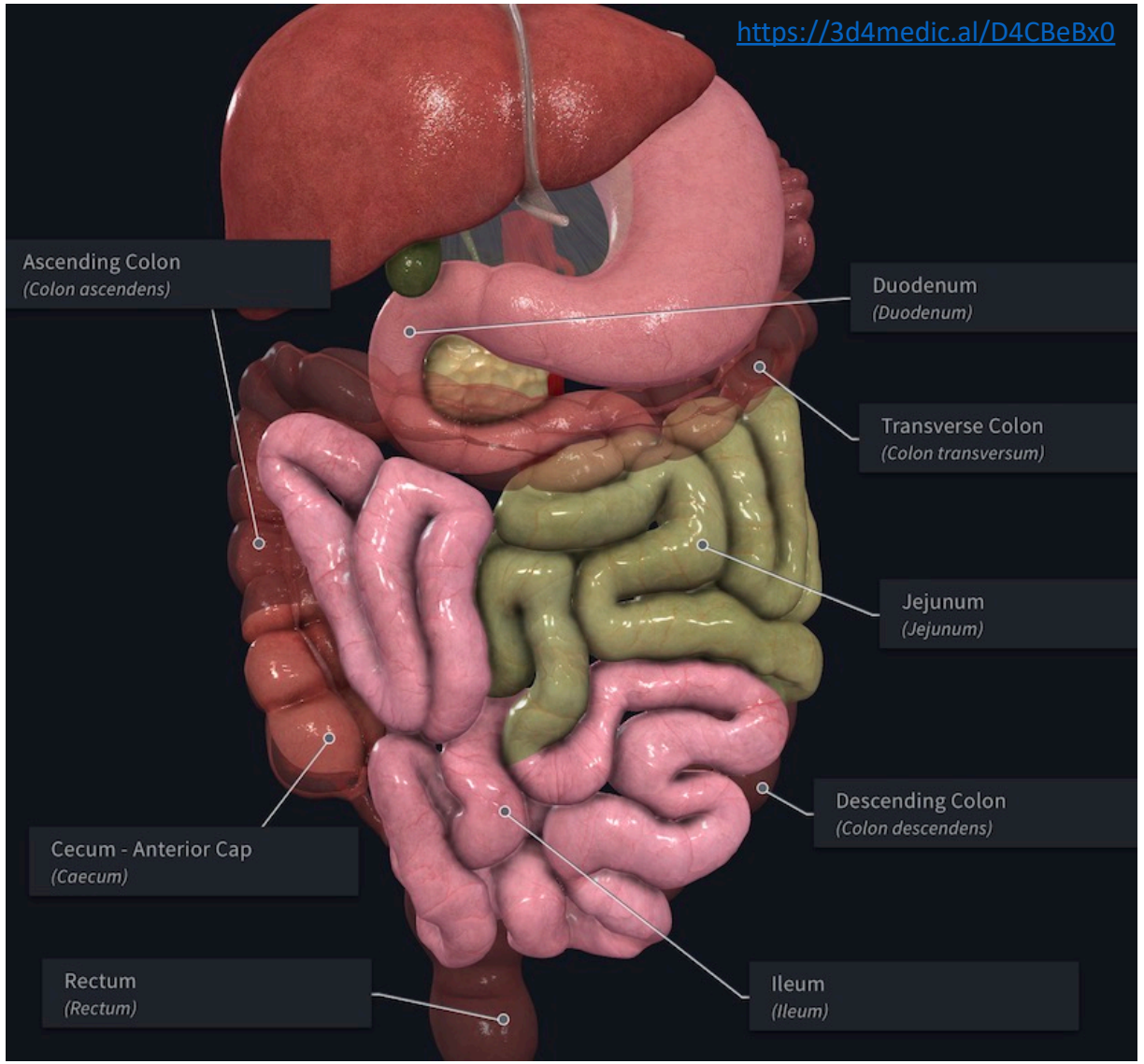
# PowerPoint Handout: Lab 4, Midgut, Hindgut, & Anal Canal

# Small Intestine: Review

The small intestine is a 20 ft long (in a cadaver), highly coiled tube. The process of digestion is completed in the lumen of small intestine, which results in nutrients that can be transported across its wall by a process called nutrient absorption.

The small intestine consists of three regions.

- The **duodenum** (“twelve finger widths long”) is the first 10 inches of small intestine.
- The **jejunum** (“empty”) is the middle portion of the small intestine that is 8 feet in length.
- The **ileum** (“twisted”) is the distal 12 feet of the small intestine that joins with the large intestine at the cecum.

