CLINICAL ANATOMY OF THE ESOPHAGUS, STOMACH, DUODENUM, LIVER, BILIARY TRACT AND PANCREAS

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ESOPHAGUS

- The esophagus is a muscular tube that starts as the continuation of the pharynx and ends as the cardia of the stomach.
- The esophagus is firmly attached at its upper end to the cricoid cartilage and at its lower end to the diaphragm.
FIG. 23-1. A. Topographic relationships of the cervical esophagus:
(a) hyoid bone, (b) thyroid cartilage,
(c) cricoid cartilage, (d) thyroid gland,
Three normal areas of esophagus narrowing are evident on the barium esophagogram or during esophagoscopy. The uppermost narrowing is located at the entrance into the esophagus and is caused by the cricopharyngeal muscle. Its luminal diameter is 1.5 cm, and it is the narrowest point of the esophagus.
The middle narrowing is due to an indentation of the anterior and left lateral esophageal wall caused by the crossing of the left main stem bronchus and aortic arch. The luminal diameter is 1.6 cm.
The lowermost narrowing is at the hiatus of the diaphragm and is caused by the gastroesophageal sphincter mechanism. The luminal diameter at this point varies somewhat depending on the distention of the esophagus by the passage of food, but has been measured at 1.6 to 1.9 cm.
The cervical portion of the esophagus is approximately 5 cm long and descends between the trachea and the vertebral column from the level of the sixth cervical vertebrae to the level of the interspace between the first and second thoracic vertebrae posteriorly or of the suprasternal notch anteriorly. Laterally, on the left and right sides of the cervical esophagus are the carotid sheaths and the lobes of the thyroid gland.
The thoracic portion of the esophagus is approximately 20 cm long. It starts at the thoracic inlet. In the upper portion of the thorax, it is in intimate relationship with the posterior wall of the trachea and the prevertebral fascia. Just above the tracheal bifurcation, the esophagus passes to the right of the aorta.
FIG. 23-7.  A. Cross-section of the thorax at the mid-left atrial level. B. CT scan at same level viewed from above: (a) aorta, (b) esophagus, (c) left atrium, (d) right atrium, (e) left ventricle, (f) right ventricle, (g) pulmonary vein. [From: Rothenberg M, DeMeester TR. Surgical anatomy of the esophagus, in Shields TW (ed): General Thoracic Surgery, 3rd ed. Philadelphia, Lea & Febiger, 1989, p 82, with permission.]
Dorsally, the thoracic esophagus follows the curvature of the spine and remains in close contact with the vertebral bodies. From the eighth thoracic vertebrae downward, the esophagus moves vertically away from the spine to pass through the hiatus of the diaphragm. The thoracic duct passes through the hiatus of the diaphragm on the anterior surface of the vertebral column behind the aorta and under the right crus. In the thorax the thoracic duct lies dorsal to the esophagus between the azygos vein on the right and the descending thoracic aorta on the left.
The abdominal portion of the esophagus is approximately 2 cm long. It starts as the esophagus passes through the diaphragmatic hiatus and is surrounded by the phrenoesophageal membrane.
**Fig. 23-8.** Attachments and structure of the phrenoesophageal membrane. Transversalis fascia lies just above the parietal peritoneum. [From: Rothberg M, DeMeester TR: Surgical anatomy of the esophagus, in Shields TW [ed]: General Thoracic Surgery, 3rd ed. Philadelphia, Lea & Febiger, 1989, p 83, with permission.]
The musculature of the esophagus can be divided into an outer longitudinal and an inner circular layer. The upper 2 to 6 cm of the esophagus contains only striated muscle fibers. From there on smooth muscle fibers gradually become more abundant. Most of the clinically significant esophageal motility disorders involve only the smooth muscle in the lower two-thirds of the esophagus. When a surgical esophageal myotomy is indicated, the incision needs to extend only this distance.
Contraction of the longitudinal muscle fibers shortens the esophagus. The circular muscle layer of the esophagus is thicker than the outer longitudinal layer.
The cervical portion of the esophagus receives its main blood supply from the inferior thyroid artery. The thoracic portion receives its blood supply from the bronchial arteries, with 75 percent of individuals having one right-sided and two left-sided branches. Two esophageal branches arise directly from the aorta. The abdominal portion of the esophagus receives its blood supply from the ascending branch of the left gastric artery and from inferior phrenic arteries.
Blood from the capillaries of the esophagus flows into a submucosal venous plexus and then into a periesophageal venous plexus from which the esophageal veins originate. In the cervical region, the esophageal veins empty into the inferior thyroid vein; in the thoracic region into the bronchial, azygos, or hemiazygos veins; and in the abdominal region into the coronary vein.
The parasympathetic innervation of the pharynx and esophagus is provided mainly by the vagus nerves.

