Chapter 1

Surgical Approaches to the Heart

When we describe the heart in this chapter, and in subsequent chapters, our account will be based on the organ as viewed in its anatomical position.[1] Where appropriate, the heart will be illustrated as it would be viewed by the surgeon during an operative procedure, irrespective of whether the pictures are taken in the operating room, or are photographs of autopsied hearts. When we show an illustration in non-surgical orientation, this will be clearly stated.

In the normal individual, the heart lies in the mediastinum, with two-thirds of its bulk to the left of the midline (Figure 1.1). The surgeon can approach the heart, and the great vessels, either laterally through the thoracic cavity, or directly through the mediastinum anteriorly. To make such approaches safely, knowledge is required of the salient anatomical features of the chest wall, and of the vessels and the nerves that course through the mediastinum (Figure 1.2). The approach used most frequently is a complete median sternotomy, although increasingly the trend is to use more limited incisions. The incision in the soft tissues is made in the midline between the suprasternal notch and the xiphoid process. Inferiorly, the white line, or linea alba, is incised between the two rectus sheaths, taking care to avoid entry to the peritoneal cavity, or damage to an enlarged liver, if present. Reflection of the origin of the rectus muscles in this area reveals the xiphoid process, which is then incised to provide inferior access to the anterior mediastinum. Superiorly, a vertical incision is made between the sternal insertions of the sternocleidomastoid muscles. This exposes the relatively bloodless midline raphe between the right and left sternohyoid and sternothyroid muscles. An incision through this raphe then gives access to the superior aspect of the anterior mediastinum. The anterior mediastinum immediately behind the sternum is devoid of vital structures, so that the superior and inferior incisions into the mediastinum can safely be joined by blunt dissection in the retrosternal space. Having split the sternum, retraction will reveal the pericardial sac, lying between the pleural cavities. Superiorly, the thymus

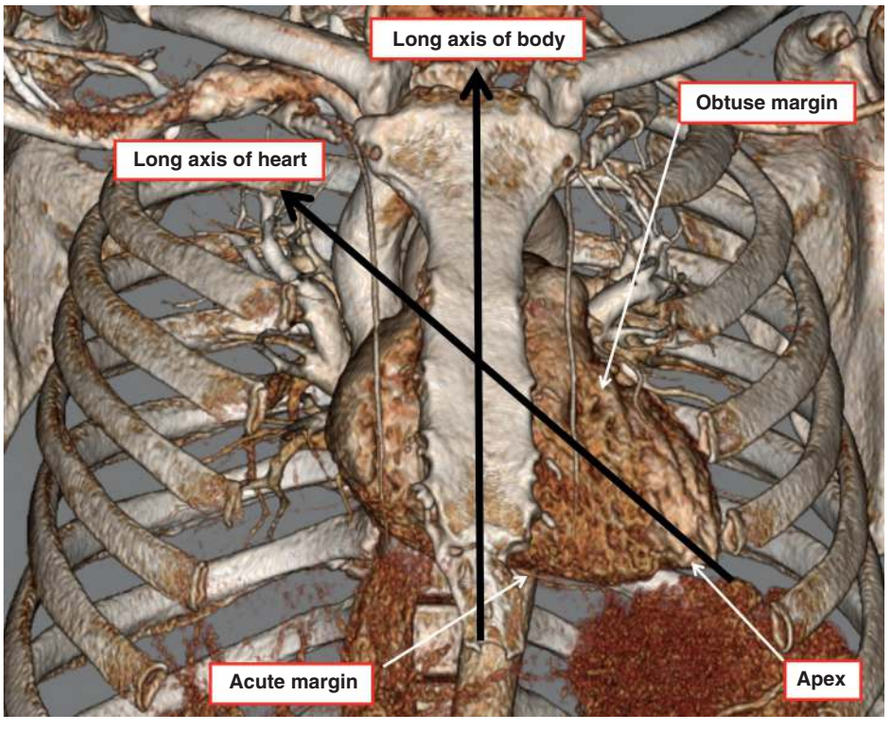

Figure 1.1 The computed tomogram, with the cardiac cavities delimited subsequent to injection of contrast material, shows well the relationships of the heart to the thoracic structures. Note the discordance between the long axis of the heart and the long axis of the body.

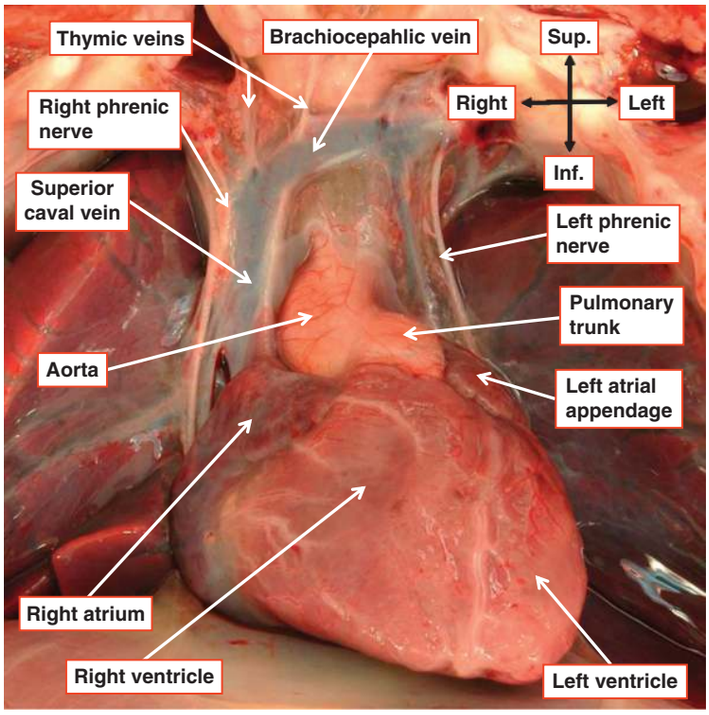

Figure 1.2 This view, taken at autopsy, demonstrates the anatomical relationships of the vessels and nerves within the mediastinum.

