

# APPLIED SURGICAL ANATOMY AND PHYSIOLOGY

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The oesophagus is a muscular tube connecting the pharynx to the stomach. It starts at the level of the cricoid cartilage (C6 vertebra) and ends at the oesophagogastric junction (OGJ) (opposite T11 thoracic vertebra). In the neck, it descends behind the trachea and anteriorly to the vertebral column following its curvature into the thorax. At the lower part of the thoracic cavity, it transverses the diaphragmatic hiatus, clasped by the crura of the diaphragm and into the stomach. There are slight curvatures of the oesophagus; in the neck, it leans slightly more towards the left side, while in the mid-chest it curves slightly towards the right and in the lower part of the thorax edges to the left again. Thus, in the neck exposure of the cervical oesophagus is generally easier from the left side. The recurrent laryngeal nerves lie in the tracheo-oesophageal grooves. On the right side, the recurrent laryngeal nerve at the lower neck is often at a small distance from the tracheo oesophageal groove, while on the left side the nerve is apposed closely to the oesophagus and trachea. This is an important anatomical detail when exposing the oesophagus and when cervical lymphadenectomy is performed. In perforation from Boerhaave's syndrome, the perforation tends to affect the lower oesophagus on the left side, as this part of the oesophagus is less well supported anatomically. There are multiple relative constrictions along the oesophagus. First is the upper oesophageal sphincter (UOS); second is where the arch of the aorta/left main bronchus crosses the oesophagus; and third is the lower oesophageal sphincter (LOS). Foreign bodies such as food boluses tend to lodge at these sites. The UOS is a structural sphincter formed by a band of striated muscles of the inferior pharyngeal constrictor and crico pharyngeus. The LOS is much less well defined. It is a complex Hermann Boerhaave, 1668–1738, Professor of Medicine and Botany, the University of Leiden, The Netherlands. Friedrich Albert Zenker, 1825–1898, Professor of Pathology, Dresden, Germany. Norman Rupert Barrett, 1903–1979, surgeon, St Thomas' Hospital, London, UK. interplay of the intrinsic muscle tone of the oesophageal wall, as well as the diaphragmatic crura. It is also variably exposed to the negative intrathoracic and positive intra-abdominal pressure. Thus, on oesophageal manometry, it is identified as a high-pressure zone; the diaphragmatic contribution is more obvious in the presence of a hiatus hernia, where two components of the high-pressure zone can be identified. Disorders of the coordination in UOS and pharyngeal function can result in dysphagia or aspiration symptoms. A common example is in elderly patients following a cerebrovascular accident or in those with neurological diseases. Dysfunction of the UOS is also related to the pathogenesis of the pharyngeal pouch/upper oesophageal diverticulum (Zenker's). Weakness of the LOS or inappropriate relaxation can result in oesophagogastric reflux disease (GORD), or tightness (incomplete relaxation) can lead to dysphagia, such as in achalasia. For clinical purposes, the oesophagus is divided into the cervical, the thoracic and the abdominal oesophagus (Figure - 66.1). These divisions are relevant for cancer staging purposes. The 'cardia' is the portion of the stomach that lies immediately below the

OGJ, but there is no clear definition of its extent. Tumours around this region are often referred to as cancer of the cardia; however, it may be better to refer to 'cancer at the oesophagogastric junction'. Anatomically the OGJ is defined as the point where the tubular oesophagus becomes the saccular stomach; histologically it is the junction between the squamous mucosa and the columnar mucosa, but these levels will be different in Barrett's oesophagus. The physiological LOS does not correspond to the anatomical OGJ; the LOS is a high-pressure zone defined physiologically but not anatomically. In practice, the most relevant definitions relate to findings on endoscopy. Endoscopically the OGJ is defined as the top of the gastric folds (the oesophagus is tubular and does not have folds while the stomach has rugae). In Japan, it is also commonly recognised as

The clinical features, investigations and treatment of •

the distal end of the oesophagus where palisading vessels are found ( Figure 66.2 ). Which definition used is not so important; rather, it requires experience from the endoscopist to define this point accurately. In a real-life situation, the junction is somewhat dynamic with the patient's breathing excursions; an excessive amount of air insufflation may 'flatten' the gastric folds, making it difficult to define their 'top'. The presence of a is important in defining hiatus hernia, assessing the presence of Barrett's oesophagus, defining cancers around the OGJ and tumour staging. Histologically the oesophageal wall has layers: mucosa, submucosa, muscularis propria and adventitia. The mucosa consists of a non-keratinised stratified squamous epithelium, the lamina propria and the muscularis mucosae. The oesophageal wall lacks a serosa; it is the muscularis mucosae and submucosa that give it strength for suture holding. The muscularis propria has an inner circular muscle and external longitudinal muscle layer ( Figure 66.3 ). The muscle of the upper third of the oesophagus is made up of striated muscle, the middle third with a mixture of striated and smooth muscle and the lower third with smooth muscle. Connective tissue disease, such as scleroderma, mainly affects smooth muscle, hence the lower oesophagus. The blood supply of the upper oesophagus is derived from the superior and inferior thyroid arteries. The middle oesophagus receives its supply from direct branches of the aorta and bronchial and intercostal vessels. The distal oesophagus has the arterial supply from the left gastric, left inferior phrenic and splenic vessels. The blood supply is usually excellent, and a long length of the oesophagus can be mobilised without compromising perfusion. An anastomotic leak from oesophageal anastomosis after oesophagectomy is rarely attributed to poor blood supply of the oesophagus; rather, it is the conduit that lacks perfusion. Venous return to the systemic circulation forms a network of vessels within the oesophageal wall. They drain to the inferior thyroid, azygos, hemiazygos and gastric veins. The communications of oesophageal veins and left gastric veins form part of the portal-systemic anastomosis. Cirrhosis leads to their dilatation (varices).

