Al-ayen Iraqi university

College of Health &Medical Technology

Department of Anesthesia

Lecture 3

Ventilation and Perfusion

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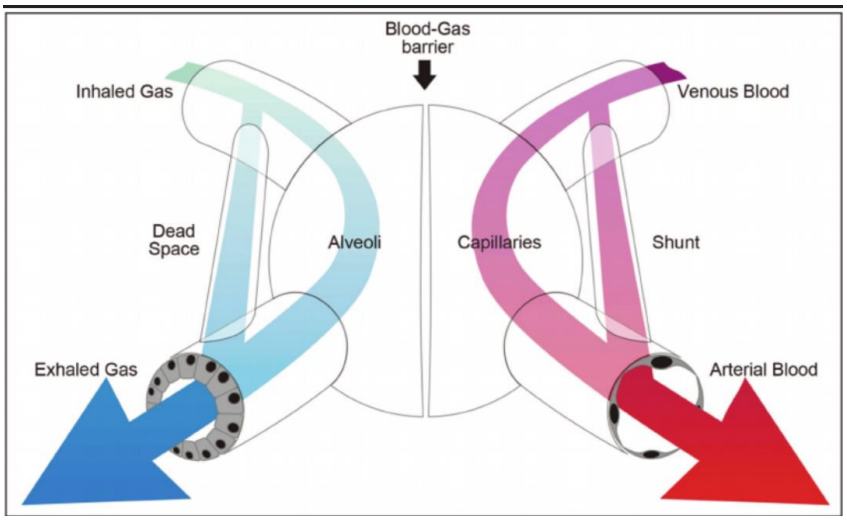
Applied physiology

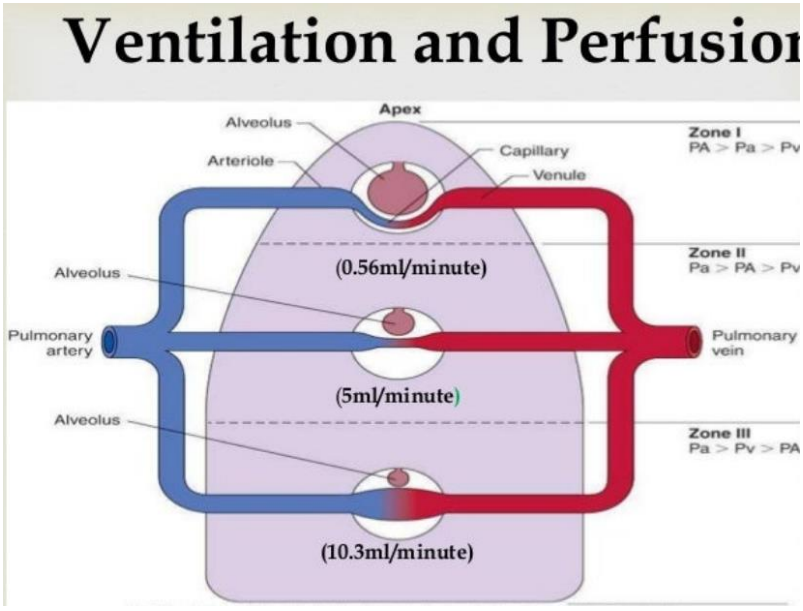
❖ **Definition:**



Gas exchange occurs in the lungs between alveolar air and the blood of the pulmonary capillaries. For effective gas exchange to occur, alveoli must be ventilated and perfused. Ventilation (V) refers to the flow of air into and out of the alveoli, while perfusion (Q) refers to the flow of blood to alveolar capillaries. Individual alveoli have variable degrees of ventilation and perfusion in different regions of the lungs. Collective changes in ventilation and perfusion in the lungs are measured clinically using the ratio of ventilation to perfusion (V/Q). Changes in the V/Q ratio can affect gas exchange and can contribute to hypoxemia.

