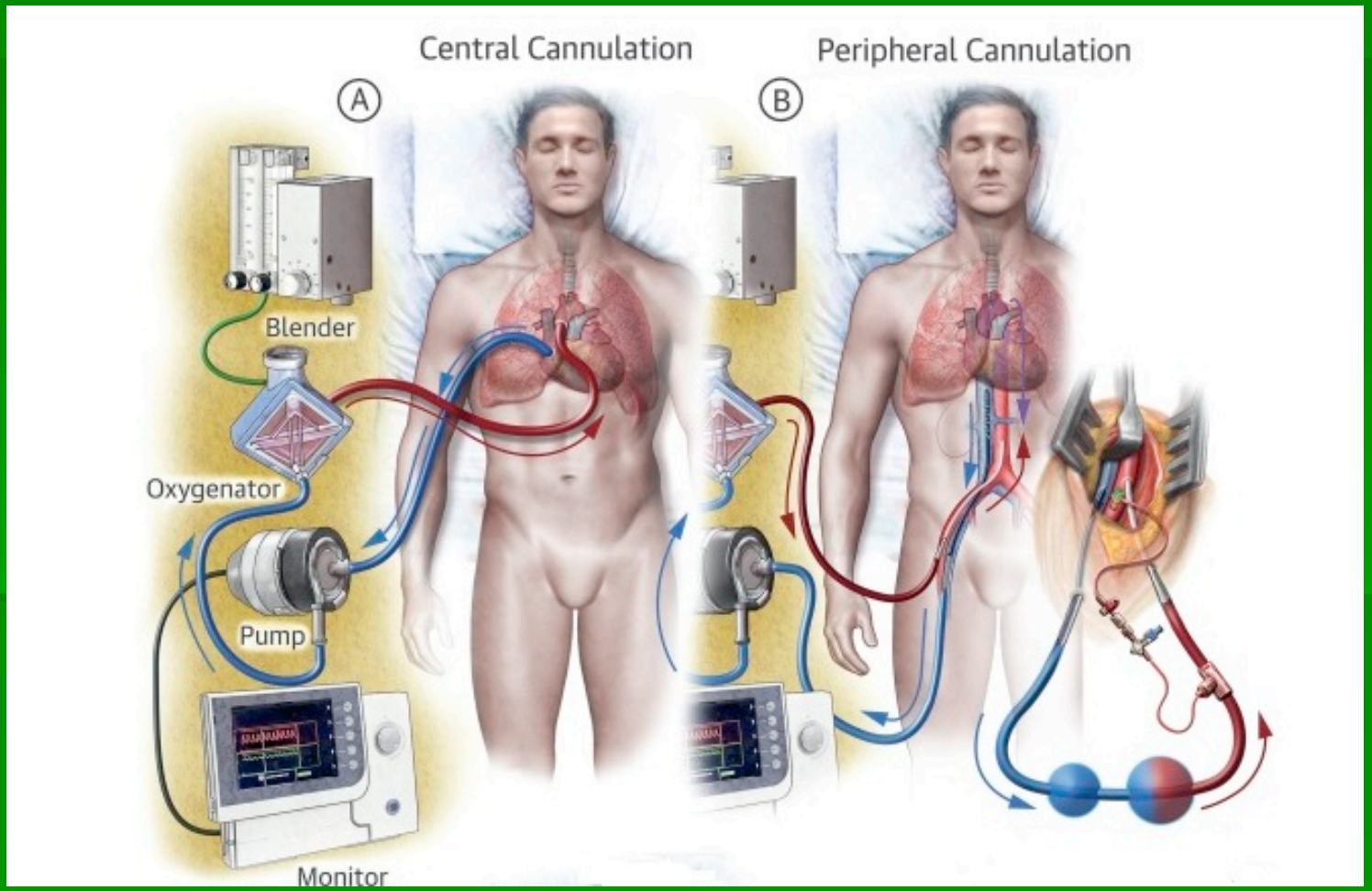
Acute severe cardiac or pulmonary insufficiency with a high risk of death, resistant to optimal traditional therapy

Extracorporeal membrane oxygenation

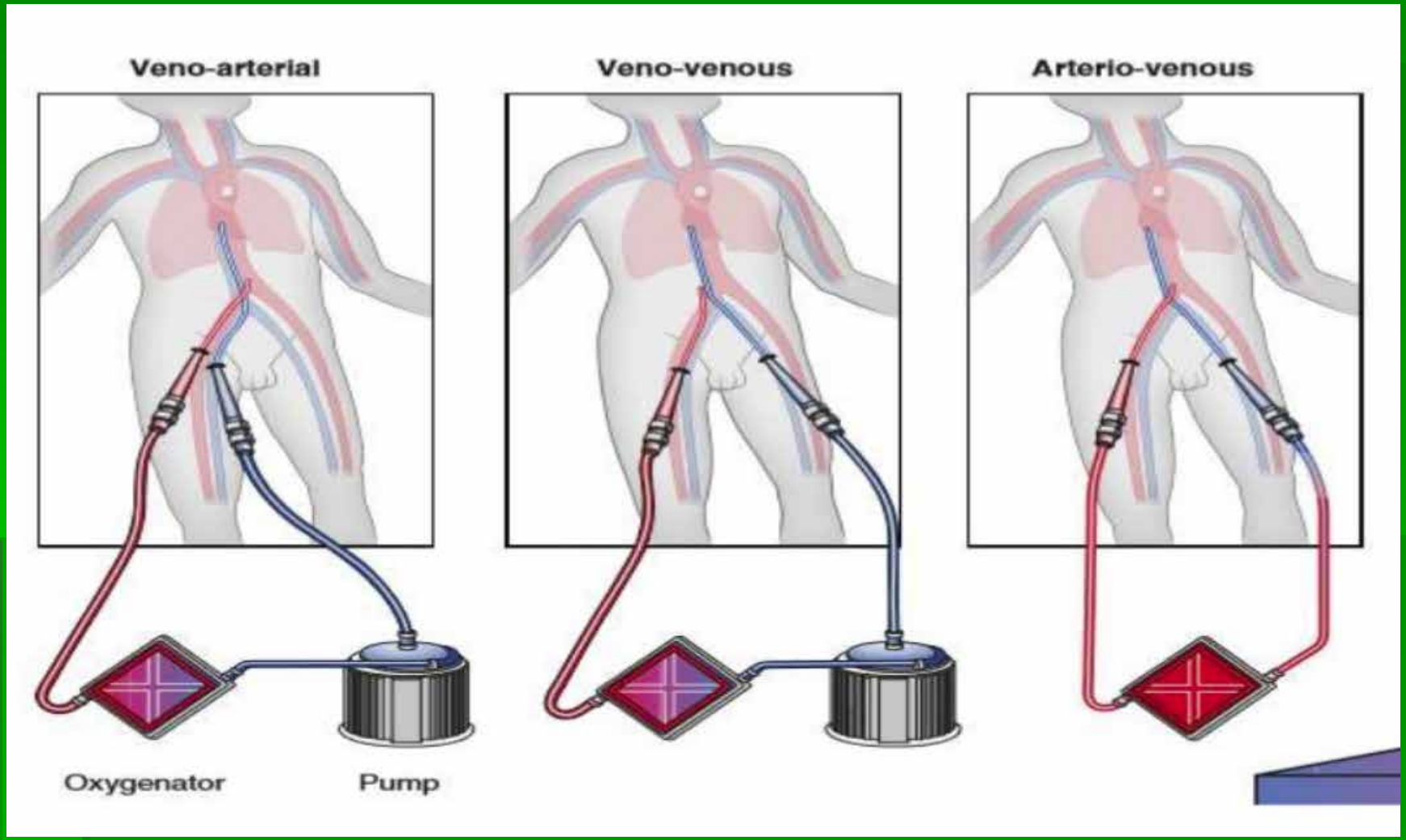
Contraindications:

- Conditions incompatible with normal life if the person recovers
- Preexisting conditions that affect the quality of life (CNS status, end-stage malignancy, risk of systemic bleeding with anticoagulation)
- Age and size

Extracorporeal membrane oxygenation. Access



Extracorporeal membrane oxygenation. Access



ARDS definition

Acute Respiratory Distress Syndrome

The Berlin Definition

	ACUTE RESPIRATORY DISTRESS SYNDROME		
Timing	Within 1 week of a known clinical insult of new/worsening respiratory symptoms		
Chest Imaging [a]	Bilateral opacities – not fully explained by effusions, lobar/lung collapse, or nodules		
Origin of Edema	Respiratory failure not fully explained by cardiac failure or fluid overload; Need objective assessment (e.g., echocardiography) to exclude hydrostatic edema if no risk factor present		
	Mild	Moderate	Severe
Oxygenation [b]	$200 < PaO_2/FiO_2 \leq 300$ with PEEP or CPAP ≥ 5 cmH_2O [c]	$100 < PaO_2/FiO_2 \leq 200$ with PEEP ≥ 5 cmH_2O	$PaO_2/FiO_2 \leq 100$ with PEEP ≥ 5 cmH_2O

