The Small Intestine

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Small Intestine: Composed of the duodenum, jejunum, and ileum; measures approximately 6 meters in length.

- Function: Responsible for complete digestion and absorption of nutrients.
- Location: Lies centrally in the umbilical region, surrounded by the large intestine.

Large Intestine: Includes the cecum, appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum, and the upper half of the anal canal; measures approximately 1.5–2.5 meters in length and has a wider diameter than the small intestine.

- Function: Absorbs water and forms feces.
- Location: Arranged peripherally around the abdominal cavity.

Duodenum: Anatomy and Relations

- The duodenum is the first part of the small intestine, beginning at the pyloric sphincter (after the stomach) and ending at the duodenojejunal junction, located at the level of the second lumbar vertebra, one inch to the left.
- This junction is stabilized by the ligament of Treitz, which connects to the right crus of the diaphragm.

Parts of the Duodenum

The duodenum is about 10 inches (25 cm) long and shaped like a "C", with four parts:

- 1. First part (2 inches) Superior
- 2. Second part (3 inches) Descending (vertical)
- 3. Third part (4 inches) Horizontal (transverse)
- 4. Fourth part (1 inch)

It is retroperitoneal, lying on the posterior abdominal wall, except for the first and last inches, which are intraperitoneal.

- First inch: Connected to the lesser omentum (above) and the greater omentum (below)—both are double layers of peritoneum.
- Last inch: Transitions into the jejunum, which is intraperitoneal and suspended by the mesentery.

Due to its retroperitoneal location, surgical access to the duodenum is more complex, requiring navigation behind the peritoneum.

- The duodenum's concavity directed to the left side and backwards. It surrounds the head of the pancreas.
- The common bile duct, main pancreatic duct, and accessory pancreatic duct open into the second (descending) part of the duodenum.

- The **major duodenal papilla** is the site where the common bile duct and main pancreatic duct merge and open.
- The **minor duodenal papilla** is the opening for the accessory duct.
- These openings are essential for delivering bile and pancreatic enzymes, especially for fat digestion.

Clinical Correlation

- Cancer of the pancreatic head may compress:
 - The common bile duct, leading to obstructive jaundice
 - The pancreatic duct, leading to pancreatitis or obstruction of the pancreatic duct

Biliary Tract and Ampulla of Vater

- Bile pathway:
 - \circ Right and left hepatic ducts (from liver) \rightarrow merge into common hepatic duct
 - \circ Common hepatic duct + cystic duct (from gallbladder) \rightarrow form the common bile duct
 - Common bile duct joins the main pancreatic duct to open at the **major duodenal papilla** in the second part of the duodenum
- The Ampulla of Vater is the dilation where the ducts meet before opening into the duodenum.
- The **sphincter of Oddi**, a smooth muscle, controls this opening:
 - At rest, it remains contracted, diverting bile to the gallbladder for storage (and to be concentrated).
 - During digestion, it relaxes to allow concentrated bile to enter the duodenum.

Important Vascular and Anatomical Structures

- The free edge of the lesser omentum contains the epiploic (Winslow's) foramen, which leads to the lesser sac behind the stomach.
- Behind the first part of the duodenum lie the common bile duct, portal vein, and hepatic artery.
- The third part of the duodenum is crossed anteriorly by the superior mesenteric artery and vein, which originate from the abdominal aorta located behind the pancreas.

First Part of the Duodenum: Anatomy and Clinical Importance

- Length: Approximately 2 inches (5 cm).
- Location: Begins at the level of the first lumbar vertebra (L1) on the transpyloric line, about 1 inch to the right of the midline.
- Direction: Extends upward and backward toward the liver and gallbladder.

