GENERAL HISTOLOGY

Lec 4

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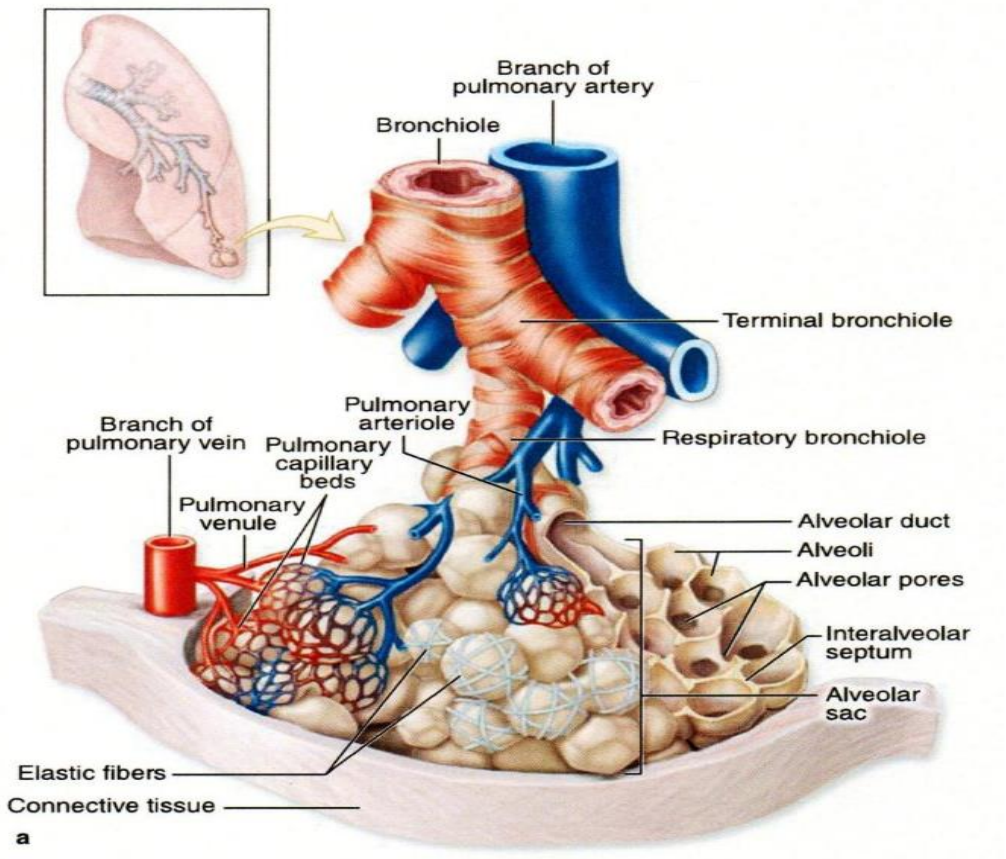
PhD. Oral Pathology

The Respiratory Portion of the Respiratory System

Respiratory Bronchioles

Each terminal bronchiole subdivides into two or more respiratory bronchioles that include saclike alveoli and represent, therefore, the first-part respiratory region of this organ system (Figure 14).



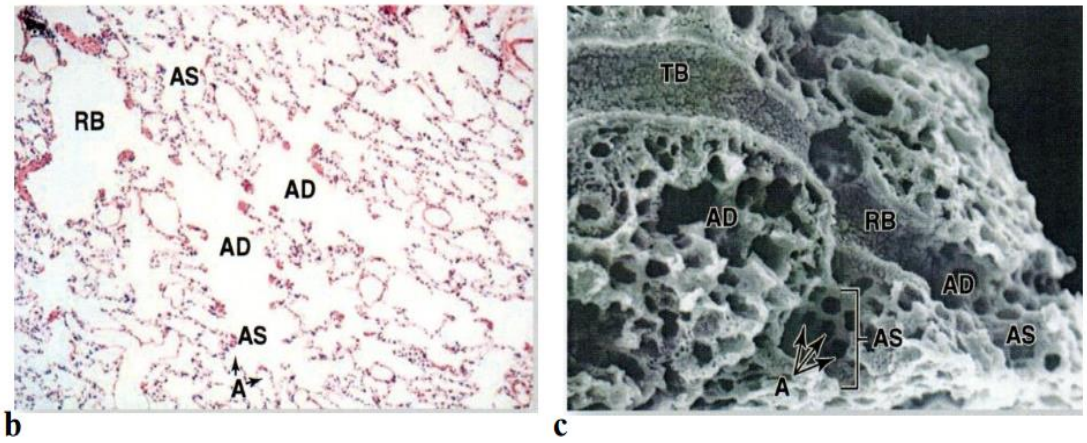


Figure 14. Terminal bronchioles, respiratory bronchioles, and alveoli. Terminal bronchioles branch into respiratory bronchioles, which then branch further into alveolar ducts and individual alveoli. Respiratory bronchiole (RB), alveolar ducts (AD), alveolar sacs (AS), individual alveoli (A), and terminal bronchiole (TB).

