Normal Gas Exchange

Oxygenation

- To achieve adequate oxygenation requires matching of ventilation and perfusion of the alveoli
- As far as oxygenation is concerned, ventilation really means inflation
- The diffusion gradient down which oxygen passes from the alveoli into the blood stream is maintained because the circulation continuously replaces oxygenated blood with de-oxygenated blood
- As long as the alveoli are inflated, oxygenation will take place
- In health, the alveoli remain partially inflated, even during expiration, and this enables oxygenation to take place throughout both inspiration and expiration
- In disease states like RDS, the alveoli collapse in expiration preventing any gas exchange and resulting in right to left shunt through alveoli that are perfused but not ventilated. Many of the alveoli may remain collapsed even during inspiration.
- Under-ventilation of some areas cannot be compensated for by increased ventilation in other areas because of the way oxygen is carried in the blood.
- Nearly all of the oxygen in the blood is bound to Haemoglobin (Hb) and only a small percentage is dissolved in the plasma
- The Hb is fully saturated at normal PO_2 and after that, although the PO_2 goes up a lot, because very little oxygen can dissolve in the plasma, the total oxygen content of the blood does not go up all that much however much oxygen you supply
- If you mix equal amounts of blood with PO_2's of 5 and 25 kPa you get blood with a PO_2 of much less than 15 kPa
- If you mix blood returning from atelectatic areas of the lung with blood returning from well-inflated areas, the oxygenation of the mixture is still compromised
- Oxygenation is proportional to the average amount of alveolar inflation. Clinically this is why in neonatal lung disease oxygenation is proportional to mean airway pressure
- **Anything that increases mean airway pressure improves oxygenation** (increased PIP, increased PEEP, increased inspiratory time)
- Oxygenation can obviously also be improved to some degree by increasing the FiO_2 Alveolar perfusion is dependent on adequate cardiac output and blood volume and is influenced by pulmonary vascular resistance
- If the lungs are not as diseased as you think they are and you apply excessive airway pressures you can compress the pulmonary circulation impair pulmonary blood flow and worsen oxygenation

Carbon Dioxide Elimination

- The principles of CO_2 elimination are a little different
- The circulation constantly supplies blood with high CO_2 content to the alveoli and the concentration gradient for diffusion of CO_2 out of the blood stream into the alveoli is maintained by removing CO_2 from the alveoli
- CO_2 elimination requires the alveoli to be ventilated (filled and emptied) rather than just inflated
- CO_2 is highly soluble in the blood rather than bound. The total CO_2 content of the blood is directly proportional to the $PaCO_2$
- When blood with two different CO_2 contents is mixed the level roughly averages out
- When blood returning from under-ventilated lung areas is mixed with blood from over-ventilated areas the CO_2 of the mixture can be normal
- Total CO_2 elimination is therefore proportional to the total amount of ventilation and less dependent on the distribution of ventilation.
- The total ventilation is expressed as the **minute ventilation**. (Tidal volume times rate per min)
- Any manipulation that increases minute ventilation usually improves CO_2 elimination (increased PIP, decreased PEEP, increased rate)