The cricopharyngeal sphincter and the cervical portion of the esophagus receive branches from both recurrent laryngeal nerves, which originate from the vagus nerves - the right recurrent nerve at the lower margin of the subclavian artery, the left at the lower margin of the aortic arch.
The lymphatics located in the submucosa of the esophagus are so dense and interconnected that they constitute a single plexus.

In the upper two-third of the esophagus the lymphatic flow is mostly cephalad, and in the lower third caudad.
The efferent lymphatics from the cervical esophagus drain into the paratracheal and deep cervical lymph nodes, and those from the upper thoracic esophagus empty mainly into the paratracheal lymph nodes. Efferent lymphatics from the lower thoracic esophagus drain into the subcarinal nodes and nodes in the inferior pulmonary ligaments.
STOMACH

- The fundus is lined by a highly specialized epithelium that secretes HCL, pepsin, and intrinsic factor. The mucosa of the antrum participates in the process of gastric acid secretion by releasing the secretagogue, gastrin, into the circulation.

- The stomach, therefore, can be considered as two organs: its proximal portion is designed for storage and digestion, and its distal part is adapted to the role of mixing and evacuation.
FIG. 24-1. Position of the stomach relative to the other principal organs of the upper abdomen.
The lesser curve of the stomach is supplied primarily by the left gastric artery, which arises from the celiac axis. The right gastric artery, arising from the ascending hepatic artery, is usually a small vessel that provides branches to the first part of the duodenum and the pylorus. Right and left gastroepiploic aretries arise from the gastroduodenal and splenic arteries, respectively. They from an arcade along the greater curve, the right providing blood to the antrum and the left supplying the lower portion of the fundus.
FIG. 24-2. Blood supply to the stomach. Legend: F—fundus; C—cardia; P—pylorus; S—spleen; A—aorta; E—esophageal arteries; SP—splenic artery; LG—left gastric artery; CH—common hepatic artery; RG—right gastric artery; GD—gastroduodenal artery; PD—pancreaticoduodenal artery; RGE—right gastroepiploic artery; LGE—left gastroepiploic artery; SG—short gastric arteries. (Courtesy of KR Larsen, PhD.)
The short gastric arteries arising from the splenic artery are small and relatively insignificant in terms of the amount of blood that they deliver to the most proximal portion of the body of the stomach.
The lymphatic drainage of the stomach follows the distribution of the blood supply.

Lymph from the upper lesser curvature of the stomach drains into the left gastric and paracardial nodes. The antral segment on the lesser curve drains into the right suprapancreatic nodes. Lesions high on the greater curvature flow into the left gastroepiploic and splenic nodes, while the distribution of flow along the right gastroepiploic enters nodes at the base of the vascular pedicle serving this area.
Motor aspects as well as secretory aspects of gastric function are controlled by the autonomic nervous system. The vagus nerves provide a predominant part of this innervation. Each vagus has a single branch within the abdomen: the hepatic arising from the left anterior vagus, and the celiac from the right posterior vagus. Each vagus terminates in the anterior and posterior nerves of Laterjet, respectively.
FIG. 24-4. Diagram of the distribution of the vagus nerve within the abdomen. It also shows where the branches of the nerve of Latarjet are divided for a parietal cell vagotomy.

Knowledge of the anatomy of these nerves has resulted in a new technique, highly selective vagotomy, for treatment of peptic ulcer. In this procedure, the antral branches called the “crow’s foot” are preserved, while the more proximal branches are divided as they enter the stomach.
The right posterior vagus may occasionally give off a small branch that courses to the left behind the esophagus to join the cardia. This branch has been termed the “criminal nerve of Grassi” in recognition of its important role in the etiology of recurrent ulcer when it is left undivided.
Morphology

- The gastric glands consist of six major cell types: surface, mucous neck, progenitor, chief, parietal, and endocrine cells.
FIG. 24-7. Diagram of a single gastric gland of the rat. Between five and seven of these units open into the base of a single gastric pit (Loveclos). (From: Ito S. et al. J Cell Biol 16:513, 1963, with permission.)
Sphincters

