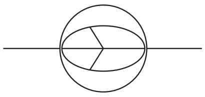
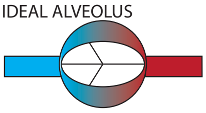
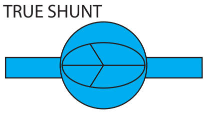
| First 2009 VIVA 7 | This information is from a patient with a pulmonary embolism<br>FIO2 0.5 PaO2 100mmHg PaCO2 20mmHg<br>Calculate the A-a gradient. |
|---|---|

**Calculate the aA gradient**

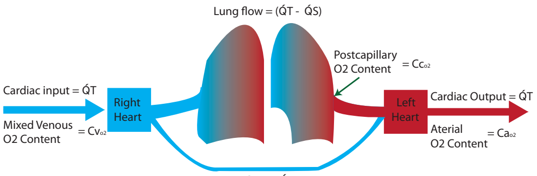
**Why does this occur with PEs?**

**Can you derive the shunt equation and what does it measure?**

**Can you derive bohr's equation and what does it measure?**

| RILEYS THREE COMPARTMENT MODEL | V/Q RATIOS | MEASUREMENT | ALVEOLAR AIR | CONSEQUENCE | TREATMENT |
|---|---|---|---|---|---|
| DEAD SPACE  | $\infty$<br>3.3 | Dead Space → Bohr equation<br>$P_{ECO_2}(TV) = P_{aCO_2}(TV - \text{Dead Space})$ | Alveolar air approaches inspired air concentrations (no exchange wasted air)<br>$PO_2 = 149$ $CO_2 = 0$ | Decreased perfusion leads wasted ventilation therefore decreased minute alveolar ventilation & primarily to increased blood CO2 | Increased tidal volumes will reduce the effect of dead space (note that Alveolar Vent = TV - PDS) |
| IDEAL ALVEOLUS  | 1<br>0.63 | V/Q Mismatch → Using the multiple inert gas elimination technique (MIDGET) or nuclear med studies<br>Alveolar air equation<br>$P_{AO_2} = FiO_2(P_{atm} - P_{H_2O}) - P_{aCO_2}/RQ$ | Alveolar air equals concentration of postcap blood due to ideal exchange<br>$PO_2 = 104$ $CO_2 = 40$ | V/Q scatter leads to decreased PaO2 because a majority of mismatch flow is at ratios < 1 and a small drop is acentuated by the point on the Hb dissociation curve | Increased FiO2 will improve oxygenation unless the V/Q ratio is 0 (true shunt). High FiO2 will remove the V/Q scatter effect. |
| TRUE SHUNT  | 0 | Shunt equation (Venous admixture)<br>$QT(\text{Art } O_2 \text{ cont}) = QS(\text{precap } O_2 \text{ cont}) + (\text{postcap } O_2 \text{ cont})(QT - QS)$ | Alveolar air approaches mixed venous concentrations (no exchange wasted blood)<br>$PO_2 = 40$ $CO_2 = 46$ | Shunt leads to both ↑CO2 and ↓O2 but the decrease in PO2 is more pronounced because it is on the flat of the dissociation curve and the CO2 dissociation is near linear | Improved recruitment may work unless the shunt is extra-pulmonary. ↑FiO2 is decreasingly effective in true shunts > 30% |

**The shunt equation** is based on the assumption that the total oxygen carried by the aterial blood may be calculated by adding the oxygen contents of the blood that passes the lungs and the shunted blood. Assuming ideal gas exchange (to calculate Postcap O2 content) it is possible to create this in an equation as follows:




Cardiac Output X Aterial O2 Content = Lung Flow X Postcap O2 Content + Shunt Flow X Mixed Venous O2 Content

Using the abbreviations shown in the diagram this becomes;

$\dot{Q}T \times Ca_{O_2} = (\dot{Q}S \times Cv_{O_2}) + (\dot{Q}T - \dot{Q}S)Cc_{O_2}$ rearranged gives the shunt equation;

$$\frac{\dot{Q}S}{\dot{Q}T} = \frac{Cc_{O_2} - Ca_{O_2}}{Cc_{O_2} - Cv_{O_2}}$$

**The Bohr equation** is based on the assumption that CO2 exchange is ideal (alveolar and post capillary values are equal) therefore any difference in the expired and arterial CO2 is due to dead space.

$P_{ECO_2}(VT) = P_{ACO_2}(VT - VD)$ it is commonly rearranged to $\frac{VD}{VT} = \frac{P_{ECO_2} - P_{ACO_2}}{P_{ACO_2}}$

$P_{EXPIRED\ CO_2}(\text{Tidal Vol})$ = $P_{ARTERIAL\ CO_2}(\text{Tidal Vol - Dead Space})$

**The alveolar equation** calculates the ideal alveolar $P_{AO_2}$. It can then be used to assess the Alveolar-arterial gradient of O2. It is never equal due to V/Q mismatching. The normal value in a 20 year old patient is around 7, but this increases gradually with age, an 70 year old patient having a normal A-a gradient of 17 (the formula is 2.5 + age x 0.21). The alveolar equation needs to account for water vapour and air pressure and is therefore represented by the following equation:

$PAO_2 = (FiO_2 \times [P_{atm} - P_{H_2O}]) - (PaCO_2 \div R)$

R is usually 0.8
Patm is 760 at sea level
PH2O is 47 at body temp

the A-a gradient = $P_{AO_2} - P_{aO_2}$

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