Chapter 3
Thorax

The thoracic cage and the intercostal space

The bony thoracic cage is formed by the 12 thoracic vertebrae at the back, the sternum in front and 12 pairs of ribs in between (Fig. 3.1). The upper seven pairs of ribs articulate anteriorly direct with the sternum through their respective costal cartilages. The costal cartilage of ribs 8, 9 and 10 articulates with that of the rib above. These ribs with the xiphisternum form the lower costal margin. The lowermost point of the thoracic cage is the 10th costal cartilage.

The space between two adjacent ribs is known as the intercostal space. Thus there are 11 intercostal spaces on each side.

The junction between the manubrium and the body of the sternum is the sternal angle. The second costal cartilage articulates at the sternal angle (Figs 3.1, 3.2). This is an important landmark and corresponds to the level of the lower border of the 4th thoracic vertebra. The seventh costal cartilage anteriorly articulates at the junction between the body of the sternum and the xiphisternum. The 8th, 9th and 10th ribs each articulate with the rib above. The 11th and 12th ribs are the floating ribs as they have no connection to bone or cartilage in front. See Clinical box 3.1.

Surface anatomy

The sternal angle is palpable on the surface as a transverse ridge (Fig. 3.1). This landmark is used to palpate the second costal cartilage and the second rib. It is possible to identify the other ribs as well as intercostal spaces by counting down from the second rib.

The first rib is not palpable as it is under the clavicle. Ribs 11 and 12 are rudimentary, confined to the back covered by muscles and hence are not palpable.

The intercostal space

The intercostal space (Fig. 3.3) contains the external intercostal, the internal intercostal and the innermost intercostal muscles arranged in three layers. The neurovascular bundle, consisting of the intercostal nerve and vessels, lies in between the internal and the innermost intercostals.

The external intercostal muscle fibres are directed downwards and forwards. In the anterior part the muscle fibres are replaced by a membrane. The internal intercostal fibres lie in the opposite direction to those of the external. The neurovascular bundle lies between the internal and the innermost intercostal muscles. If it is necessary to insert a chest drain or a needle into the intercostal space it is always placed in the lower part of the space to avoid damage to the neurovascular bundle (which lies along the lower border of the rib along the upper part of the space). The neurovascular bundle consists of, from above downwards, intercostal vein, artery and nerve. See Clinical box 3.2.

The intercostal nerves are the anterior rami of the first 11 thoracic nerves. These supply the intercostal muscles, the skin of the chest wall as well as the parietal pleura. The lower intercostal nerves, 7th downwards, supply the

Clinical box 3.1
Rib fractures and ‘stove-in-chest’

Rib fractures can be fracture of a single rib or can be multiple fractures and are caused by direct blow on the rib or by a crush injury. In a severe crush injury several ribs can fracture in front as well as behind producing a loose segment of chest wall disconnected from the rest. This is known as a ‘stove-in-chest’. The loose segment may show paradoxical movements during respiration i.e. moves inwards during inspiration and blows out during expiration. Stove-in-chest is a serious condition needing urgent intubation and positive pressure ventilation using a respirator as well as a chest drain.
anterior abdominal wall as well. Segments of skin supplied by the intercostal nerves are common sites of vesicles in Herpes zoster, a viral infection affecting the spinal nerve ganglia spreading through the intercostal nerves.

The internal thoracic artery, a major artery on the anterior aspect of the chest wall, is a branch of the subclavian artery and it descends vertically downwards lying about 1 cm lateral to the sternum. In the sixth intercostal space it divides into its two terminal branches, the musculophrenic and superior epigastric arteries, the latter entering the anterior abdominal wall by passing through the diaphragm.

The anterior intercostal arteries are branches of the internal thoracic artery or those of its musculophrenic branch. Most of the posterior intercostal arteries are derived from the descending thoracic aorta. Anastomoses between the anterior and posterior intercostal arteries are important collateral channels for circulation in cases of obstruction to the blood flow in the aorta anywhere beyond the origin of the left subclavian artery.

The thoracic cavity, lungs and pleura

The thoracic cavity contains on either side the right and left lungs surrounded by the pleural cavities and the mediastinum in between.

