Pleura and Lungs

Overview of the Airways

The respiratory pathway begins with the trachea, which starts at the lower border of the larynx or cricoid cartilage, located just below the thyroid cartilage (commonly known as the Adam's apple). The trachea is a single tube composed of cartilaginous rings that extend down to approximately the level of the T4-T5 vertebra, where it bifurcates into the right and left main bronchi. This bifurcation occurs around the sternal angle, also known as the manubriosternal joint, at the level of the IV disc between T4 and T5.

In cross-section, the posterior part of the trachea is deficient in cartilage, forming a U-shape, with a muscle bridging the gap to close it. The cartilaginous rings are crucial for maintaining airway patency, preventing collapse during breathing.

Branching of the Main Bronchi

At the bifurcation, the trachea divides into the right and left main bronchi. The right main bronchus is shorter, wider, and more vertical than the left, making it more prone to aspirated objects entering the right lung. The left main bronchus passes through the hilum of the left lung, which is the entry point for the lung's vessels and bronchi.

On the right side, the main bronchus further branches into a superior and an intermediate lobar bronchus, leading to the three lobes of the right lung: superior, middle, and inferior. The left lung has only two lobes—superior and inferior—separated by the oblique fissure. The left main bronchus enters the hilum directly, while the right main bronchus divides before reaching the hilum.

Levels of Bronchial Branching

1. **Main bronchi**: The primary division from the trachea.
2. **Lobar (secondary) bronchi**: Branches that supply each lobe of the lung (two on the left, three on the right).
3. **Segmental (tertiary) bronchi**: Further subdivisions that supply individual bronchopulmonary segments, each segment being a functionally independent unit of the lung.

Each bronchopulmonary segment receives air from one segmental bronchus, and these segments are supplied by their own arteries and veins, which follow a similar branching pattern to the airways.

Lower Airways and Alveoli

Beyond the segmental bronchi, the airway tree continues to branch into smaller bronchioles, which lack cartilage support. The transition from bronchi to bronchioles occurs when the cartilage plates diminish and disappear, leaving only smooth muscle. These bronchioles lead to alveolar ducts and alveoli, the grape-like structures where gas exchange occurs. Capillaries surround alveoli, facilitating oxygen and carbon dioxide exchange.

Structural Features and Clinical Relevance

The absence of cartilage in the distal airways makes them susceptible to collapse, especially during conditions like asthma. In asthma, smooth muscle spasms constrict the airways, which can totally close the smaller bronchioles, making breathing difficult. Triggers such as cold air exacerbate this constriction cold induces smooth muscle contraction, worsening airflow obstruction.

Asthma attacks are particularly problematic in cold climates or during physical activity outdoors, where cold air triggers bronchospasm. The lack of cartilage support in these lower airways is a key factor in the pathophysiology of asthma.

The Lungs: Anatomy and Features

There are two lungs: the right and the left. Each lung has an apex that projects above the first rib and a base that rests on the diaphragm. The right lung has three lobes—superior, middle, and inferior—separated by the horizontal and oblique fissures. The left lung has two lobes—superior and inferior—separated by the oblique fissure and features a cardiac notch, an indentation accommodating the heart's apex.

The anterior surfaces of the lungs are sharp and fill the anterior thoracic cavity, while the posterior surfaces are rounded, following the contours of the thoracic wall. These features help in orienting the lungs during dissection or imaging.

Blood Supply to the Lungs

Pulmonary Circulation

The pulmonary blood supply is dedicated to gas exchange. It involves the pulmonary arteries and veins. The pulmonary arteries carry deoxygenated blood from the right ventricle of the heart through the pulmonary trunk to the lungs. The pulmonary veins return oxygenated blood to the left atrium of the heart.

Contrary to common misconception, pulmonary arteries are deoxygenated, and pulmonary veins are oxygenated. The pulmonary arteries are represented in red in diagrams, but they carry deoxygenated blood, and the veins carry oxygenated blood back to the heart.

At the hilum, each lung has one pulmonary artery and two pulmonary veins. The arteries and veins follow a branching pattern similar to the airways, with each tertiary branch supplying a bronchopulmonary segment.