- The entrance of ingestants into the stomach is controlled by a highly specialized 5-cm area of smooth muscle, termed the lower esophageal sphincter. This sphincter, which presents a high-pressure zone between the esophagus and stomach, relaxes to allow the passage of foodstuffs. It then contracts to prevent the regurgitation of gastric contents into the esophagus.
SMALL INTESTINE

- The small bowel extends from the pylorus to the cecum. Careful estimates provide a duodenal length of 20 cm, a jejunal length of 100 to 100 cm, and an ileal length of 150 to 160 cm. The jejunooileum extends from the peritoneal fold that supports the duodenal-jejunal junction (the ligament of Treitz) downward to the ileocecal valve.
The jejunum has a larger circumference and is thicker than the ileum, and it may be identified at operation because of this and also because the mesenteric vessels usually from only one or two arcades and send out long straight vasa recta to the mesenteric border of jejunum. By contrast, the blood supply to the ileum may have four or five separate arcades, the vasa recta are shorter, and, most important, there is usually much more fat in the mesentery of the ileum than in that of the jejunum.
FIG. 25-1. Jejunum contrasted with ileum. Note the larger jejunal diameter, the thicker wall, prominent plicae circulares, one or two arterial arcades, long vasa recta, and translucent [fat-free] areas at the mesenteric border. The ileum is smaller, thinner walled, has few plicae, multiple vascular arcades with short vasa recta, and abundant mesenteric fat.
Except for the proximal duodenum, which is supplied by branches of the celiac axis, the blood supply of the small bowel is entirely from the superior mesenteric artery, which is the second major branch of the infradiaphragmatic aorta. The superior mesenteric artery also supplies the appendix, cecum, and ascending and proximal transverse colons.
Venous drainage of the segments of the small bowel is in parallel with the arterial supply. The superior mesenteric vein joins the splenic behind the neck of the pancreas to from the portal vein.
The small bowel contains major deposits of lymphatic tissue, particularly in the Peyer’s patches of the ileum.

The small bowel mucosa is characterized by transverse folds (plicae circulares or valves of Kerckring), but actually these are absent in the duodenal bulb and in the distal ileum.
The innervation of the small bowel comes both sympathetic and parasympathetic systems. Parasympathetic fibers come from the vagus and traverse the celiac ganglia. They affect secretion and motility and probably all phases of bowel activity. Vagal afferent fibers are present but apparently do not carry pain impulses. The sympathetic fibers come from the three sets of splanchnic nerves. Pain from the intestine is mediated through general visceral afferent fibers in the sympathetic system.
Histology

- The wall of the small bowel has four layers - the serosa, the muscularis, the submucosa, and the mucosa.

- The crypts of Lieberkühn contain four types of cells - goblet cells that secrete mucus, enterochromaffin cells whose endocrine function is unknown, Paneth cells that secrete zymogen granules and whose function is also unknown, and undifferentiated epithelial cells whose function is to provide for cell renewal. The major known functions of the villi are digestion and absorption.
FIG. 25-2. Layers of the small intestine: A large surface is provided by villi for the absorption of required nutriments. The solitary lymph follicles in the lamina propria of the mucous membrane are not labeled. In the stroma of both sectioned villi are shown the central chyle (lacteal) vessels or the villous capillaries. [From: Sabotta/Figge: Atlas of Human Anatomy. New York, Hafner, 1974, with permission.]
LIVER

- True division into right and left lobes is in line with fossa for the inferior vena cava posteriorly and the gallbladder fossa anteroinferiorly.

Biliary Drainage

- The anterior and posterior sectoral ducts in the right lobe join to form the right hepatic duct, while the medial and lateral segmental ducts in the left lobe terminate in the left hepatic duct in the porta hepatis.
FIG. 28-1. Lobar and segmental divisions of the liver. A. Lobar fissure. B. Left segmental fissure. A right segmental fissure divides the right lobe into its anterior and posterior segments. (From: Schwartz SI, 1964, with permission.)
Blood Supply

- The afferent blood supply to the liver arises from two sources: (1) the hepatic artery, which carries oxygenated blood and accounts for approximately 25 percent of hepatic blood flow, and (2) the portal vein, which accounts for approximately 75 percent of hepatic blood flow and drains the splanchnic circulation.
The common hepatic artery originates from the celiac axis and, after contributing the gastroduodenal and right gastric artery, ascends in the hepatoduodenal ligament to the left of the common bile duct and anterior in the portal vein. It bifurcates into a right and left branch to the left of the main lobar fissure.
Intrahepatic anastomoses between the right and left hepatic arteries do not occur. The cystic artery is usually an extrahepatic branch of the right hepatic artery.

