Lunge mit Lungenbläschen
Lung with Alveoli
Poumons avec alvéoles pulmonaires
Pulmón con alvéolos pulmonares

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Lung with Alveoli

Model I

A diagrammatic representation of a pulmonary lobule with cartilaginous bronchi and non-cartilaginous bronchioles. The vertical distances of the bronchial tree are greatly shortened. Some of the alveoli show the capillary network, others show the reticulum of elastic fibres. The network of smooth muscle is also shown. Mucous membrane – yellow-red; glands – green; cartilage – light blue; muscle – brown; elastic fibres – black; pulmonary vein – carmine; pulmonary artery – violet; bronchial artery – vermilion; bronchial vein – blue; lymph vessels – orange; nerves – yellow. The back of the model shows the circulation within the pulmonary lobule and in the pleural cover.

On account of anatomical differences the bronchial system is divided into the following sections: (The rings of cartilage on the major bronchi are not shown.)

1. The intra-pulmonary bronchi have only cartilaginous plates.
2. Non-cartilaginous bronchioles divide into
3. respiratory bronchioles of 1st, 2nd and 3rd order. The respiratory bronchiole has lateral hemispherical protrusions, the
4. alveoli – the actual respiratory elements of the lung. The respiratory bronchioles of 1st, 2nd and 3rd order are distinguished by their varying densities of alveoli. Beyond the respiratory bronchioles begin the lung tissues that serve the external breathing apparatus. The lining of the bronchi is composed of
5. mucous membrane, which lies in longitudinal folds when the lung is relaxed. A strong network of longitudinal
6. elastic fibres (black) runs through the sub-epithelial connective tissue. The latter also contains
7. smooth muscle (brown), running at first in circular, then in a spiral direction. Its contraction, together with
the filling of the pulmonary plexus of the bronchial vein leads to a narrowing of the air passage. The mucous glands of the bronchi can penetrate deep into the outer fibro-cartilaginous layer through gaps in the cartilaginous framework. Precise information on the number of alveoli is not available. Estimates vary between 150 and 1,800 million. Physiologists estimate the respiratory surface area attained by the presence of alveoli to be between 50 and 90 square metres. The diameter of the alveoli varies between .15 and .6 mm. The width increases with age. The pulmonary pleura shows the limiting membranes with translucent alveoli, the layer of dense capillaries, the layer of collagenous fibres, the layer of elastic fibres and the epithelium.

The dense arrangement of elastic fibres (black) makes the lung the most elastic of all the organs of the body. The elastic beginning in the pleura and end in their finest branches in the wall of the alveoli.

Pulmonary and pleural circulation

The right side of the heart sucks the dark venous blood of the body through the vena cavae, and that of the heart wall through the coronary sinus and pumps it through the pulmonary trunk artery to the lungs for oxygen enrichment. Simultaneously, the left side of the heart sucks the pale red oxygenated blood from the pulmonary veins and pumps it through the aorta into the systemic circulation; thus the two circulatory systems function side by side. The right side of the heart containing venous blood supplies the pulmonary circulation.

The lung contains two vascular systems. The vessels of the pulmonary circulation bring the blood directly from the heart into the capillary circulation of the alveoli, and from there back to the heart. These are the pulmonary arteries and veins. Their circulation directly serves the metabolism of the entire organism. The systemic supply, which nourishes the lung tissues, is carried by the bronchial arteries which are branches of the aorta. The bronchial veins open mainly into the vena azygos and hemiazygos veins.

The pulmonary arteries are of the elastic type (like the aorta) and run together with the bronchi into the larger lung segments. They enter the lobules as arterioles, together with the terminal bronchioles. The arterioles reach the capillary network of the alveoli together with the alveolar duct.

The pulmonary veins take another route. They collect at the tips of the alveoli and run in the interlobular septa to the larger bronchi. From here, bronchus, artery and vein run together to the hilum of the lung. The veins are firmly embedded in the pulmonary connective tissue. Between the pulmonary circulation and the systemic blood supply are arterial anastomoses. Numerous arterio-venous anastomoses are also present in the visceral pleura, in which the terminal branches of the bronchial arteries communicate with interlobular branches of the pulmonary artery.

Network of lymph vessels

The visceral pleura contains a network of lymph vessels. The larger vessels follow the borders of the lobules. There are numerous small subpleural lymph nodes. The endothelia of these lymph vessels absorb dust particles, and this can be seen as a darkening of the surface of the lung. From there, interlobular lymph vessels follow the venules to bronchial lymph nodes. Lymph nodes lie at the bifurcation of the bronchi – even in the smallest branches. The lymph vessels, which carry the lymph from the bronchial wall also open into the
bronchial lymph nodes. There are no lymph vessels in the alveolar wall.

Nerve supply

Groups of autonomic ganglion cells occur in many places in the bronchi as in the trachea. Together with their sympathetic and parasympathetic fibres they form the pulmonary plexus which regulates the dilation of the blood vessels and also the function of the smooth muscle of the bronchioli and the alveolar ducts.

Modell II

enlargement: approx. X 1000

The model shows sections of alveoli (diam.: 0.1 – 0.5 mm). On the front are alveoli with the alveolar epithelium, the "anucleate discs" and the translucent layer beneath. On the back are shown (1) capillaries with the lattice fibre network and the connective tissue stroma and the epithelial cells – here seen in niches (3) in the capillary mesh. The blood capillaries in the alveolar wall consist of an endothelial tube, and a basal membrane with reticulated circular fibrils (2). The tortuosity of the capillaries is eliminated during inspiration. The connective tissue framework of the alveolar wall (4) is part of the fibrous system extending throughout the organ that consists of delicate collagenous fibres as well as reticulated fibrils. The alveolar wall is surrounded by a basket-like framework of elastic fibres (5). This permits a reversible stretching of the alveoli up to three times their diameter. At the openings of the alveoli the thick elastic fibres form characteristic peripheral rings. Together with smooth muscle fibres these form the alveolar arches (6). This musculature regulates the width of the orifices and the tension of the elastic fibrous framework.

The front of the model shows alveoli with the alveolar epithelium (7) and the "anucleate discs". The alveolar epithelium is the continuation of the epithelium of the respiratory bronchioles and lines the alveolar ducts and alveolar sacs: it is single-layered, flat, and lies in direct contact with the inspired air. Four tissue layers separate the capillary blood from the alveolar air: the capillary endothelium, two basal membranes and the alveolar epithelium. The connective tissue can be included as a fifth layer. Oxygen and carbon-dioxide must pass through these layers during the gaseous exchange.

The alveolar wall is interrupted by

(8) alveolar pores that connect alveoli to each other. The fibrinous threads occurring in pneumonia can jut into neighbouring alveoli through these tiny openings.

(9) afferent and

(10) efferent capillary vessels

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