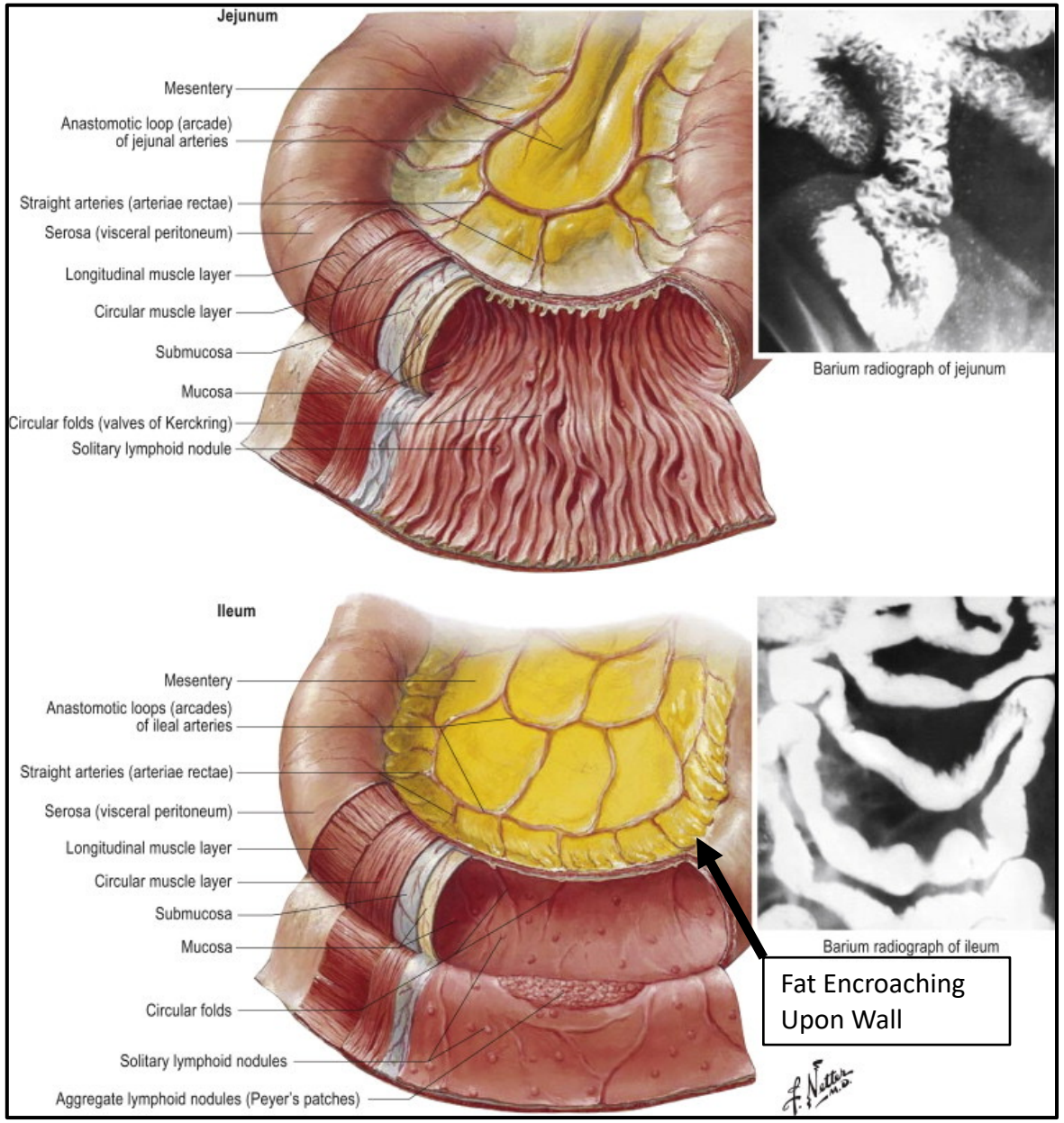


# Small Intestine: Continued

**Plicae circulares** (“circular folds”) are visible circular ridges along the wall of the small intestine that are formed by folds of the mucosa and submucosa. They function to increase surface area and reduce the speed of passage of chyme, the now liquefied remnants of the meal, through the small intestine. The density and size of plicae circulares is the greatest in the distal duodenum and the jejunum.

The external feature that can be used to differentiate the jejunum from the ileum is the the location of fat within the mesentery.

