HYPOXEMIC RESPIRATORY FAILURE

ALVEOLAR GAS EQUATION
• How much O₂ in the alveolus
  \[ \text{PAO}_2 = [713 \times \text{FiO}_2] - (\text{PaCO}_2/0.8) \]
  or
  \[ \text{PAO}_2 = [(\text{P}_{\text{ATM}} - \text{P}_{\text{H2O}}) \times \text{FiO}_2] - (\text{PaCO}_2/0.8) \]
  \( \text{P}_{\text{ATM}} = \) Atmospheric pressure
  \( \text{P}_{\text{H2O}} = \) Partial pressure of water (humidity)
• Each of these components can affect oxygenation

A-a GRADIENT
• Classic method of assessing difficulties in oxygenation
  \[ \text{A-a gradient} = \text{PAO}_2 - \text{PaO}_2 \]
  \( \text{PAO}_2 = \) Alveolar PO₂; \( \text{PaO}_2 = \) Arterial PO₂
• Normal A-a gradient is less than 20 mm Hg while breathing ambient air (FiO₂ 0.21).

DECREASED INSPIRED OXYGEN
• Low \( \text{P}_{\text{ATM}} \) can decrease first part of alveolar gas equation
  \( \text{P}_{\text{ATM}} = 760 \) mm Hg at sea level
  \( \text{P}_{\text{H2O}} = 47 \) mm Hg in average settings
• Causes: High altitude (eg, climbing the Andes or Mount Everest)

HYPOVENTILATION
• Rising \( \text{PaCO}_2 \) 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)

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

<table>
<thead>
<tr>
<th>Cause of Hypoxemia</th>
<th>A-a Gradient</th>
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<tbody>
<tr>
<td>Decreased inspired O₂</td>
<td>Normal A-a gradient. Fully corrects w/ O₂.</td>
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<tr>
<td>Hypoventilation</td>
<td>↑ A-a gradient. Partially corrects w/ O₂.</td>
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<tr>
<td>Diffusion disorder</td>
<td>↑ A-a gradient. WON'T CORRECT w/ O₂.</td>
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<tr>
<td>V/Q mismatch</td>
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<td>Shunt</td>
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