Final FRCA Teaching

2nd March 2022

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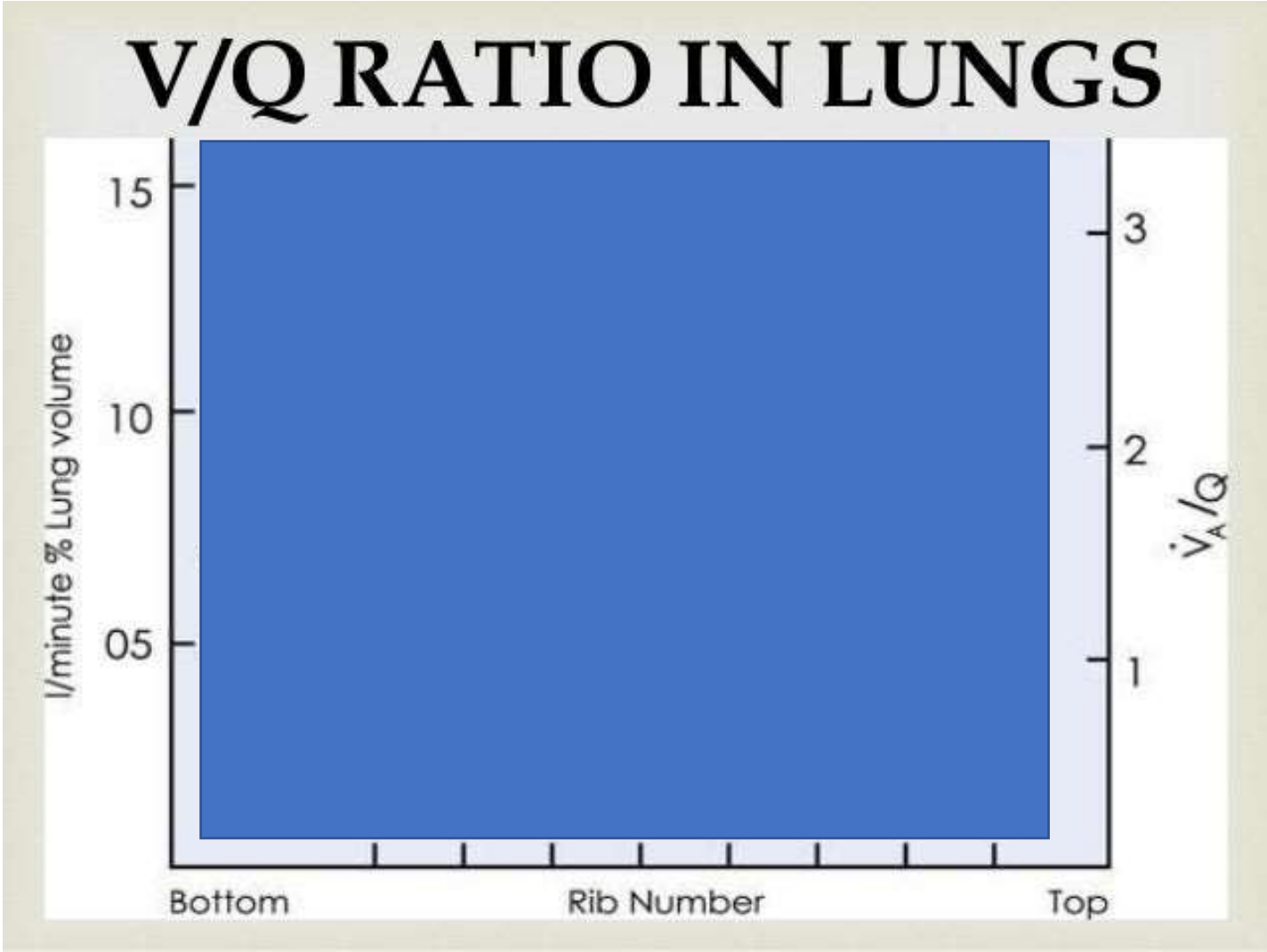
ST6 anaesthetics/ICM