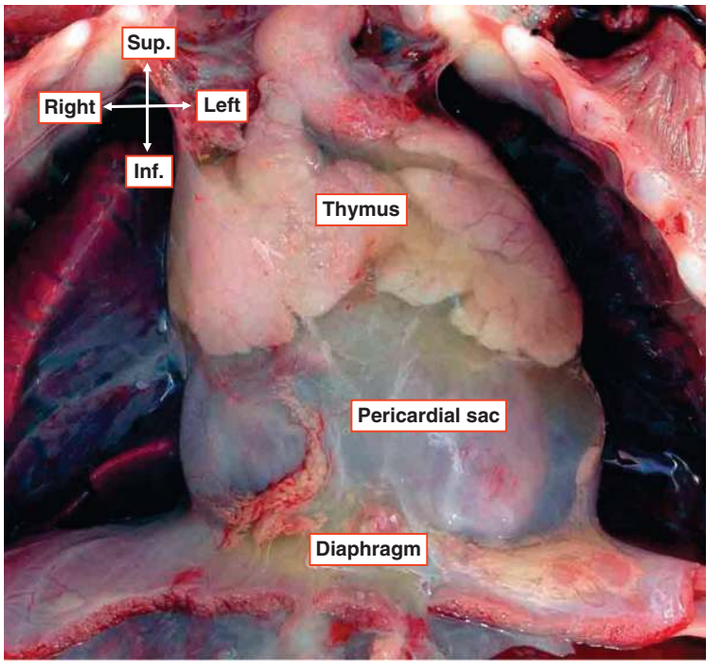

Figure 1.3 This view, taken at autopsy, demonstrates the extent of the thymus as it extends over the anterior and lateral aspects of the pericardial sac at the base of the heart.

gland wraps itself over the anterior and lateral aspects of the pericardium in the area of exit of the great arteries, the gland being a particularly prominent structure in the infant (Figures 1.3, 1.4). It has two lateral lobes, joined more or less in the midline. Sometimes this junction between the lobes must be divided, or partially excised, to provide adequate exposure. The arterial supply to the thymus is from the internal thoracic and inferior thyroid arteries. If divided, these arteries tend to retreat into the surrounding soft tissues, and can produce troublesome bleeding. The veins draining the thymus are fragile, often emptying into the left brachiocephalic, or innominate, vein via a common trunk (Figure 1.5). Undue traction on the gland can lead to damage to this major vessel.

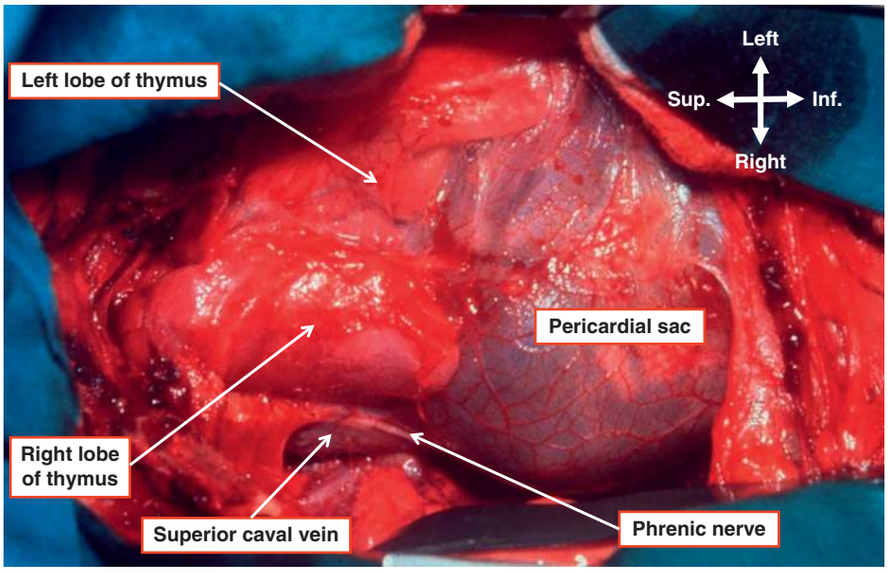

Figure 1.4 This view, taken in the operating room through a median sternotomy in an infant, shows the extent of the thymus gland. Note the right phrenic nerve adjacent to the superior caval vein.