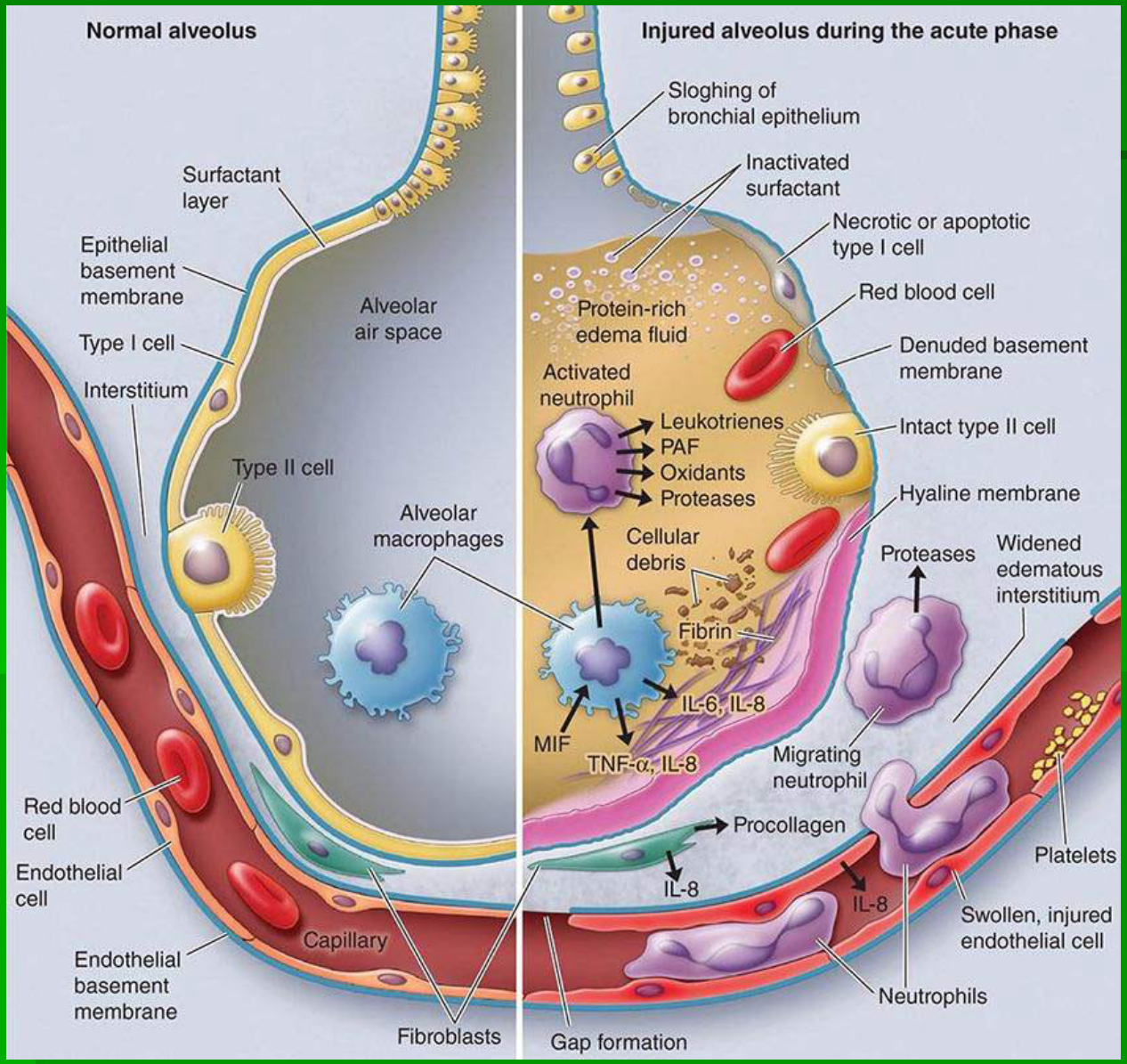
[a] Chest x-ray or CT scan

[b] If altitude higher than 1000 m, correction should be made: $PaO_2/FiO_2 \times$ (barometric pressure/760)

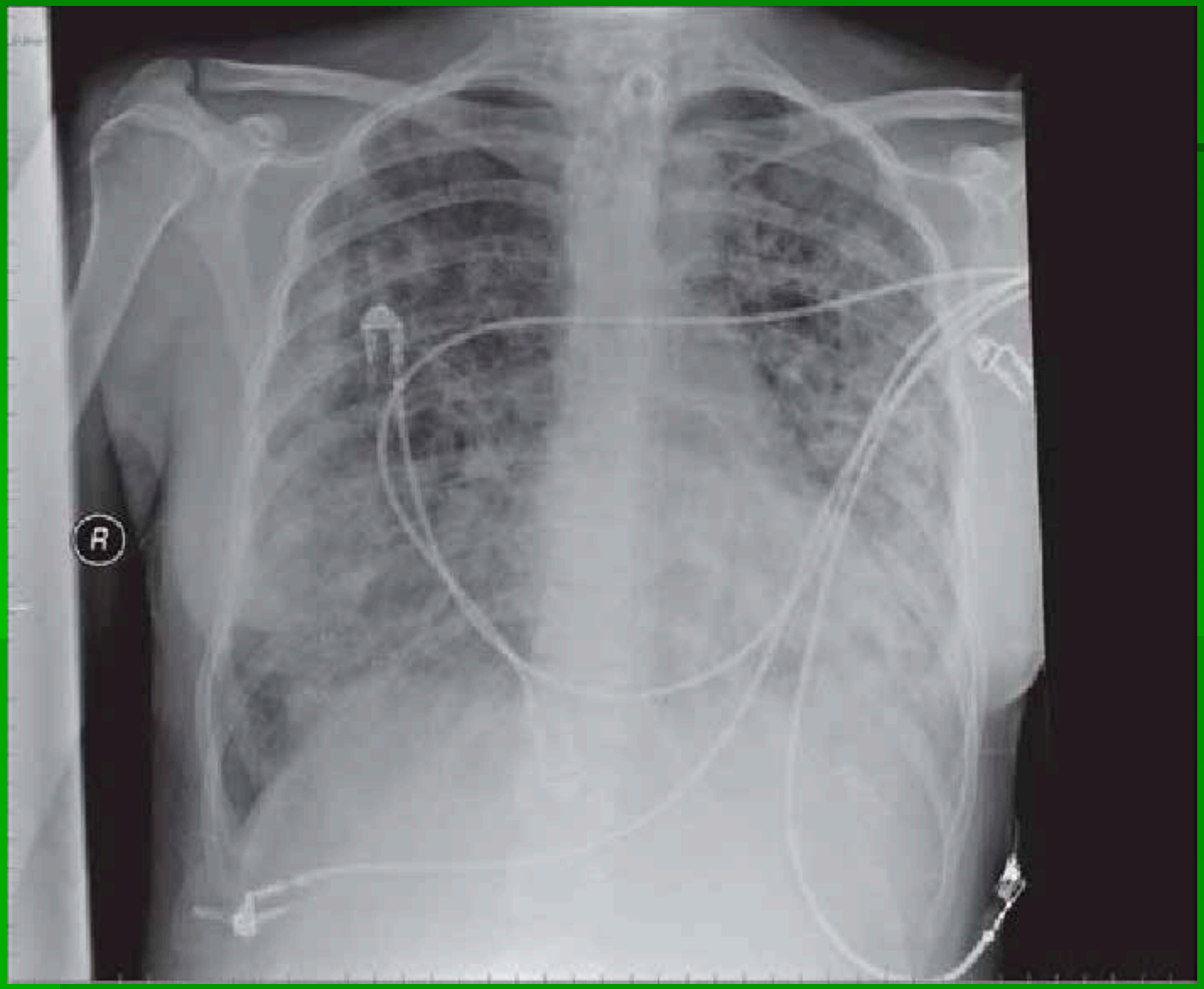
[c] This may be delivered non-invasively in the Mild ARDS group

The ARDS Definition Taskforce. JAMA 2012;307:2526-2533.

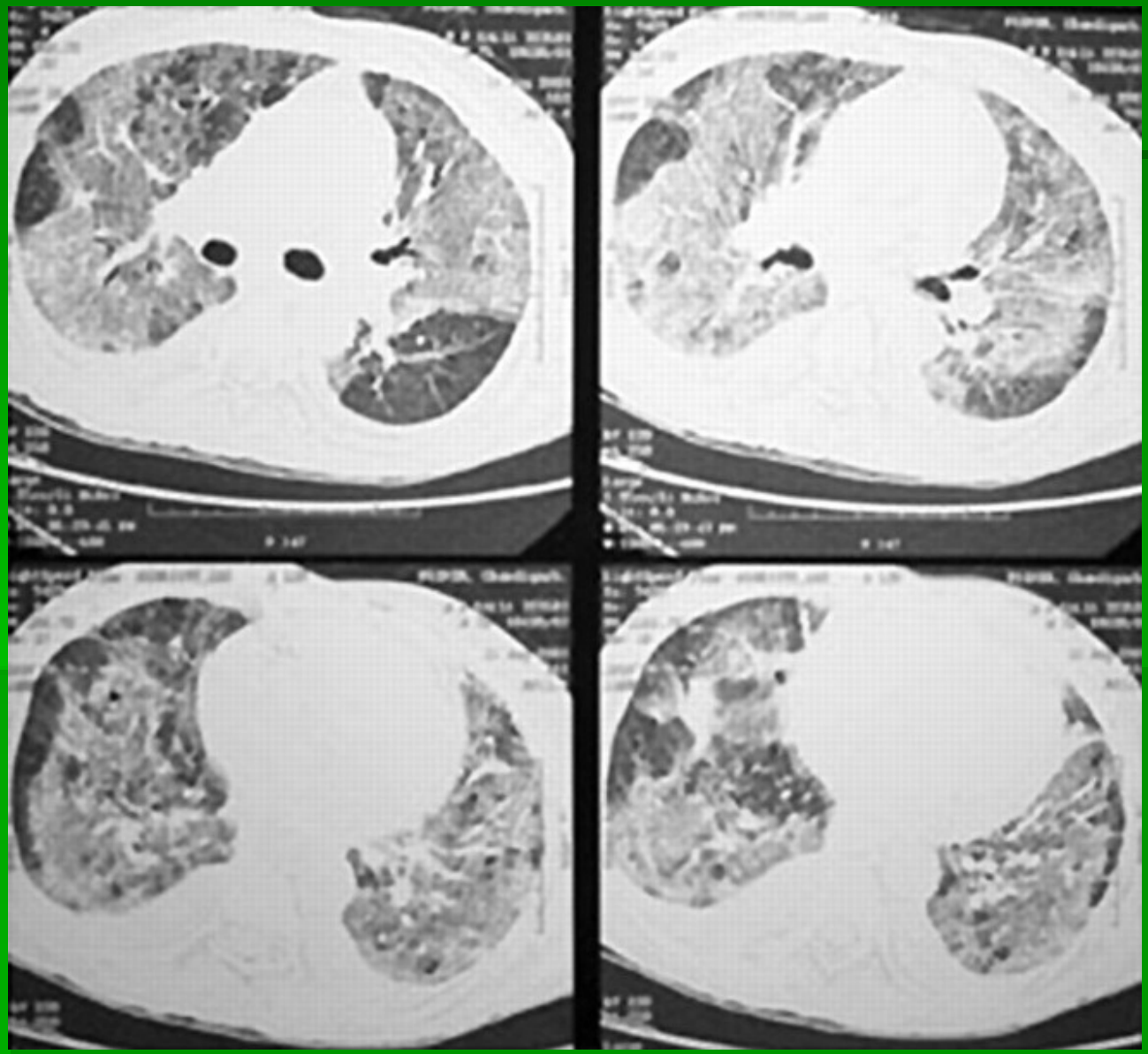
ARDS pathogenesis



ARDS X-Ray



ARDS CT



ARDS risk factors

Direct lung injury

- pneumonia
- gastric content aspiration
- inhalation injury
- drowning
- severe blow to the chest or other accident that bruises the lungs

ARDS risk factors

Indirect lung injury

- sepsis
- non-chest trauma
- pancreatitis
- burns
- non-cardiogenic shock
- drug overdose
- acute lung injury following tranfusions (TRALI)

ARDS infection

Most common pathogens responsible for ARDS genesis.