Prone positioning in health and disease

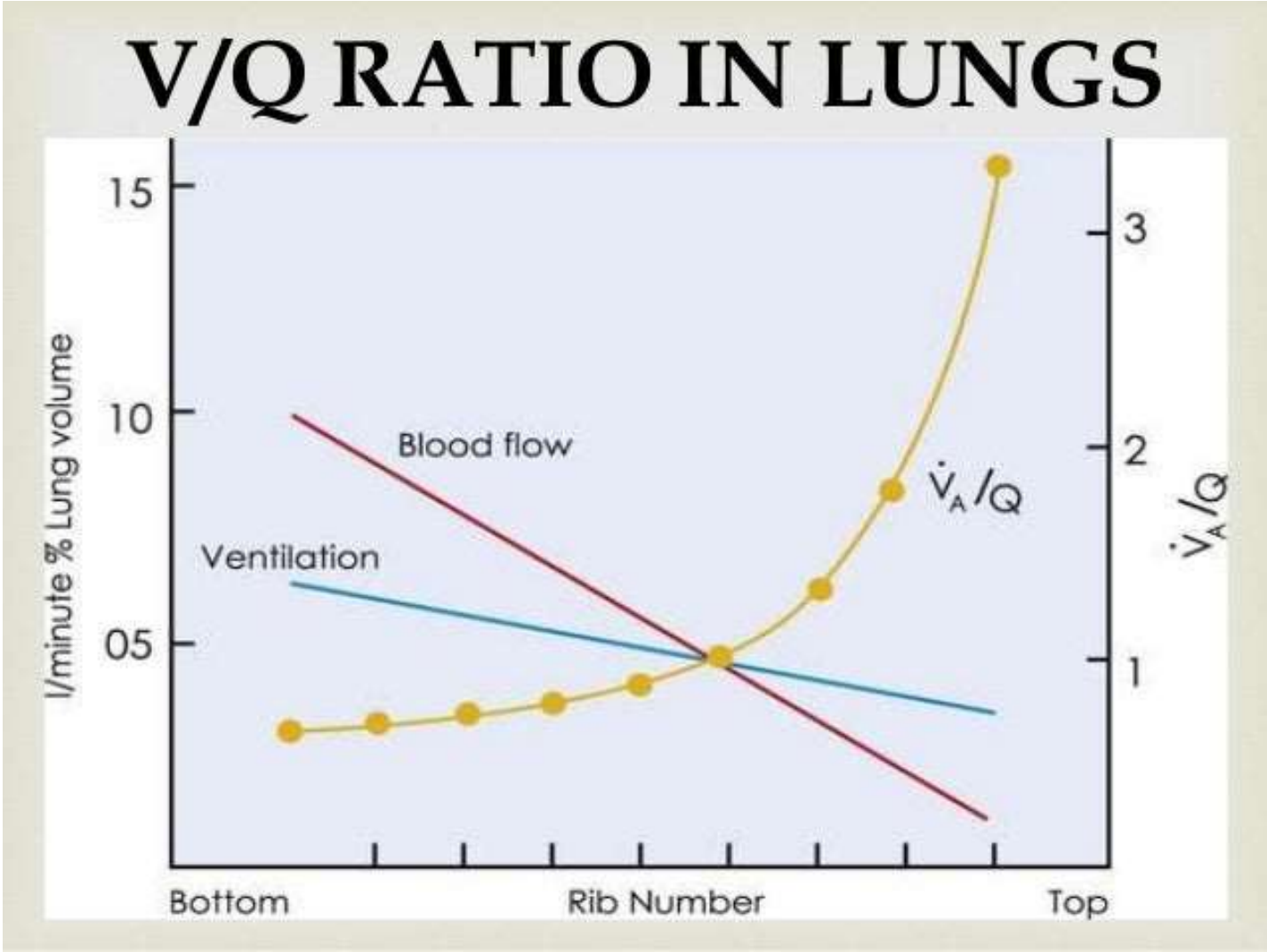
Overview

- Recap of relevant respiratory physiology
- Prone physiology in health/spont ventilation
- Prone physiology in disease +/- IPPV
- Some questions about prone positioning

