

HYPOXEMIC RESPIRATORY FAILURE

Cause of Hypoxemia	Typical Findings
Decreased inspired O ₂	Normal A-a gradient. Fully corrects w/ O ₂ .
Hypoventilation	
Diffusion disorder	↑A-a gradient. Partially corrects w/ O ₂ .
V/Q mismatch	
Shunt	↑A-a gradient. WON'T CORRECT w/ O ₂ .

ALVEOLAR GAS EQUATION

- How much O₂ in the alveolus

$$PAO_2 = [713 \times FiO_2] - (PaCO_2/0.8)$$

or

$$PAO_2 = [(P_{ATM} - P_{H_2O}) \times FiO_2] - (PaCO_2/0.8)$$

P_{ATM} = Atmospheric pressure

P_{H₂O} = Partial pressure of water (humidity)

- Each of these components can affect oxygenation

A-a GRADIENT

- Classic method of assessing difficulties in oxygenation

$$\text{A-a gradient} = PAO_2 - PaO_2$$

PAO₂ = Alveolar PO₂; PaO₂ = Arterial PO₂

- Normal A-a gradient is less than 50 mm Hg

DECREASED INSPIRED OXYGEN

- Low P_{ATM} can decrease first part of alveolar gas equation
 - P_{ATM} = 760 mm Hg at sea level
 - P_{H₂O} = 47 mm Hg in average settings
- Causes: High altitude (eg, climbing the Andes or Mount Everest)

HYPOVENTILATION

- Rising PaCO₂ decreases second part of alveolar gas equation
- Causes: Decreased respiratory drive due to neurologic injury or sedatives, obesity-hypoventilation syndrome, OSA

DIFFUSION DISORDER

- Difficulty diffusing oxygen across capillary-alveolar interface
- Less common than V/Q mismatch and shunt
- Improves with supplemental oxygen
- Causes: Interstitial lung diseases, pulmonary edema (most common cause of reversible diffusion defects)

Zones of the Lung

Upper

Middle

Lower



High V/Q ↑Ventilation ↓Perfusion



Normal V/Q Ventilation ≈ Perfusion



Low V/Q ↓Ventilation ↑Perfusion

VENTILATION/PERFUSION (V/Q) MISMATCH

- Most common cause of hypoxemic respiratory failure
- There are gravity-dependent gradients of both perfusion (Q) and ventilation (V) in the lungs
- Ideal gas exchange depends upon matching adequate ventilation with adequate perfusion
- Mismatching in either direction leads to hypoxemia
- Causes: Pneumonia, asthma, COPD, pulmonary embolus

SHUNT

- Occurs when blood is bypassing the lungs
- Causes: Intrapulmonary shunting (eg, pulmonary AVMs, hepatopulmonary syndrome), intracardiac shunting (eg, atrial or ventricular septal defects)
- Does not improve** with supplemental oxygen