0 cm Cricopharyngeal 15 cm  
constriction Aortic and bronchial

25 cm constriction Diaphragmatic  
and 'sphincter' constriction 40 cm  
Figure 66.1 Anatomy of the  
oesophagus, divisions of the  
oesophagus and measurements  
endoscopically from the incisors.  
The three relatively 'narrow' parts  
of the oesophagus are at the level  
of the cricopharyngeus muscle  
(upper oesophageal sphincter),  
where the left main bronchus and  
aorta cross the oesophagus and  
the oesophagogastric junction  
(lower oesophageal sphincter). (a)  
Figure 66.2 (a) Endoscopic image  
showing the 'top of the gastric

folds' (black arrows), indicating that this is the oesophagogastric junction. (b) The distal end of the 'palisading vessels' also indicates the oesophagogastric junction (blue arrows pointing at the end of the palisading vessels).

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(b)

The lymphatic drainage of the oesophagus is important, especially for cancer spread. There is a rich plexus of lymphatics in the submucosa, and direct drainage to the thoracic duct is also demonstrated. Submucosal spread of cancer along the oesophagus proximally and distally is common, and a longer resection margin reduces the chance of local recurrence. In the neck, the cervical oesophagus drains to the deep cervical and paratracheal nodes. In the thoracic oesophagus, lymphatic spread from a tumour can travel widely; potentially, it can spread to the neck, mediastinum and the nodes around the coeliac axis. Although upper third tumours tend to spread upwards and lower oesophageal cancer distally, this can be unpredictable and skip lesions can occur. Of particular importance is lymph node spread along the bilateral recurrent laryngeal nerves. This should be treated as a continuum of lymph node chains along both nerves, and thus they traverse from the chest into the neck. This widespread lymph node spread is the rationale behind the concept of three-field lymphadenectomy, whereby lymph nodes in the cervical region, mediastinum and around the coeliac axis are treated as regional nodes and dissection is recommended in curative surgery. The data mostly come from studies on squamous cell cancers in Japan. The lack of sufficient data for adenocarcinomas (mostly in the lower oesophagus) makes the benefit of such extended lymphadenectomy less certain. The thoracic duct is the largest lymphatic vessel in the body. It is formed from the abdominal confluence of the left and right lumbar lymph trunks, as well as the left and right intestinal lymph trunks between T12 and L2. The confluence of lymph trunks is saccular and is referred to as cisterna chyli. Through the diaphragmatic hiatus, the thoracic duct is formed as it ascends along the aorta, next to the azygos vein and oesophagus. It then crosses to the left side at T4-T6, going

Rudolf Virchow, 1821-1902, pathologist, Charité Hospital, Berlin, Germany. Charles Émile Troisier, 1844-1919, pathologist,

University of Paris, Paris, France. the left neck, it drains into the junction between the left jugular vein and left subclavian vein. Around 75% of the lymph from the entire body (aside from the right upper limb, right breast, right lung and right side of the head and neck) passes through the thoracic duct. The cells of the immune system circulate through the lymphatic system. Also, large molecular products of digestion, such as fats, first need to be absorbed into the lymphatic system, and then reach the systemic circulation through the venous system. During oesophagectomy, the thoracic duct and its tributaries may be damaged, postoperatively presenting as chylothorax. The thoracic duct may also be injured during cervical lymphadenectomy, leading to a chylous leak from the neck wound after surgery. Prolonged chylous drainage cannot be tolerated because there is loss not only of fluid and electrolytes but also important proteins as well as lymphocytes, which cannot be replaced. The path of drainage of lymph explains the finding of Virchow's node (Troisier's sign), when a metastatic node is found in the left supraclavicular fossa, both from intra-abdominal malignancies as well as from oesophageal cancer.

Stratified squamous epithelium Lamina propria Muscularis mucosae Submucosa Muscularis propria: inner circular muscle layer Muscularis propria: outer longitudinal muscle layer Adventitia  
Figure 66.3 Histological layers of the oesophagus (courtesy of Dr Anthony Lo, Department of Pathology, Queen Mary Hospital, Hong Kong SAR, China).

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