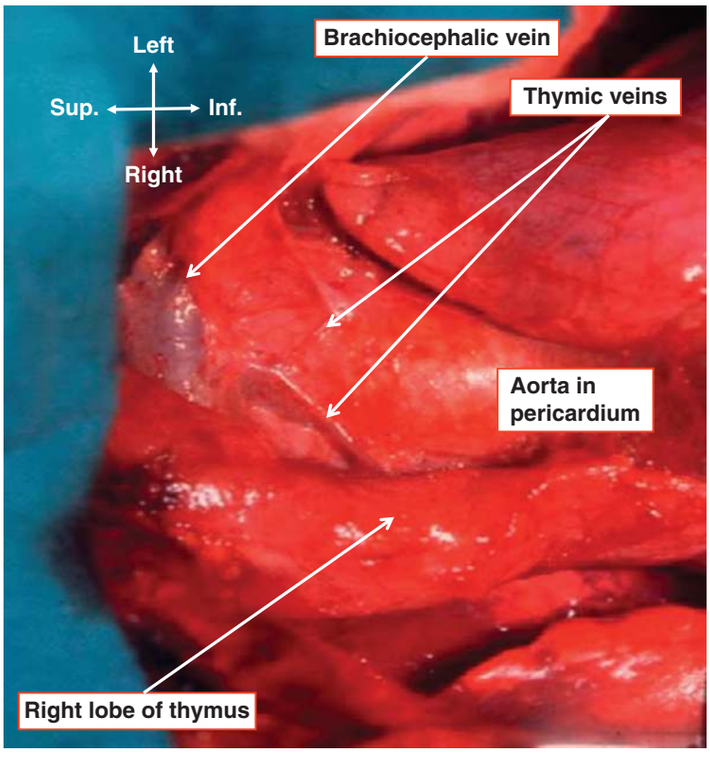

Figure 1.5 This operative view, again taken through a median sternotomy, shows the delicate veins that drain from the thymus gland to the left brachiocephalic veins.

When the pericardial sac is exposed within the mediastinum, the surgeon should have no problems in gaining access to the heart. The vagus and phrenic nerves traverse the length of the pericardium, but are well lateral (Figures 1.2, 1.6). The phrenic nerve on each side passes anteriorly, and the vagus nerve posteriorly, relative to the hilums of the lungs (Figure 1.6).

At operation, the course of the phrenic nerve is seen most readily through a lateral thoracotomy (Figure 1.7). It is when the heart is approached through a median sternotomy, therefore, with the nerve not immediately evident, that it is most liable to injury. Although it can sometimes be seen through the reflected pericardium (Figure 1.8), its proximity to the superior caval vein (Figures 1.2, 1.9, 1.10), or to a persistent left caval vein when that structure is present (Figure 1.11), is not always easily appreciated when these vessels are dissected from the anterior approach. Near the thoracic inlet, it passes close to the internal thoracic artery (Figures 1.6, 1.10),

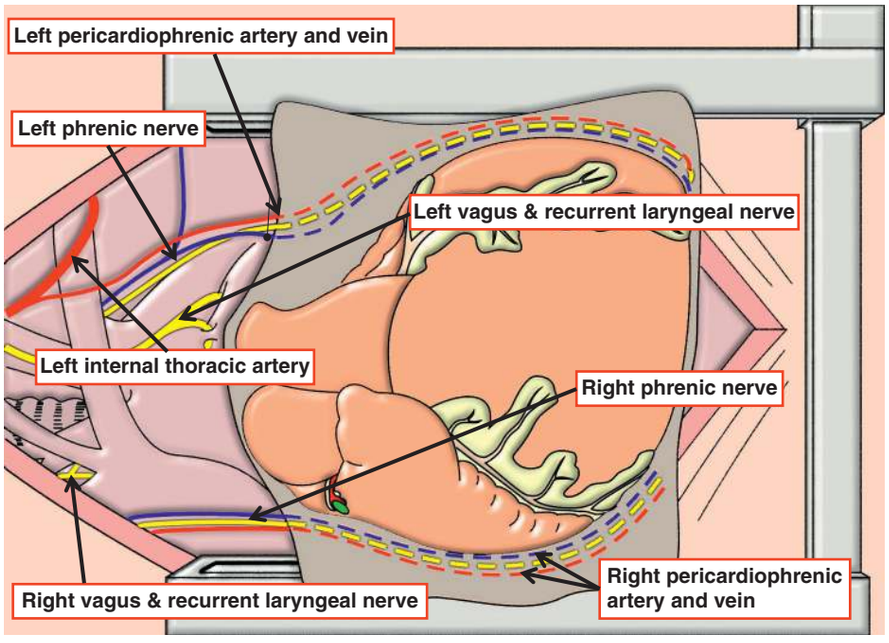

Figure 1.6 As shown in this cartoon of a median sternotomy, the pericardium can be opened in the midline so that the phrenic and vagus nerves stay well clear of the operating field.