The respiratory bronchiolar mucosa is structurally identical to that of the terminal bronchioles, except for a few openings to the alveoli where gas exchange occurs. The mucosa lining consists of Clara cells and ciliated cuboidal cells, with simple squamous cells at the alveolar openings and extending into the alveolus. Proceeding distally along the respiratory bronchioles, alveoli are more numerous and closer together. Smooth muscle and elastic connective tissue make up the lamina propria.

Alveolar Ducts

Distal ends of respiratory bronchioles branch into tubes called alveolar ducts that are completely lined by the openings of alveoli (see fig 14.15).

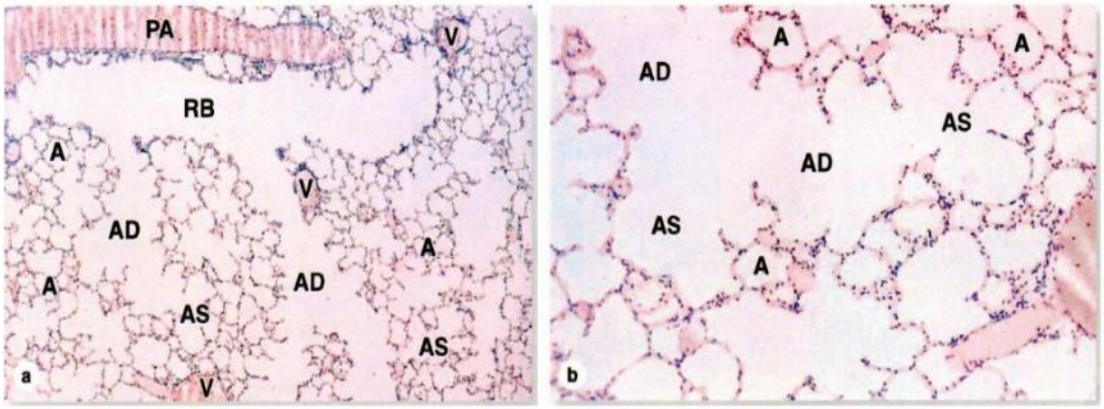


Figure 15. Respiratory bronchioles, alveolar ducts, and alveoli.Lung tissue has a spongy structure because of the abundant air passages and pockets called alveoli. Respiratory bronchioles (RB), and shows the branching continuity with alveolar ducts (AD), alveolar sacs (AS), alveoli (A), and pulmonary artery (PA), while branches of the pulmonary vein (V) course elsewhere in the parenchyma.

Both the alveolar ducts and the alveoli themselves are lined with extremely attenuated squamous cells. In the thin lamina propria, a strand of smooth muscle cells surrounds each alveolar opening and a matrix of elastic and collagen fibers supports both the duct and its alveoli. Larger clusters of alveoli called alveolar sacs form the ends of alveolar ducts distally and occur occasionally along their length (see Figures 14 and 15). The lamina propria is now extremely thin, consisting essentially of a network of elastic and reticular fibers that encircles the alveolar openings and closely surrounds each alveolus. Prominent in this sparse connective tissue, another network of capillaries also surrounds each alveolus.

Alveoli

Alveoli are saclike evaginations, each about 200 μm in diameter, from the respiratory bronchioles, alveolar ducts, and alveolar sacs. Along with the airways, alveoli are responsible for the spongy structure of the lungs (see

Figures 14 and 15). Each adult lung has approximately 200 million alveoli with a total internal surface area of 75m2. Each alveolus resembles a small rounded pouch open on one side to an alveolar duct or alveolar sac. Air in these structures' exchanges O2 and CO2 with the blood in surrounding capillaries, through thin specialized alveolar walls that enhance diffusion between the external and internal environments. Between neighboring alveoli lie thin interalveolar septa consisting of scattered fibroblasts and sparse extracellular matrix (ECM), notably elastic and reticular fibers, of connective tissue. The arrangement of elastic fibers enables alveoli to expand with inspiration and contract passively with expiration; reticular fibers prevent both collapse and excessive distention of alveoli. The interalveolar septa are vascularized with the richest capillary networks in the body (see Figure 14). The densely anastomosing pulmonary capillaries within the interalveolar septa are supported by the meshwork of reticular and elastic fibers, which also provide the primary structural support of the alveoli. Air in the alveoli is separated from capillary blood by three components referred to collectively as the respiratory membrane or blood-air barrier (Figure 16):

♣ two to three highly attenuated, thin cells lining the alveolus,

♣ the fused basal laminae of these cells and of the capillary endothelial cells, and

♣ the thin endothelial cells of the capillary.

