

P. Marco Fisichella  
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Mario Morino  
Marco G. Patti *Editors*

# Esophageal Diseases

Evaluation  
and Treatment



Springer

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Mario Morino • Marco G. Patti  
Editors

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Evaluation and Treatment



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# Esophageal Diseases

*To Carlos Alberto Pellegrini, MD, mentor,  
role model, friend.*

The Editors

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# Introduction

The United States has been the largest recipient country in the world of Italian immigrants. They have outnumbered immigrants from any other European nation, driven by the search for better opportunities.

Irrespective of their backgrounds and professions, Italians have always proven themselves diligent and hard workers, capable of establishing harmonious relations wherever they go.

Today, a new wave of Italians is pursuing opportunities in the United States to improve their education, skills, and chances for a brighter career. They represent a new breed of inspired and well-educated Italians, who chose to become citizens of the world, motivated by the desire to succeed in their profession, not only for the benefit of their own careers but also for their country of birth and their new country of residence.

Italians abroad are the ambassadors of our excellence, and thanks to their collaboration from the new host country with many Italian academic institutions, they help transfer their experience and expertise to their colleagues in Italy.

This book by Drs. Fisichella, Allaix, Morino, and Patti represents an excellent example of such collaboration. Two of the authors (Fisichella and Patti) left Italy after completing medical school, trained in surgery in the United States, where they eventually started a career at prestigious academic institutions. Today, Dr. Fisichella is Associate Professor of Surgery at Harvard Medical School, Associate Chief of Surgery at the Boston Veterans Administration Medical Center, and Associate Surgeon at Brigham and Women's Hospital in Boston. Dr. Patti is Professor of Surgery and Director of the Center for Esophageal Diseases at the University of Chicago Pritzker School of Medicine. Dr. Patti has served as President of the International Society of Digestive Surgery and is the President Elect of the International Society of Surgery. Dr. Allaix trained at the University of Torino and was sent by Professor Morino to Chicago to spend 18 months working with Dr. Patti in order to improve his skills in the diagnosis and treatment of esophageal disorders. Today, Dr. Allaix is back in Torino, where he has brought back to the excellent Department led by Professor Morino the experience gained in the States.



To all of them, our thanks and best wishes for a brighter future and a continuous collaboration.

February 14, 2014  
Chicago, USA

Adriano Monti  
Consul General of Italy, Chicago

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# Chapter 1

## Esophageal Anatomy and Physiology

Marco E. Allaix and Marco G. Patti

**Abstract** The esophagus can be divided into three anatomic segments: the cervical, thoracic, and abdominal esophagus. Three layers form the esophageal wall: the mucosa, the submucosa, and the muscle layer, with an inner circular and an outer longitudinal layer. The lymphatic drainage is not segmental: lymph can flow for a long distance in the plexus before crossing the muscular layer and reaching the paraesophageal lymph nodes.

**Keywords** Cervical esophagus • Thoracic esophagus • Abdominal esophagus • Vagus nerves • Upper esophageal sphincter • Lower esophageal sphincter • Esophageal peristalsis

### Anatomy of the Esophagus

The esophagus originates at the level of the sixth cervical vertebra, posterior to the cricoid cartilage, and extends to the eleventh thoracic vertebra. It is divided into three anatomic segments. The *cervical esophagus* lies just left of the midline,

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#### Conflict of Interest

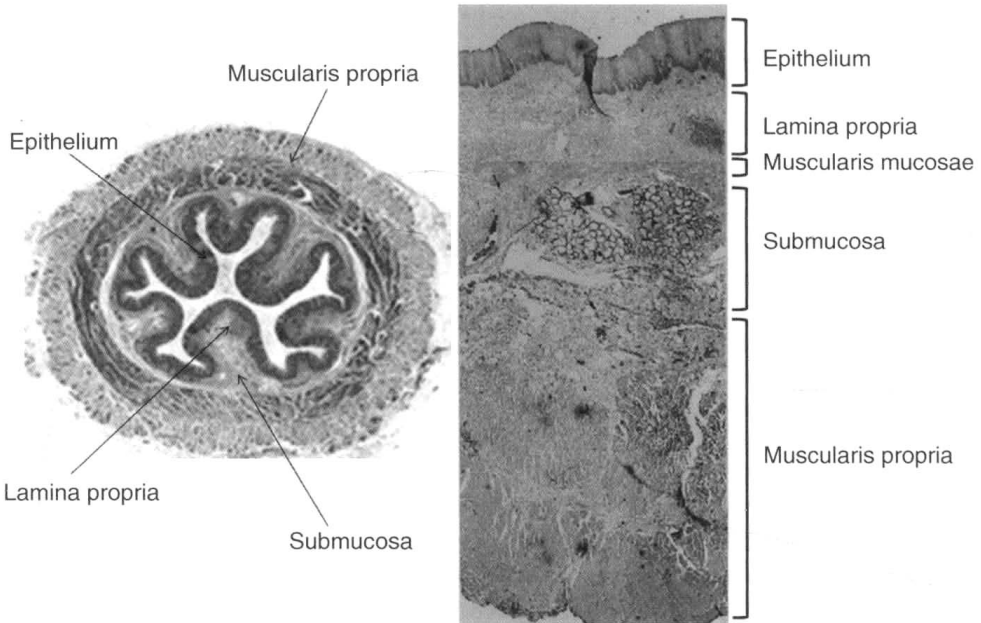
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**Fig. 1.1** Layers in the esophageal wall