Bacteria	Virus	Fungi	Parasites
Streptococcus pneumoniae	Influenza A and B		
Haemophilus influenzae	Rhinoviruses		
Enterobacteriaceae	RSV	*Pneumocystis Jirovecii*	
Staphylococcus aureus	Parainfluenza viruses		
Legionella pneumophila	Coronavirus		*Toxoplasma gondii*
Clamydia pneumoniae	Enterovirus		
Mycoplasma pneumoniae	HSV		
Pseudomonas aeruginosa	CMV	*Aspergillus fumigatus*	
Acinetobacter baumannii	–		
Stenotrophompnas maltophilia	–		

ARDS severity

Murray Score

Variable	Score				
	0	1	2	3	4
PaO_2/FiO_2 (on 100% oxygen) in mm Hg	≥300	225-299	175-224	100-174	<100
CXR (quadrant)	Normal	1	2	3	4
PEEP (cm H_2O)	≤5	6-8	9-11	12-14	≥15
Compliance (mL/cm H_2O)	≥80	60-79	40-59	20-39	≤19

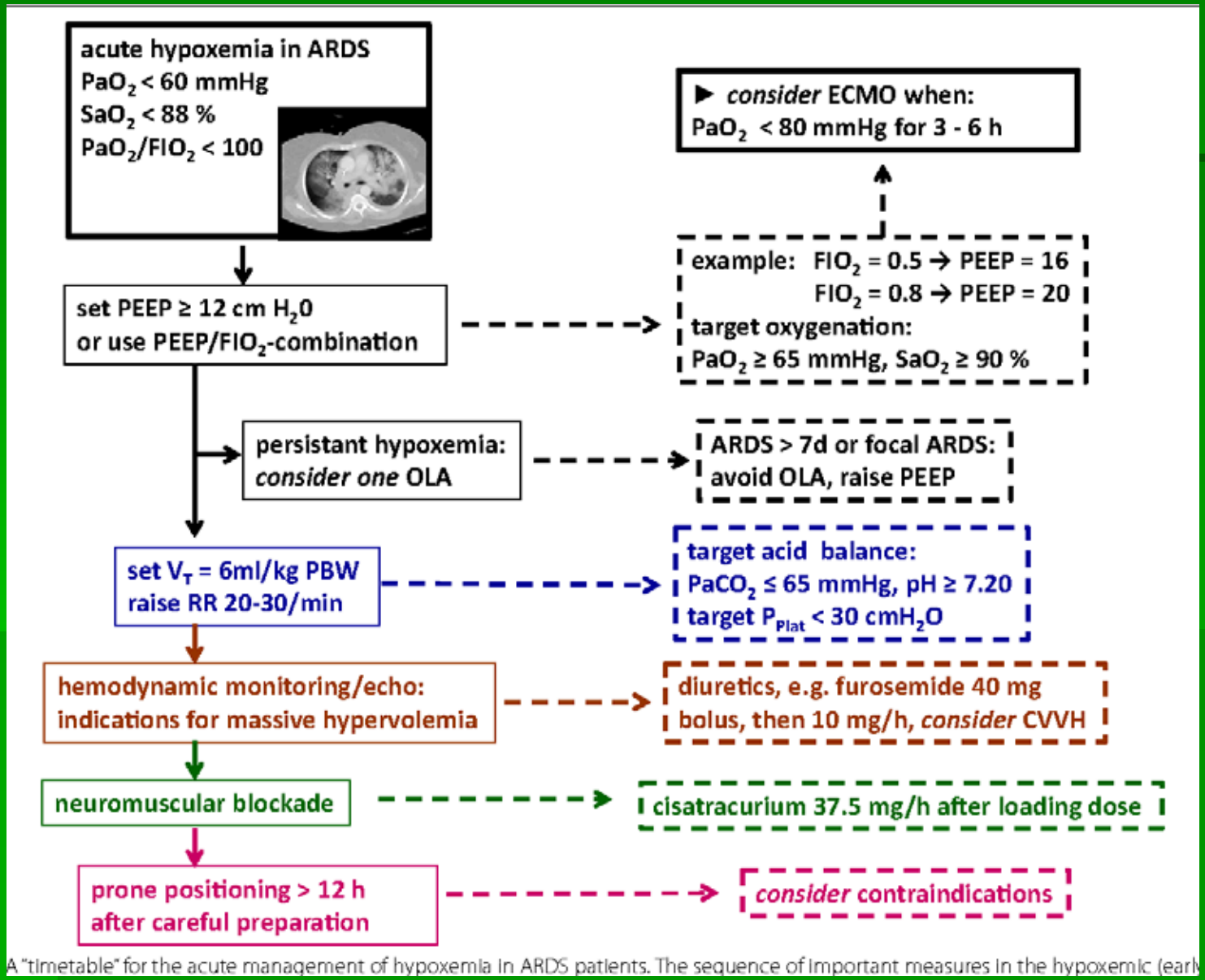
Abbreviations: CXR = chest X-ray; FiO_2 = fraction of inspired oxygen; PaO_2 = partial pressure of oxygen; PEEP = positive end-expiratory pressure

0 no lung injury;

1 - 2.5 mild to moderate lung injury

>2.5 severe lung injury

ARDS treatment



A "timetable" for the acute management of hypoxemia in ARDS patients. The sequence of important measures in the hypoxemic (earl

ARDS Corticosteroids

Corticosteroids compared to placebo for Acute Respiratory Distress Syndrome

Patient or population: Adults with ARDS
Settings: Intensive Care
Intervention: Corticosteroids
Comparison: Placebo

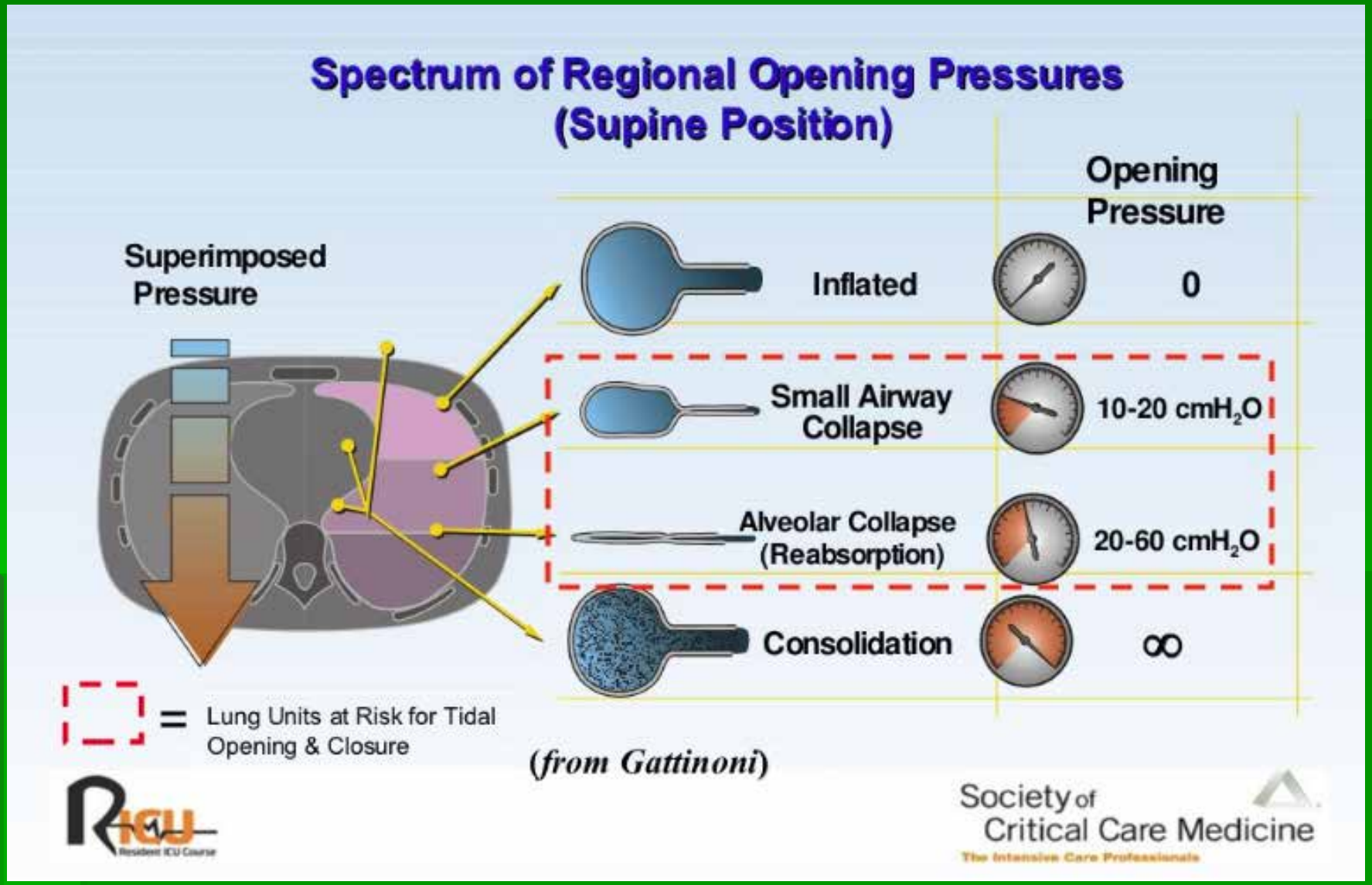
Outcomes	Illustrative comparative risks (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of evidence (GRADE)	Comments
	Control risk	Intervention risk				
	Placebo	**Corticosteroids**				
Mortality (Hospital)	**526 per 1000**	**326 per 1000** (121 to 663)	**RR 0.62** (0.23 to 1.26)	561 (5 studies)	+--- **VERY LOW** Due to serious risk of bias, serious inconsistency and serious imprecision	All studies conducted in the pre-lung protection strategy era. One study changed ventilation protocol during the study, following ARDS Net ARMA result
Mortality (Hospital or 60 day)	**500 per 1000**	**455 per 1000** (355 to 590)	**RR 0.91** (0.71 to 1.18)	725 (8 studies)	++-- **LOW** Due to serious inconsistency and serious imprecision	Pooled estimate from studies of both treatment and preventative steroids
Adverse Events	**350 per 1000**	**287 per 1000** (175 to 477)	**RR 0.82** (0.5 to 1.36)	494 (4 studies)	++-- **LOW** Due to serious risk of bias and serious imprecision	Composite of infection; neuromyopathy; diabetes, Gastro-intestinal bleeding and others

A large, multi-centre study on steroids in established ARDS is currently planned.