The portal venous system contains no valves. It returns to the liver the blood that the celiac, superior mesenteric, and inferior mesenteric arteries supply to the gastrointestinal tract, pancreas, and spleen.
In the porta hepatis the vein divides into two branches, which course to each lobe. The average length of the main portal vein is 6.5 cm, and the average diameter is 0.8 cm.

The hepatic venous system begins as a central vein of the liver lobule and represents the only vessel in human beings into which the sinusoids empty. The major hepatic veins are classified as right, left and middle.
FIG. 28-5. Prevailing pattern of drainage of hepatic veins in the human liver. (From: Schwartz SI, 1964, with permission.)
In human beings there are no valves in the hepatic venous system. Total hepatic blood flow can be measured by means of hepatic vein catheterization and the use of the Fick principle. The average value is 1500 mL/min/1.73 m² of body surface.
GALLBLADDER AND EXTRAHEPATIC BILIARY SYSTEM

Gallbladder

- The gallbladder is a saclike, hollow organ measuring about 10 cm in length that lies in a fossa on the undersurface of the liver.
- The gallbladder is attached to the liver by loose areolar tissue rich in small blood vessels and lymphatics.
- The gallbladder has a fundus, body, infundibulum, and neck.
FIG. 29-1. Normal anatomy. The diagram depicts the relationships in the porta hepatis. The triangle of Calot is bordered by the edge of the liver, the cystic duct, and the hepatic duct.
The infundibulum, also known Hartmann’s pouch, is a small bulbous diverticulum, typically lying on the inferior surface of the gallbladder.

The cystic duct is the tubular structure that connects the gallbladder to the common bile duct. The so-called spiral valves of Heister are situated within the cystic duct; they appear to play an important role in the passage of bile into and out of the gallbladder.
The major blood supply to the gallbladder is through the cystic artery, which is typically a branch of the right hepatic artery.

The cystic artery runs close to the cystic duct in the triangle of Calot. This anatomic area is defined by the edge of the liver, the common hepatic bile duct, and cystic duct. The venous drainage of the gallbladder is variable and generally does not run parallel with the arteries. Drainage is into the right branch of the portal vein.
The wall of the gallbladder is richly innervated with sympathetic and parasympathetic nerve fibers. The sensation of pain is mediated by visceral, sympathetic fibers. The motor stimulus for gallbladder contraction is carried through the vagus nerves and the celiac ganglion.
Bile Duct

- The biliary tract has its origin within the small intra hepatic bile ducts. Using the classic definitions, the extrahepatic biliary tract begins with the right and left hepatic duct. The common hepatic duct makes up the left border of the triangle of Calot, and is continuous with the common bile duct, and the division, which is fairly arbitrary, occur at the level of the cystic duct. The common bile duct is approximately 8 cm in length and courses from the junction with the common hepatic duct, through the substance of the pancreas and ultimately drains into the duodenum. The common bile duct empties into the duodenum at the papilla of Vater.
Anomalies of the gallbladder include ectopic locations, disorders of number of gallbladders (agenesis or multiple), or defects in gallbladder formation and development. Perhaps the most common anomaly is that of the gallbladder being located intrahepatically.
FIG. 29-2. Common variations of the cystic duct. A. Normal relationship of the cystic duct to the common bile duct and the common hepatic duct. B. Long cystic duct entering the common duct close to the duodenum. C. Long cystic duct running inseparably in the common bile duct. D. Cystic duct entering the right hepatic duct. E. Meandering cystic duct entering the left side of the common bile duct. F. Long cystic duct entering the common duct near the ampulla of Vater. G. Absent cystic duct with gallbladder entering directly in the common bile duct. H. Meandering cystic duct anterior to the common bile duct and entering on the left side.
FIG. 29-3. Common variations of the cystic artery. A. Normal relationship of cystic artery arising from the right hepatic artery. B. Cystic artery arises from the gastroduodenal artery. C. Two cystic arteries, one arising from the right hepatic artery, and the other from the gastroduodenal or hepatic artery. D. Two cystic arteries, abnormal one arising from the left hepatic artery and crossing the common hepatic duct anteriorly. E. Cystic artery arises from the hepatic artery but courses anteriorly to common hepatic duct. F. Two cystic arteries arising from right hepatic artery. Right hepatic artery is adherent to the cystic duct and neck of gallbladder. Posterior cystic artery is very short (a common finding).
PANCREAS