The total thickness of these layers varies from 0.1 to 1.5μm.Macrophages and other leukocytes can also be found within the septa (see Figure 16) and (Figure 17).

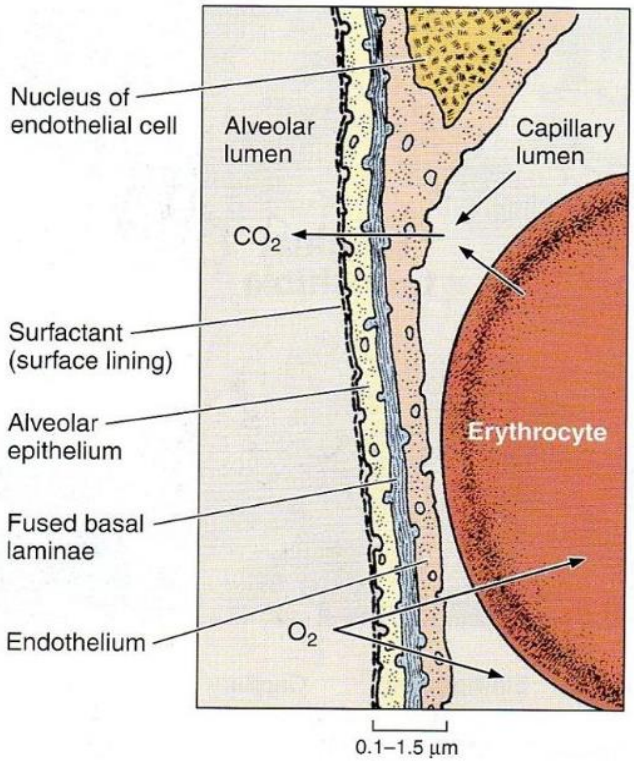


Figure 16. Portion of the interalveolar septum showing the blood-air barrier.

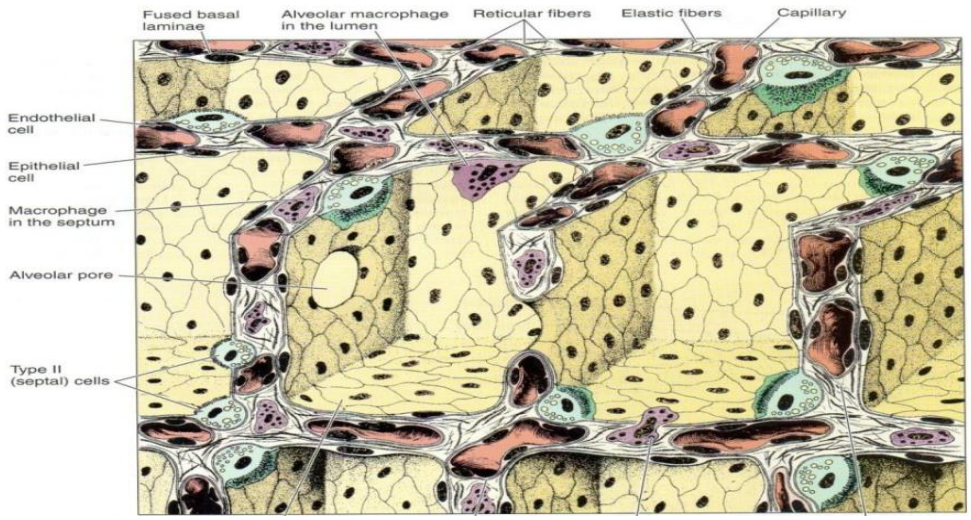


Figure 17. Pulmonary alveoli

Alveolar pores (of Kohn), ranging 10-15 μm in diameter, penetrate the interalveolar septa (see Figure 17) and connect neighboring alveoli that open to different bronchioles. The pores equalize air pressure in these alveoli and permit collateral circulation of air when a bronchiole is obstructed. O2 from the alveolar air diffuses through the blood-air barrier into the capillary blood and binds hemoglobin in erythrocytes; CO2 diffuses into the alveolar air from the pulmonary blood. Most CO2 arrives in the lungs as part of H2CO3 inside erythrocytes and is liberated through the action of carbonic anhydrase.

