Princess Alexandra Hospital

CRFS – The Tough Ones

Jarrod Warner CRFS
Scientific Director
Princess Alexandra Hospital

Metro South Health

Queensland Government

Q 12

- Normal haemoglobin has an affinity for carbon monoxide compared to oxygen in a ratio of:

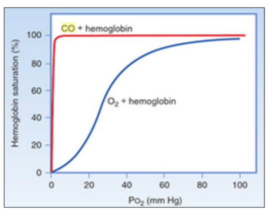
A - 210:1
B - 100:1
C - 50:1
D - 1:1

Q 12

- CO competes with O_2 for same binding sites on Hb
- O_2 and Hb
  - 4 binding sites
  - cooperative binding (i.e. 1st O_2 molecule binds weakly, next tighter, the next tighter and so on until the 4th is bound)
  - requires high partial pressure (i.e. lungs are a good place for this)
- CO and Hb
  - once Hb molecule has even one bound CO molecule, cannot adopt the configuration necessary to start binding O_2
  - one or two CO molecules effectively inhibit all four of the O_2 binding sites on Hb
- CO will bind with same amount of Hb as O_2 at a partial pressure 210 times lower than that of O_2

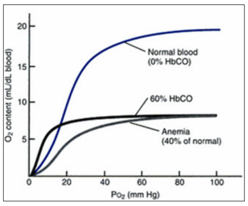
Q 12

- Hb + CO ⇔ Hb_{CO}
  - Reversible reaction
    - Breathing higher [CO] will favour right
- Breathing room air will favour left
- Room air (21% O_2) containing 0.1% CO
  - 50% Hb saturated with CO
  - 50% Hb saturated with O_2



Q 12

- Left-shift in Oxygen Dissociation Curve for Hb in presence of Hb_{CO}
  - O_2 more tightly bound to Hb
  - Less oxygen released to tissue
  - Aerobic metabolism is impaired
  - Depriving tissues of O_2
- Loses sigmoid shape



- Blood 60% saturated with CO (Hb_{CO})
  - O_2 content ~ 8 mL/dL
  - Normal O_2 content ~ 20 mL/dL

Q 12

- Normal haemoglobin has an affinity for carbon monoxide compared to oxygen in a ratio of:

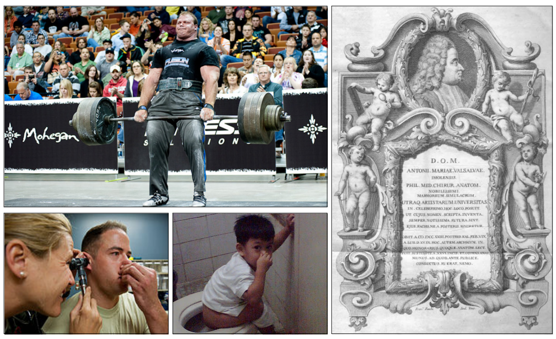
A - 210:1 ✓
B - 100:1 ✗
C - 50:1 ✗
D - 1:1 ✗

Q 24

- A Valsalva's manoeuvre results in

A - Decreased alveolar pressure
B - Decreased intrathoracic pressure
C - No change in transpulmonary pressure
D - Increased venous return to the heart

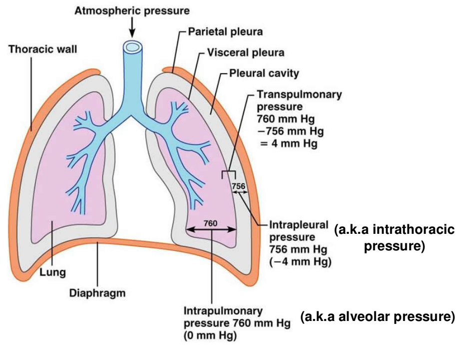
Q 24



Q 24

	Physiology
Phase I Onset of strain	• Increased intrathoracic pressure compresses vessels within thorax • Increase arterial pressure
Phase II Maintenance of strain	• Reduced venous return to right atrium • Decreased Q and systolic BP • Peripheral vasoconstriction
Phase III Release of strain	• Venous return of pulmonary bed increase abruptly
Phase IV Relaxation	• Accumulated venous return reaches LV, increased SV is pumped into constricted systemic vascular bed causing overshoot of arterial pressure

