

The Gastro-intestinal System

The GI system is the system concerned with supplying the body with nutrients & energy. It does so by a series of physiological processes including food ingestion, digestion, nutrients absorption, & eliminating the food waste products by defecation. Anatomically, the system is formed by a long tubular structure (the gastrointestinal tract-GIT), with digestive glands associated with it.

THE GASTROINTESTINAL TRACT:

The GIT is a continuous tubular structure with variable diameter according to the region. It starts from the oral orifice (the mouth) & ends with the anal opening (the anus), with its parts present in the head, neck, thorax, abdomen, pelvis & perineum. The GIT is divided into multiple parts (organs), which are (according to their location):

- In the head & neck: the oral orifice, oral cavity, the pharynx, & the esophagus (cervical part).
- In the thorax: the esophagus (thoracic part).
- In the abdomen: the esophagus (abdominal part), the stomach, the small intestine, the large intestine.
- In the pelvis: the large intestine (the rectum).
- In the perineum: the anal canal & anal orifice.

Embryologically, the GIT originates as a simple tube which is supplied by branches from the aorta. The proximal 1/3rd of the tube is the "foregut", the middle 1/3rd is the "midgut", & the distal 1/3rd is the "hindgut".

The Mouth & Oral Cavity:

The mouth is the opening of the oral cavity. It is made by the upper & lower lips, that contain a circular skeletal muscle (orbicularis oris) which opens & closes the mouth. The oral cavity is the space behind the mouth. It is bounded by the cheeks laterally, the palate superiorly, the floor of the mouth (that contains the tongue) inferiorly, & is continuous with the pharynx posteriorly. The cheeks contain the right & left buccinator muscles, with each muscle extending between the upper & lower jaws. The buccinator muscles act during mastication to keep the bolus of food between the teeth. The orbicularis oris & buccinator muscles are supplied by the facial nerve (CN VII).

The oral cavity & the tongue are lined by mucosa, that contains many small "minor salivary glands" that secrete serous & mucous secretions. The tongue is a muscular structure that serves the following functions: (1) speech, (2) controlling mastication & initiation of swallowing, (3) taste sensation. The muscles of the tongue are supplied by the hypoglossal nerve (CN XII). The general sensation of the tongue is mediated by the trigeminal nerve (for the anterior 2/3rd) & the glossopharyngeal nerve (for the posterior 1/3rd), while taste sensation is mediated by the facial nerve (for the anterior 2/3rd) & the glossopharyngeal nerve (for the posterior 1/3rd). The oral cavity also contains the upper & lower teeth. Permanent teeth are 28 – 32 in the adult. The oral cavity receives the ducts of some "major salivary glands" (discussed later). Near the back of the tongue, the lateral walls of the oral cavity contains 2 lymphoid collections, the "palatine tonsils", which serve a defence function against microorganisms.

The Pharynx:

The pharynx is a common passage for food & air, so, it is part of both GIT & respiratory system. The pharynx is a midline muscular tube (made of skeletal muscles) extending from the nasal cavity to the esophagus, it is divided into 3 parts:

1. The nasopharynx: the upper part, continuous anteriorly with the nasal cavity,
2. The oropharynx: in the middle, continuous anteriorly with the oral cavity,
3. The laryngopharynx: the lower part, continuous anteriorly with the larynx.

The pharynx mediates swallowing & air conduction from the nasal cavity to the larynx. The motor & sensory supply of the pharynx is supplied by the glossopharyngeal & vagus nerves (CNs IX & X).

The Esophagus:

A long muscular tube connecting the pharynx to the stomach. Peristaltic waves of the esophageal muscles (that occur even at rest) are necessary for swallowing. In the upper 1/3rd of the esophagus, the skeletal muscle fibers coming from the pharynx are gradually replaced by smooth muscle fibers that form the muscular layer of the rest of the GIT, until the lower half of the anal canal, where skeletal muscle appear again in the wall forming the external anal sphincter. In the neck & thorax, the esophagus run vertically posterior to the trachea, & anterior to the aorta, to perforate the diaphragm & enter the abdomen. In the abdomen, the esophagus runs shortly (3-4 cm) to open into the stomach, forming an acute angle with it.