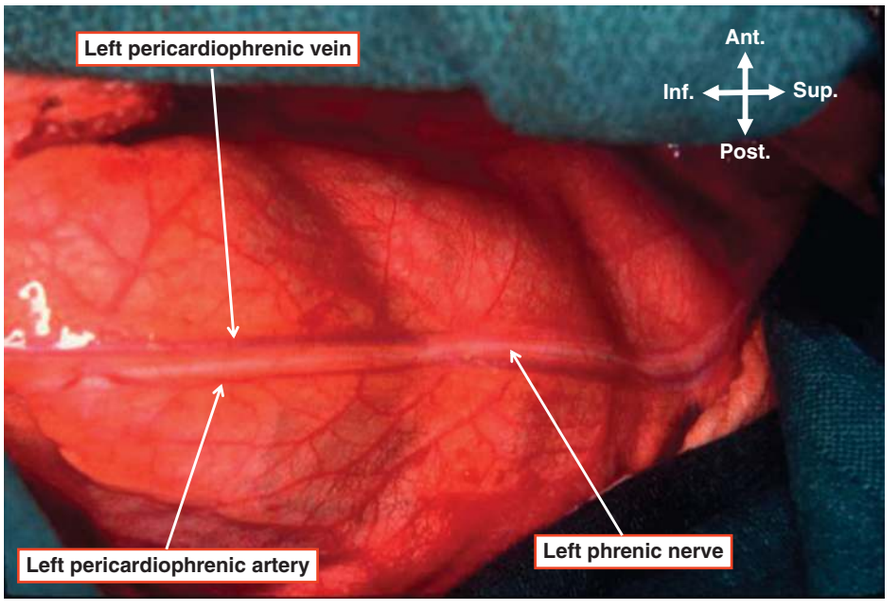

Figure 1.7 This operative view, taken through a left lateral thoracotomy, shows the course of the left phrenic nerve over the pericardium.

exposing it to injury either directly during takedown of that vessel, or by avulsing the pericardiophrenic artery with excessive traction on the chest wall. The internal thoracic arteries themselves are most vulnerable to injury during closure of the sternum. The phrenic nerve may be injured when removing the pericardium to use as a cardiac patch, or when performing a pericardiectomy. Injudicious use of cooling agents within the pericardial cavity may also lead to phrenic paralysis or paresis.

A standard lateral thoracotomy provides access to the heart and great vessels via the pleural space. Left-sided incisions provide ready access to the great arteries, left pulmonary veins, and the chambers of the left side of the heart. Most frequently, the incision is made in the fourth intercostal space. The posterior extent is through the triangular, and relatively bloodless, space between the edges of the latissimus dorsi, trapezius, and teres major muscles (Figure 1.12). The floor of this triangle is the sixth intercostal space. Division of the latissimus dorsi, and a portion of trapezius posteriorly, frees the scapula so that the fourth intercostal space can be identified. Its precise identity should be confirmed by counting down the ribs from above. The so-called

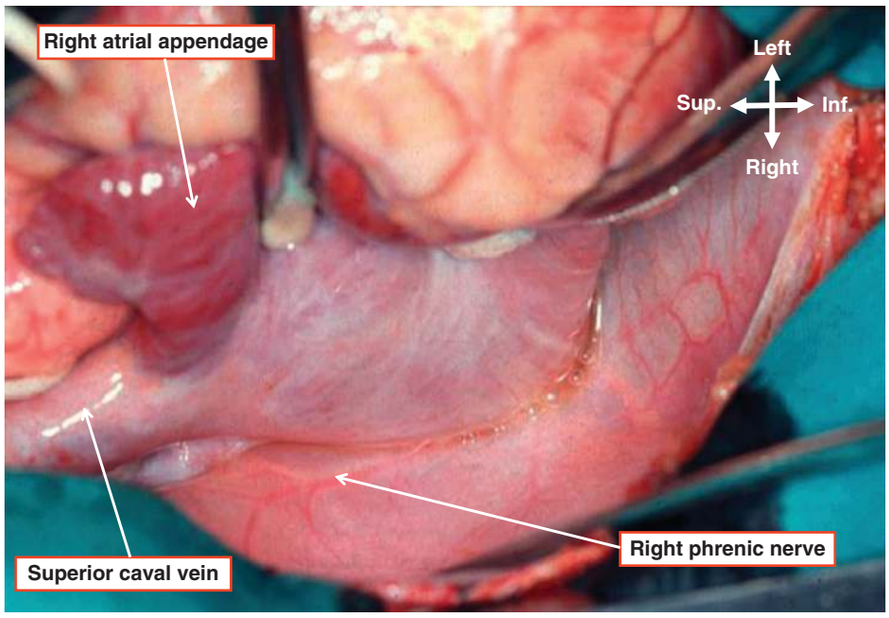

Figure 1.8 This operative view, taken through a median sternotomy, shows the right phrenic nerve as seen through the reflected pericardium.

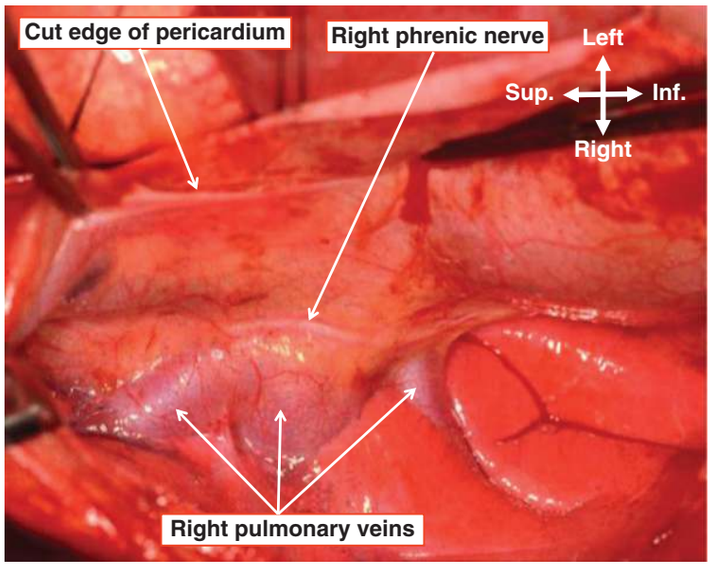

Figure 1.9 This operative view, taken through a median sternotomy having pulled back the edge of the pericardial sac, shows the right phrenic nerve in relation to the right pulmonary veins.