Anatomical Relations of the First Part

- 1. Anteriorly:
 - Liver

- Gallbladder
- 2. Superiorly:
 - Epiploic (Winslow's) foramen
- 3. Posteriorly (from anterior to posterior):
 - Lesser sac
 - Gastroduodenal artery
 - Common bile duct
 - \circ Portal vein
 - Inferior vena cava
- 4. Inferiorly:
 - \circ Head of the pancreas

Clinical Significance (IMPORTANT)

- This segment is a common site of peptic ulcers, specifically duodenal ulcers.
- Posterior perforation of such an ulcer can erode nearby structures—especially the gastroduodenal artery (branch of hepatic artery), leading to severe hemorrhage.

Second Part of the Duodenum (Descending/Vertical Part)

- Length: Approximately 3 inches (7.5 cm).
- Location:
 - Begins below the right lobe of the liver.
 - Extends vertically downward, ending between the levels of L3 and L4 vertebrae.

- 1. Anteriorly:
 - Fundus of the gallbladder
 - Right lobe of the liver
 - Transverse colon
 - Coiled of small intestine, mainly ileum
- 2. Posteriorly: (IMPORTANT)
 - Hilum of the right kidney
 - \circ Right ureter
- 3. Laterally (Right side):
 - Ascending colon
 - Hepatic (right colic) flexure
 - Right lobe of the liver
- 4. Medially (Left side):
 - Head of the pancreas
 - Site of entry of the common bile duct and main pancreatic duct

Functional Importance

- This segment receives secretions from the liver, gallbladder, and pancreas.
- These secretions enter via:
 - The common bile duct
 - The main pancreatic duct
 - Opening together at the major duodenal papilla, typically on the medial wall of the second part.

Clinical Relevance: ERCP and Gallbladder Disease

- In the past, treatment of cholecystitis or common bile duct stones required open surgery, often involving:
 - Extended hospital stays (7–10 days)
 - Complications like bleeding or infection
- Today, a less invasive method called ERCP (Endoscopic Retrograde Cholangiopancreatography) is commonly used:
 - A flexible endoscope is passed through the mouth \rightarrow esophagus \rightarrow stomach \rightarrow duodenum
 - The major duodenal papilla is accessed
 - The sphincter of Oddi is incised to allow entry into the bile or pancreatic ducts
 - Stones are retrieved using a basket device, and flushed into the duodenum with saline to be passed naturally in the stool:
 - Same-day discharge (typically within 6 hours)
 - Also effective in cases of pancreatic duct obstruction, such as pancreatitis from dehydration during Ramadan

Third Part of the Duodenum (Horizontal/Inferior Part)

- Length: Approximately 4 inches (10 cm).
- Location:
 - Lies horizontally on the posterior abdominal wall.
 - Found at the level of the subcostal plane, crossing over the lumbar vertebrae.
 - Crosses important retroperitoneal structures, including the inferior vena cava (IVC), abdominal aorta, and right psoas major muscle.

- 1. Anteriorly:
 - The root of the mesentery (a double layer of peritoneum)
 - Begins at the level (L2), one inch to the left of the midline
 - Ends in front of the right sacroiliac joint,
 - Measures about 6 inches (15 cm) long
 - It's free edge encloses 6 meters of small intestine (jejunum and ileum)
 - Superior mesenteric artery (SMA) and vein (SMV) these vessels cross anteriorly over the third part
 - Coils of jejunum

- 2. Posteriorly:
 - Right ureter
 - Right psoas major muscle
 - Inferior vena cava (IVC)
 - Abdominal aorta
- 3. Superiorly:
 - Head of the pancreas
- 4. Inferiorly:
 - Coils of jejunum

Fourth Part of the Duodenum (Ascending Part)

- Length: Approximately 1 inch (2.5 cm)
- Course:
 - Ascends upward and to the left
 - Ends at the duodenojejunal junction, which marks the transition from the retroperitoneal duodenum to the intraperitoneal jejunum