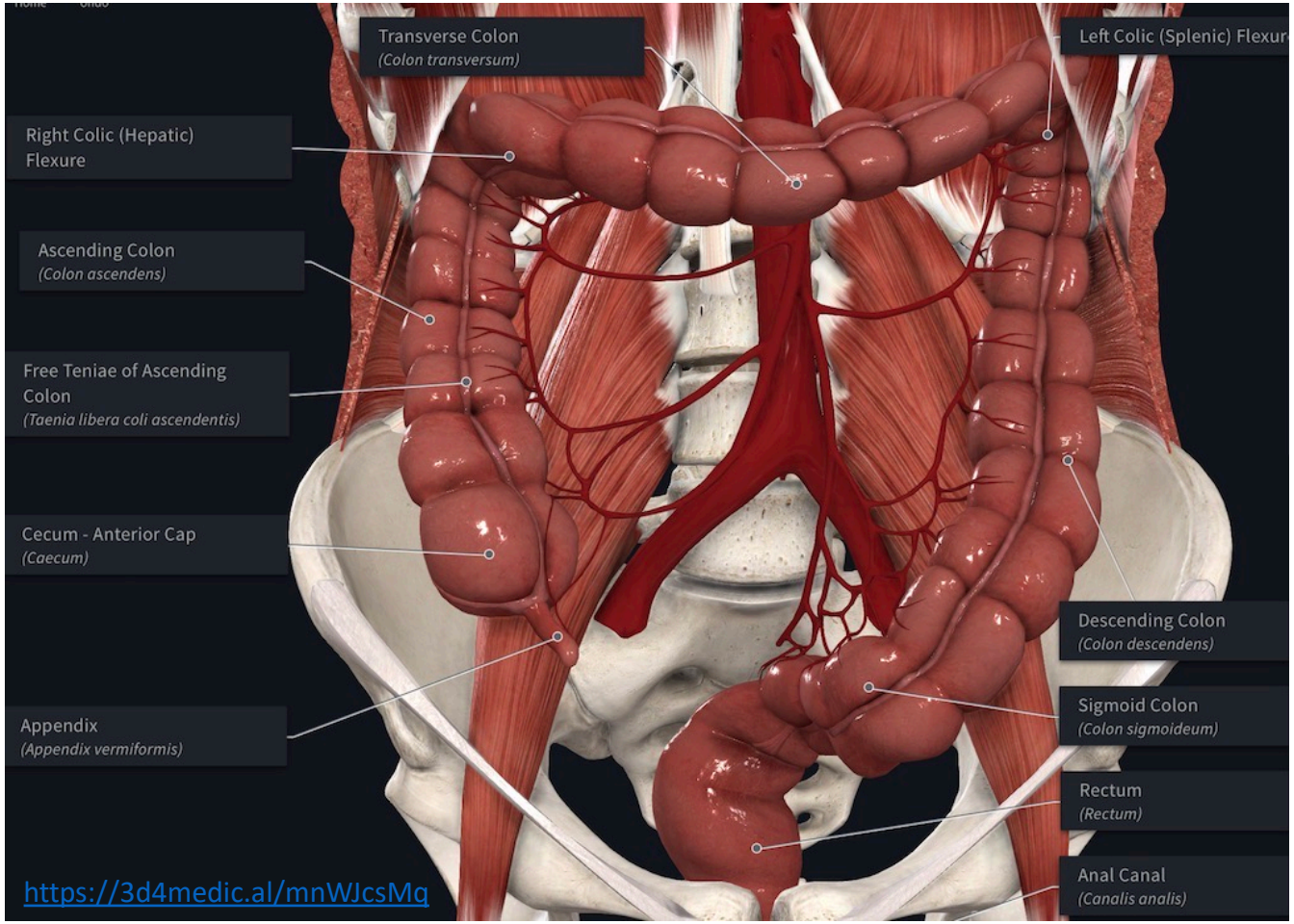
- The mesenteric fat of the jejunum does NOT encroach upon the intestinal wall.
- The mesenteric fat of the ileum DOES encroach upon the intestinal wall.