posterior to the larynx and trachea, and anterior to the prevertebral layer of the cervical fascia.

The upper portion of the *thoracic esophagus* curves slightly to the right and passes behind the tracheal bifurcation and the left mainstem bronchus. The lower portion of the thoracic esophagus lies behind the pericardium and the left atrium, where it bends to the left and enters the abdomen through the esophageal hiatus.

The *abdominal esophagus* is 2–4 cm long and ends at its junction with the stomach.

There are three points of anatomical narrowing of the esophageal lumen: (1) at the level of the cricoid cartilage, (2) at the left main bronchus and the aortic arch, and (3) at the esophageal hiatus of the diaphragm.

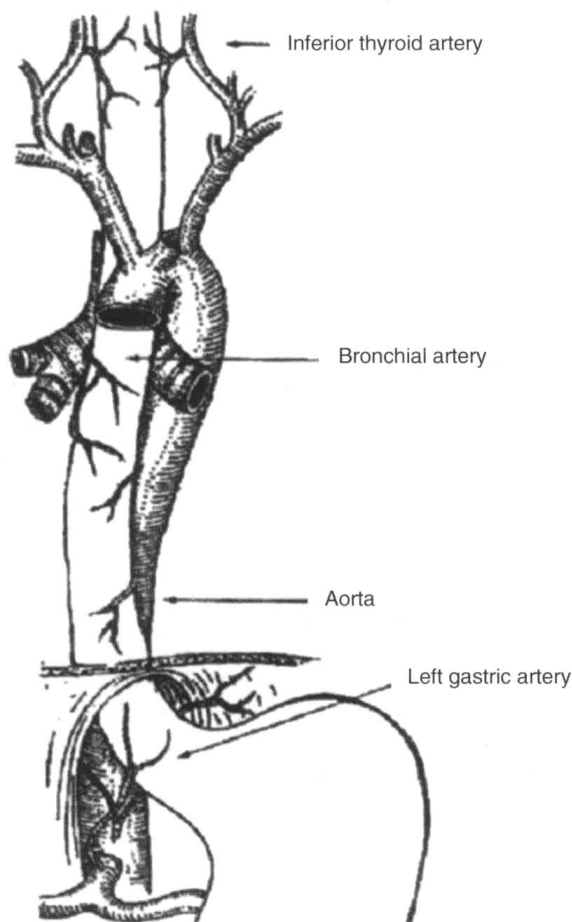
### ***Architecture of the Esophageal Wall***

The epithelium of the esophagus is composed of stratified squamous cells that overlay the lamina propria and muscularis mucosa that is mainly formed by longitudinal muscular fibers (Fig. 1.1). The squamous epithelium joins the junctional columnar epithelium of the gastric cardia at the Z-line.

The *submucosal layer* contains elastic and fibrous tissue and is the strongest layer of the esophageal wall.

The *muscular layer* consists of an inner circular and an outer longitudinal layer. The upper esophageal sphincter is formed by the cricopharyngeal muscle and fibers from the esophageal wall and the inferior constrictors of the pharynx.

**Fig. 1.2** Arterial blood supply to the esophagus



The *lower esophageal sphincter* is not a well-defined anatomic structure, even though a thickening of the circular esophageal musculature at the level of the manometric high-pressure zone has been reported.

Contrary to the rest of the gastrointestinal tract, the esophagus is not covered by a serosal layer.

## ***Blood Supply***

The cervical segment of the esophagus receives blood supply by branches of the inferior thyroid arteries.

The upper thoracic segment is supplied by the bronchial arteries, while the mid-thoracic segment receives blood by esophageal branches that originate from the aorta. The intercostal arteries may also contribute.

The arterial supply of the lower thoracic, diaphragmatic, and abdominal segments includes the left inferior phrenic artery and the esophageal branches of the left gastric artery (Fig. 1.2).

The submucosal venous drainage is more complex and variable. The veins that drain the cervical esophagus are tributary of the inferior thyroid veins; the veins from the thoracic esophagus drain into the hemiazygos and azygos veins. The most important veins are those that drain the lower esophagus. Blood from this region passes into the esophageal branches of the coronary vein, which is a tributary of the portal vein.