Q 24



Q 24

- Transpulmonary Pressure = Alveolar Pressure – Intrathoracic Pressure

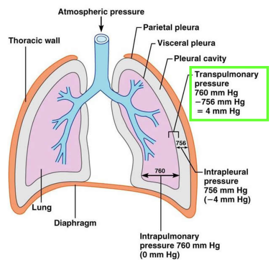
OR

- Transpulmonary Pressure = Intrapulmonary Pressure - Intrapleural Pressure

- Transpulmonary Pressure = 760 mmHg – 756 mmHg = +4 mmHg
- Transpulmonary pressure, under normal physiological conditions, is always positive
- Pneumothorax
  - Intrapleural space punctured
  - Alveolar Pressure = Intrapleural Pressure
  - Lung collapses

Q 24

- Transpulmonary pressure must remain positive
  - otherwise lung will collapse
- During Valsalva
  - Intrathoracic pressure ↑
  - Alveolar pressure ↑



Q 24

- A Valsalva's manoeuvre results in

A - Decreased alveolar pressure ×
B - Decreased intrathoracic pressure ×
C - No change in transpulmonary pressure ✓
D - Increased venous return to the heart ×

Q 84

- Differences in the calculation of single breath D_{LCO} due to the timing of the breath-hold period may be minimised by:

A - Having the patient practice breath-holding before testing
B - Measuring breath-hold from the mid-point of inspiration
C - Having the subject inspire and expire rapidly
D - Limiting the breath-hold to less than 9 seconds

Q 84

- ATS/ERS DLCO Test Standardisation (2017)
- Inspiratory manoeuvres
  – Inspiration must be rapid
  – DLCO calculations assume instantaneous lung filling
- Expiratory manoeuvres
  – Quick, smooth exhalation
  – DLCO calculations assume instantaneous lung emptying

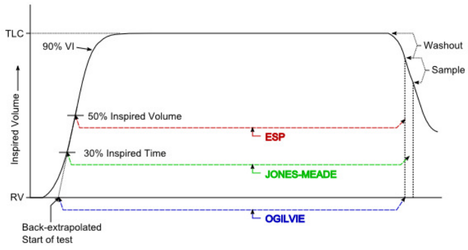
Q 84

- ATS/ERS DLCO Test Standardisation (2017)
- Breath-hold time (BHT)
  – 10 $\pm$ 2 secs
  – when reducing BHT, the inspired and expired components become a significant part of the overall time period

Q 84

- Goldilock's Principle to DLCO BHT
  - ESP (Epidemiology Standardisation Project)
    - Starts at 50% inspired volume
    - Stops at beginning of alveolar sampling period
    - Shortest BHT, highest calculated DLCO
  - Ogilvie
    - Starts at very beginning of inhalation
    - Stops at beginning of alveolar sampling period
    - Longest BHT, lowest calculated DLCO
  - Jones-Meade (ATS/ERS Recommendation 2017)
    - Starts at 30% of inspiratory time
    - Stops in the middle of alveolar sampling
    - Falls between ESP and Ogilvie in normals

Q 84



$$DLCO(ml/min/mmHg) = \frac{VA}{(BHT/60)\times(Pb - PH2O)} \times \ln\left[\frac{(FA_{trace} \times FICO)}{(FI_{trace} \times FACO)}\right]$$

Q 84

- Differences in the calculation of single breath D_{LCO} due to the timing of the breath-hold period may be minimised by:

A - Having the patient practice breath-holding before testing ✗

B - Measuring breath-hold from the mid-point of inspiration ✗

C - Having the subject inspire and expire rapidly ✓

D - Limiting the breath-hold to less than 9 seconds ✗

Q 90

- Failure to achieve TLC during the test gas inhalation phase of a TLCO manoeuvre results in an increase in KCO because –

A - the reduction in VA is greater than the reduction in TLCO

B - VA is reduced but TLCO is unaffected

C - test gas does not penetrate the peripheral regions of the lung

D - all of the above

Q 90

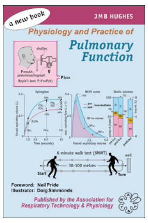
- Assuming question is related to a normal, non-obstructed patient
  - V_A is an accessible volume seen by gas-exchanging surface
  - Roberts et al (ERJ, 1990)
    - V_A within 10% of TLC
    - Mean V_A/TLC ratio (combing men and women)
      - 93.5% ± 6.6

Q 90

- Roughton-Forster equation
  - $1/D_L = 1/D_M + 1/\theta \cdot Vc$
  - partitions alveolar-capillary diffusion of oxygen (O_2) and carbon monoxide (CO)
    - membrane conductivity (DM)
      - diffusion properties of the alveolar capillary membrane
    - red cell component ($\theta \cdot Vc$)
      - θ is the CO-Hb chemical reaction rate
      - Vc is the pulmonary capillary volume