The lungs and pleural cavities

See Figures 3.4–3.11. The right lung is subdivided into superior, middle and inferior lobes by an oblique fissure and a horizontal fissure (Figs 3.4 and 3.5). The left lung usually has only two lobes, a superior and an inferior with an oblique fissure in between. Each lung has an apex which extends about 3 cm above the clavicle into the neck, a costal surface, a mediastinal surface and a base or diaphragmatic surface.

Clinical box 3.2

Thoracocentesis, insertion of a chest drain

Insertion of a chest tube into the pleural cavity is required to remove large amounts of serous fluid, blood, pus or air. The site of insertion of the tube is usually at the 5th intercostal space just anterior to the midaxillary line on the affected side. This site will avoid the tube going through the pectoral muscles which lie more anteriorly and will avoid possible damage of liver (right side) and spleen (left side) which are overlapped by the pleural cavity more inferiorly (see Clinical box 3.3).

Nerve to serratus anterior lies at the level of insertion of the tube and may be damaged occasionally, causing winging of the scapula (see Clinical box 2.1).

A needle thoracocentesis done in a critically ill patient with tension pneumothorax may be life saving. An over the needle catheter is inserted into the pleural cavity on the side of the tension pneumothorax through the second intercostal space in the midclavicular line. Insertion medial to the midclavicular line has a potential danger of damaging the great vessels in the mediastinum.

The needle or chest drain is always inserted superior to the rib (lower part of the intercostal space) to avoid damaging the neurovascular bundle. Damage of the intercostal nerve will cause neuritis and pain (neuralgia) and puncture of the vessels may result in bleeding into the pleural cavity (haemothorax).

The parietal pleura, the periosteum and other structures in the area of needle insertion and chest drain have rich innervation and hence a good local anaesthesia is required for procedures mentioned above.
surface (Figs 3.6 and 3.7). The anterior border of the lung separates the costal and the mediastinal surfaces whereas the lower border is between the costal and the diaphragmatic surface (Fig. 3.6).

The root of the lung connects the lung to the mediastinum and consists of, anterior to posterior, two pulmonary veins, the pulmonary artery and the bronchus. The pulmonary veins are at a lower level compared with the pulmonary artery (Figs 3.7 and 3.8). The area where these structures enter the lung is the hilum of the lung. These structures are enclosed in a sleeve of pleura which loosely hangs down in its lower part as the pulmonary ligament. The right main bronchus gives off the superior lobar bronchus outside the lung. All the branches of the left bronchus are given off inside the lung. The root of the lung also contains the bronchial arteries supplying the bronchi and bronchioles, the pulmonary plexus of autonomic nerves innervating the lung as well as the lymph nodes draining the lung. The phrenic nerve lies in front of the root of the lung and the vagus nerve behind.

The right bronchus is shorter, wider and more vertical than the left. The angle between the two bronchi is about

Fig. 3.4 The lungs in situ – anterior aspect.

Fig. 3.5 The lungs in situ – posterior aspect.
70° in the adult: 25° to the right and 45° to the left from the midline. Therefore foreign bodies getting into the trachea tend to go to the right bronchus rather than into the left. At birth the bifurcation angle is about 110° with both bronchi angulating equally from the midline (55° each way).

The lung is surrounded by the pleural cavity, the potential space between the two layers of pleura. The outer parietal layer of pleura lines the thoracic cavity and the inner visceral or pulmonary layer closely fits on to the surface of the lung. The two layers become continuous with each other at the root of the lung. The parietal pleura lining the diaphragm is known as the diaphragmatic pleura and that lining the mediastinum as the mediastinal pleura. See Clinical box 3.3.
**Clinical box 3.3**

**Surface anatomy of the lung and pleura**

Knowledge of the extent of the lung and pleura is clinically important (Fig. 3.9). Their lower parts overlap abdominal organs such as the liver, kidney and spleen. On the apical pleura lie the subclavian vessels and the brachial plexus. The stellate ganglion of the sympathetic trunk lies behind the apex of the lung and pleura on the neck of the first rib. Pancoast’s tumour affecting the apex of the lung may involve these structures when it spreads locally. Cannulation of the subclavian vein may inadvertently produce a pneumothorax (air in the pleural cavity) resulting in collapse of the lung. Procedures such as exposure of the kidney, kidney and liver biopsies may also produce pneumothorax. This is due to the fact that the diaphragm is dome shaped and hence the lower parts of the lung and pleura overlap the upper abdominal organs (separated, of course, by the diaphragm).