Normal Breathing Physiology – recap

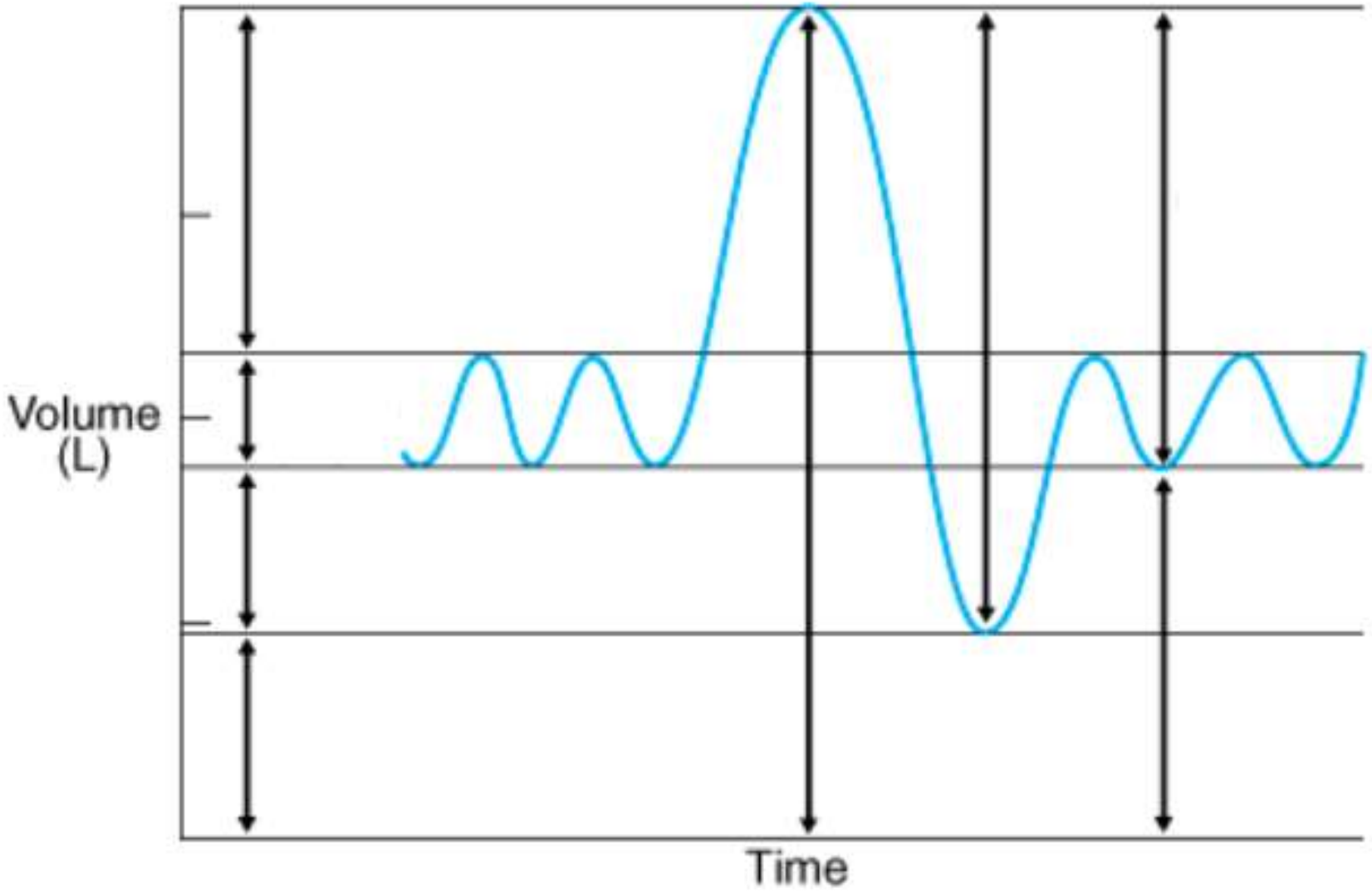


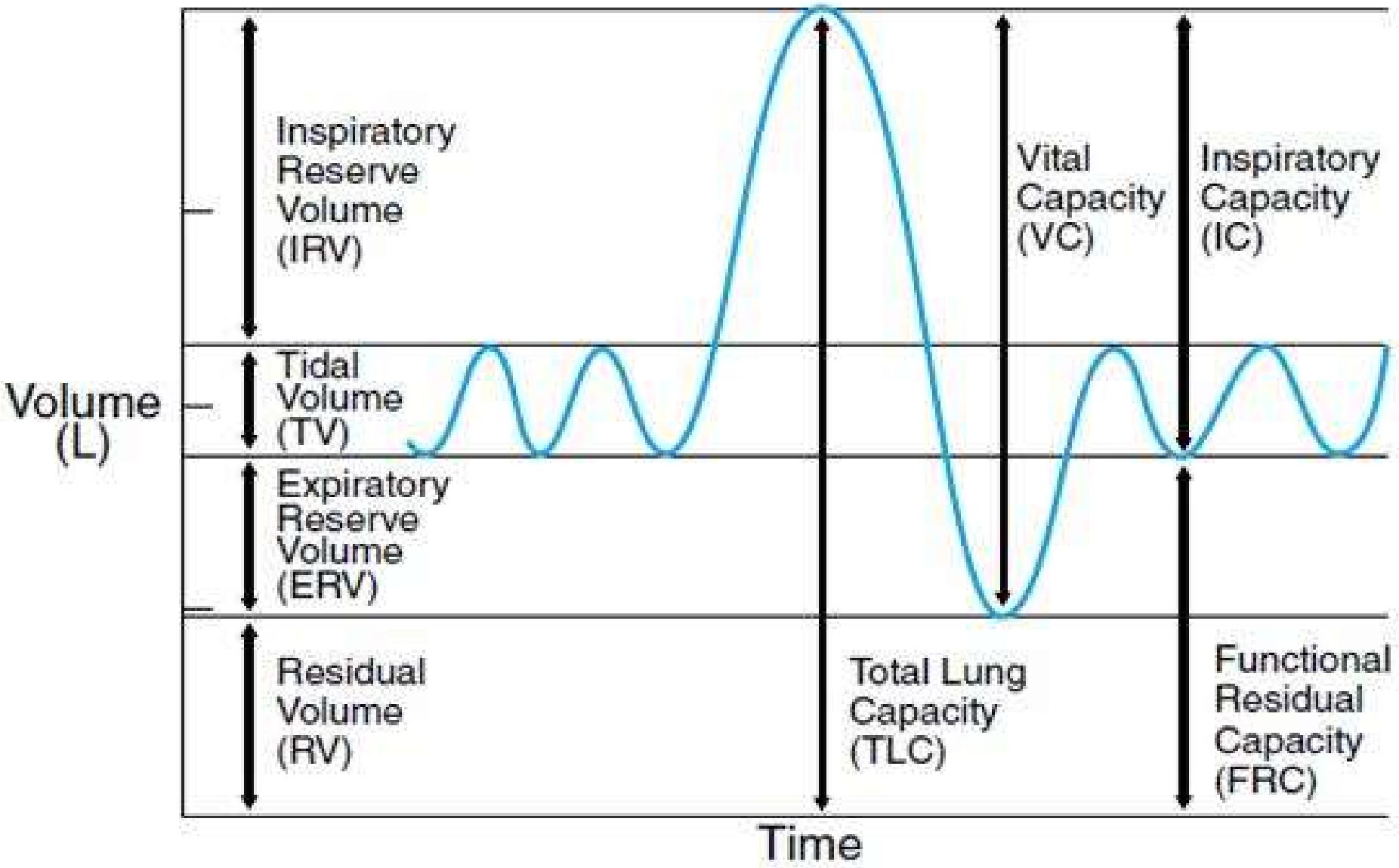
Normal Breathing Physiology – recap



Normal breathing physiology

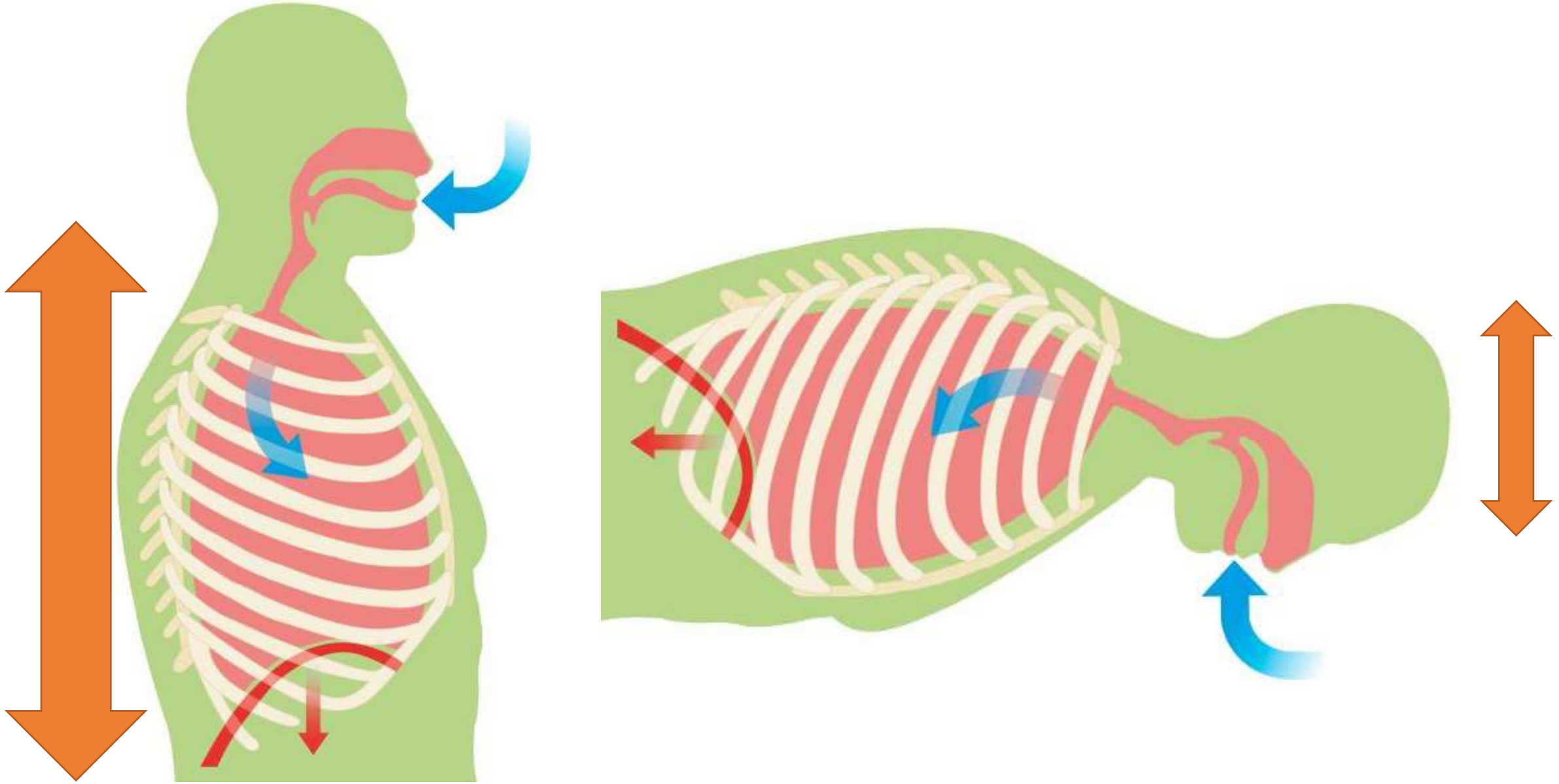
- Bipeds – upright position
- VQ mismatch is the norm
- Both V and Q are increased in the dependant areas (Q > V)
- Gravitational component

