Chapter 6: The pleura and lungs

The Pleura

Each pleural sac is a closed cavity lined by a serous membrane which is invaginated by a lung. Parietal pleura lines the outer walls of the cavity and visceral (pulmonary) pleura covers the lungs. The layers of pleura are continuous around the root of the lung and are separated only by a thin layer of serous fluid. The two layers of pleura can glide easily on each other but are prevented from separating by the surface tension of the serous fluid and the negative pressure in the closed cavity. As a resulted, when the diaphragm descends and the thoracic cage expands, the lung also has to expand and so air is drawn in from the trachea.

The pleura is a fibro-elastic membrane lined by squamous mesothelial cells. The parietal pleura lines the ribs, costal cartilages and the intercostal spaces, the lateral surface of the mediastinum and the upper surface of the diaphragm. Superiorly it extends beyond the thoracic inlet into the neck to form the cervical dome of pleura. Inferiorly, around the margin of the diaphragm, it forms a narrow gutter, the costodiaphragmatic recess. Anteriorly, in front of the heart, the left costal and mediastinal surfaces are in contact forming the costomediastinal recess. The mediastinal pleura invests the main bronchi and pulmonary vessels as an overlarge collar and passes on to the surface of the lung to become pulmonary pleura. This completely covers the lung and extends into its interlobar fissures.

The extent of the pleural sacs on each side should be noted. On both sides the upper limit of the cervical pleura lies about 3 cm above the medial third of the clavicle. From there the lines of pleural reflections descend behind the sternoclavicular joints to meet in the midline at the level of the 2nd costal cartilages. At the 4th cartilage, the left pleura deviates laterally and descends along the lateral border of the sternum as far as the 6th cartilage, whereas the right pleura continues vertically downwards near the midline to the 6th cartilage. At the 6th costal cartilage the lower border of both pleural reflections passes laterally just behind the costal margin to reach the 8th rib in the midclavicular line, the 10th rib in the midaxillary line and the 12th rib in the paravertebral line. The paravertebral line lies about 3 cm from the midline and corresponds to the tips of the transverse processes.

The pleura is supplied by blood from the tissues it covers. Pulmonary pleura has no pain fibres but the parietal pleura is richly supplied by the nerves in the subjacent tissues. Lymph from the pulmonary pleura passes to a superficial plexus in the lung and then to the hilar nodes. The parietal pleura drains to parasternal, diaphragmatic and posterior mediastinal nodes.

The parietal and visceral pleura envelop a potential space, the pleural cavity, which can fill with fluid in pathological conditions, with blood after intrathoracic haemorrhage or with air after penetrating trauma to the chest wall. The distended pleural sac may interfere with expansion of the lung during respiration. Fluid can be drained from the pleural sac by inserting a needle, or tube, attached to an underwater seal into the 8th intercostal space in the posterior axillary line.
The lungs

The lungs are paired organs of respiration. Each lies in its pleural sac attached to the mediastinum at the hilus. The lung is spongy and elastic in texture and cone-shaped to conform to the contours of the thoracic cavity. The right lung weights about 620 g and the left about 560 g. The lungs have a characteristic mottled appearance on radiographs. The clear areas are lung tissue and the dense shadows at the hilus and radiating outwards are caused by hilar tissues (lymph nodes) and by blood vessels.

Each lung has an apex in the root of the neck and a base resting on the diaphragm. The base is separated by a sharp inferior border from a lateral convex costal surface and a medial concave (mediastinal) surface. In the centre of this latter surface, the structures forming the root of the lung are seen to be surrounded by a collar of pleura. The concavity of the medial surface is accentuated on the left to accommodate the left ventricle of the heart. The anterior border on the left side is deeply indented by the heart to form the cardiac notch. The posterior border is rounded and lies in the paravertebral sulcus.

The lungs are divided into lobes by fissures which extend deeply into their substance. An oblique fissure divides the left lung into an upper and a lower lobe; oblique and horizontal fissures divide the right lung into upper, middle and lower lobes. The oblique fissure of both lungs may be marked by a line curving around the chest wall from the spine of the 3rd thoracic vertebra to the 6th costochondral junction. The horizontal fissure is marked by a horizontal line passing laterally to the oblique line from the 4th right costal cartilage.

The lower lobes of both lungs lie below and behind the oblique fissure and comprise most of the posterior and inferior borders and parts of the medial and costal surfaces. The upper lobe of the left lung lies above and in front of the oblique fissure and comprises the apex, substantial portions of the mediastinal and costal surfaces and the whole of the anterior border including the cardiac notch. The equivalent part of the right lung is divided by the horizontal fissure into a large upper lobe and wedge-shaped anteriorly placed smaller middle lobe. A thin antero-inferior part of the left upper lobe, adjacent to the cardiac notch, is known as the lingula and represents the middle lobe. Variation exists in this lobar pattern. Fissures, especially the horizontal, may be incomplete or absent, and occasionally additional lobes are present.