When the lung fields are markedly hyperinflated, as in emphysema, the liver is pushed down by the diaphragm and may be palpable.

The apex of the lung and the surrounding pleural cavity extends about 3 cm above the medial part of the clavicle. The apical pleura is covered by a fascia, the suprapleural membrane (Sibson’s fascia), attached to the inner border of the first rib. This fascia prevents the lung and pleura expanding too much into the neck during deep inspiration.

From the apex, the anterior border of the pleural cavity descends behind the sternoclavicular joint to reach the midline at the level of the sternal angle. (Here the two pleural cavities are close to each other.) The anterior limit of the right pleural cavity descends vertically downwards in the midline from the sternal angle to the level of the sixth costal cartilage. From there the lower border extends laterally, crossing the eighth rib in the midclavicular line, the 10th rib in the midaxillary line and then ascends to the middle of the 12th rib at the back. The posterior border then ascends almost vertically upwards in the paravertebral region. A midline sternotomy (splitting of the sternum) is done to open up the chest cavity for cardiac surgery. During this procedure the right lung and pleura will be seen extending up to the midline, and occasionally even beyond, just behind the sternum.

From the sternal angle the anterior border of the left pleural cavity deviates laterally to the lateral border of the sternum. The extent of the lower and the posterior margins are similar to those on the right.

The surface marking of the lung is the same as that of the pleura except for the lower margin and the cardiac notch (Fig. 3.9). The lower margin of the lung is about two ribs higher than the lower margin of the pleura. Because of the bulge of the heart and pericardium, the anterior border of the left lung deviates laterally from the sternal angle to the apex of the heart (usually in the fifth intercostal space a little inside the midclavicular line) producing the cardiac notch. The oblique fissure of the lung lies along the sixth rib on both sides and the horizontal fissure of the right lung extends anteriorly from the midaxillary line along the fourth rib.
The trachea, bronchi and bronchioles

The trachea, which is slightly to the right of the midline, divides at the carina into right and left main bronchi. The right main bronchus is more vertical than the left and, hence, inhaled material is more likely to pass into it. The right main bronchus divides into three lobar bronchi (upper, middle and lower), whereas the left only into two (upper and lower) (Fig. 3.10). Each lobar bronchus divides into segmental and subsegmental bronchi. There are about 25 generations of bronchi and bronchioles between trachea and the alveoli; the first 10 are bronchi and the rest bronchioles (Fig. 3.11). The bronchi have walls consisting of cartilage and smooth muscle, epithelial lining with cilia and goblet cells, submucosal mucous glands and endocrine cells containing 5-hydroxytryptamine. The bronchioles are tubes less than 2 mm in diameter and are also known as small airways. They have no cartilage or submucosal glands. Their epithelium has a single layer of ciliated cells but only few goblet cells and Clara cells secreting a surfactant-like substance. See Clinical box 3.4.

The alveolar ducts and alveoli

Each respiratory bronchiole supplies approximately 200 alveoli via alveolar ducts. There are about 300 million alveoli in each lung and their walls have type I and type II pneumocytes. Type II pneumocytes are the source of surfactant. The type I pneumocytes and the endothelial cells of adjoining capillaries constitute the blood–air barrier, the thickness of which is about 0.2–2 μm.

The heart

Borders and surfaces of the heart

The heart has an anterior or sternocostal surface, formed mostly by the right ventricle, an inferior or diaphragmatic surface, formed mostly by the left ventricle, a base or posterior surface, formed by the left atrium, and an apex, formed entirely by the left ventricle. The borders of the heart (Fig. 3.12) are the right border, formed by the right atrium, the inferior border, formed by the right ventricle, the left or obtuse border, formed mostly by the left ventricle with the left auricle at its superior end (Fig. 3.13).
The apex beat is defined as the lower-most and lateral-most cardiac pulsation in the precordium, normally felt inside the midclavicular line in the fifth left intercostal space (approximately 6cm to the left of the midline) (Fig. 3.13). However it is felt in the anterior axillary line when lying on the left side. The right border of the heart extends from the third to the sixth right costal cartilage approximately 3cm to the right of the midline; the inferior border from the lower end of the right border to the apex, and the left border from the apex to the second left intercostal space approximately 3cm from the midline. See Clinical box 3.5.