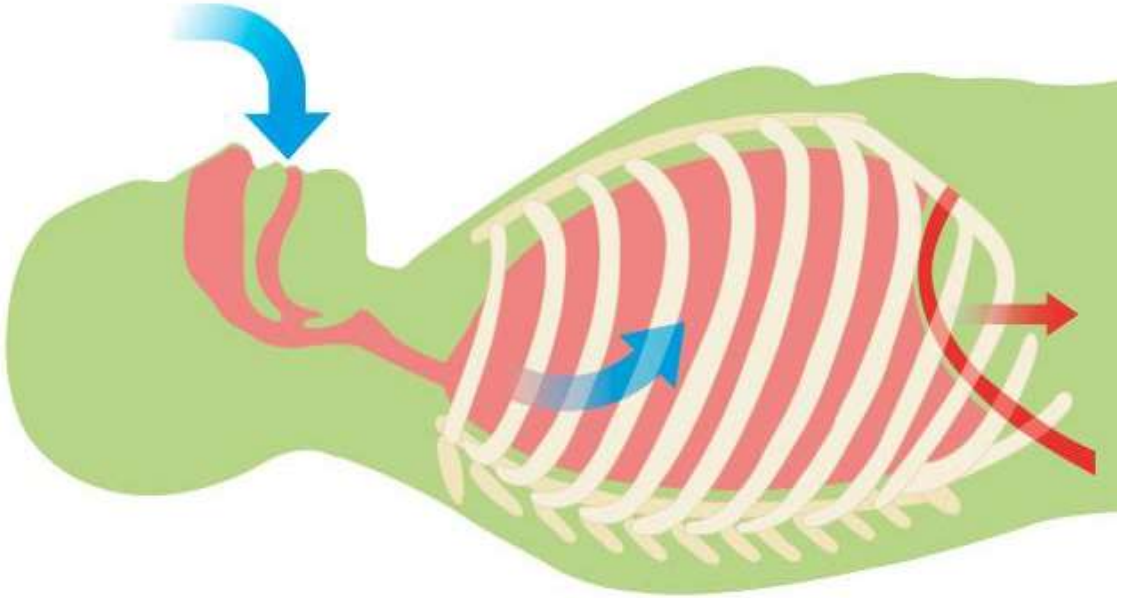

Volume
(L)
Time

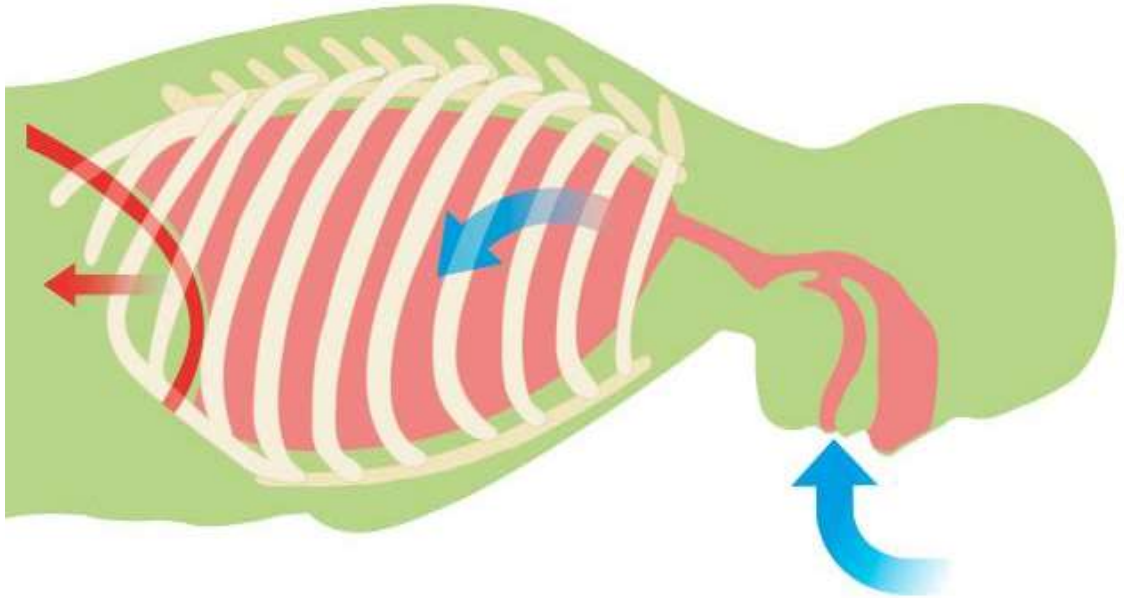

Volume
(L)
Inspiratory
Reserve
Volume
(IRV)
Tidal
Volume
(TV)
Expiratory
Reserve
Volume
(ERV)
Residual
Volume
(RV)
Vital
Capacity
(VC)
Inspiratory
Capacity
(IC)
Total Lung
Capacity
(TLC)
Functional
Residual
Capacity
(FRC)
Time

Upright to horizontal position

- Gravitational component is reduced
- So VQ heterogeneity is reduced
- Less diaphragmatic contribution

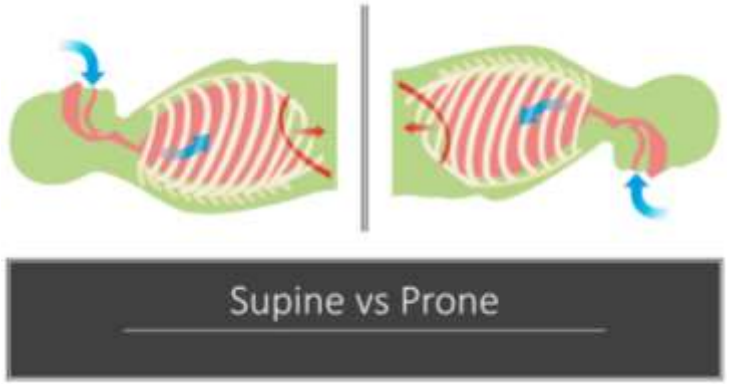






Supine vs Prone

Mechanical ventilation in healthy lungs



- Ventral chest wall more compliant:
  (V ↑ in non-dependant areas)
- Deadspace may increase if West Zone 1 is increased
- Chest wall compliance reduced and more even
- Diaphragmatic excursion less restricted
- Regional ventilation more even
- Regional perfusion more even