ARDS Fluid management

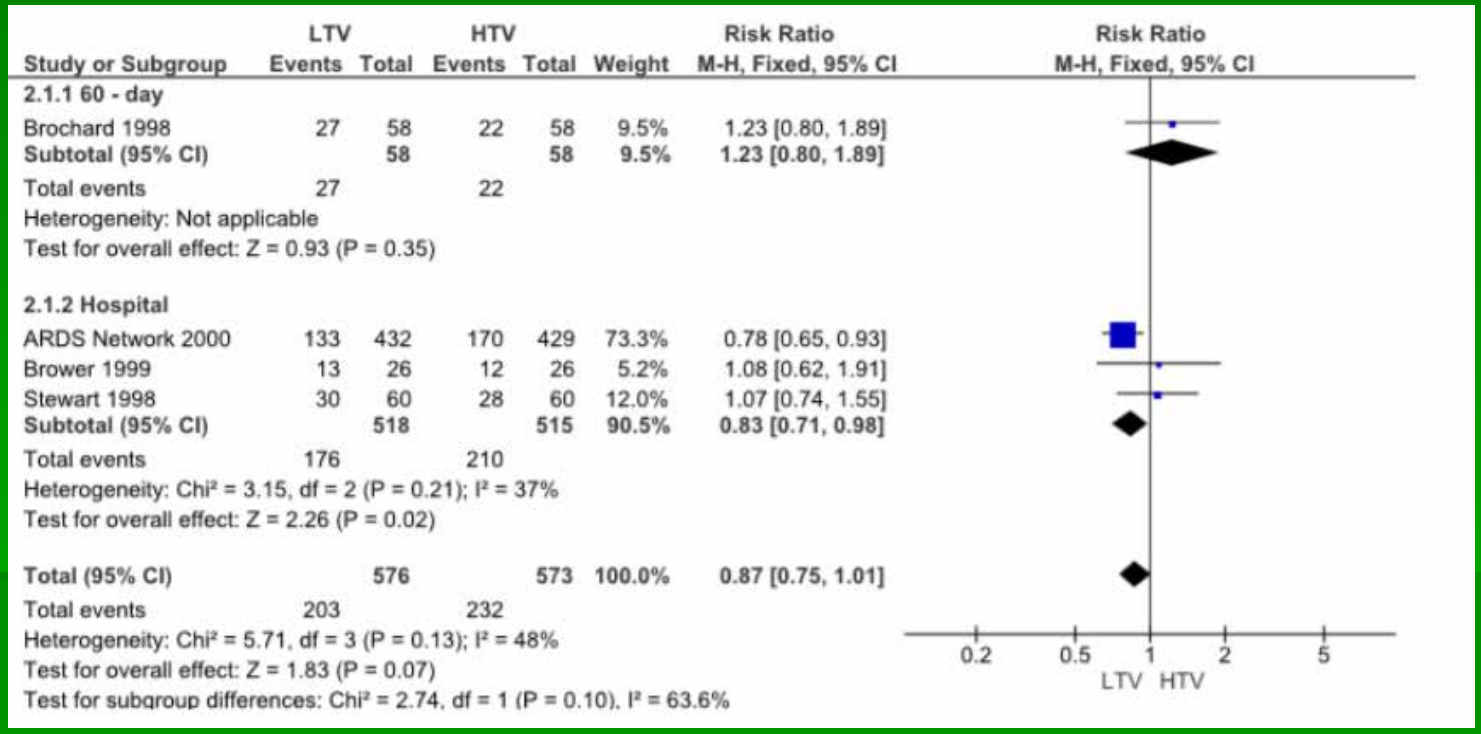
- suggesed the use of a conservative fluid strategy in patients with ARDS. (GRADE recommendation: weakly in favour)

ARDS mechanical ventilation



ARDS mechanical ventilation

Tidal volume 6 ml/kg predicted body weight or less with a plateau pressure less than or equal to 30 cmH_2O

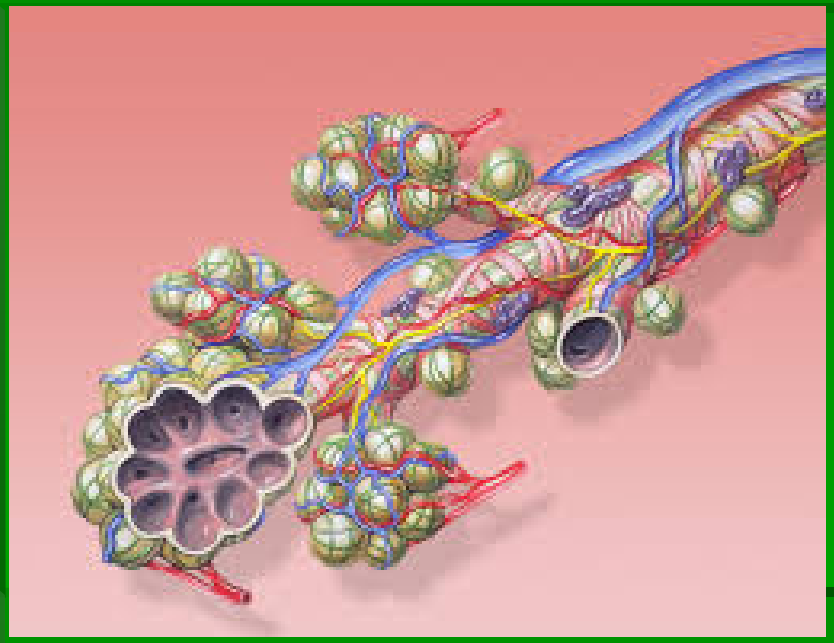


Study or Subgroup	LTV Events	LTV Total	HTV Events	HTV Total	Weight	Risk Ratio M-H, Fixed, 95% CI
2.1.1 60 - day						
Brochard 1998	27	58	22	58	9.5%	1.23 [0.80, 1.89]
Subtotal (95% CI)		**58**		**58**	**9.5%**	**1.23 [0.80, 1.89]**
Total events	27		22			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.93 (P = 0.35)						
2.1.2 Hospital						
ARDS Network 2000	133	432	170	429	73.3%	0.78 [0.65, 0.93]
Brower 1999	13	26	12	26	5.2%	1.08 [0.62, 1.91]
Stewart 1998	30	60	28	60	12.0%	1.07 [0.74, 1.55]
Subtotal (95% CI)		**518**		**515**	**90.5%**	**0.83 [0.71, 0.98]**
Total events	176		210			
Heterogeneity: $Chi^2 = 3.15$, df = 2 (P = 0.21); $I^2 = 37\%$						
Test for overall effect: Z = 2.26 (P = 0.02)						
Total (95% CI)		**576**		**573**	**100.0%**	**0.87 [0.75, 1.01]**
Total events	203		232			
Heterogeneity: $Chi^2 = 5.71$, df = 3 (P = 0.13); $I^2 = 48\%$						
Test for overall effect: Z = 1.83 (P = 0.07)						
Test for subgroup differences: $Chi^2 = 2.74$, df = 1 (P = 0.10), $I^2 = 63.6\%$						

q recommended the routine use of lower tidal volumes for the management of patients with ARDS (GRADE Recommendation: strongly in favour)

ARDS

positive end-expiratory pressure

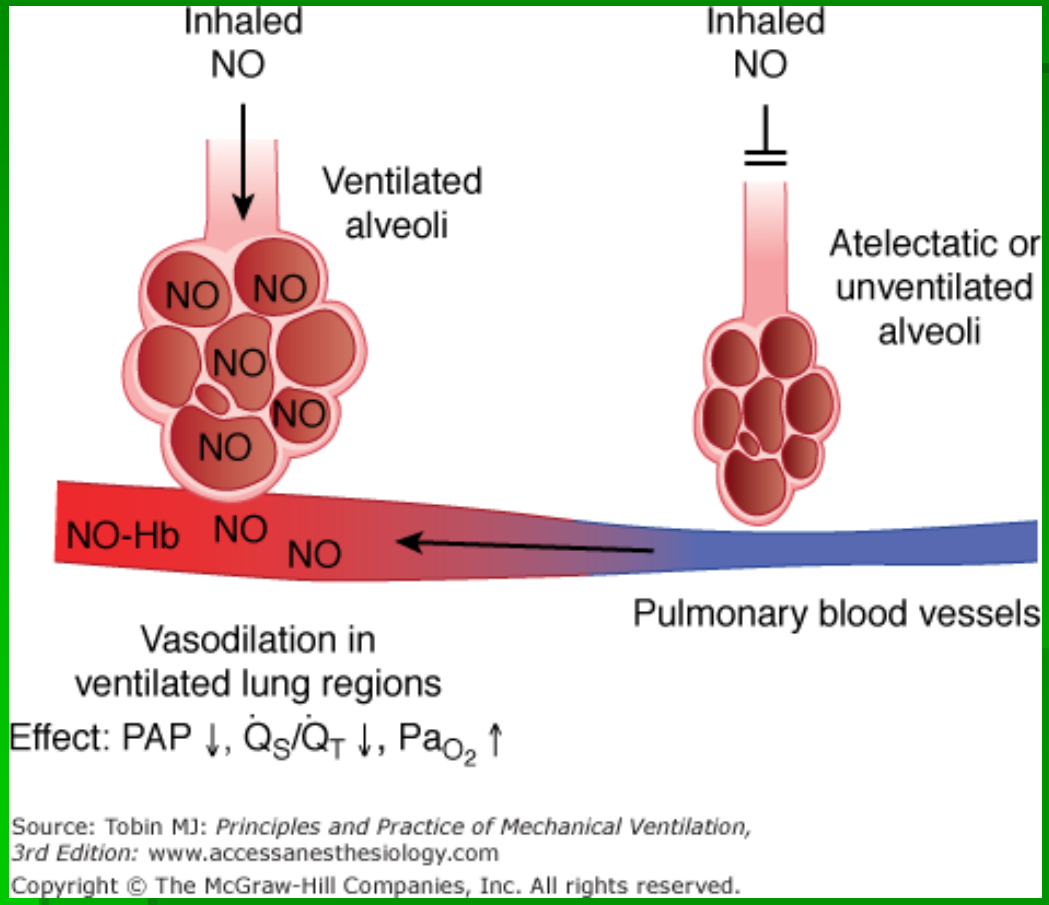


q suggested the using of high PEEP strategies for patients with moderate or severe ARDS
(GRADE Recommendation: weakly in favour)

ARDS High frequency oscillatory ventilation

q not recommended the use of HFOV in the management of patients with ARDS
(GRADE recommendation: strongly against).