Walls of alveoli are composed of two types of cells:

1. **Type I alveolar cells (or type I pneumocytes)** are also extremely attenuated cells that line the alveolar surfaces. Type I cells which composed of simple squamous epithelium maintain the alveolar side of the blood-air barrier and cover about 95% of the alveolar surface; type II alveolar cells (see Figure 17) cover the remainder. Pinocytotic vesicles in the attenuated cytoplasm may play a role in the turnover of surfactant and the removal of small particulate contaminants from the outer surface. In addition to desmosomes, all type I epithelial cells have occluding junctions that prevent the leakage of tissue fluid into the alveolar air space.
2. **Type II alveolar cells (type II pneumocytes or septal cells)** are cuboidal cells that bulge into the air space, interspersed among the type I alveolar cells and bound to them with occluding junctions and desmosomes. Type II cells often occur in groups of two or three along at points where two or more alveolar walls unite (see Figure 17). These epithelial cells rest on the same basal lamina and have the same origin as the type I cells that line most of the alveolus. Type II cells

divide to replace their own population after injury and to provide progenitor cells for the type I cell population. Type II cell nuclei are rounded and may have nucleoli, and their cytoplasm is typically lightly stained with many vesicles. Many vesicles of type II alveolar cells are lamellar bodies, which about 1 to 2 μm in diameter. Lamellar bodies can be considered markers for type II cells. They contain various lipids, phospholipids, and proteins that are continuously synthesized and released at the apical cell surface. The secreted material spreads over the entire inner alveolar surface as a film of complexed lipoproteins and water that acts as pulmonary surfactant. The surfactant film lowers alveolar surface tension, which helps prevent alveolar collapse at exhalation and allows alveoli to be inflated with less inspiratory force, easing the work of breathing. The surfactant layer turns over constantly, with lipoproteins gradually removed by pinocytosis in both types of alveolar cells and by macrophages. In fetal development, surfactant appears in the last weeks of gestation as type II cells differentiate and form lamellar bodies. Lack of adequate surfactant is a major cause of respiratory distress in premature neonates. Alveolar macrophages, also called dust cells, are found in alveoli and in the interalveolar septum (see Figure 17). Tens of millions of monocytes migrate daily from the microvasculature into the lung tissue, where they phagocytose, erythrocytes lost from damaged capillaries and airborne particulate matter that has penetrated as far as the alveoli. Active macrophages in alveoli can often be distinguished from type II pneumocytes because they are slightly darker due to their content of dust and carbon from air and complexed iron (hemosiderin) from erythrocytes (see Figure 17). Filled macrophages have various fates: most migrate into bronchioles where they move up the mucociliary apparatus for removal in the pharynx;

others exit the lungs in the lymphatic drainage; and some remain in the interalveolar septa connective tissue for years.

Alveolar lining fluids are also removed via the conducting passages as a result of ciliary activity. As the secretions pass up through the airways, they combine with bronchial mucus to form bronchoalveolar fluid, which helps remove particulate components from inspired air. The bronchoalveolar fluid is bacteriostatic, containing lysozyme and other protective agents produced by Clara cells, type II alveolar cells, and alveolar macrophages.

Medical Application

In congestive heart failure, the lungs become congested with blood, and erythrocytes pass into the alveoli, where they are phagocytized by alveolar macrophages. In such cases, these macrophages are called heart failure cells when present in the lung and sputum; they are identified by a positive histochemical reaction for iron pigment (hemosiderin).

Regeneration in the Alveolar Lining

Inhalation of toxic gases or similar materials can kill types I and II cells lining pulmonary alveoli. Death of the first cells results in increased mitotic activity in the remaining type II cells, the progeny of which become both cell types. The normal turnover rate of type II cells is estimated to be 1% per day and results in a continuous renewal of both alveolar cells. With increased toxic stress, some Clara cells can also be stimulated to divide and give rise to alveolar cells.