The Stomach:

The stomach is the widest part of the GIT. It is an ear-shaped extendible organ lying in the upper left part of the abdominal cavity. It functions to mix the food & start the digestion of proteins by pepsin & trypsin enzymes, in addition to its strong antimicrobial function mediated by its HCl secretion. The stomach is divided into a fundus, body, & pyloric regions. At the end of pyloric region, the muscle layers of the stomach wall enlarges forming a sphincter (the pyloric sphincter) that can open & close to control food passage from the stomach to the duodenum.

At the junction between the esophagus & stomach, the muscular layer is not significantly large, & there is no real sphincter. Therefore, sometimes when the pressure inside the stomach increases, the gastric content "reflux" up to the esophagus, causing burning sensation & discomfort. This condition is called "gastro-esophageal reflux disease (GERD)".

The Small Intestine:

The small intestine is a large, coiled tubular structure situated in the central part of the abdomen. It is subdivided into 3 parts: the duodenum, the jejunum, & the ileum. The small intestine function to digest food & absorb it.

The Duodenum: A C-shaped structure coming after the stomach, & is continuous distally with the jejunum. The head of pancreas is situated in the concavity of the duodenum. The mid-point of the duodenum contains the duodenal papilla, which receives the common opening of the common bile duct (from the liver) & the main pancreatic duct. Also, the mid-point of the duodenum is the level where the foregut becomes the midgut.

The Jejunum: A longer tube than the duodenum, it is tortuous structure lying on the left below the transverse colon.

The Ileum: the last & longest part of small intestine. It is the main absorptive part of the GIT. It also contains lymphatic nodules that serve a defense function.

The Large Intestine:

The large intestine is larger in diameter than the small intestine, & significantly shorter in length than it. It is divided into: the cecum, the appendix, the ascending colon, transverse colon, descending colon, sigmoid

colon, the rectum, & the anal canal. The main function of the appendix is water & electrolytes absorption, & defecation.

The Cecum & appendix: the cecum is a sac-like structure that comes next to the ileum. It is situated in the right lower part of the abdomen. Inferiorly it is connected to the appendix, & superiorly to the ascending colon. The appendix is a small, worm-like blind tube attached to the cecum. Its function is thought to be related to the immune system as it contains large many lymphoid follicles. The appendix can be inflamed, causing an emergency condition (acute appendicitis) that needs surgical removal of the inflamed appendix.

The colon: the colon is situated around the small intestine, as 4 parts: ascending colon (on the right), transverse colon (horizontally below the stomach & above the jejunum), descending colon (on the left), & sigmoid colon (left inferior region). The sigmoid colon enters the pelvic cavity & becomes the rectum. In the transverse colon, the junction of its proximal 2/3rd & distal 1/3rd represents the transition of the midgut into the hindgut.

The Rectum: the dilated part of large intestine where the fecal material is stored before defecation.

The Anal Canal: small (4 cm) muscular canal surrounded by the internal anal sphincter (involuntary, smooth muscles) & the external anal sphincter (voluntary, skeletal muscles). The anal canal opens externally as the anus.

Arterial Supply of the GIT:

In the head & neck, the GIT structures are supplied by branches of the nearby arteries. In the thorax, the esophagus is supplied by the aorta. In the abdomen, the GIT organs are supplied by 3 main arteries, all coming from the abdominal aorta, as follows:

- The celiac trunk: supplies the foregut organs (lower esophagus, stomach, proximal half of the duodenum, liver, & pancreas) in addition to the spleen.
- The superior mesenteric artery: supplies the midgut organs (distal part of duodenum, jejunum, ileum, cecum, appendix, ascending colon, & proximal 2/3rd of the transverse colon).
- The inferior mesenteric artery: supplies the hindgut organs (distal 1/3rd of transverse colon, descending colon, sigmoid colon, rectum, & anal canal).