The alveolar septum has numerous capillaries and thin walls for gas exchange. In addition to capillary endothelial cells, the alveolar septum contains pneumocytes that are very thin and line the alveoli and secrete dipalmitoyl-phosphatidylcholine (DPPT) surfactant. Gas exchange in the alveoli occurs primarily by diffusion. Traveling from the alveoli to capillary blood, gases must pass through alveolar surfactant, alveolar epithelium, basement membrane, and capillary endothelium. diffusion of a gas across the alveolar membrane increases with: Increased surface area of the membrane, increased alveolar pressure difference (PA-Pa), Increased solubility of the gas, Decreased membrane thickness.

❖ **Mechanism**



The V/Q ratio evaluates the matching of ventilation (V) to perfusion (Q). There is regional variation in the V/Q ratio within the lung. Ventilation is 50% greater at the base of the lung than at the apex. The weight of fluid in the pleural cavity increases the intrapleural pressure at the base to a less negative value. As a result, alveoli are less expanded and have higher compliance at the base, resulting in a more substantial increase in volume on inspiration for increased ventilation. Perfusion is also greater at the base of the lung due to gravity pulling blood down towards the base. Overall, perfusion increases more than ventilation at the base of the lung, resulting in lower V/Q ratios in the base of the lung compared to the apex. In a healthy individual, the V/Q ratio is 1 at the middle of the lung, with a minimal spread of V/Q ratios from 0.3 to 2.1 from base to apex. In cases of high V/Q ratios, PO2 increases and PCO2 decreases as alveolar air more closely matches the larger volume of inspired air than perfused blood. On the other hand, low V/Q ratios result in a decreased PO2 and an increased PCO2.

❖ Clinical Significance

A number of conditions can cause right-to-left shunts that cause a V/Q mismatch. At a microscopic level, pulmonary arteriovenous malformations provide a route from arterial to venous blood in the pulmonary circulation that bypasses the pulmonary capillaries where gas exchange occurs. Congenital heart defects can cause right-to-left shunts at a macroscopic level. In the case of ventricular septal defects, the right ventricle may hypertrophy to the point that the right ventricle has a higher pressure during systole than the left ventricle, causing blood to flow from the right to left ventricle, bypassing the pulmonary circulation. Physiologic right-to-left shunts may also occur if perfusion reaches areas of the lungs that are not ventilated, which may result from airway obstructions, pulmonary edema, and pneumonia.

Asthma is often referred to as a “false shunt” because bronchoconstriction decreases ventilation, resulting in a low V/Q ratio, as occurs in alveolar dead space. In the case of asthma, oxygen therapy is indicated because some ventilation of the bronchoconstricted alveoli still occurs, and oxygen therapy increases the PAO2 of alveoli with obstructed airflow. Treatment with a bronchodilator such as a beta-2 agonist is more beneficial to patients with asthma than oxygen therapy because of its reduction of bronchoconstriction.

V/Q mismatches can occur in the case of pulmonary embolism (PE). Emboli may restrict blood flow in the pulmonary circulation, resulting in alveoli that are ventilated but not perfused; this results in an increased V/Q ratio and decreased gas exchange. The impaired gas exchange may cause hypoxemia in cases of PE.

Inspiratory hypoxia, as occurs at high altitudes, can cause a V/Q mismatch and affect blood gases. The decreased atmospheric pressure at altitude causes a decreased PAO2. However, normal diffusion occurs (normal A-a gradient), the arterial PaO2 decreases, and hypoxemia results. Oxygen therapy can correct the hypoxemia in this instance because the inspired air increases the PAO2 back to normal levels.

A significant cause of diffusion problems is pulmonary edema, as fluid in the lungs increases the effective thickness of the alveolar wall and decreases the area of gas exchange. Pulmonary edema results in greater hypoxemia than hypercapnia because carbon dioxide can more easily dissolve into the fluid to reach the alveolar membrane for exchange. The edema prevents air from reaching pulmonary capillaries, resulting in perfusion without ventilation and shunting.

Pulmonary edema has several causes. Over-administration of IV fluids may similarly increase capillary hydrostatic pressure to cause edema. Acute respiratory distress syndrome (ARDS) and sepsis can cause increased capillary permeability to cause pulmonary edema. Decreases in capillary osmotic pressure can also cause pulmonary edema, as occurs in nephrotic syndrome and liver failure. Pulmonary edema may also result from obstructed lymphatic drainage of filtered fluid, as may occur with tumors.