**Blood supply of the heart**

The heart muscle is supplied by the right and left coronary arteries and is drained by the cardiac veins (Figs 3.14–3.19). The coronary arterial supply is of great clinical importance. Its occlusion is the chief cause of death in the western world.

The right coronary artery arises from the anterior aortic sinus. It passes between the pulmonary trunk and the right atrium to lie in the atrioventricular groove (Fig. 3.14). It winds round the inferior border to reach the diaphragmatic surface where it anastomoses with the terminal part of the left coronary artery. It gives off an artery to the sinoatrial node, the right (acute) marginal artery and the posterior interventricular artery, which is also known as the posterior descending artery (Fig. 3.15).

**Clinical box 3.5**

**Apex beat**

Apex beat is the lower and lateral-most cardiac pulsation in the precordium, its normal site being just medial to the midclavicular line in the fourth or fifth left intercostal space. It may be normally felt in the anterior axillary line when lying on the left side. There are abnormal forms of apex beats in various clinical conditions.

A heaving apex beat which is forceful and sustained may be present in hypertension and aortic stenosis (pressure overload) whereas a thrusting one which is forceful but not sustained is a sign of mitral or aortic regurgitation (volume overload). A tapping apex beat is a sudden but brief pulsation and occurs in mitral stenosis.

Apex beat may be missing (i.e. not palpable) in obesity, pleural effusion, pericardial effusion and emphysema.

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**Fig. 3.12** Posteroanterior radiograph of the chest.

**Fig. 3.13** Surface projections of the heart. A, P, T and M indicate auscultation areas for the aortic, pulmonary, tricuspid and mitral valves.
The left coronary artery arises from the left posterior aortic sinus. It passes behind the pulmonary trunk and the left auricle to reach the atrioventricular groove where it divides into the circumflex and the anterior interventricular (anterior descending) arteries, both of equal size (Figs 3.14, 3.15). The circumflex artery winds round the left margin where it gives off the left (obtuse) marginal artery and reaches the diaphragmatic surface to anastomose with the right coronary artery. The anterior descending artery (LAD), also known as the ‘widow maker’ because many men die of blockage of this artery, descends in the interventricular septum and gives off ventricular branches, septal branches as well as the diagonal artery. It then winds round the apex reaching the diaphragmatic surface to anastomose with the posterior descending artery. The main stem of the left coronary artery varies in length between 4mm and 10mm. In 10% of the population in whom the left coronary is larger and longer than usual – ‘left dominance’ – the posterior descending artery arises from it instead of from the right coronary. Another 10% have ‘co-dominant’ coronary circulation where both left and right coronaries contribute equally to the posterior interventricular artery. In a third of the population the left main stem divides into three branches instead of two, the third being a branch lying between the circumflex and the anterior descending on the lateral aspect of the left ventricle.

The blood supply of the conducting system is of clinical importance. In about 60% of the population the sinoatrial node is supplied by the right coronary and in the rest by the circumflex branch of the left coronary. However occasionally (3%) it can have a dual supply. The atrioventricular node is supplied by the right coronary in 90% and the circumflex in 10%.
Thorax

Cardiac veins accompany the arteries. Most of them are tributaries of the coronary sinus, a sizable vein lying in the posterior part of the atrioventricular groove and opening into the right atrium. The great cardiac vein accompanies the anterior interventricular artery; the middle cardiac vein accompanies the posterior interventricular artery and the small cardiac vein accompanies the marginal artery. Anterior cardiac veins seen on the anterior wall of the right ventricle drain directly into the right atrium. Additionally there are very small veins on the various walls – venae cordis minimae, draining directly into the cardiac cavity. See Clinical box 3.6.