Venous Drainage of the GIT:

- In the head, neck, & thorax, the GIT structures drain to the nearby veins.
- In the abdomen, the splenic vein, superior mesenteric vein, & inferior mesenteric vein unite together forming the "portal vein", which enters the liver.
- Note: there is no celiac vein in the abdomen.

Nerve Supply of the GIT:

The GIT is supplied by sympathetic & parasympathetic postganglionic nerves. These nerves control the GIT movements, sphincters, & glands secretion. Sensation from the GIT is mediated by afferent visceral sensory nerves. Together, all of these nerves are called the "enteric nervous system".

Sympathetic Supply:

- In the head, neck & thorax, GIT organs receive postganglionic sympathetic fibers from the cervical sympathetic chain.
- In the abdomen, GIT organs receive postganglionic sympathetic fibers from 3 sympathetic ganglia: celiac (to the foregut), superior mesenteric (to the midgut), & inferior mesenteric ganglion (to the hindgut).

- Sympathetic stimulation in the GIT relaxes the gut walls, contracts the sphincters, & reduces glandular secretion.

Parasympathetic Supply:

- The vagus nerve (CN X) supplies the GIT (foregut & midgut) with preganglionic parasympathetic fibers.
- The pelvic nerve (spinal nerves S2, 3, 4) supplies the GIT (hindgut) with preganglionic parasympathetic fibers.
- Parasympathetic ganglia usually lie within the gut wall, & parasympathetic postganglionic nerves are very short.
- Parasympathetic stimulation in the GIT increases peristaltic movement, relaxes the sphincters, & stimulates glandular secretion.

GLANDS ASSOCIATED WITH THE GIT

Major Salivary glands: 3 pairs of large exocrine glands that secrete saliva, present in the head as parotid, submandibular, & sublingual glands. The parotid gland has a large duct that opens in the oral cavity lateral wall. The submandibular & sublingual glands open in the floor of the oral cavity below the tongue. The parotid gland is a pure serous gland, while the other 2 are mixed (sero-mucous) glands.

The Liver: the largest inner organ in the body. It is an exocrine gland that secretes bile salts & pigments (for lipid digestion). In addition, the liver serves many hematological, metabolic, immunological, synthetic, & other functions. The liver is situated in the upper right part of the abdomen, crossing the midline to the left side, covering the stomach partially. It is divided into larger right lobe & a smaller left lobe, separated from each other by the falciform ligament.

Blood supply: the liver receives blood from 2 sources: the hepatic artery (branch from the celiac trunk), carrying oxygen, & the portal vein, carrying all absorbed nutrients from the GIT. Blood of both sources enter the liver sinusoidal capillaries, then the capillaries fuse to form the hepatic veins, which ultimately drain the venous blood from the liver.

Biliary System: a complex tree-like set of ducts that transport bile from the liver to the duodenum. They are arranged as follows: intrahepatic biliary canaliculi → right & left hepatic ducts → join to form the common hepatic duct → join the cystic duct → forming the common bile duct (CBD) → open on the duodenal papilla. The gall bladder is a pouch-like structure that stores bile. It has the cystic duct that connects it to the common hepatic duct.

The Pancreas: a large exocrine gland with small islets of endocrine glands inside it. The exocrine gland is concerned with secreting digestive enzymes to complete the digestion of carbohydrates & proteins. They are secreted via the main pancreatic duct that opens (with the CBD) on the duodenal ampulla. The pancreas is divided into head, neck, body & tail. The endocrine portion (the islets of Langerhans) secrete many hormones, like insulin, glucagon, etc.

The Spleen: this is not a part of the GI system, it only shares a common blood supply with it (the celiac trunk). The spleen is a lymphoid organ situated in the upper left part of the abdomen, behind the fundus of stomach & below the diaphragm. It receives the splenic artery from the celiac trunk, & gives the splenic vein to the portal vein. It has immune (defence) function & hematological function. The spleen may be injured in accidents & traumas to the abdomen, & when it tears, it bleeds severely, so that it must be removed surgically to stop bleeding.