muscle-sparing thoracotomy is designed to preserve the latissimus dorsi and serratus anterior. In cases requiring greater degrees of exposure, the latissimus dorsi can be partially divided. It is rarely, if ever, necessary to divide the serratus anterior. The intercostal muscles are then divided equidistant between the fourth and fifth ribs. The incision is rarely carried forward beyond the midclavicular line in a submammary position, being careful to avoid damage to the nipple and the tissue of the breast. The intercostal neurovascular bundle is well protected beneath the lower margin of the fourth rib. Having divided the musculature as far as the pleura, the pleural space is entered and the lung permitted to collapse away from the chest wall. Posterior retraction of the lung reveals the middle mediastinum, in which the left lateral lobe of the thymus, with its associated nerves and vessels, is seen overlying the pericardial sac and the aortic arch. Intrapericardial access is usually gained anterior to the phrenic nerve. On occasion, the thymus gland may require elevation when the incision is extended superiorly, taking precautions to avoid unwanted damage, as discussed above. The lung is retracted anteriorly to approach the aortic isthmus and descending thoracic aorta, and the parietal pleura is divided on its mediastinal aspect. This is usually done posterior to the vagus nerve. In this area, the vagus nerve gives off its left recurrent laryngeal branch, which then passes around the inferior border of the arterial

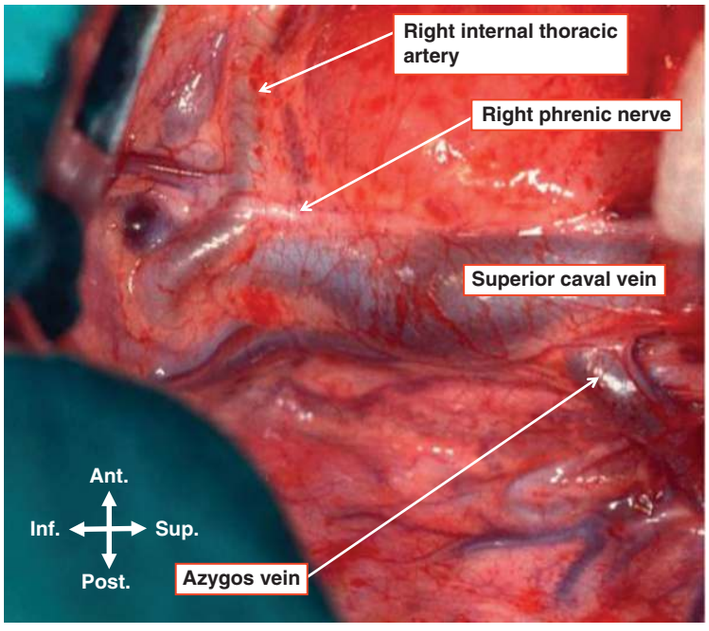

Figure 1.10 This operative view, taken through a right thoracotomy, shows the relationship of the right phrenic nerve to the right internal thoracic artery and the superior caval vein.

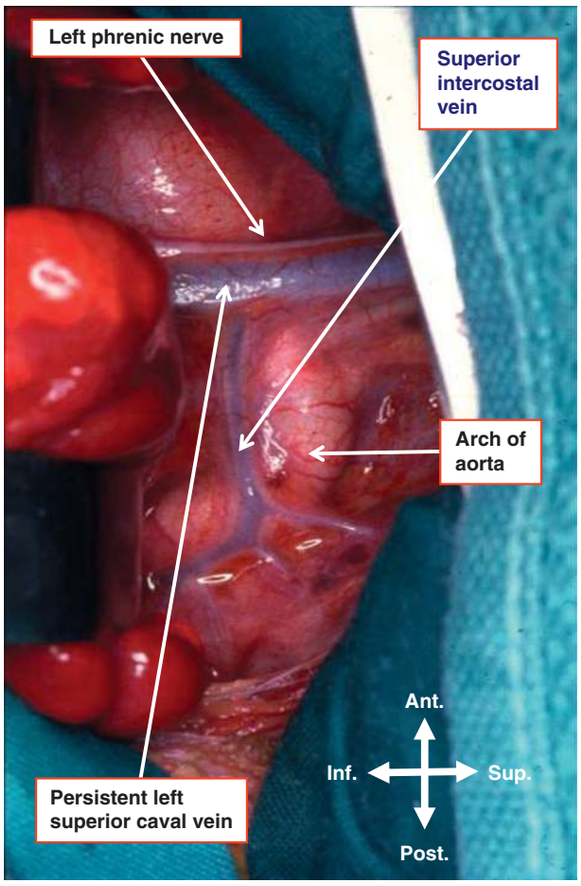

Figure 1.11 This operative view, taken through a left thoracotomy, shows the relationship of the left phrenic nerve to a persistent left superior caval vein. Note also the course of the superior intercostal vein.

ligament, or the duct if the arterial channel is still patent (Figure 1.13). The recurrent nerve then ascends towards the larynx on the medial aspect of the posterior wall of the aorta, running adjacent to the oesophagus. Excessive traction of the vagus nerve as it courses into the thorax along the left subclavian artery can cause injury to the recurrent laryngeal nerve just as readily as can direct trauma to the nerve in the environs of the ligament. The superior intercostal vein is seen crossing the aorta, then insinuating itself between the phrenic and vagus nerves (Figures 1.11, 1.14, 1.15). This structure is rarely of surgical significance, but is frequently divided to provide surgical access to the aorta. The thoracic duct (Figure 1.16) ascends through this area, draining into the junction of the left subclavian and internal jugular veins. Accessory lymph channels draining into the duct, which is usually posteriorly located, and runs along the vertebral column, can be troublesome when dissecting the origin of the left subclavian artery.