The pericardium

The heart lies within the pericardial cavity, in the middle mediastinum. The pericardial cavity is similar in structure and function to the pleural cavity. The pericardium provides a friction-free surface for the heart to accommodate its sliding movements.

Components of the pericardium are the fibrous pericardium and the serous pericardium, the former being a collagenous outer layer fused with the central tendon of the diaphragm. The serous pericardium consists of a parietal layer which lines the inner surface of the fibrous pericardium and a visceral layer which lines the outer surface of the heart and the commencement of the great vessels. The pericardial cavity is the space between the parietal and the visceral layers.

Two regions of the pericardial cavity have special names. The transverse sinus of the pericardial cavity lies between the ascending aorta and the pulmonary trunk in front and the venae cavae and the atria behind. The pericardial space...
behind the left atrium is the oblique sinus (Fig. 3.20). The oblique sinus separates the left atrium from the oesophagus.

Anteriorly the pericardium is related to the sternum, third to sixth costal cartilages, lungs and the pleura. Posterior relations are oesophagus, descending aorta and T5–T8 vertebrae. Laterally on either side lie the root of the lung, mediastinal pleura and the phrenic nerve. Innervation of the fibrous and the parietal layer of serous pericardium is by the phrenic nerves. Pericardial pain originates in the parietal layer and is transmitted by the phrenic nerves. The pericardial cavity is closest to the surface at the level of the xiphoid process of sternum and the sixth costal cartilages. See Clinical box 3.7.

**Interior of the chambers of the heart**

**The right atrium**

The right atrium (Fig. 3.21) has a smooth and a rough part which are separated by a vertical ridge, the crista terminalis, extending between the superior and inferior venae cavae behind the left atrium is the oblique sinus (Fig. 3.20). The oblique sinus separates the left atrium from the oesophagus.

Anteriorly the pericardium is related to the sternum, third to sixth costal cartilages, lungs and the pleura. Posterior relations are oesophagus, descending aorta and T5–T8 vertebrae. Laterally on either side lie the root of the lung, mediastinal pleura and the phrenic nerve. Innervation of the fibrous and the parietal layer of serous pericardium is by the phrenic nerves. Pericardial pain originates in the parietal layer and is transmitted by the phrenic nerves. The pericardial cavity is closest to the surface at the level of the xiphoid process of sternum and the sixth costal cartilages. See Clinical box 3.7.

**Interior of the chambers of the heart**

**The right atrium**

The right atrium (Fig. 3.21) has a smooth and a rough part which are separated by a vertical ridge, the crista terminalis, extending between the superior and inferior venae cavae
muscular ridges known as musculae pectinatae from the primitive atrium. The fossa ovalis (Fig. 3.21), an oval depression on the interatrial wall, is the remnant of the foramen ovale in the fetus. Before birth the foramen ovale allowed blood to flow from the right atrium to the left atrium bypassing the lungs. At birth when the lungs begin to function the foramen ovale closes to produce the fossa ovalis.

The right ventricle
The right ventricular wall is thicker than that of the atrium. The tricuspid orifice is guarded by the tricuspid valve which has an anterior, posterior and a septal cusp. The interior of the ventricle has muscular ridges known as trabeculae carneae as well as the anterior, posterior and septal (small) papillary muscles and the chordae tendineae (Fig. 3.22). The chordae tendineae connect the papillary muscles to the tricuspid valve cusps. These prevent the valve cusps being everted into the atrium during ventricular systole. Failure of this mechanism due to breakage of the papillary muscle or chordae tendineae causes tricuspid incompetence and regurgitation of blood back into the atrium during ventricular systole. When this happens blood from the atrium can pool back into the liver and the neck veins causing enlarged neck veins and palpable liver as the superior and inferior venae cavae do not have valves.

The septomarginal trabecula (moderator band) is a muscular ridge extending from the interventricular septum to the base of the anterior papillary muscle of the heart. The moderator band is a part of the conducting system of the heart which regulates the cardiac cycle.

The infundibulum leads on to the orifice of the pulmonary trunk. The pulmonary orifice has the pulmonary valve with three semilunar cusps. Each cusp has a thickening in the centre of its free edge.