Duodenojejunal Junction and Ligament of Treitz

- The duodenojejunal junction is supported by the ligament of Treitz
 - Attached to the right crus of the diaphragm
 - Significance in surgery:
 - Serves as a landmark to identify the beginning of the jejunum
 - Surgeons often locate it during abdominal surgeries to orient themselves in the small intestine
- The jejunum is mobile and suspended by mesentery, allowing it to be exteriorized during surgery
 - This mobility is utilized in procedures like gastrojejunostomy, where the jejunum is connected to the stomach

- 1. Anteriorly:
 - Beginning of the mesentery
 - Coils of jejunum
- 2. Posteriorly:
 - Left psoas major muscle
 - Left sympathetic chain
 - Margin of the abdominal aorta
- 3. Superiorly:
 - Uncinate process of the pancreas (a projection from the head of the pancreas that extends to the left)

Blood Supply of the Duodenum

The duodenum is divided into two vascular zones based on embryological origin:

- 1. Upper Half (Proximal to the major duodenal papilla)
 - Embryologically part of the foregut
 - Supplied by the celiac trunk, specifically:
 - Superior pancreaticoduodenal artery, a branch of the gastroduodenal artery
 - Gastroduodenal artery itself is a branch of the common hepatic artery, which arises from the celiac trunk
 - Superior pancreaticoduodenal artery divides into anterior and posterior branches
- 2. Lower Half (Distal to the major duodenal papilla)
 - Embryologically part of the midgut
 - Supplied by the superior mesenteric artery (SMA), specifically:
 - Inferior pancreaticoduodenal artery, which also divides into anterior and posterior branches

Venous Drainage

- Upper half drains into the portal
- Lower half drains into the superior mesenteric vein

Lymphatic Drainage

- Upper half drains to the celiac lymph nodes
- Lower half drains to the superior mesenteric lymph nodes
 - These nodes lie near the origins of the artery

Nerve Supply

Nerve supply follows the arterial pathways via perivascular nerve plexuses:

- 1. Sympathetic Innervation:
 - Originates from the thoracic sympathetic chain in the chest (Preganglionic fibers)
 - Synapse in:
 - Celiac ganglion
 - Superior mesenteric ganglion
 - Postganglionic fibers travel along blood vessels to reach the duodenum
- 2. Parasympathetic Innervation:
 - \circ Provided by the vagus nerve (cranial nerve X)
 - Synapse in wall of the organ in:
 - Myenteric (Auerbach's) plexus (between muscle layers)
 - Submucosal (Meissner's) plexus
 - Postganglionic fibers are very short
 - Forgut (with branches of celiac trunk), Midgut (superior mesenteric artery)

Jejunum and Ileum

- Together form the distal portion of the small intestine, extending from the duodenojejunal flexure (at the ligament of Treitz) to the ileocecal junction (where the ileum opens into the cecum).
- They are intraperitoneal organs, completely enclosed in mesentery, making them mobile.
- Length: Approximately 6 meters total:
 - Jejunum: Upper 2/5
 - Ileum: Lower 3/5

Ileocecal Junction

- Located in the right iliac fossa, where the ileum opens into the cecum
- Guarded by the ileocecal valve:
 - Not a true anatomical sphincter (no thickened muscle)
 - Formed by a mucosal fold that prevents backflow from the cecum into the ileum
 - Functions physiologically by responding to pressure in the cecum, closing the fold to prevent reflux

Mesentery of the Small Intestine

- A fan-shaped double layer of peritoneum
- Attaches the jejunum and ileum to the posterior abdominal wall
- Root of the mesentery:
 - Measures about 15 cm (6 inches)
 - Extends obliquely from the left of L2 vertebra, ends in front to the right sacroiliac joint
 - It's free edge is 6 meters long encloses the small intestine (jejunum and ileum)
- Contents of the mesentery:
 - Branches of the superior mesenteric artery and vein
 - Lymph nodes and lacteals
 - Nerve plexuses (sympathetic and parasympathetic)
 - o Fat