A right thoracotomy, in either the fourth or fifth interspace, is made through an incision similar to that for a left thoracotomy. The fifth interspace is used when approaching the heart, while the fourth permits access to the right-sided great vessels. Access to the pericardium is gained by incising anterior to the phrenic nerve, this approach often necessitating retraction of the right lobe of the thymus. To reach the right pulmonary artery, and its adjacent mediastinal structures, it is sometimes useful to divide the azygos vein near its junction with the superior caval vein (Figure 1.17). Extension of this incision superiorly exposes the origin of the right subclavian branch of the brachiocephalic trunk. Laterally, this artery is crossed by the right vagus nerve. The right recurrent laryngeal nerve takes origin from the vagus, and curls around the postero-inferior wall of the artery before ascending into the neck (Figure 1.18). Also encircling the

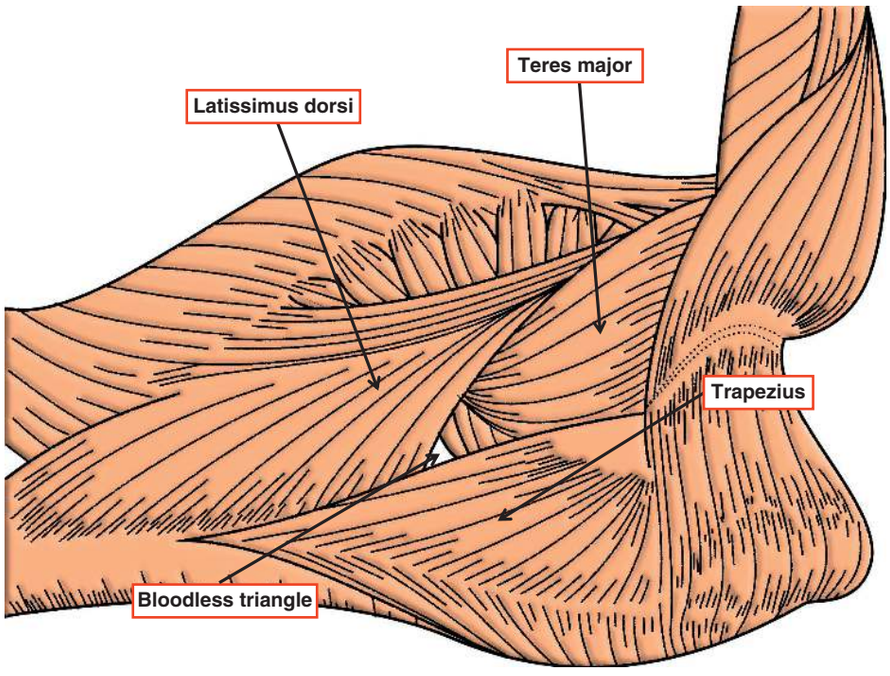

Figure 1.12 The cartoon shows the location of the bloodless area overlying the posterior extent of the sixth intercostal space.

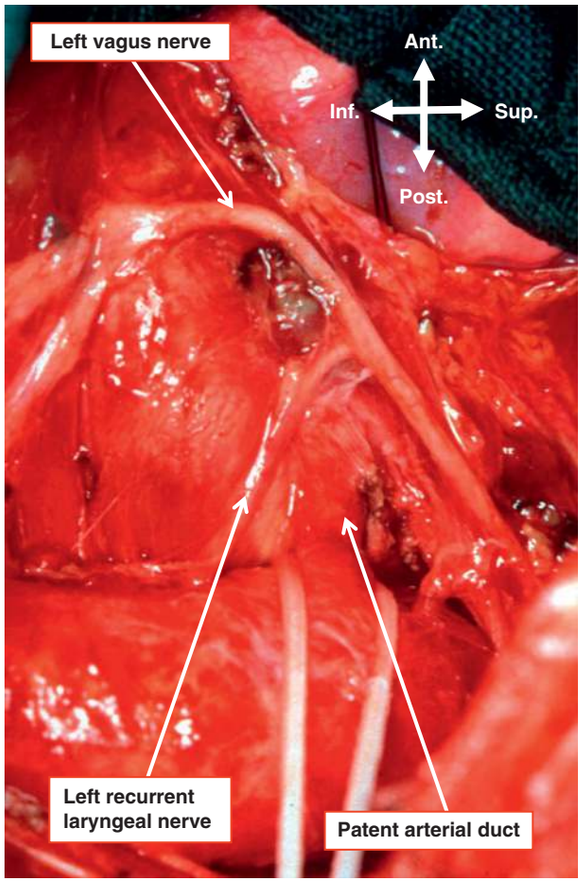

Figure 1.13 This operative view, taken through a left lateral thoracotomy in an adult, shows the left recurrent laryngeal nerve passing around the arterial duct.