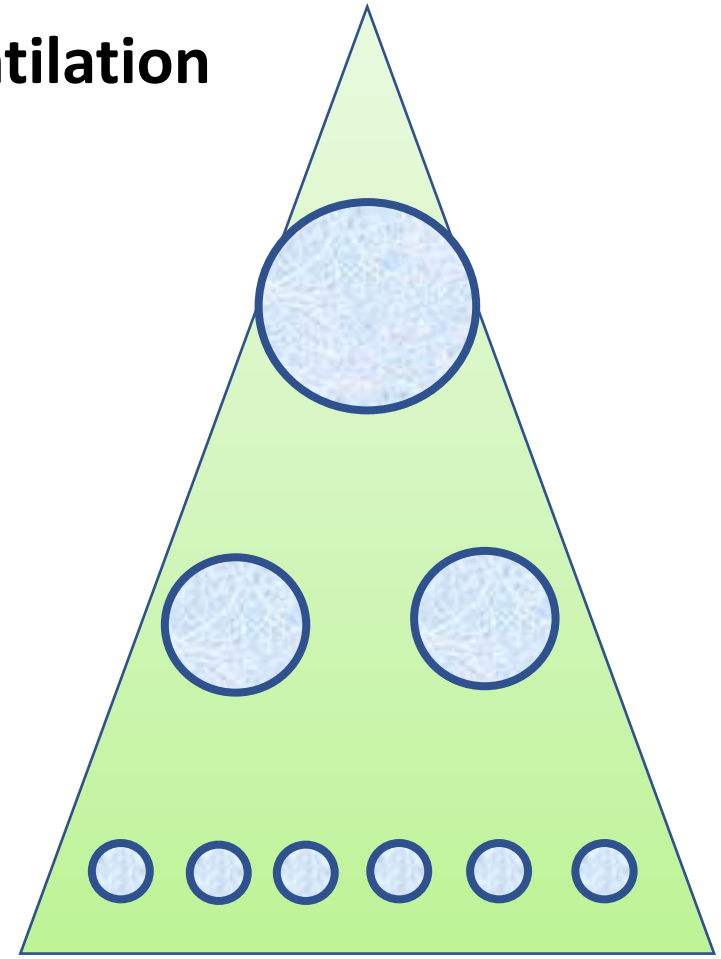
Supine

Ventilation

1

2

0



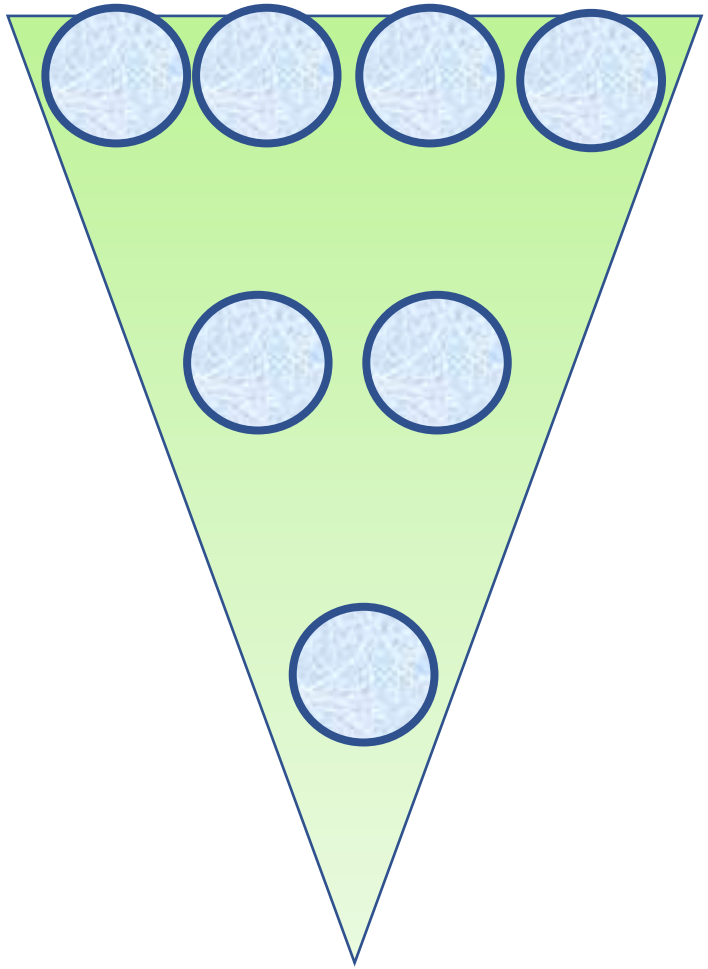
Perfusion

1

2

3

Prone



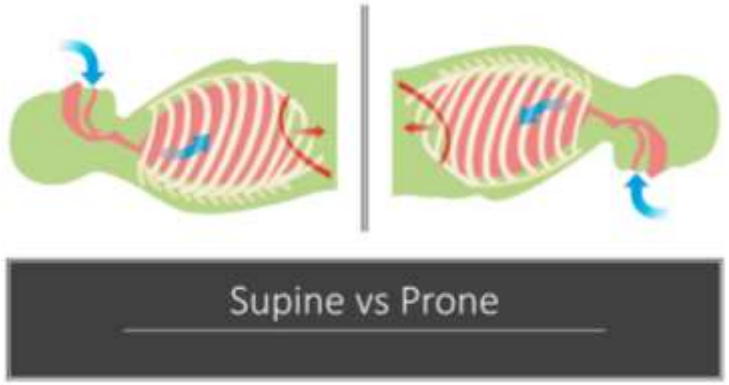
Ventilation

2

2

2

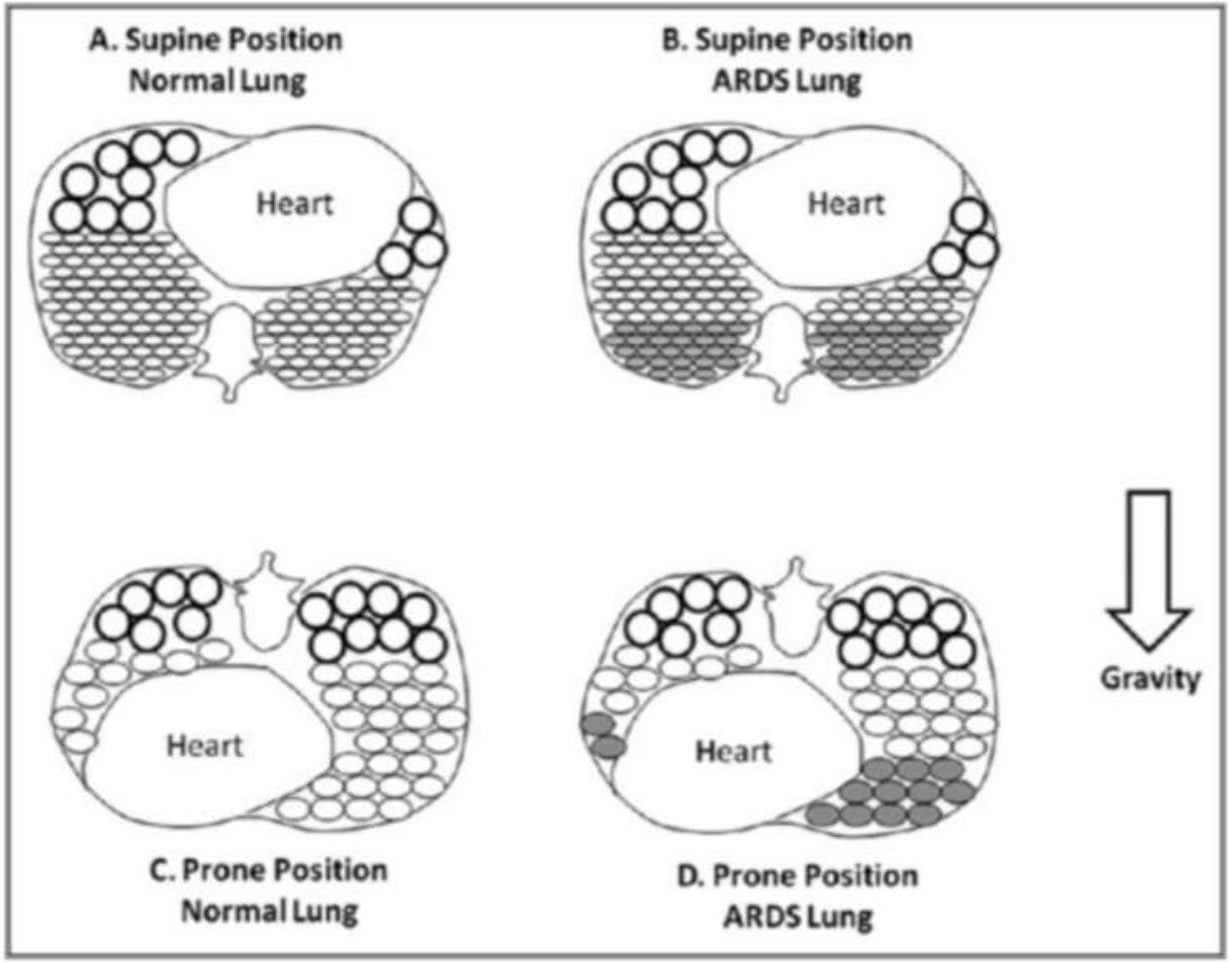
Mechanical ventilation in injured lungs

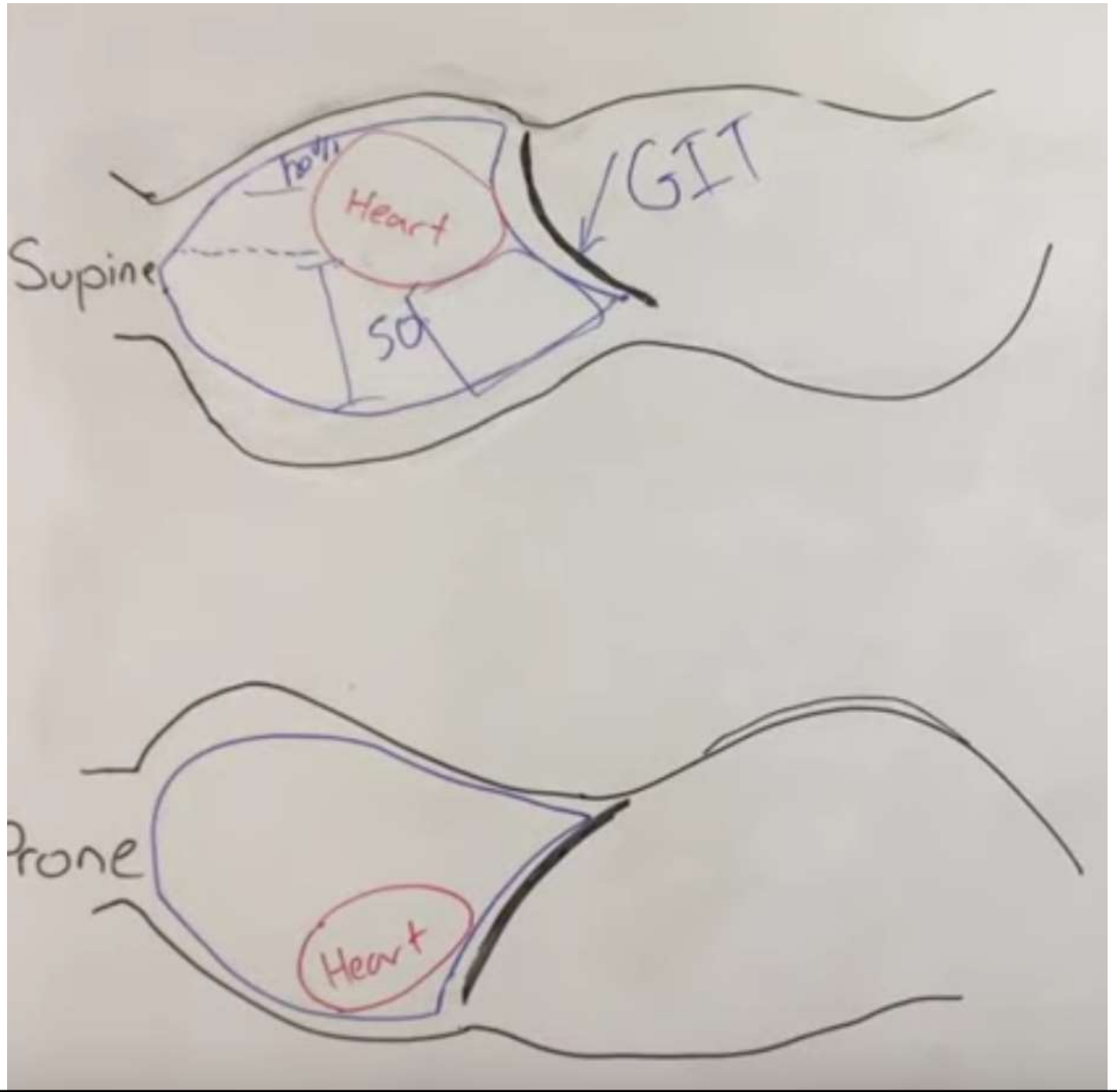


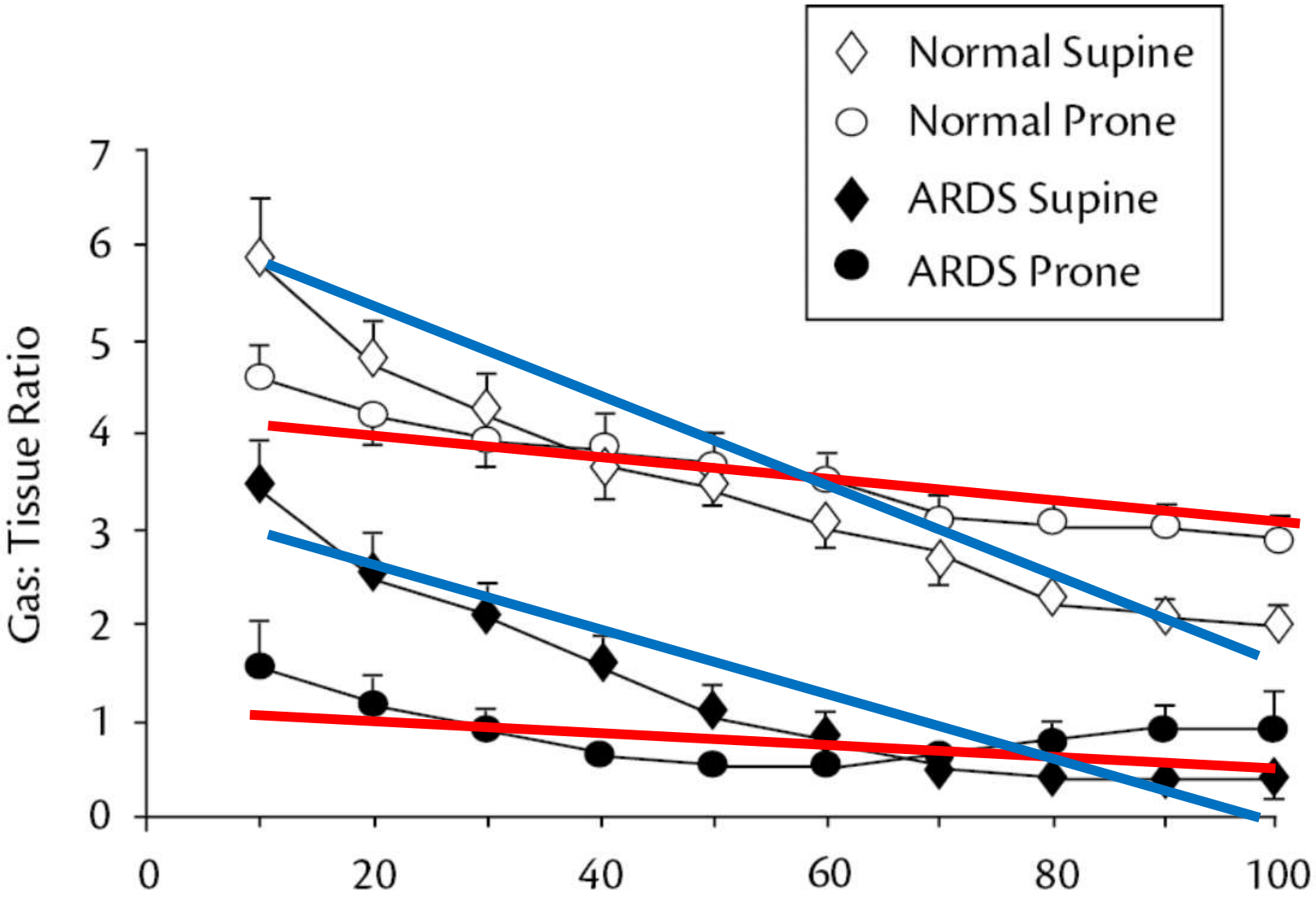
Lung weight is increased secondary to oedema

- ↑↑↑ Pleural pressure gradient:
  - Over inflation of non-dependent region
  - Compression atelectasis of dependent region
- Compression by the heart: up to 50%
- Compression by intra-abdominal contents
  - Worsened by sedation/paralysis

- ↑ Pleural pressure gradient:
  - More homogeneous alveolar V
- Less compression by heart
- Less compression by intra-abdominal contents

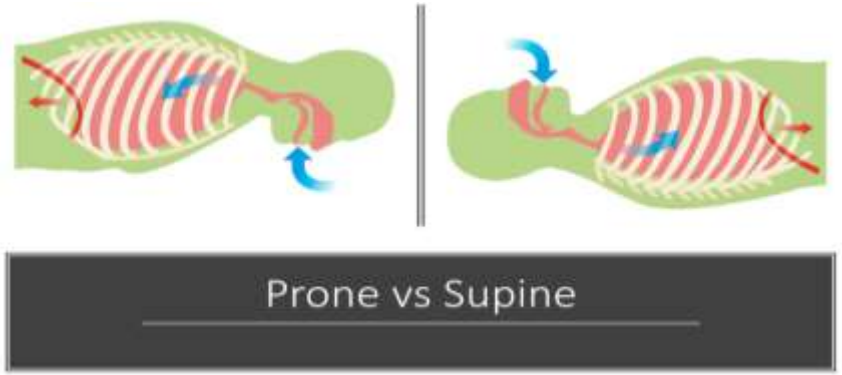



Heart
GIT
Supine
SC
Prone
Heart