The hilus of each lung contains a main bronchus, pulmonary artery, two pulmonary veins, the pulmonary nerve plexus, and lymph nodes, all surrounded by the collar of pleura whose narrow inferior extension is known as the pulmonary ligament. On both sides the bronchus lies behind the pulmonary artery, and the two pulmonary veins lie antero-inferior to both other structures.

The intrapulmonary bronchi and bronchopulmonary segments

The right upper lobe bronchus arises from the right main bronchus just before the hilus, and soon after entering the lung substance it divides into apical, anterior and posterior segmental bronchi. The middle lobe bronchus arises from the right bronchus just below the upper lobe bronchus and divides into radial and lateral segmental bronchi. The continuation
of the right bronchus passes to the lower lobe and divides into apical, anterior, medial, lateral and posterior basal segmental bronchi.

The left upper lobe bronchus arises from the main bronchus within the lung and divides into five segmental bronchi, the anterior and inferior passing to the lingula. The continuation of the left bronchus passes to the lower lobe and divides into five segmental branches. The names of the segmental bronchi are the same as those on the right. Each segmental bronchus is distributed to a functionally independent unit of lung tissue - a bronchopulmonary segment.

Relations

Parietal relations

The borders of the lungs closely follow the lines of pleural reflection on the chest wall except below, where the inferior border of the lung lies approximately two intercostal spaces above the inferior limit of the pleura, and in front, where the anterior border of the left lung in the region of the cardiac notch lies about 3 cm lateral to the pleural reflection in this region. The costal surface is related to the thoracic wall. The base is separated by the diaphragm from the right lobe of the liver on the right side and the left lobe of the liver, stomach and spleen on the left. The apex is covered by the dome of pleura which lines the supracleural membrane, a fibrous sheet extending from the transverse process of the 7th cervical vertebra to the inner border of the 1st rib. The subclavian vessels arch over the apex above the pleura and membrane. Posteriorly the branch of the 1st thoracic nerve to the brachial plexus, the superior intercostal artery, the sympathetic trunk and the pleura separate the apex of the lung from the neck of the 1st rib.

The medial relations of the two lungs differ.

On the left: there is a large concavity antero-inferiorly for the left ventricle of the heart. It is continuous superiorly with a groove for the aortic arch which passes in front of and above the hilus. Above the groove the surface is in contact with the left brachiocephalic vein, left common carotid and left subclavian arteries, and the oesophagus.

On the right: there is a shallow concavity in front of the hilus for the right atrium. This is continuous above with a groove for the superior vena cava and with a short one below for the inferior vena cava. The azygos vein grooves the lung as it arches forwards above the hilus. The oesophagus, which lies near the posterior border, is in contact throughout its length save where the azygos vein separates it from the lung. Between the superior vena cava and the oesophagus superiorly is the trachea.

Blood supply

Lung tissue is supplied by the bronchial branches of the descending thoracic aorta. Some of this blood returns to the heart by the pulmonary veins. The bronchial veins drain to the azygos or accessory hemiazygos veins. Poorly oxygenated blood is conveyed to the lung alveoli by the pulmonary artery whose branches correspond to and accompany the bronchial
tree. The terminal branches end in a capillary network within the alveolar walls. Venous tributaries from the network return with the bronchi to upper and lower pulmonary veins.

**Lymph drainage**

This is via a superficial subpleural lymph plexus and a deep plexus of vessels accompanying the bronchi. Both groups drain through hilar (bronchopulmonary) lymph nodes to tracheobronchial nodes around the bifurcation of the trachea and thence to mediastinal lymph trunks.

**Nerve supply**

Sympathetic (bronchodilator) fibres from the upper thoracic segments and parasympathetic (bronchoconstrictor) fibres from the vagus, both pass through the pulmonary plexus. Sensory fibres pass mainly in the vagus.

**Histology**

The walls of intrapulmonary bronchi, lined by respiratory epithelium, are formed of fibrous tissue and smooth muscle, and contain incomplete rings of hyaline cartilage. The bronchi divide and redivide until their diameter is less than 1 mm after which they are known as bronchioles, the walls of which lack mucous glands and cartilaginous plates. The bronchioles subdivide and form respiratory bronchioles whose walls, lined by nonciliated columnar epithelium, contain smooth muscle. Each respiratory bronchiole opens into a number of alveolar ducts from which arise alveolar sacs whose walls possess the terminal respiratory saccules, the alveoli. Alveolar walls are lined by simple squamous epithelium.

**Embryology**

The lungs develop from a single ventral pharyngeal outgrowth which bifurcates. The lung buds enlarge into the coelomic pericardioperitoneal canals.

Radiographs of the chest allow accurate localisation of disease of the lung, in addition to defining abnormal collections of air or fluid in the pleural space. CT and MRI scans increase the definition and localization of pulmonary lesions and can be used to guide fine needles to biopsy abnormal lesions. The use of radiopaque contrast substances greatly facilitates localisation of the lesion. Excision of a segment, a lobe or a whole lung can be undertaken. A knowledge of the pattern of division of the bronchi helps when a part of the lung has to be drained of pus.