V/Q and Positioning

On-Call Training
Amy Charnock-Barron

Definitions
- Ventilation - supply of air to the lungs
  - An area with ventilation but no perfusion = dead space
- Perfusion - supply of blood to the lungs
  - An area with perfusion but no ventilation = shunt
- V/Q ratio - ratio between amount of air getting to alveoli and the amount of blood being sent to the lungs
- V/Q mismatch - normal balance between lung ventilation and perfusion is disturbed

Ventilation
- Average air into lungs per minute = 4 litres
- Dependent regions better ventilated for 2 reasons:
  - Alveoli in upper regions already more inflated, alveoli in lower regions more squashed and therefore more potential to expand
  - In horizontal position the lower lung receives twice the ventilation of the upper lung due to the lower fibres of the diaphragm being stretched by the abdominal pressure, therefore contracting from a position of mechanical advantage

Perfusion
- Average blood into lungs per minute = 5 litres
- Pulmonary circulation has 1/10th the resistance of systemic circulation, and is therefore very responsive to gravity -> Steep perfusion gradient top to bottom
- In the very bases of the lungs the greater volume of perfusion may lead to some airway closure
- In the apices the arterial pressure barely overrides alveolar pressure. Vessels vulnerable to collapse if decrease in arterial pressure or increase in alveolar pressure

V/Q Disturbance – Wasted Ventilation
- When perfusion defect causes an increase in alveolar dead space. Fresh gas is delivered to non-perfused alveoli
- Reasons for decreased perfusion include:
  - PEs
  - Atherosclerosis
  - Cardiac arrhythmias
  - Decreased cardiac output
  - Bleed

V/Q Disturbances - Wasted Perfusion
- When blood is shunted through areas of lung that are not ventilated
- Reasons for decreased ventilation include:
  - Collapse
  - Consolidation
  - Damage
V/Q Disturbances

- A compensatory mechanism that occurs when ventilation is reduced
- A potent regulator of the disruption of blood flow to match areas of ventilation
- Pulmonary artery will constrict in the absence of oxygen
- Improves gas exchange by reducing blood flow to areas with low V/Q ratios
- Counterproductive in severe lung disease

Hypoxic Vasoconstriction

The Upright Lung

- Positioning is a simple action but is an integral part of respiratory care.
- Lung volumes related to displacement of diaphragm and abdo contents, most volumes responsive to positioning
- Different positions:
  - Supine
  - Slumped
  - Sitting
  - Side Lying
  - Forward Lean Sitting

Positioning - Supine

- Worst position for ventilation
- Abdominal contents restrict diaphragmatic movement
- Lung bases are compressed
- FRC is reduced
- Lung volume is reduced by about 7% even in healthy lungs

Positioning - Slumped

- Half lying rapidly becomes slumped and should be avoided unless necessary
- Perfusion is good to bases
- Ventilation is poor as abdominal contents compress diaphragm and reduce FRC
- Deep breathing not effective because of competition from abdominal contents
Positioning - Sitting
- Same as an upright lung
- However in reality patients will tend to slump

Positioning - Side Lying
- In full side lying the abdominal contents fall forwards and push the lower diaphragm higher into the chest, increasing efficiency
- Dependent lung is smaller and more compliant
- Increase in ventilation occurs in the dependent lung
- Perfusion continues to favour the bases
- Increases FRC and gas exchange
- Affected lung positioned uppermost

Positioning - Forward Lean Sitting
- Similar to upright
- Improved ventilation to bases as abdominal contents fall forwards and allow good diaphragmatic movement

The Ventilated Adult - Ventilation
- Inactive diaphragm is pushed upwards by abdominal contents
- Incoming gas takes the path of least resistance
- Progressive atelectasis of dependent areas occur

The Ventilated Adult - Perfusion
- The gradient from apices to bases is exaggerated further with the application of positive pressure and PEEP
- Pressure from the distended alveoli will cause compression of the capillaries in the more non dependent areas further decreasing blood flow

The Ventilated Adult - Positioning
- Down with the good lung????
  - Perfusion goes to good lung
  - Diseased lung receives more ventilation, maximising any perfusion going to the upper lung and also helping reinflate collapsed areas, drainage of sputum etc
- Up with the good lung????
  - Good lung receives most ventilation
  - Progressive atelectasis of diseased lung will further divert ventilation to upper lung
  - Anaesthesia plus weight of overlying body/mediastinum may have impact on atelectasis
  - Hypoxic vasoconstriction will divert perfusion to better ventilated upper lung
Things to Consider
- Area to be ventilated
- Area to be perfused
- Drainage of secretions
- Re inflation of atelectasis/collapse
- Thoracic surgery
- Mechanical ventilation
- Cardiovascular effects

Summary
- The position of the patient for maximal oxygenation should be chosen on an individual basis
- Consideration to comfort, effects on ventilation/perfusion, drainage of secretions, re inflation of collapse must be given as well as to pressure care, limits due to trauma, surgery etc
- Documentation of effects of position change is vital to ensure patients lung function is optimised