Reproduced from Gattinoni L et al., 'Prone positioning in acute respiratory distress syndrome'. In: Tobin MJ, *Principles and Practice of Mechanical Ventilation*, © 2012 McGraw-Hill Education.

Mechanical ventilation in injured lungs: Perfusion



- Perfusion distribution is less gravity-dependent
- Perfusion maintained in dorsal region
- Less shunt
- High shunt fraction in dorsal areas
- HPV
- Mechanical compression on vessels

Table 1 Summary of physiological changes between supine and prone positions in spontaneous breathing and mechanical ventilation. The physiological effects of prone position on ventilation ($\dot{V}$) and perfusion ($\dot{Q}$) with IPPV are greater in injured lungs when lung density is increased. V_T, tidal volume

	Spontaneous breathing		IPPV	
	Supine	Prone	Supine	Prone
FRC	Dependent on body position Minimal when supine, greater when upright.	Midway between upright and supine	Usually reduced, more so if neuromuscular blocking agent used. Dependent on PEEP level	As for supine
Respiratory muscles	Supine: two-thirds of V_T from intercostal activity Upright: two-thirds of V_T from diaphragm	As for supine	Muscles inactive	Muscles inactive Chest wall compliance reduced
Regional ventilation	Slightly greater in dependent region (supine = dorsal; upright = bases)	More uniform than supine	Predominantly non-dependent (ventral)	Greater in non-dependent (dorsal) Less heterogeneity
Regional perfusion	Greater in dependent region (supine = dorsal; upright = bases)	Greater in dependent (ventral)	Predominantly dependent (dorsal)	Greater in dependent (ventral)
V/Q ratio	Lower in dependent regions	Lower in dependent regions (ventral). Less heterogeneity	High degree of mismatch	Better matching than supine

Studies

- **The Prone-Supine study II** (2009):
- 342 ARDS patients (PaO_2/FiO_2 ratio < 100)
- prolonged prone positioning protocol (18 hrs/day)
- No sig effect on mortality
- Trend in 6-month mortality ↓ 10%