Clinical Significance of Pulmonary Vasculature

Understanding the branching pattern is essential for surgical procedures, such as segmental resections. Surgeons can tie off segmental arteries, veins, and bronchi to remove diseased segments, like in lung cancer surgeries.

Vascular Relationships at the Hilum

At the hilum of the lungs, the arteries are consistently positioned superiorly and posteriorly relative to the veins. Conversely, the veins are always located anteriorly and inferiorly to the arteries. This relationship holds true on both the left and right sides of the lungs. It is important to note that the position of these structures relative to the airways varies between lungs, so memorizing both positions is unnecessary. Instead, identifying the airway is straightforward because it is surrounded by cartilage, which can be felt and manipulated, making it easy to distinguish from blood vessels.

The key relationship to remember is that pulmonary arteries are always superior and posterior to the veins, which are anterior and inferior. This understanding is crucial for correctly identifying arteries and veins during dissection or imaging.

Structural Differences Between Pulmonary and Systemic Vessels

Unlike systemic arteries, pulmonary arteries are not characterized by thick walls or distensibility because they do not need to withstand high pressure. They develop as relatively thin-walled, elastic vessels since they carry blood from the right ventricle to the lungs, where pressure drops significantly after the capillary beds. Pulmonary veins, on the other hand, are also thin-walled and collapsible, as they return blood to the left atrium with low pressure, and do not require the thick walls seen in systemic arteries.

In the lungs, both arteries and veins appear similar in structure—thin, elastic, and distensible—because they are not subjected to the high pressures of systemic circulation. Therefore, relying on their appearance alone can be misleading; instead, their positional relationships are essential for identification.

Bronchial Blood Supply

The bronchial blood supply supplies the lung parenchyma, which includes all tissue between the airways that is not directly involved in gas exchange. This tissue comprises connective tissue, elastic fibers, and other non-respiratory components. The bronchial arteries originate from the aorta and are very small vessels that run alongside the airways, following their course into the lungs.

Bronchial veins drain blood in the opposite direction, ultimately emptying into the azygous system of veins. This system has a special relationship with thoracic structures and will be discussed further in the context of the mediastinum and thoracic anatomy.

Bronchopulmonary Segments

Bronchopulmonary segments are pyramid-shaped zones within the lungs, with their apex directed towards the hilum. Each segment is supplied by a single segmental bronchus, a pulmonary artery, and pulmonary veins. These segments are functionally distinct and can be surgically resected by isolating their tertiary branches.

Historically, knowledge of these segments was used in physiotherapy to aid in draining fluid from specific lung areas by positioning patients appropriately. Today, physiotherapy primarily encourages coughing to clear the lungs, but understanding segmental anatomy remains relevant for clinical practice.

The Hilum of the Lung

The hilum is the medial entry and exit point on each lung, characterized by a comma-shaped area. On the right lung, the hilum features a sharp anterior border, a rounded posterior border, a base resting on the diaphragm, and an apex projecting upward. The right main bronchus has already split into lobar bronchi before entering the lung.

Within the hilum, the following structures are visible:

- One pulmonary artery, positioned posteriorly and superiorly to the veins
- Two pulmonary veins, located anteriorly and inferiorly to the artery
- Airways with cartilaginous plates
- Small bronchial vessels supplying non-respiratory lung tissue
- Hilar lymph nodes, which are the first lymph nodes encountered and are part of the lymphatic drainage system

The left lung's hilum shares similar features, with a sharp anterior border (including a cardiac notch), a rounded posterior border, and a comma-shaped hilum. The left main bronchus enters the lung and branches into lobar bronchi. The pulmonary artery remains posterior and superior to the veins, which are anterior and inferior.

Nerve Supply of the Lungs

The lungs receive sympathetic and parasympathetic innervation, which regulate airway tone and other functions. The sympathetic innervation originates from spinal cord segments T1 to T4 via the sympathetic chain and passes through anterior and posterior pulmonary plexuses. Sympathetic stimulation causes bronchodilation by inhibiting smooth muscle contraction around the bronchi.