The left atrium
The left atrium which develops by a combination of absorption of the pulmonary veins as well as from the primitive atrium has the openings of the four pulmonary veins. The mitral orifice separates the left atrium from the left ventricle.

The left ventricle
The walls of the left ventricle are about three times thicker than those of the right ventricle because of the increased resistance of the systemic circulation compared with that of the pulmonary circulation. The mitral orifice is guarded by the mitral valve with an anterior and a posterior cusp. The large anterior cusp lies between the aortic and mitral orifices. The trabeculae carneae, papillary muscles and chordae tendineae are similar to those in the right ventricle. The aortic orifice has the aortic valve (Fig. 3.23) with the three semilunar aortic cusps, one anterior and two posterior in the anatomical position of the heart. These are thicker than those of the pulmonary valves to cope with the increased pressure. Alongside each cusp there is a dilation, the aortic sinus. The coronary arteries originate from the
sinuses, the right from the anterior (also known as the right coronary sinus) and the left from the left posterior aortic sinus (also known as the left coronary sinus). The interventricular septum which has the muscular and the membranous parts bulges into the right ventricle and separates the left ventricle from the right. See Clinical boxes 3.8 and 3.9.

**Clinical box 3.8**
**Valves, heart sounds and murmurs**
The valves between the atria and the ventricles, i.e. the tricuspid and the mitral valves, prevent regurgitation of blood from the ventricles back into the atria during ventricular contraction (systole). Similarly the pulmonary and aortic valves prevent regurgitation during diastole (relaxation of ventricle) from these vessels back into the ventricles. Closure of the tricuspid and mitral valves occurs at the beginning of systole and causes the first heart sound and closure of the aortic and pulmonary valves, which happens at the beginning of diastole, the second sound. Thus the interval between the first and the second heart sounds is the period of ventricular systole and that between the second and the next first sound is the diastole. A hissing sound heard during systole is a systolic murmur and that during diastole is a diastolic murmur. Murmurs are caused by blood flow through narrow orifice or leaking valves. Pulmonary or aortic valve stenosis (narrowing) cause systolic murmur. It can also be heard in mitral or tricuspid incompetence (regurgitation). A diastolic murmur, on the other hand, is a characteristic of mitral or tricuspid stenosis. It is also a sign of aortic or pulmonary valve incompetence.

The conducting system of the heart
Specialised cardiac muscle cells initiate and regulate the heart-beat. The sinoatrial node (SA node) or ‘pacemaker of the heart’ initiating the heart-beat is situated in the right atrium at the upper end of the crista terminalis (Fig. 3.24). From there the cardiac impulse spreads through the atrial musculature to reach the AV node (atrioventricular node) which is situated in the interatrial septum near the opening of the coronary sinus. After a brief pause there the impulse passes through the atrioventricular bundle of His (AV bundle). The AV bundle which starts from the AV node passes through the fibrous ring at the atrioventricular junction to reach the membranous part of the interventricular septum where it divides into a right and left bundle branch. The atrioventricular bundle is the only pathway through which impulses can reach the ventricles from the atrium. The left
and right bundles descend towards the apex and break up into Purkinje fibres which activate the musculature of the ventricle in such a way that the papillary muscles contract first followed by the simultaneous contraction of both the ventricles from apex towards the base.

The mediastinum

The mediastinum is the region between the two pleural cavities. It contains the heart, great vessels, trachea, oesophagus and many other structures. The mediastinum is divided into four parts for descriptive purposes. The superior mediastinum lies above the horizontal plane joining the sternal angle to the lower border of T4 vertebra. The middle mediastinum contains the heart and pericardium; the anterior mediastinum is in front of this and the posterior mediastinum behind.

The brachiocephalic vein and the superior vena cava

The brachiocephalic vein, one on each side, is formed by the union of the subclavian and the internal jugular veins. The right and left brachiocephalic veins join together to form the superior vena cava which drains into the right atrium (Fig. 3.25).
The azygos vein which receives segmental veins from the thoracic and posterior abdominal walls (intercostal and lumbar veins) joins the superior vena cava.