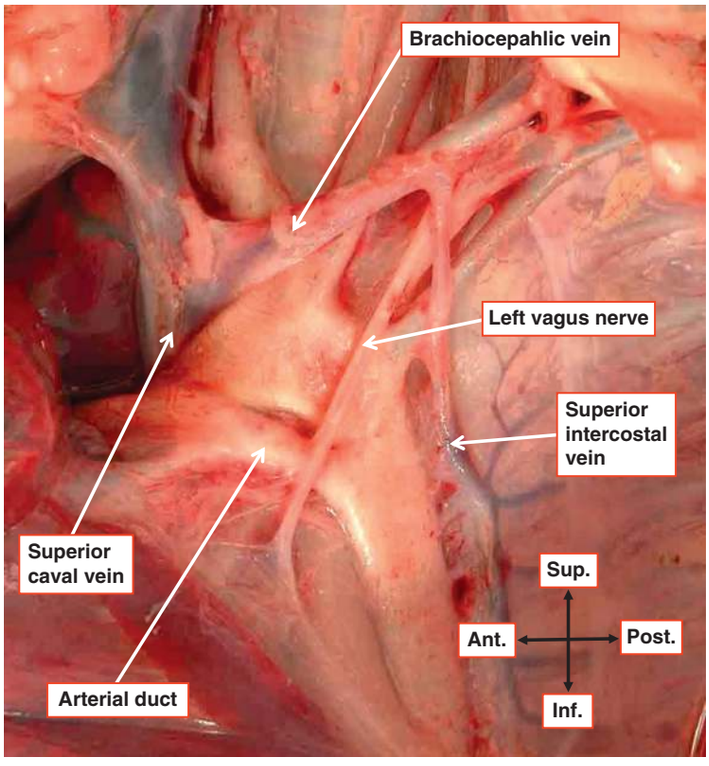

Figure 1.14 The anatomical image shows the course of the left superior intercostal vein.

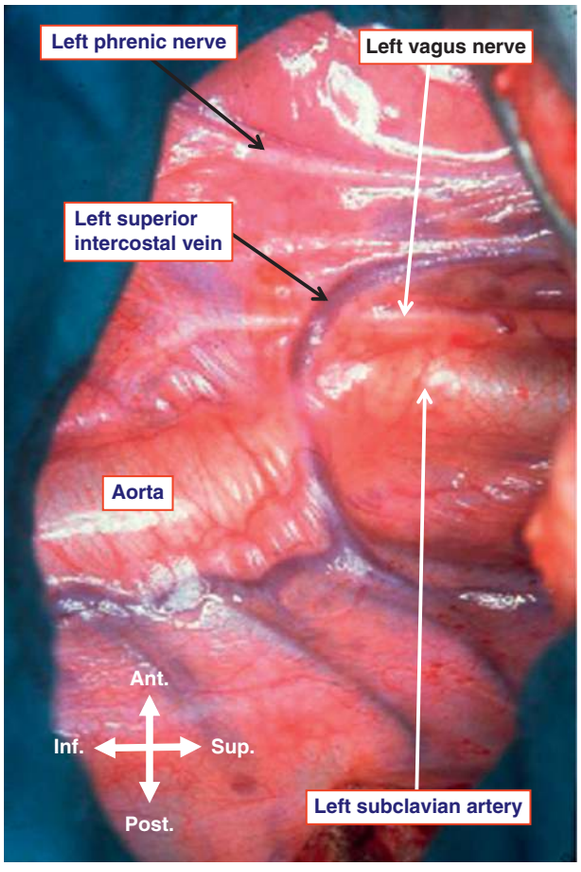

Figure 1.15 This operative view, taken through a left lateral thoracotomy, shows the course of the left superior intercostal vein. Compare with Figure 1.14.

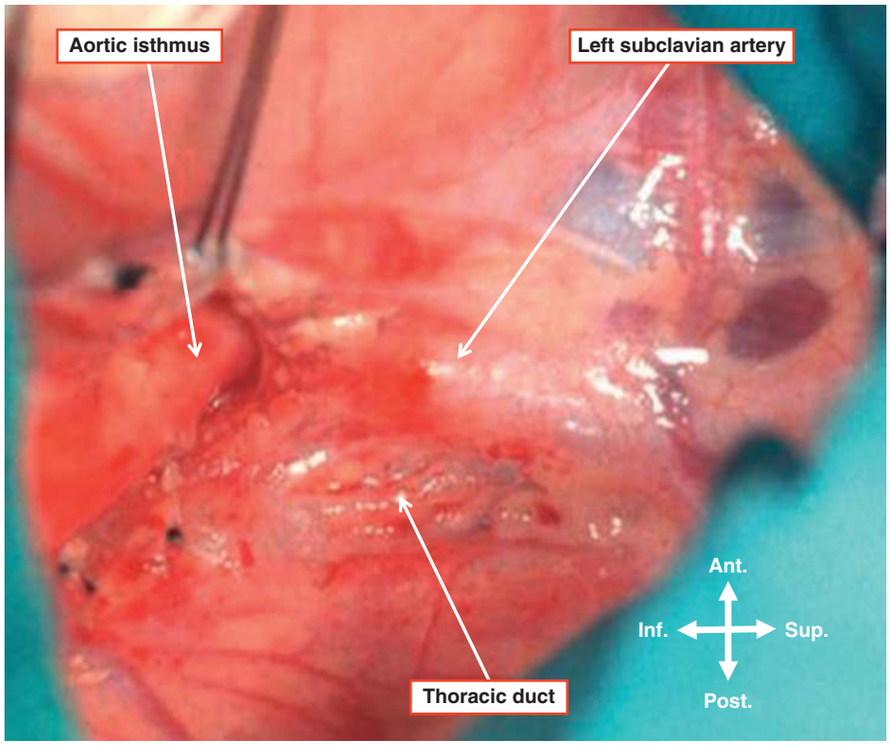

Figure 1.16 In this operative view, taken through a left thoracotomy, the thoracic duct is seen coursing below the left subclavian artery to its termination in the brachiocephalic vein.