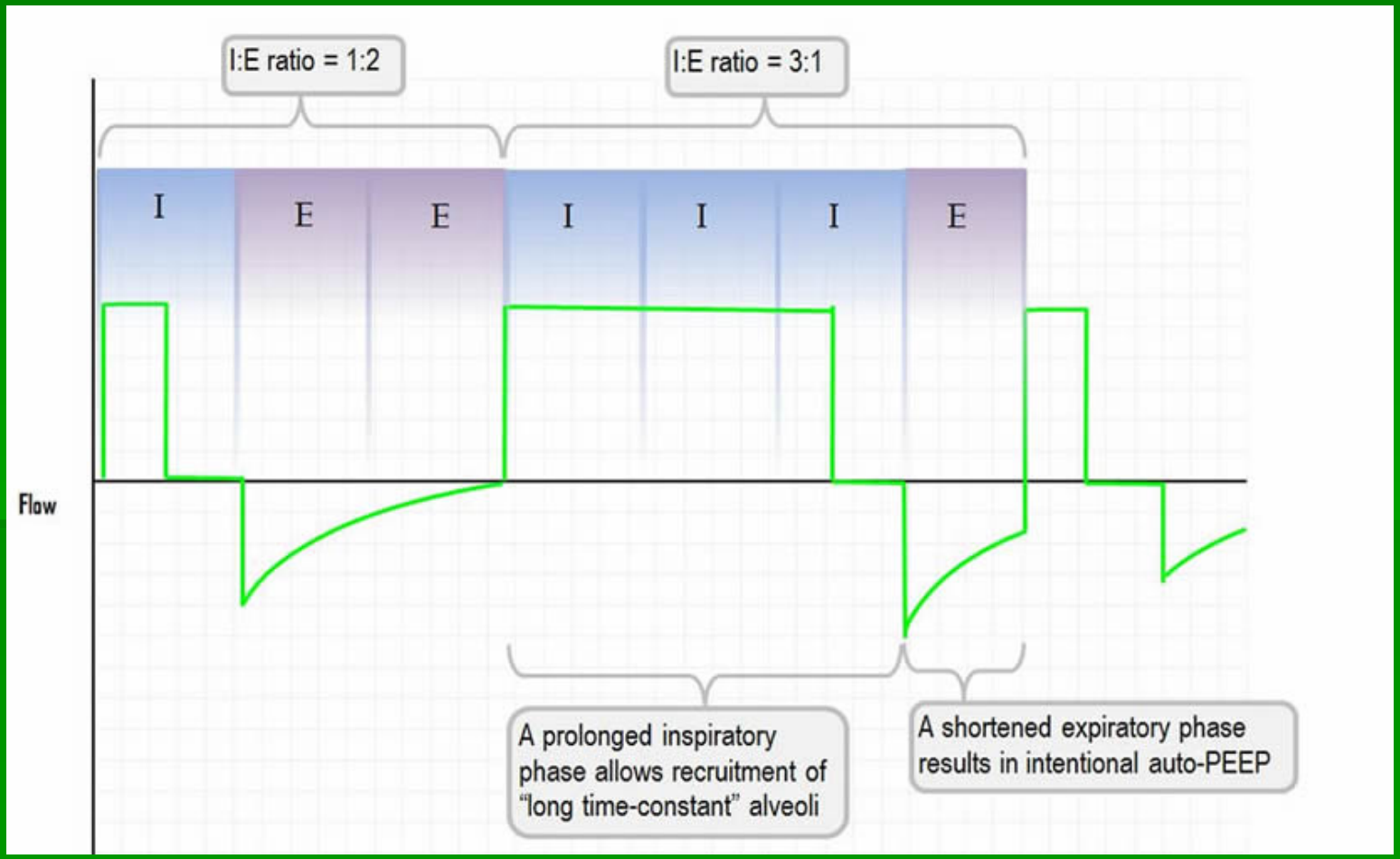
ARDS inhaled vasodilators



- not suggested using iNO in patients with ARDS (GRADE Recommendation: weakly against).

ARDS

Inverse I:E ratio ventilation



ARDS
Inverse I:E Ratio Ventilation

Risk

Lung damage

- Auto-PEEP (hyperinflation)
-
-

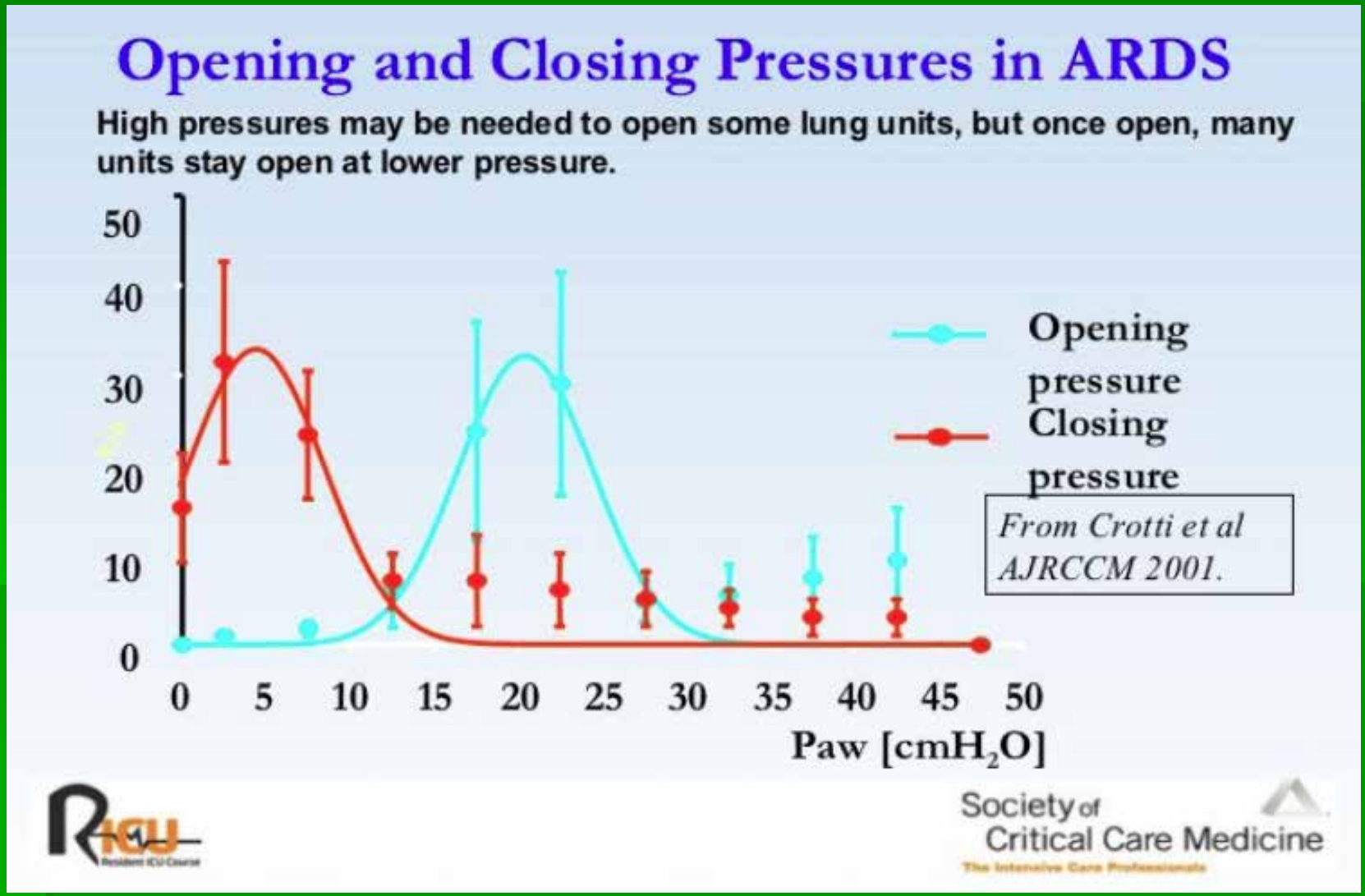
Cardiovascular compromise

-

Patient discomfort / asynchrony

-
- Air trapping

ARDS Recruitment Maneuver



ARDS Recruitment Maneuver

Advantages

- improved gas exchange
- improved compliance
- cheap
- quick
- easy
- can reduce conversion to adjuncts: iNO, prostacycline, ECMO, oscillation

ARDS Recruitment Maneuver

Disadvantages

- may require heavy sedation or paralysis
- benefit may be transient
- haemodynamic instability (decrease preload)
- only some disease states respond
- hypercapnia
- may worsen oxygenation by shunting blood to poorly aerated regions
- may contribute to ventilator-induced lung injury (VILI) due to overdistension and repeated opening of lung
- risk of pneumothorax