The phrenic nerves

The right and left phrenic nerves are formed in the cervical plexus (C3, 4, 5). Besides supplying the diaphragm they give sensory innervation to pleura, pericardium and peritoneum (all starting with ‘p’!). The thoracic part of the right phrenic nerve (Fig. 3.25) reaches the diaphragm lying on the surface of the right brachiocephalic vein, the superior vena cava, the right side of the heart and pericardium (where it lies in front of the root of the lung) and the inferior vena cava. In other words it lies on the big veins and the right atrium.

The left phrenic nerve crosses the arch of the aorta (Figs 3.26, 3.27). It descends in front of the root of the lung then lies on the pericardium as it descends to reach the diaphragm.

The right and left vagus nerves

The right vagus nerve lies on the trachea (Fig. 3.25) and crosses behind the root of the lung and breaks up into...
branches on the oesophagus forming the oesophageal plexus. It leaves the thorax by passing along with the oesophagus through the diaphragm as the posterior gastric nerve.

The left vagus, like the left phrenic nerve, crosses the arch of the aorta (Figs 3.26, 3.27). It crosses behind the root of the left lung (the phrenic nerve descends in front). The left vagus gives off an important branch, the left recurrent laryngeal nerve, as it crosses the arch of the aorta. The left recurrent laryngeal nerve winds round the ligamentum arteriosum, a fibrous connection between the left pulmonary artery and the arch of the aorta. The ligamentum arteriosum is the remnant of the ductus arteriosum which shunts blood from the pulmonary trunk to the aorta in the fetus. The recurrent laryngeal nerve ascends to the neck lying in the groove between the trachea and the oesophagus and supplies the muscles and mucous membrane of the larynx.

Carcinoma of the oesophagus, mediastinal lymph node enlargement and aortic arch aneurysm may compress the left recurrent laryngeal nerve to cause change in voice.

Below the root of the lung the left vagus, like the right, breaks up into branches contributing to the oesophageal plexus and leaves the thorax by passing along with the oesophagus through the diaphragm as the anterior gastric nerve.

**Arch of the aorta**

The ascending aorta commencing from the left ventricle continues upwards and to the left over the root of the left lung as the arch of the aorta (Figs 3.26–3.28). It then descends down to become the descending thoracic aorta. The arch of the aorta commences at the level of the sternal angle and ends at the lower border of T4. It is entirely confined to the superior mediastinum. It has three branches: the brachiocephalic trunk which divides into the right common carotid and the right subclavian arteries, the left common carotid artery and the left subclavian artery (Fig. 3.28). The left vagus and the left phrenic nerves cross the arch of the aorta. The small vein lying across the arch of the aorta is the left superior intercostal vein. This drains the second and third left intercostal spaces and in turn drains into the left brachiocephalic vein (Fig. 3.26). See Clinical box 3.10.

**Clinical box 3.10**

**Arch of the aorta**

The arch of the aorta hooks over the left bronchus and lies on the left side of the trachea and oesophagus with the left recurrent laryngeal nerve lying between the two. An aneurysm of the arch of the aorta can occlude the left bronchus and collapse the left lung. It can produce a change in voice due to compression of the left recurrent laryngeal nerve. Pathology of the aorta, trachea, bronchus and the oesophagus tend to involve one another due to their close relationship. Pulsation of the arch of the aorta is visible during bronchoscopy and oesophagoscopy.

**The trachea**

The trachea (Figs 3.29, 3.30) extends from the lower border of the cricoid cartilage in the neck to the tracheal bifurcation at the level of the lower border of the T4 vertebra. In the living, in the erect posture, the tracheal bifurcation is at a lower level. The trachea is about 15cm long, the first 5cm
being in the neck. The cervical part of the trachea lies in the midline and is easily palpable.

The diameter of the lumen of the trachea is correlated to the size of the subject and has approximately the same diameter as his/her index finger. It is made up of 15–20 'C'-shaped cartilaginous rings which prevent it from collapsing. The gap in the cartilage is at the back and is bridged by the trachealis muscle which allows the trachea to constrict and dilate. It is elastic enabling it to stretch during swallowing and its diameter changes during coughing and sneezing.

The thoracic part of the trachea is in the superior mediastinum. Anteriorly it is related to the left brachiocephalic vein, the commencement of the