Q 90

- Hughes and Pride (AJRCCM, 2012)
  - Normalised Roughton-Forster equation to V_A
  - $V_A/DL_{CO} = 1/KCO = V_A/DM_{CO} + V_A/\ \theta \cdot Vc$
    - DM (membrane diffusing capacity)
    - θ (reaction of CO with blood)
    - Vc (pulmonary capillary volume)



Q 90

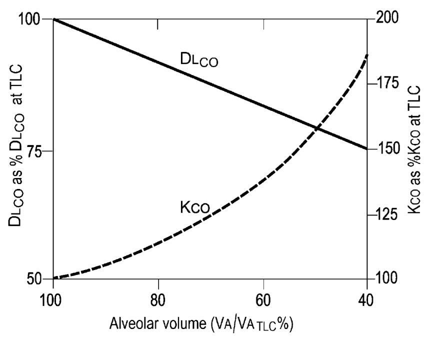
- Hughes and Pride (AJRCCM, 2012)
  - Reduced alveolar expansion
    - e.g. – failure to achieve TLC during gas inhalation
  - V_A/DM_{CO} remains almost constant
    - i.e. – ratio of alveolar volume to membrane diffusing capacity
    - as alveoli get smaller
      - Surface area (DM)
      - Volume (VA)

      } Decrease proportionately

Q 90

- Hughes and Pride (AJRCCM 2012)
  - Why does KCO rise as lung volume decreases?
    - Pulmonary capillary blood volume is independent of lung volume change
    - Decrease in V_A/Vc (i.e. ↑ Vc/V_A)
      - ratio of pulmonary capillary blood to alveolar volume
    - Vc remains constant as V_A decreases
      - Pulmonary blood flow (~ cardiac output) is stable with changing lung volumes

Q 90



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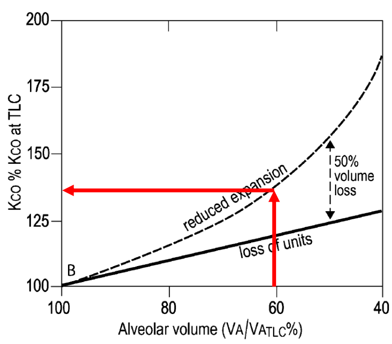
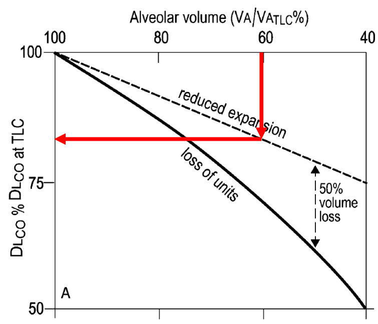


Q 90



Q 90

- Failure to achieve TLC during the test gas inhalation phase of a TLCO manoeuvre results in an increase in KCO because –

A - the reduction in VA is greater than the reduction in TLCO (*__due to incomplete alveolar expansion__*) ✓

B - VA is reduced but TLCO is unaffected ✗

C - test gas does not penetrate the peripheral regions of the lung ✗

D - all of the above ✗

Q 91

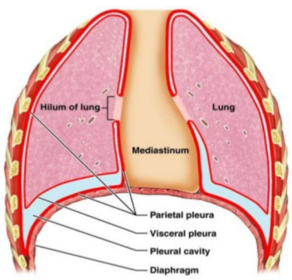
- Which of the following refers to a localised collection of pus in the pleural space:

A - Pulmonary oedema

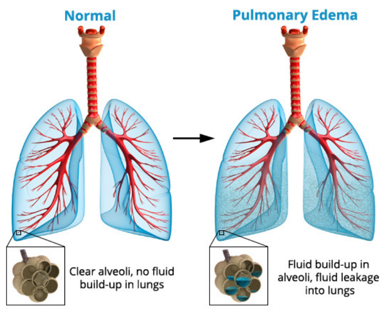
B - Lung abscess

C - Bleb

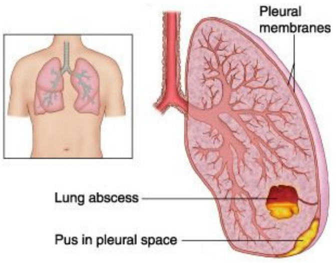
D - Empyema



Pulmonary Oedema

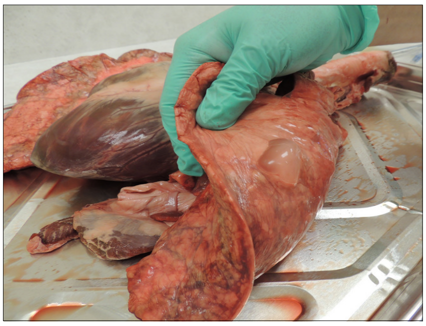


Lung Abscess



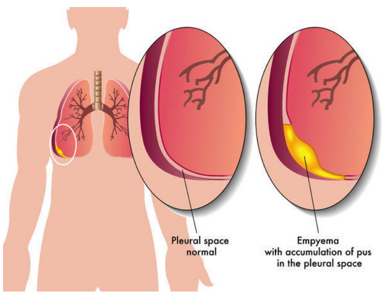
- necrosis of the pulmonary tissue
- formation of cavities containing necrotic debris or fluid caused by microbial infection

Bleb



- small subpleural thin walled air containing spaces
- not larger than 1-2 cm in diameter
- walls are less than 1 mm thick
- rupture results in air escaping into pleural space resulting in a spontaneous pneumothorax

Empyema



Q 91

- Which of the following refers to a localised collection of pus in the pleural space:

A - Pulmonary oedema ✗
B - Lung abscess ✗
C - Bleb ✗
D - Empyema ✓

Q 95

- An anaemic subject at rest has the following physiological parameters:

Arterial oxygen saturation	98	%
Hb concentration	10	g dL-1
Oxygen Consumption	250	mL min-1
Cardiac output	5	L min-1
Hb-O2 affinity	1.34	mL g-1

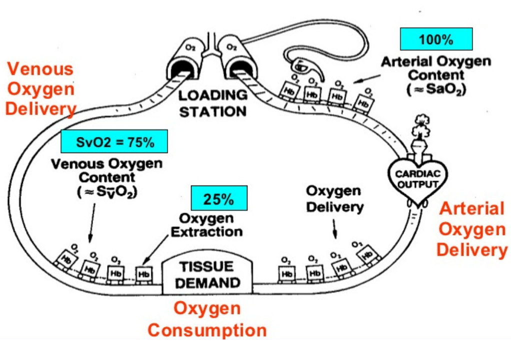
What would the subjects venous saturation be?

A - 75%
B - 70%
C - 65%
D - 60%

Q 95

- Percentage of oxygen bound to haemoglobin in blood returning to the right side of the heart
- Amount of O_2 "left over" after the tissues remove what they need
- Increase in extraction is the bodies way to meet tissue O_2 demands when the amount of O_2 reaching the tissues is less than needed

Q 95



Q 95

- **Fick Equation**

$$VO_2 = Q (CaO_2 - CvO_2)$$

where

VO_2 = O_2 consumption per minute (mL O_2/min)

Q = pulmonary blood flow (mL/min)

CaO_2 = O_2 concentration in blood leaving lung (mL/100mL)

CvO_2 = O_2 concentration in mixed venous blood (mL/100mL)

Q 95

- Derivation of Fick equation
  - VO_2 = Arterial O2 Transport – Venous O2 Transport
    - $VO_2 = (CO \times CaO_2) - (CO \times CvO_2)$
    - $VO_2 = CO \times (CaO_2 - CvO_2)$
    - $VO_2 = CO (Hb \times SaO_2 \times 1.34) - CO (Hb \times SvO_2 \times 1.34)$
    - $VO_2 = CO \times Hb \times 1.34 \times (SaO_2 - SvO_2)$

    Hb oxygen carrying capacity – 1.34 $mL.O_2.g^{-1}$

    - $SvO_2 = SaO_2 - VO_2 /(Q \times Hb \times 1.34)$

$$S_vO_2 = \left(S_aO_2 - \frac{VO_2}{Q \times Hb \times 1.34}\right) \times 100$$

$$S_vO_2 = \left(0.98 - \left(\frac{250mL.\min^{-1}}{5L.\min^{-1} \times 100g.L^{-1} \times 1.34ml.g^{-1}}\right)\right) \times 100$$

$$S_vO_2 = \left(0.98 - \left(\frac{250}{675}\right)\right) \times 100$$

$$S_vO_2 = (0.98 - 0.3703) \times 100$$

$$S_vO_2 = 0.6097 \times 100$$

$$S_vO_2 = 60\%$$

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Q 95

- An anaemic subject at rest has the following physiological parameters:

Arterial oxygen saturation	98	%
Hb concentration	10	$g.dL^{-1}$
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