- **The PROSEVA study** (2013) :
- randomized 466 severe ARDS patients (PaO_2/FiO_2 ratio < 150; PEEP > 5 cmH_2O)
- prone ≥ 16 hours vs supine
- 28-day mortality rate: 16% vs 32.8% (*P* < 0.001)

Summary

Alveolar ventilation more homogenous

- As a result of ↓ transpleural pressure gradient
- Therefore less over-distension in some areas/less compression atelectasis in other areas
- Therefore less volutrauma/atelectrauma/VILI

Perfusion more homogenous

Better drainage of secretions

Note on Covid – selfproning in conscious patients

- Microthrombi causing increased deadspace
- Reducing self-inflicted lung injury
- Avoiding intubation

Indications

Moderate to severe ARDS:

- PaO_2: FiO_2 ratio < 150mmHg (20kPa)

$FiO_2 \geq 0.6$

Early in course of disease (ideally < 48 hrs)

Continue to use lung protective ventilation strategy

Contraindications

Absolute

- Spinal instability
- Open chest/abdomen
- Central cannulation for ECMO
- < 24 hrs post cardiac surgery

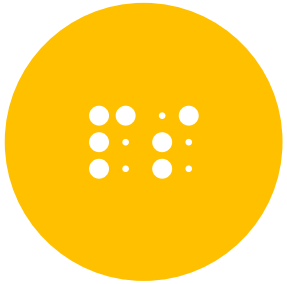
Relative

- Multiple trauma
- Severe facial fractures
- Head injury/raised ICP
- Raised IOP
- Recent tracheostomy < 24 hrs
- Pregnancy

Complications

Airway

Cardio



Pressure areas: eyes, face, brachial plexus

Monitoring and lines

Airway + Breathing

- Access to tube
- Displacement whilst prone = difficult airway
- Chest tube placement/dislodgement

Cardiovascular

Venous return: preload

- Abdominal pressure may reduce preload
- Dependant on underlying volume status

Cardiac function

- Conflicting mechanisms
- Increased intrathoracic pressure: may reduce preload → reduced CO
- But may also reduce RV afterload
- And lower PVR

Pressure areas

- Eyes: ischaemic optic atrophy/central retinal vein occlusion
- Face: especially nose
- Humeral head
- ASIS
- Genitals
- Knees

Others

- Monitoring
- Increased ICP
- increased intra-abdominal pressure
- Peripheral nerve injury

The Faculty of
Intensive Care Medicine

intensive care society
care when it matters

Guidance For:

Prone Positioning in Adult Critical Care

a)
List 4 procedures for which the prone position is indicated (4 marks)

1) .....

2) .....

3) .....

4) .....

b)
What is the minimum number of staff required to prone a patient? (1 mark)

.....

c)
List 4 physiological changes seen when turning a patient prone (4 marks)

1) .....

2) .....

3) .....

4) .....

d)

List 3 complications of the prone position and for each, 2 ways you can minimize the complication. (9 marks)

1) Complication: .....

How it can be minimized:

a) .....

b) .....

2) Complication: .....

How it can be minimized:

a) .....

b) .....

3) Complication: .....

How it can be minimized:

a) .....

b) .....

	Answer	Mark	
a) List 4 procedures for which the prone position is indicated (4 marks) 1) ..... 2) ..... 3) ..... 4)	Facilitate surgical access to posterior structures: • Back surgery (e.g. Scoliosis correction) • Posterior fossa surgery • Cervical spine surgery • Laparoscopic-assisted oesophagectomies Management of severe ARDS	1 mark for each (Max. 4 marks)	
b) What is the minimum number of staff required to prone a patient? (1 mark)	• 6 people	1	
c) List 4 physiological changes seen when turning a patient prone (4 marks) 1) ..... 2) ..... 3) ..... 4)	Cardiovascular • Blood pooling causes a reduction in preload • Caval compression causes a reduction in preload • Positive pressure ventilation reduces preload Respiratory • FRC improved (heart displaced and diaphragmatic excursion impeded by abdominal contents • V/Q mismatching is improved as the heart is displaced by gravity – less lung is compressed Neurological • Rotated head position/over flexion or extension of the neck will cause compression of the arteries and venous drainage – reduction in cerebral blood flow and increased ICP	1 mark for each (Max. 4 marks)	

d)
List 3 complications of the prone position and for each, 2 ways you can minimize the complication. (9 marks)

1) Complication: .....

How it can be minimized:

a) .....

b) .....

2) Complication: .....

How it can be minimized:

a) .....

b) .....

3) Complication: .....

How it can be minimized:

a) .....

b) .....

d)	<u>Postoperative visual loss (secondary to ischaemic optic atrophy or central retinal artery occlusion</u> • Ensure that eyes are not compressed by headrest • Check eyes every 30 mins • Optimise BP • Optimise oxygenation <u>Intra-abdominal organ ischaemia (compromised blood flow to e.g. liver/pancreas</u> • Ensure careful positioning • If signs of acidosis, check LFTs • Turn supine if LFTs abnormal <u>Pressure injuries (skin necrosis, tracheal compression, pinna, genitals)</u> • Careful positioning and padding of areas • Careful examination of skin and vulnerable areas prior to positioning • Ensure BP is maintained to prevent ischaemia at pressure points • <u>Peripheral nerve injury (Common peroneal, brachial plexus, all peripheral nerves are at risk)</u> • Place arms by the side to protect brachial plexus and ulnar nerve • Ensure careful positioning and padding of legs when strapped • If arms abducted, no more than 90 degrees flexion at shoulder and elbow	1 mark for each complication with 1 mark for each associated method to minimise the complication (Max. 9 marks)	

Other questions

Start with respiratory physiology

- What is FRC? Normal values?
- West zones

Proning protocol

- Indications/contraindications
- Patient prep
- Equipment prep
- Staffing prep
- Procedure itself

References

- Taccone, P., & Chiumello, D. (2016-04). Prone positioning in the ICU. In Oxford Textbook of Critical Care. Oxford, UK: Oxford University Press. Retrieved 20 Feb. 2022, from https://oxfordmedicine.com/view/10.1093/med/9780199600830.001.0001/med-9780199600830-chapter-99
- Intensive Care Society Prone Positioning Guidance https://www.ics.ac.uk/ICU/Guidance/PDFs/Prone_Position_Guidance_in_Adult_Critical_Care
- BJA ED: Breathing in the prone position in health and disease 2021 https://www.bjaed.org/article/S2058-5349(21)00051-2/fulltext

- Taccone P, Pesenti A, Latini R, et al. (2009). Prone positioning in patients with moderate and severe acute respiratory distress syndrome: a randomized controlled trial. *Journal of the American Medical Association*, **302**(18), 1977–84.
- Guerin C, Reignier J, Richard JC et al. (2013). Prone positioning in severe acute respiratory distress syndrome. *New England Journal of Medicine*, **368**, 2159–68.