4.5.6

Ventilation/Perfusion Ratio

Gas exchange is dependent on ventilating the alveoli. It is also dependent on proper perfusion of the lung with capillary blood. This relationship is expressed as the ventilation/perfusion ration or V/Q ratio. V = the air that reaches the alveoli and Q = the blood that reaches the alveoli. Stated another way, the ratio defines the amount of air that reaches the alveoli per minute to the amount of blood that reaches the alveoli per minute, two variables that ultimately determine the final blood concentrations of both O_2 and CO_2.

One liter of alveolar air holds about 200 ml of oxygen and 1 liter of arterial blood contains about 200 ml of oxygen. Therefore, if the ratio is optimized the oxygen provided should be able to saturate the blood as it passes by. Thus, the ideal V/Q ratio would be 1. However, not all alveoli and capillaries need to or are able to exchange O_2 at any given moment. Also, gravity tends to pull blood more to the inferior lung and perfusion of the upper lung is less. The body will try and match the most ventilated alveoli to areas with the most blood flow. This is accomplished by altering blood flow or air flow. Ultimately the true physiologic value of the V/Q ratio is ≈ .8.

Alterations in blood flow are the result of arteriole constriction or dilation and associated capillaries and their ability to collapse. Capillaries in the lungs are extremely sensitive to blood flow and pressure. If blood flow through a capillary falls to a certain level because of “upstream” arteriole constriction, the resultant decrease in pressure will cause the capillary to collapse and divert blood somewhere else. Resistance in the pulmonary arterioles is regulated by the oxygen content of the surrounding fluid. If the PO_2 drops in a given area, the arteriole will constrict which then results in diversion of blood away from the under-ventilated area of the lung. Note that this response is exactly opposite that of the systemic arterioles.

Alterations in ventilation are regulated by bronchiole diameter which in turn is regulated by exhaled CO_2. Increases in PCO_2 of expired air causes bronchioles to dilate while decreases in expired CO_2 cause constriction.

Lower V/Q ratios imply that there is relatively less ventilation than perfusion. An example of this would be chronic bronchitis, asthma or pulmonary edema which would create an airway blockage in such a way that ventilation would decrease substantially. However, blood flow would remain relatively normal. These scenarios would lower the V/Q ratio.

High V/Q ratios imply that there is more ventilation relative to the perfusion. An example of this would be a pulmonary embolism. An embolism in the pulmonary circulation would block normal blood flow through the lung and Q would decrease relative to V which stays close to normal. Another example of something that could cause a high V/Q ratio is emphysema. Emphysema causes the alveoli to stretch and fuse in such a way that the available capillaries must be dispersed over a larger area. This would lower the blood flow that is available to a region of the lung and the amount of air (V) on the other side of the capillaries would be relatively higher.