ARDS Recruitment Maneuver

Indications

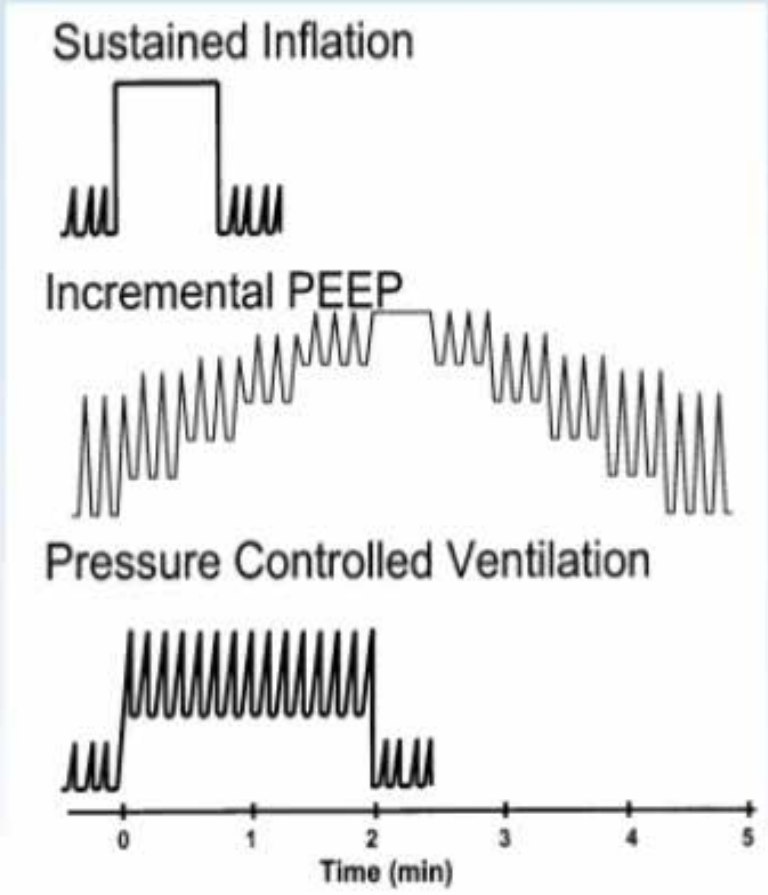
- severe ARDS of <1 week duration

Contraindications

- circulatory instability
- pneumothorax or other air leaks
- high risk of pneumothorax (e.g. necrotising lung infection, lung cysts, etc)
- ventilated ARDS present >1 week (poor responders)

ARDS Recruitment Maneuver

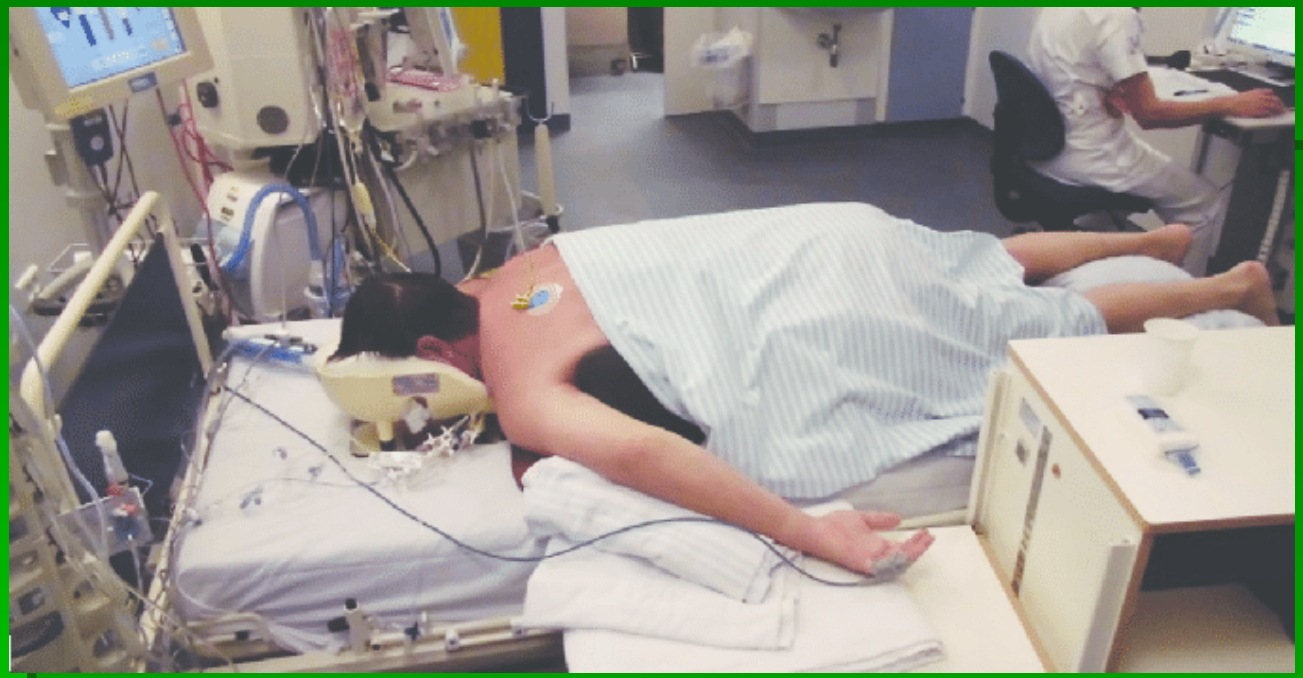
Three Types of Recruitment Maneuvers



S-C Lim, et al
Crit Care Med 2004

Society of Critical Care Medicine
The Intensive Care Professionals

ARDS Prone position



q recommended the using of prone positioning for at least 12 hours per day in patients with moderate/severe ARDS
(GRADE recommendation: strongly in favour)

ARDS Prone position

Contraindications

- Severe hemodinamic instability
- Life-threatening arrhythmias
- Serious burns or open wounds on the face or ventral body surface
- Intracranial hypertension
- Spinal instability
- Chest tubes inserted in the dorsal or ventral pleural space

ARDS mechanical ventilation

Incidence of side effects and complications of mechanical ventilation in ARDS

Side effect/complication	Incidence	Comment
Ventilator-associated lung injury (VALI)	Not known	Incidence and intensity depend on invasiveness/duration of mechanical ventilation
Ventilation-associated pneumonia (VAP)	14–28 %	Problem: incidence depends on VAP definition; incidence increases with duration and invasiveness of mechanical ventilation
Right ventricular dysfunction, acute cor pulmonale	Up to 50 %	Often associated with severe hypercapnia/acidosis
Pleural effusions	Up to 80 %	Frequently related to fluid overload, hypo-oncotic states, cardiac dysfunction, and altered pleural pressure
Barotrauma/pneumothorax	6–12 %	Depends on the invasiveness (P_{Plat}) of mechanical ventilation
Damage of other organ systems via cross talk	Not known exactly	Lung, brain, and—renal cross talk via inflammation pathways
Prolonged sedation and immobilization	Not known	Incidence and intensity depend on sedation strategy, (early) wake up, and spontaneous breathing trials
Fibroproliferative response of the lung parenchyma	Up to 50 % in the "lung-protective era"	Decrements in lung function (vital capacity, forced expiratory volume) up to 5 years after discharge

ARDS mechanical ventilation

Permissive hypoxemia

Conservative oxygenation strategy (aimed target SpO_2 88 - 92%) as a lung-protective approach.

Permissive hypercapnia

Even severe hypercapnia may be well tolerated (described the case of patient survival with CO_2 level of 373 mmHg). No severe side effects associated with hypercapnia were observed.

ARDS ECMO

- not recommended the routine use of ECMO for all patients with ARDS (GRADE Recommendation: weakly against)

- suggested the use of ECMO with lung-protective mechanical ventilation in selected patients with severe ARDS (GRADE Recommendation: weakly in favour).

ARDS neuromuscular blocking agents

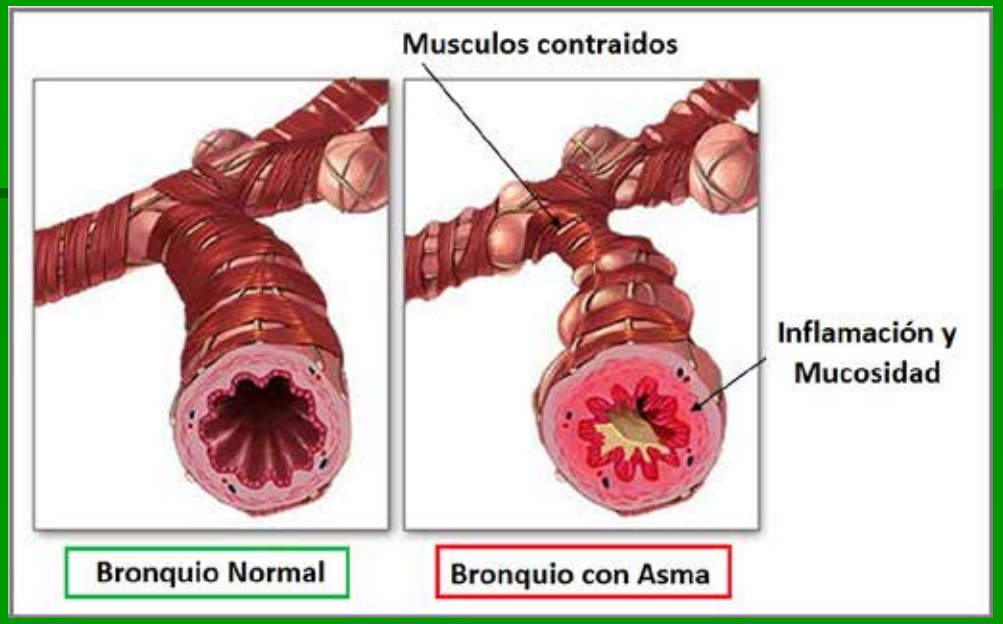
- not suggested using NMBAs for all patients with ARDS (GRADE Recommendation: weakly against).
- suggested the using of cisatracurium besylate by continuous 48-hour infusion in patients suffering early moderate/severe ARDS (< 20kPa) (GRADE Recommendation: weakly in favour).