### ***Lymphatic Drainage***

Abundant lymphatic vessels form a dense submucosal plexus. Lymph usually flows longitudinally, running proximal in the upper two thirds and distal in the lower third of the esophagus. Lymph from the cervical esophagus drains mostly into the cervical and paratracheal lymph nodes, while lymph from the lower thoracic and abdominal esophagus reaches preferentially the retro-cardiac and celiac nodes. However, the drainage is not segmental; therefore, lymph can flow for a long distance in the plexus before crossing the muscular layer and reaching the paraesophageal lymph nodes.

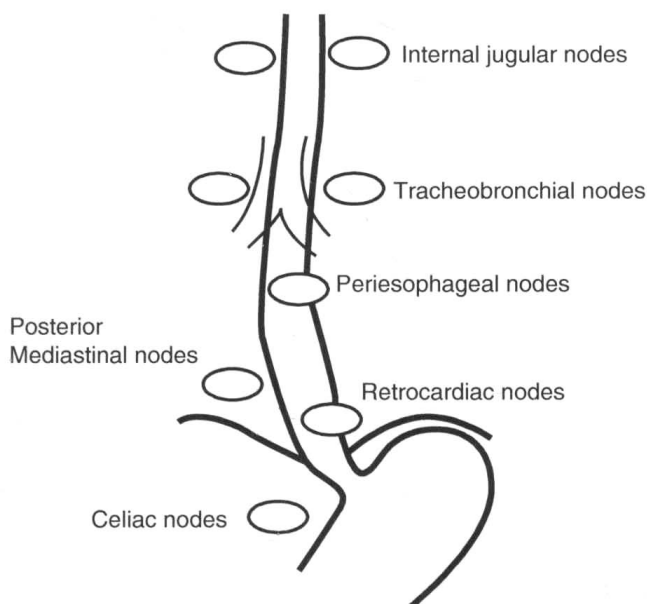
The thoracic duct originates from the cisterna chyli that is located in the abdominal cavity, at the level of the second lumbar vertebra. The duct enters the chest through the aortic hiatus and runs in the posterior mediastinum to the right of the midline between the esophagus and the azygos vein. At the level of the fifth thoracic vertebra, it crosses the midline behind the esophagus and reaches the base of the neck. Then, it curves to the right to drain into the internal jugular vein. A single thoracic duct is described in about 70 % of people, while two or more are present in the remainder individuals (Fig. 1.3).

### ***Innervation***

The striated muscle of the pharynx and upper esophagus receives nerves fibers that originate in the brain stem at the level of the nucleus ambiguus. The distal esophagus and LES are innervated by nerves that originate in the dorsal motor nucleus of the vagus and end in ganglia in the myenteric plexus. The myenteric plexus is located between the longitudinal and the circular muscle layers and receives efferent impulses from the brain stem and afferent impulses from the esophagus. Two main types of effector neurons are found in this plexus: (1) excitatory neurons and (2) inhibitory neurons that mediate contraction of the musculature via cholinergic receptors and via vasoactive intestinal polypeptide and nitric oxide.

The vagus nerves run along each side of the neck until they reach the thoracic esophagus, where they form an extensive plexus. Above the diaphragm, they form two trunks. The left trunk runs anterior, while the right trunk is more posterior once they cross the esophageal hiatus. The anterior vagus then divides and gives rise to the hepatic branch and the anterior nerve of Latarjet, while the posterior vagus gives rise to the celiac branch and the posterior nerve of Latarjet. The posterior nerve of Latarjet runs parallel but deeper to the anterior counterpart in the gastrohepatic ligament about 1 cm from the lesser curvature of the stomach.

**Fig. 1.3** Lymphatic drainage of the esophagus



Branches of the superior and inferior cervical ganglia in the neck, the splanchnic nerves, and the celiac plexus in the chest and in the abdomen provide the sympathetic innervations. These nerves do not have a motor function and mainly modulate the activity of other neurons.

### ***Right Thoracoscopic View***

The thoracoscopic approach to the right chest provides an excellent view of the esophagus from the thoracic inlet to the gastroesophageal junction (Fig. 1.4). In order to obtain adequate exposure, the right lung is deflated and retracted anteriorly, while the inferior pulmonary ligament is divided. After incision of the mediastinal pleura, most thoracic esophagus is exposed. The upper thoracic part of the esophagus is crossed anteriorly by the right brachiocephalic vessels. At the level of the right mainstem bronchus, the azygos vein passes from a paravertebral position anteriorly to enter the superior vena cava, crossing over the esophagus. Distal to the inferior pulmonary vein, the esophagus lies between the heart and the descending aorta. The sympathetic chain and ganglia run vertically, parallel and lateral to the azygous vein, crossing over the intercostals vessels.