Histological Structure

- Mucosal Features:
 - Villi: Finger-like projections increasing the surface area for absorption
 - Lined by simple columnar epithelium with goblet cells
 - Contain capillaries, smooth muscle fibers, lacteals (blind-ended lymphatic vessels), and microvilli
 - Microvilli: Found on the apical surface of enterocytes (brush border), further increasing surface area
 - The finger-like projection (upper half is villi, lower half is glands)

• Jejunum vs. Ileum:

Feature	Jejunum	Ileum
Location	Upper left quadrant of the abdomen	Lower right quadrant of the abdomen
Wall thickness	Thicker and redder	Thinner and less redder
Arterial arcades	Fewer, simpler arcades	More numerous and complex arcades
Vasa recta	Longer and fewer	Shorter and more numerous
Fat in mesentery	Less	More
Intestinal	Wider	Narrower
diameter		
Villi	Longer and more numerous	Shorter and fewer
Plicae circulares	Large, numerous, and prominent	Smaller, fewer, and sparse
Lymphoid tissue	Scattered	Aggregated lymphoid (Peyer's patches)

The arcades in the mesentery are formed by branches of the superior mesenteric artery, which interconnect to create a network. From these arcades arise straight vessels called vasa recta, which supply the intestinal wall directly. In the jejunum, the arcades are fewer and simpler, resulting in longer and straighter vasa recta. In contrast, the ileum has more complex and numerous arcades, producing shorter vasa recta.

Blood Supply of Jejunum and Ileum

- Arterial Supply:
 - Supplied by branches of the Superior Mesenteric Artery (SMA).
 - Jejunum: Fewer arterial arcades, longer vasa recta
 - Ileum: More complex arcades, shorter vasa recta
- Venous Drainage:
 - Tributaries from the jejunum and ileum drain into the Superior Mesenteric Vein (SMV).

Lymphatic Drainage

- Primary drainage:
 - Lymph from both the jejunum and ileum drains into superior mesenteric lymph nodes, located around the origin of the superior mesenteric artery.
- Lymph from the lower limbs, pelvis, and abdomen is collected into the **cisterna chyli**, a lymphatic sac located near the aortic opening of the diaphragm, on the right side of the abdominal aorta.
- The thoracic duct originates from the cisterna chyli, ascends through the thorax, ending at the left brachiocephalic vein.
- On the right side of the chest, the right lymphatic duct drains lymph into the right venous angle, at the junction of the right internal jugular and right subclavian veins.

Nerve Supply

- Sympathetic Innervation:
 - $^{\circ}$ Originates from the thoracic sympathetic chain (T6–T9).
 - Preganglionic sympathetic fibers synapse in the celiac or superior mesenteric ganglion.

- Postganglionic fibers follow the superior mesenteric artery to reach the small intestine.
- Functions:
 - Vasoconstriction of intestinal blood vessels (indirect effect on secretion)
- Parasympathetic Innervation:
 - Supplied by the vagus nerve, originating from the medulla oblongata.
 - Preganglionic fibers travel to the intestine and synapse in the myenteric (Auerbach's) and submucosal (Meissner's) plexuses.
 - Postganglionic fibers are very short and innervate smooth muscle and glands.
 - Functions:
 - Stimulates peristalsis
 - Stimulates secretions (secretomotor activity)

Meckel's Diverticulum

Definition

• A congenital anomaly of the ileum, representing a remnant of the vitelline duct, which normally connects the midgut to the umbilicus during embryonic development.

Embryological Basis

- The vitelline duct should obliterate during fetal development.
- Failure of obliteration results in Meckel's diverticulum

Rule of 2s (classic clinical features):

- Occurs in 2% of the population.
- Found approximately 2 feet (~60 cm) from the ileocecal junction.
- Typically about 2 inches (5 cm) in length.
- Can contain 2 types of tissue: gastric and pancreatic.

Clinical Presentation

- May be asymptomatic, but can present with:
 - Right iliac fossa pain (mimicking appendicitis)
 - \circ Perforation \rightarrow peritonitis

Complications

- Ulceration
- Perforation
- Peritonitis

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