McCance: Pathophysiology, 6th Edition

Chapter 32: Structure and Function of the Pulmonary System

Key Points – Print

SUMMARY REVIEW

Structures of the Pulmonary System

1. The pulmonary system consists of the lungs, airways, chest wall, and pulmonary and bronchial circulation.
2. Air is inspired and expired through the conducting airways, which include the nasopharynx, oropharynx, trachea, bronchi, and bronchioles to the sixteenth division.
3. Gas exchange occurs in structures beyond the sixteenth division: the respiratory bronchioles, alveolar ducts, and alveoli. Together these structures comprise the acinus.
4. The chief gas-exchange units of the lungs are the alveoli. The membrane that surrounds each alveolus and contains the pulmonary capillaries is called the *alveolocapillary membrane.*
5. The gas-exchange airways are served by the pulmonary circulation, a separate division of the circulatory system. The bronchi and other lung structures are served by a branch of the systemic circulation called the *bronchial circulation.*
6. The chest wall, which contains and protects the contents of the thoracic cavity, consists of the skin, ribs, and intercostal muscles, which lie between the ribs.
7. The chest wall is lined by a serous membrane called the *parietal pleura;* the lungs are encased in a separate membrane called the *visceral pleura.* The area where these two pleurae come into contact and slide over each another is called the *pleural space.*

Function of the Pulmonary System

1. The pulmonary system enables oxygen to diffuse into the blood and CO_2 to diffuse out of the blood.
2. Ventilation is the process by which air flows into and out of the gas-exchange airways.
3. Successful ventilation involves the mechanics of breathing: the interaction of forces and counterforces involving the muscles of inspiration and expiration, alveolar surface tension, elastic properties of the lungs and chest wall, and resistance to airflow.
4. The major muscle of inspiration is the diaphragm. When the diaphragm contracts, it moves downward in the thoracic cavity, creating a vacuum that causes air to flow into the lungs.
5. The alveoli produce surfactant, a lipoprotein that lines the alveoli. Surfactant reduces alveolar surface tension and permits the alveoli to expand more easily as air flows in.
6. Compliance is the ability of the lungs and chest wall to expand during inspiration. Lung compliance is ensured by adequate production of surfactant; chest wall expansion depends on flexibility.

7. Elastic recoil is the tendency of the lungs and chest wall to return to their resting state after inspiration. The elastic recoil forces of the lungs and chest wall are in opposition and pull on each other, creating the normally negative pressure of the pleural space.
8. Most of the time ventilation is involuntary. It is controlled by the sympathetic and parasympathetic divisions of the ANS, which adjust airway caliber (by causing bronchial smooth muscle to contract or relax) and control the rate and depth of ventilation.
9. Neuroreceptors in the lungs (lung receptors) monitor the mechanical aspects of ventilation. Irritant receptors sense the need to expel unwanted substances, stretch receptors sense lung volume (lung expansion), and *J*-receptors sense alveolar size.
10. Chemoreceptors in the circulatory system and brain stem sense the effectiveness of ventilation by monitoring the pH status of cerebrospinal fluid and the oxygen content of arterial blood (PaO_2).
11. The pulmonary circulation is innervated by the ANS, but vasodilation and vasoconstriction are controlled mainly by local and humoral factors, particularly arterial oxygenation and acid-base status.
12. Gas transport depends on ventilation of the alveoli, diffusion across the alveolocapillary membrane, perfusion of the pulmonary and systemic capillaries, and diffusion between systemic capillaries and tissue cells.
13. Efficient gas exchange depends on an even distribution of ventilation and perfusion within the lungs. Ventilation and perfusion are greatest in the bases of the lungs because the alveoli in the bases are more compliant (their resting volume is low), and perfusion is greater in the bases as a result of gravity.
14. Almost all of the oxygen that diffuses into pulmonary capillary blood is transported by hemoglobin, a protein contained within red blood cells. The remainder of the oxygen is transported dissolved in plasma.
15. Oxygen enters the body by diffusing down the concentration gradient, from high concentrations in the alveoli to lower concentrations in the capillaries. Diffusion ceases when alveolar and capillary oxygen pressures equilibrate.
16. Oxygen is loaded onto hemoglobin by the driving pressure exerted by PaO_2 in the plasma. As pressure decreases at tissue level, oxygen dissociates from hemoglobin and enters tissue cells by diffusion, again down the concentration gradient.
17. CO_2 is more soluble in plasma than oxygen is and diffuses readily from tissue cells into plasma. CO_2 returns to the lungs dissolved in plasma, as bicarbonate, or in carbamino compounds (e.g., bound to hemoglobin).
18. Vasoconstriction of the pulmonary arterial system is caused by alveolar hypoxia, acidemia, and inflammatory mediators—histamine, serotonin, prostaglandins, and bradykinin.

Tests of Pulmonary Function

1. Spirometry measures volume and flow rate during forced expiration.

2. The alveolar-arterial oxygen gradient is used to evaluate the cause of hypoxia.
3. Diffusing capacity is a measure of the gas diffusion rate at the alveolocapillary membrane.
4. Arterial blood gas analysis can be used to determine pH and oxygen and CO_2 concentrations.
5. Radiographic examination of the chest evaluates air trapping, consolidation, cavity formation, or presence of tumors.

Aging and the Pulmonary System

1. Aging affects the mechanical aspects of ventilation by decreasing chest wall compliance and elastic recoil of the lungs. Changes in these elastic properties reduce ventilatory reserve.
2. Aging causes the PaO_2 to decrease but does not affect the $PaCO_2$.