### ***Left Thoracoscopic View***

Left thoracoscopy provides a good view of the esophagus from the aortic arch to the gastroesophageal junction (Fig. 1.5). After deflation and anterior retraction of the lung, the inferior pulmonary ligament is divided and the mediastinal pleura opened. The esophagus can be identified in the space between the pericardium and the



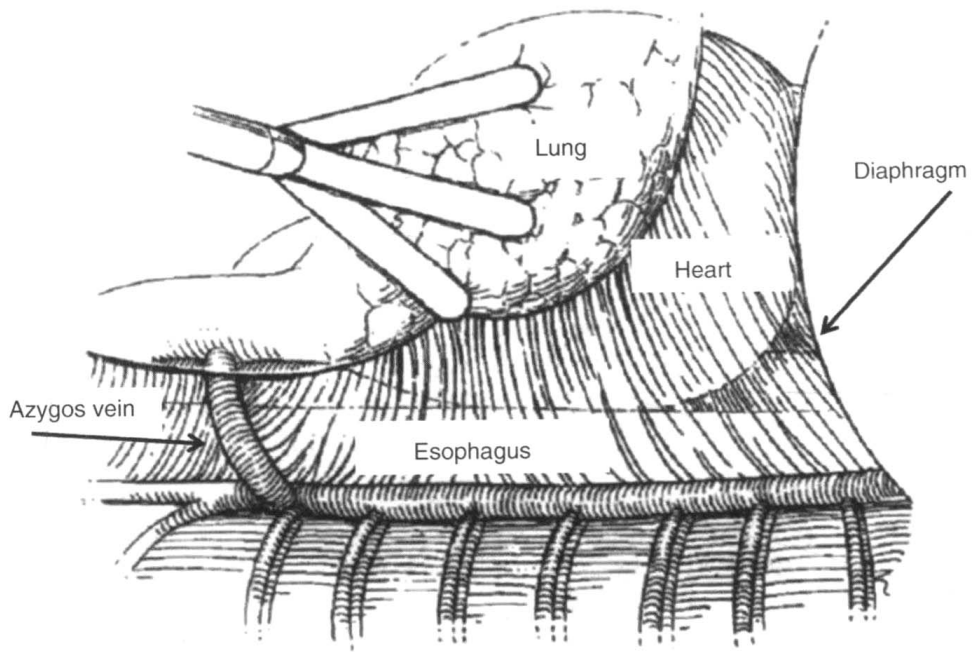


Fig. 1.4 Right thoracoscopic view

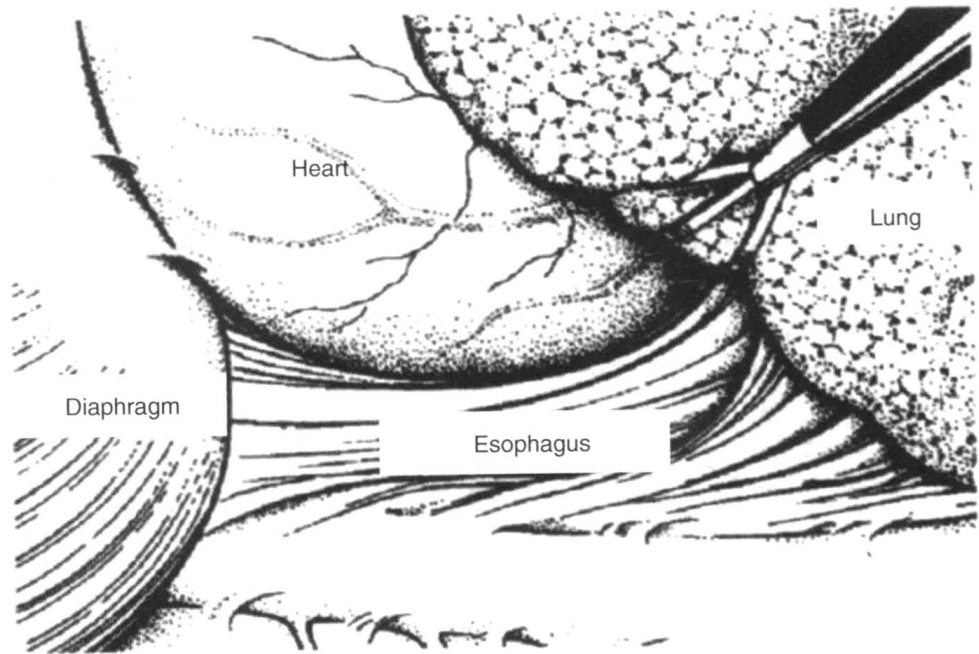


Fig. 1.5 Left thoracoscopic view