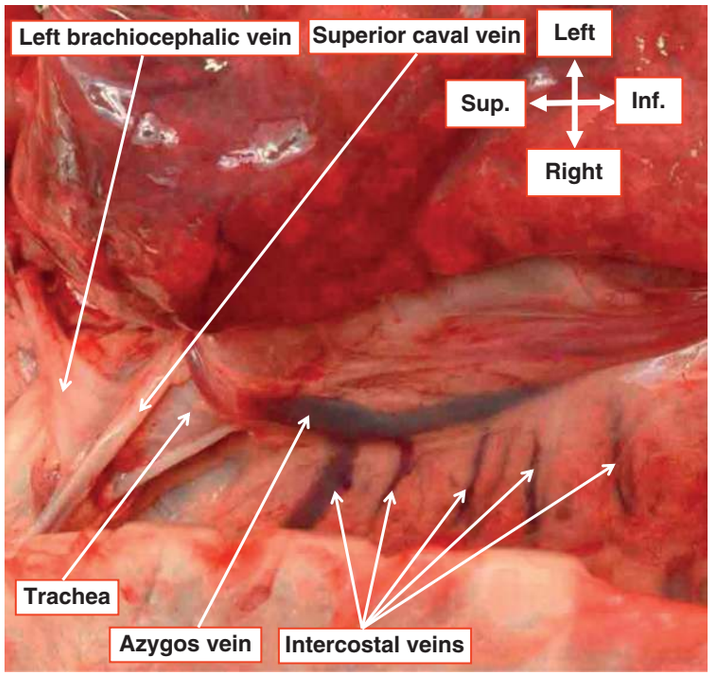

Figure 1.17 This anatomical image, taken at autopsy, shows the normal location of the azygos vein as it branches from the superior caval vein over the root of the right lung and extends along the spine.

subclavian origin on this right side is the subclavian sympathetic loop, the so-called ansa subclavia. This is a branch of the sympathetic trunk that runs up into the neck. Damage to this structure can produce Horner's syndrome.

An anterior right or left thoracotomy is occasionally used in treating congenital malformations. Once the chest is opened, the same basic anatomical rules apply as described above. Thus far, our account has presumed the presence of normal anatomy. In many instances, the disposition of the thoracic structures will be altered by a congenital malformation. These alterations will be described in the appropriate sections.

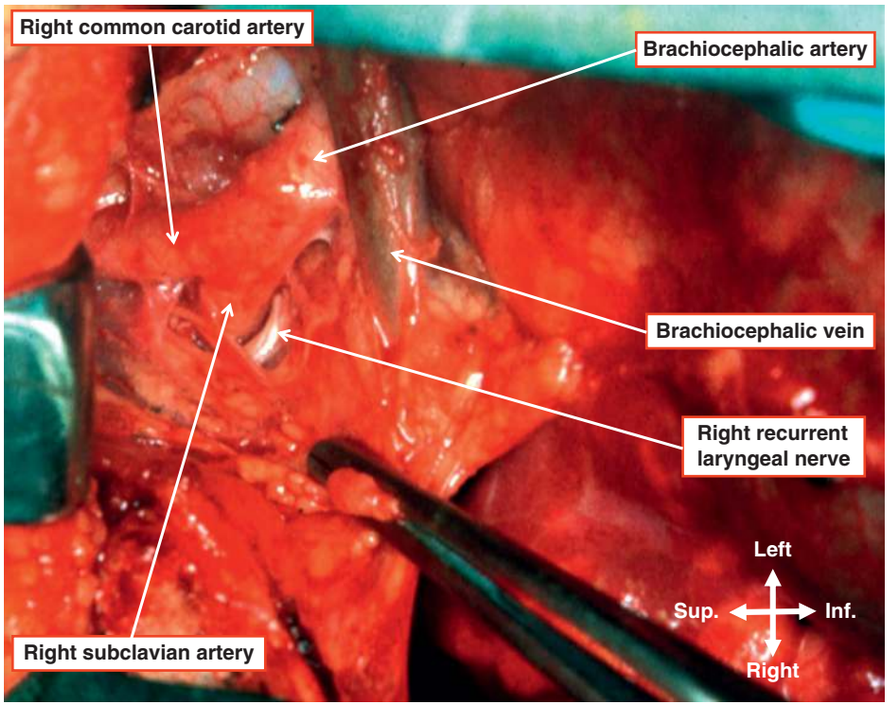

Figure 1.18 This operative view, taken through a median sternotomy, shows the course of the right recurrent laryngeal nerve relative to the right subclavian artery.

Reference Cited

1. Cook AC, Anderson RH. Attitudinally correct nomenclature. *Heart* 2002; **87**: 503–506.