ARDS treatment

Topic	GRADE Recommendation	Conditions
Tidal Volume	Strongly in favour	Tidal volume ≤ 6 ml/Kg ideal body weight; Plateau pressure < 30cmH_2O
Prone Positioning	Strongly in favour	Proning for ≥ 12 hours per day Patients with moderate/severe ARDS (P:F ratio ≤ 20kPa)
High frequency oscillation (HFOV)	Strongly against	
Conservative Fluid Management	Weakly in favour	
Higher Peek End-Expiratory Pressure (PEEP)	Weakly in favour	Patients with moderate or severe ARDS (PF ratio ≤ 27kPa)
Neuromuscular Blocking Agents (NMBA)	Weakly in favour	Evidence for cisatracurium besylate Continuous 48-hour infusion Patients with moderate/severe ARDS (≤ 20kPa)
Extra-Corporeal Membrane Oxygenation (ECMO)	Weakly in favour	With lung-protective mechanical ventilation Patients with severe ARDS, lung injury score ≥3 or pH <7.20 due to uncompensated hypercapnoea
Inhaled Vasodilators	Weakly against	Evidence for inhaled nitric oxide
Corticosteroids	Research recommendation	
Extra-Corporeal Carbon Dioxide Removal (ECCO2R)	Research recommendation	

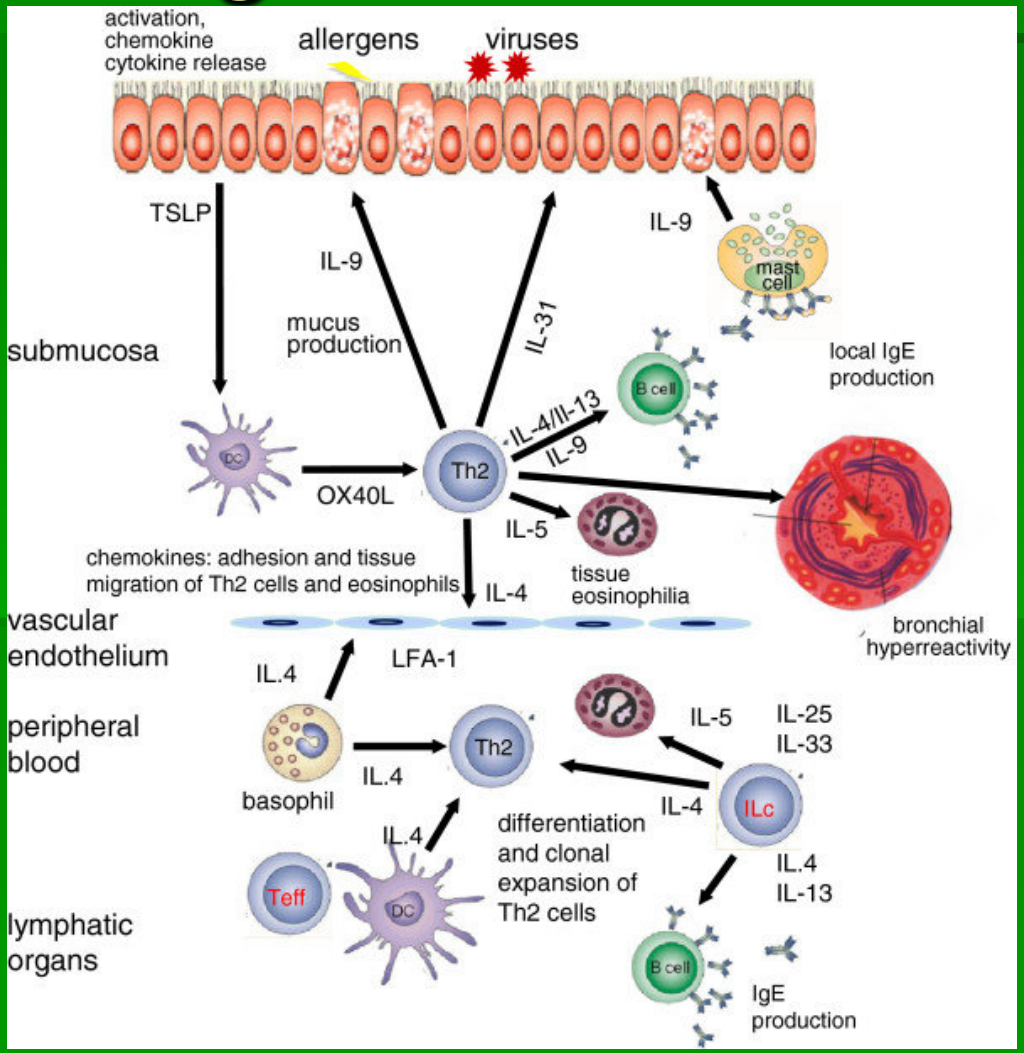
Status asthmaticus Definition

a prolonged severe attack of asthma that is unresponsive to initial standard therapy



Status asthmaticus

Pathogenesis



Status asthmaticus

Causes

- Viral infections
- Air pollutants - dust, cigarette smoke, and industrial pollutants
- Medications - beta-blockers, aspirin, and nonsteroidal anti-inflammatory drugs (NSAIDs)
- Cold temperature
- Exercise
- Insufficient use of inhaled or oral corticosteroids

Status asthmaticus

Risk

- Increased use of home bronchodilators without improvement or effect
- Previous intensive care unit (ICU) admissions, with or without intubation
- Asthma exacerbation despite recent or current use of corticosteroids
- Frequent emergency department visits and/or hospitalization
- Less than 10% improvement in peak expiratory flow rate (PEFR)
- History of syncope or seizures during acute exacerbation
- Oxygen saturation below 92% despite supplemental oxygen

Status asthmaticus

	Moderate	Severe	Respiratory arrest imminent
Breathlessness	Prefers sitting	Sits upright	
Talks	Phrases	Words	
Alertness	Usually agitated	Usually agitated	Drowsy or confused
Respiratory rate	Increased	> 30/minute	
Use of accessory muscles	Commonly	Usually	Paradoxical thoracoabdominal movement
Wheeze	exhalation	inhalation and exhalation	Absence
Pulse	100–120	> 120	Bradycardia
PEF %	40–69	< 40	< 25
PaO2, mm Hg (on air)		< 60	

Status asthmaticus

Tests

- pulsoxymetry
- spirometry
- complete blood count
- arterial blood gases
- electrolites
- serum lactate level
- theophylline level
- chest X-Ray

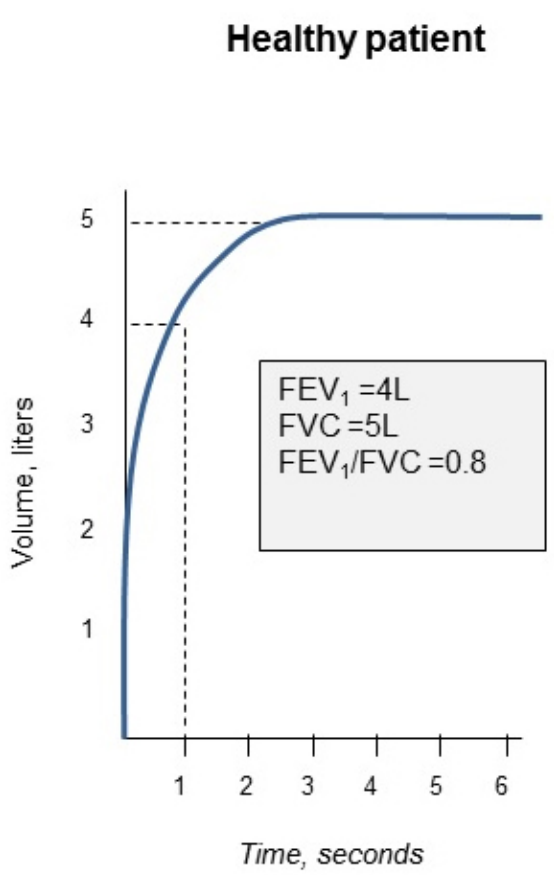
Status asthmaticus

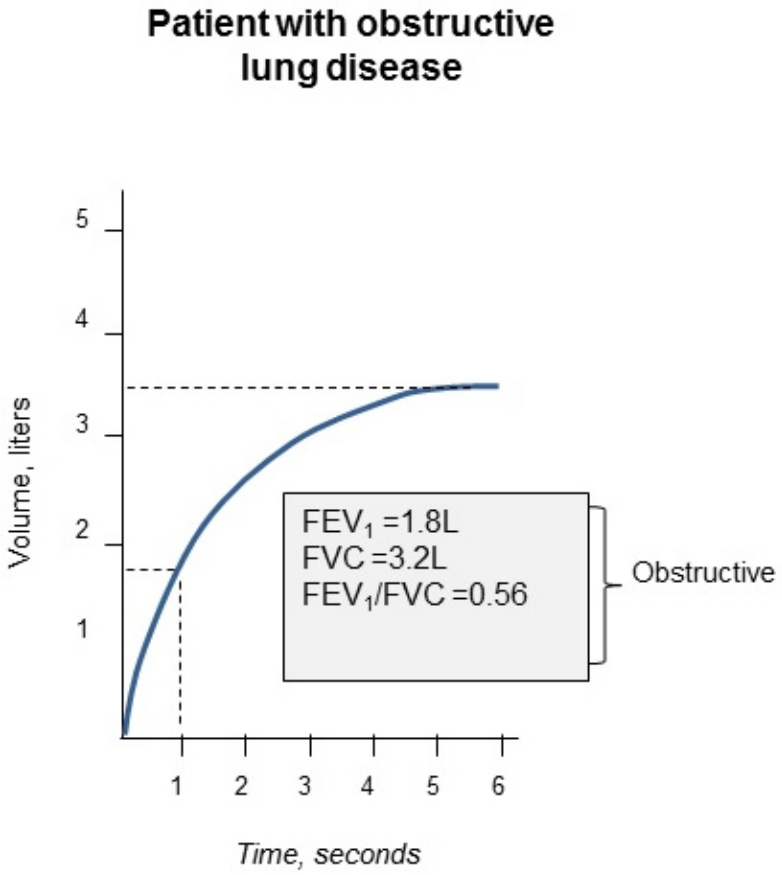
Severity

	PaCO2	PaO2
Stage 1	decrease	normal
Stage 2	decrease	decrease
Stage 3	normal	decrease
Stage 4	high	decrease