Lung Vasculature & Nerves

Circulation in the lungs includes both nutrient (systemic) and functional (pulmonary) vessels. Pulmonary arteries and veins represent the functional circulation. Pulmonary arteries are thin-walled as a result of the low pressures (25 mm Hg systolic, 5 mm Hg diastolic) encountered in the pulmonary circuit. Within the lung the pulmonary artery branches, accompanying the bronchial tree (Figure 18). Its branches are surrounded by adventitia of the bronchi and bronchioles. At the level of the alveolar duct, the branches of this artery form a capillary network in the interalveolar septum and in close contact with the alveolar epithelium. The lung has the best-developed capillary network in the body, with capillaries between all alveoli, including those in the respiratory bronchioles.

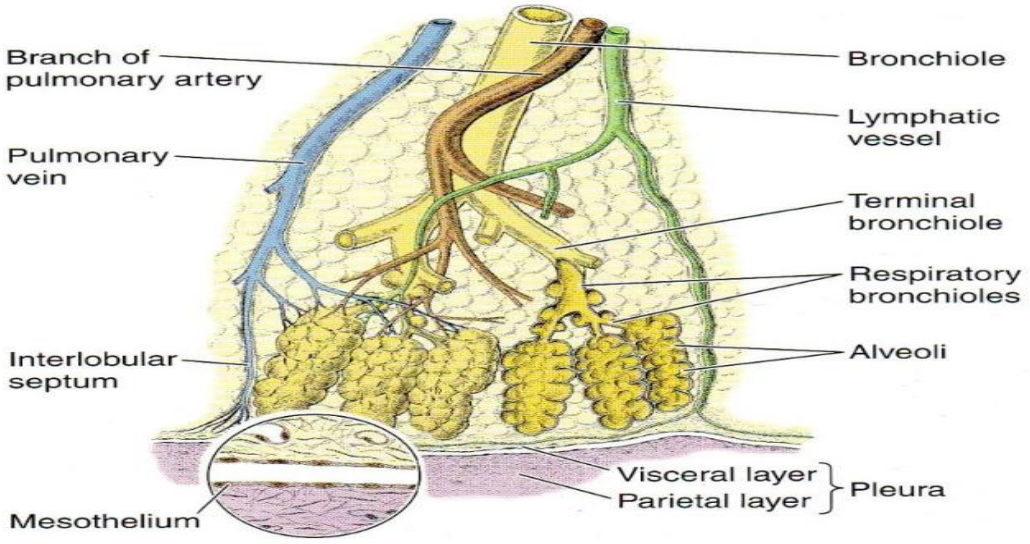


Figure 18. Blood and lymph circulation in a pulmonary lobule. At the lower left, an enlargement of the pleura shows its mesothelial lining.

Venules that originate in the capillary network are found singly in the parenchyma, somewhat removed from the airways; they are supported by a thin covering of connective tissue and enter the interlobular septum (see Figure 18). After veins leave a lobule, they follow the bronchial tree toward the hilum.

Nutrient vessels follow the bronchial tree and distribute blood to most of the lung up to the respiratory bronchioles, at which point they anastomose with small branches of the pulmonary artery.

The Lymphatic vessels (see Figure 18) follow the bronchi and the pulmonary vessels; they are also found in the interlobular septum, and they all drain into lymph nodes in the region of the hilum. This lymphatic network is called the deep network to distinguish it from the superficial network, which includes the lymphatic vessels in the visceral pleura.

The lymphatic vessels of the superficial network drain toward the hilum. They either follow the entire length of the pleura or penetrate the lung tissue via the interlobular septum. Lymphatic vessels are not found in the terminal portions of the bronchial tree or beyond the alveolar ducts.

Both parasympathetic and sympathetic efferent fibers innervate the lungs; general visceral afferent fibers, carrying poorly localized pain sensations, are also present. Most of the nerves are found in the connective tissues surrounding the larger airways.

Pleura

The pleura (see Figure 18) is the serous membrane covering the lung. It consists of 2 layers, parietal and visceral, that are continuous in the region of the hilum. Both membranes are composed of mesothelial cells resting on a fine connective tissue layer that contains collagen and elastic fibers. The elastic fibers of the visceral pleura are continuous with those of the pulmonary parenchyma.

The parietal and visceral layers define a cavity entirely lined with squamous mesothelial cells. Under normal conditions, this pleural cavity contains only a film of liquid that acts as a lubricant, facilitating the smooth sliding of one surface over the other during respiratory movements.

In certain pathologic states, the pleural cavity may contain liquid or air .Like the walls of the peritoneal and pericardial cavities, the serosa of the pleural cavity is water- permeable and fluid exuded from blood plasma commonly accumulates (as a pleural effusion) in this cavity during inflammation and other abnormal conditions.