- It is arbitrarily divided into a head with its incinate process, a neck, a body, and a tail.
- There are usually no tributaries between the anterior surface of the superior mesenteric and portal veins and the posterior surface of the neck.

**Bile and Pancreatic Ducts**

- The common bile duct passes posterior to the head of the pancreas on its way to the duodenum, and is partially or completely covered by the pancreas in over 70 percent of cases.
The main pancreatic duct (Wirsung) arises in the tail of the pancreas and enters the duodenal wall caudal to the bile duct.

The ampulla of Vater is a dilatation of the common pancreaticobiliary channel within the papilla and is distal to the junction of the two ducts. An ampulla is present in about 90 percent of cases, and it usually is quite short (5 mm or less).
The accessory pancreatic duct (Santorini) usually drains the anterior and superior portion of the head of the pancreas. In 60 percent of cases, it enters the duodenum about 2 cm cranial and slightly anterior to the papilla of Vater, through the minor papilla.

Numerous variations of ductal anatomy occur, but only pancreas divisum, which occurs in up to 10 percent of normal people, may occasionally cause disease.
FIG. 30-2. A. Normal arrangement of ducts, present in about 60 percent of cases. B. and C. Pancreas divisum: the principal drainage of the pancreas is through the minor papilla. This occurs in about 10 percent of cases. (From: Skandalakis JE, Gray SW, et al: Anatomical complications of pancreatic surgery. Contemp Surg 15(5,6):17, 1979, with permission.)
Blood Supply

- The blood supply to the head of the gland comes from the superior pancreaticoduodenal artery, which arises from the gastroduodenal artery and divides into anterior and posterior branches.

- The dorsal pancreatic artery usually arises from the proximal 2 cm of the splenic artery and, after supplying some branches to the head, passes to the left to supply the body and tail of the gland. There it is called the transverse pancreatic artery. Numerous branches from the splenic artery anastomose with the transverse artery and also supply the body and tail.
The head of the pancreas is drained by veins which parallel the arteries. The superior pancreaticoduodenal, right gastroepiploic, and a colic vein join to form a major gastrocolic trunk on the anterior surface of the head. This trunk empties into the superior mesenteric vein just before it passes under the neck of the pancreas, and may be a useful anatomic landmark to identify the vessel during pancreatic surgery.

Venous drainage of the body and tail of the pancreas is directly to the splenic vein, and through the inferior pancreatic vein to the inferior or superior mesenteric veins.
Lymphatics

- Lymphatic drainage of the pancreas is rich and, in general, follows venous drainage in all directions. The superior nodes, located along the superior border of the pancreas, collect lymph from the anterior and superior upper half of the gland.
The inferior nodes, along the inferior margin of the head and body, drain the anterior and posterior lower half. Anterior nodes drain the anterior surface of the head of the pancreas. They are located beneath the pylorus, anteriorly in the groove between the pancreas and duodenum, and the root of the mesentery of the transverse colon.
Posterior nodes drain the posterior surface of the head. They are found posteriorly in the groove between the pancreas and duodenum, along the common bile duct, the aorta as high as the origin of the celiac axis artery, and at the origin of the superior mesenteric artery. Splenic nodes drain the tail of the pancreas. Lymphatic drainage is important in regard to the spread of pancreatic cancer, which arises most commonly in the head of the gland.
Nerves

- The pancreas receives symphatetic fibers via the splanchnic nerves and parasympathetic innervation by way of the vagus nerves (celiac division of the posterior vagus trunk). The splanchnic nerves also carry visceral afferent pain fibers which pass through the celiac plexus and ganglia. It is not known whether afferent fibers of the vagus are involved in pancreatic pain. Because pancreatic cancer and chronic pancreatitis are often accompanied by significant pain, efforts to relieve it sometimes include destruction of the celiac ganglia, with variable success.
References