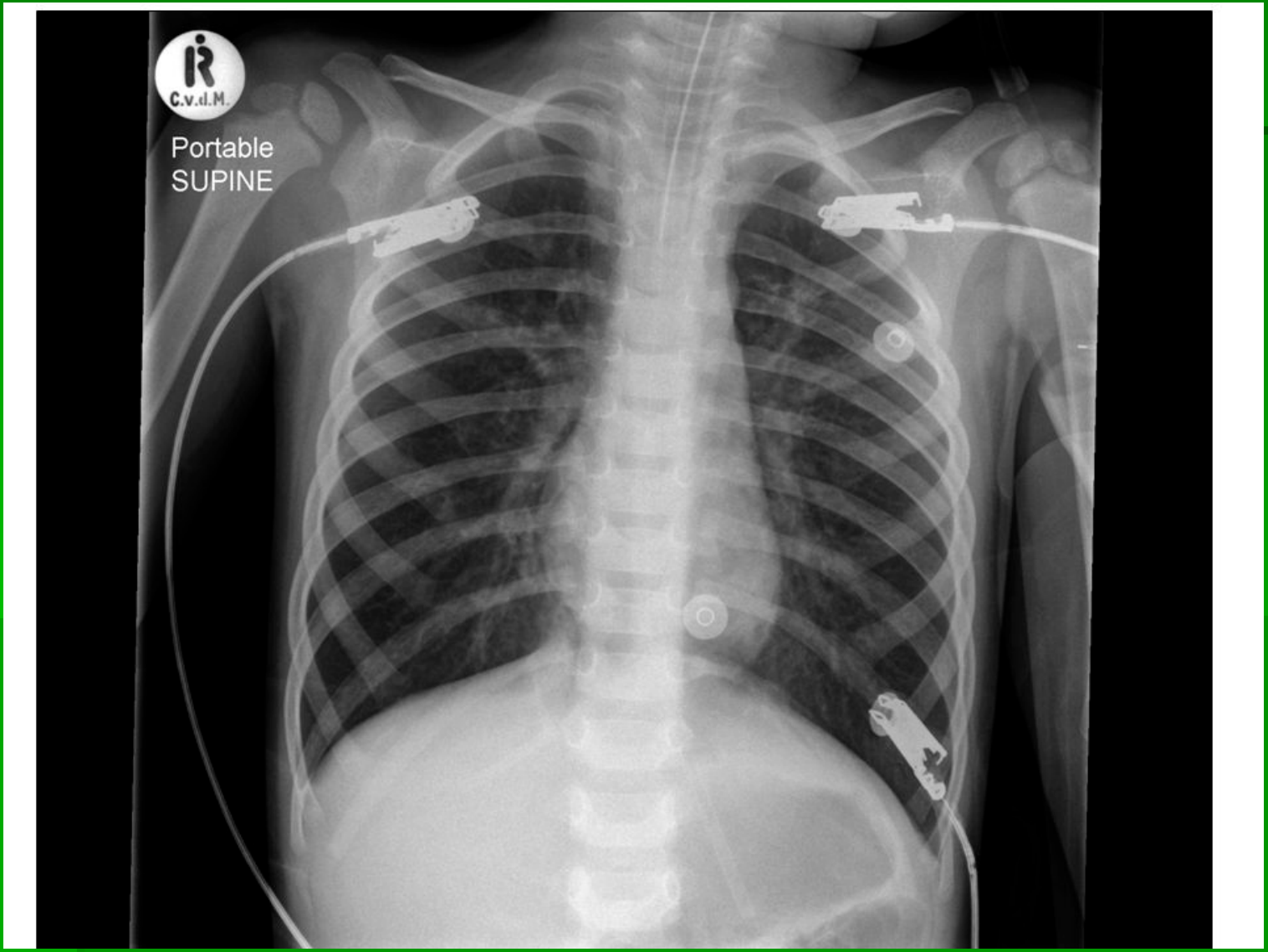
Status asthmaticus

spirometry





Status asthmaticus X-Ray



Status asthmaticus

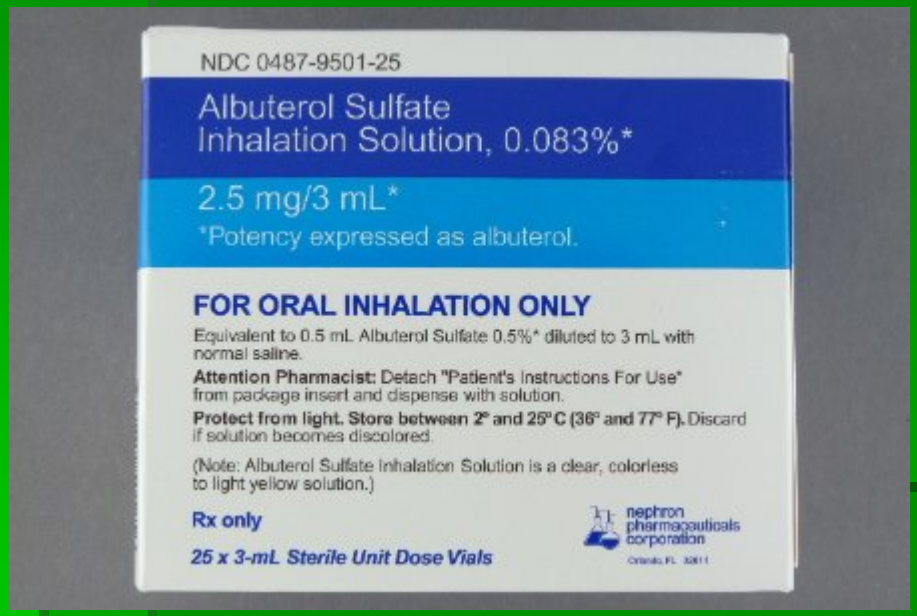
ICU admission criteria

- Altered sensorium
- Use of continuous inhaled beta-agonist therapy
- Exhaustion
- Markedly decreased air entry
- Rising PCO_2 despite treatment
- Presence of high-risk factors for a severe attack
- Failure to improve despite adequate therapy

Status asthmaticus treatment

Beta2-Agonists

The first line of therapy



Albuterol nebulizing continuously (10-15 mg/h) or by frequent timing (eg, q5-20min)

*Nonselective beta2-agonists are not recomended

Status asthmaticus treatment

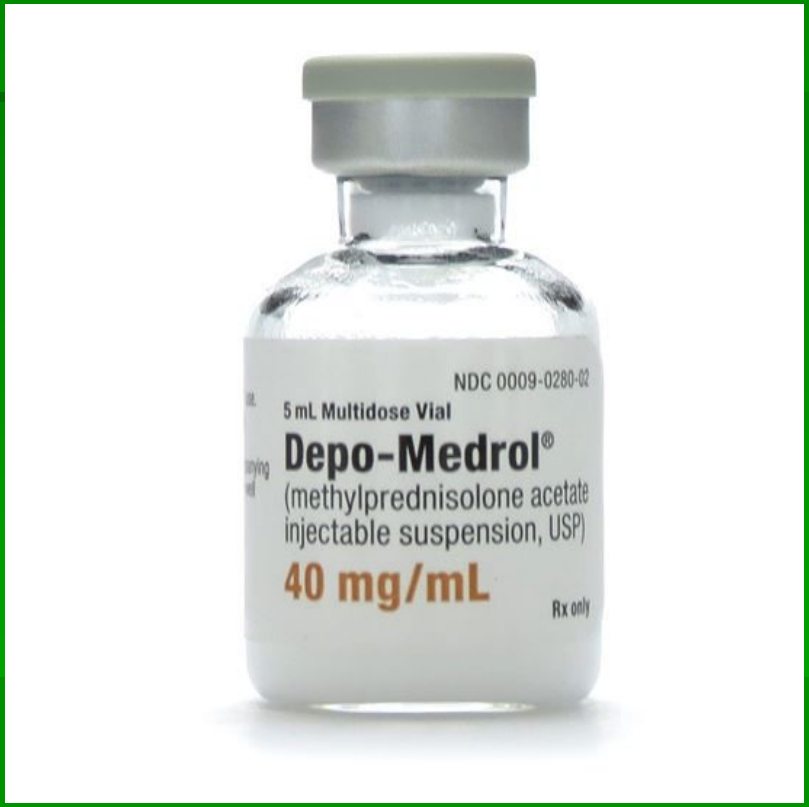
Anticholinergics

Ipratropium bromide nebulizing every 4-6 hours

Status asthmaticus treatment

Corticosteroids

intravenously
methylprednisolone
1 mg/kg/dose every 6 h



*The use of nebulized corticosteroids for treating status asthmaticus is controversial.

Status asthmaticus treatment

Methylxanthines (theophylline)

IV load 5 mg/kg

Infusion:

- smokers 0,72 mg/kg/h;
- non-smokers 0,48 mg/kg/h;
-heart feilure, hepatic feilure mg/kg/h.

*does not demonstrate a benefit to adding methylxanthines
-adrenergic agonists

Magnesium Sulfate

40 mg/kg infused over 20 min

**may be an adjunct to beta2-bronchodilator therapy

Status asthmaticus treatment

Fluid replacement

- Hydration, with intravenous normal saline at a reasonable rate
- Hypokalemia may result from either corticosteroid use or beta-agonist use
- Hypophosphatemia may result from poor oral intake

*Correcting hypokalemia and hypophosphatemia may help to wean an intubated patient

Status asthmaticus treatment

Antibiotics

The routine administration of antibiotics is discouraged. Patients are administered antibiotics only when they show evidence of infection (eg, pneumonia, sinusitis).

Status asthmaticus treatment

Mechanical Ventilation

Indications

- Apnea or respiratory arrest
- Diminishing level of consciousness
- Impending respiratory failure marked by significantly rising PCO_2 with fatigue, decreased air movement, and altered level of consciousness
- Significant hypoxemia that is poorly responsive or unresponsive to supplemental oxygen therapy alone

Status asthmaticus treatment

Mechanical Ventilation

- longer inspiration/expiration (I/E) ratio, often greater than 1:3-4
- low respiration rate (8 – 10 per min)
- the use of positive end-expiratory pressure (PEEP) is controversial

Status asthmaticus treatment

Heliox

- reduces turbulent airflow across narrowed airways,
- reduce the work of breathing
- high the helium concentration reduced of supplemental oxygen

Resistant status asthmaticus treatment

- Ketamine
- Neuromuscular blockers
- Inhaled anesthetics (isoflurane)
- Nitrate oxide
- ECMO

Literature

- Tobin, Martin J.
  New York: McGraw-Hill Medical Pub. Division, 2018. Print.

Questions for the next lecture

Respiratory, circulatory, and renal dysfunction: Is there a connection?

Acute kidney injury and acute renal failure: Identity and differences?