# Large Intestine: Review

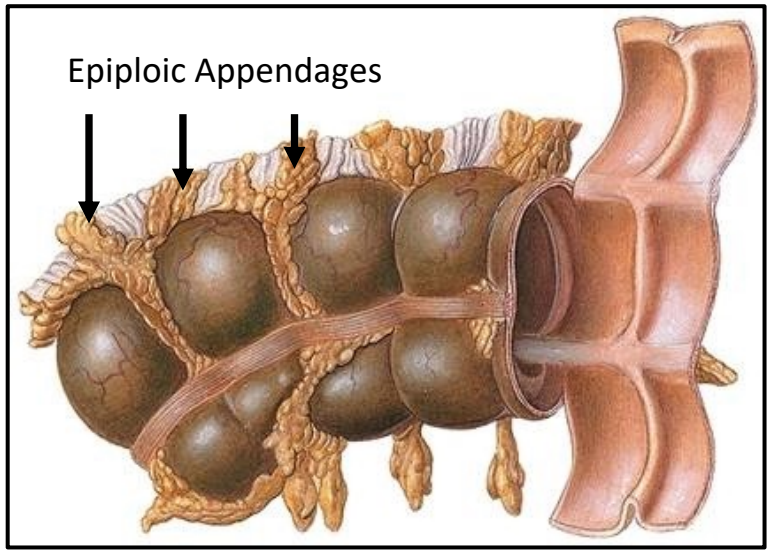
The large intestine is five feet long and surrounds the small intestine on three sides. Its major functions include water absorption from the remaining indigestible material and formation of solid waste called feces. The large intestine consists of the cecum, the colon, and the rectum.

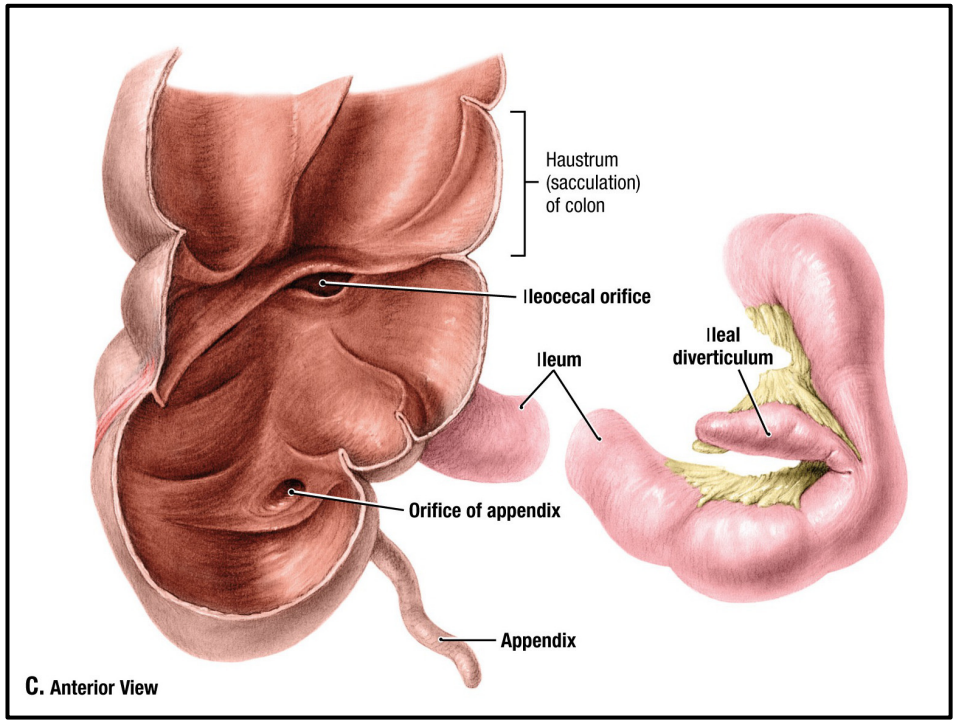
- The **cecum** is the first part of the large intestine. It is a pouch-like cul-de-sac of the colon just inferior to the ileocecal valve.
    - •The **ileocecal valve** is a sphincter at the junction of the ileum to the cecum in the lower right abdominal quadrant. It controls the movement of chyme into the cecum from the small intestine.
    - •The **vermiform appendix**, is a small 'worm-like' appendage dangling from the cecum that contains immune cells.
- The colon is the largest portion of the large intestine consisting of four regions.
    - •The **ascending colon** (retroperitoneal) rises along the right abdominal wall and leads to the first bend in the colon, the hepatic flexure.
    - •The **transverse colon** (intraperitoneal) runs horizontally across the abdomen just superior to the small intestine and leads to the second bend in the colon, the splenic flexure.
    - •The **descending colon** (retroperitoneal) descends down the left abdominal wall.
    - •The **sigmoid colon** (intraperitoneal) is the S-shaped portion that leads into the fecal storage region, the **rectum** and then to the **anal canal** and anus, through which feces pass during elimination.

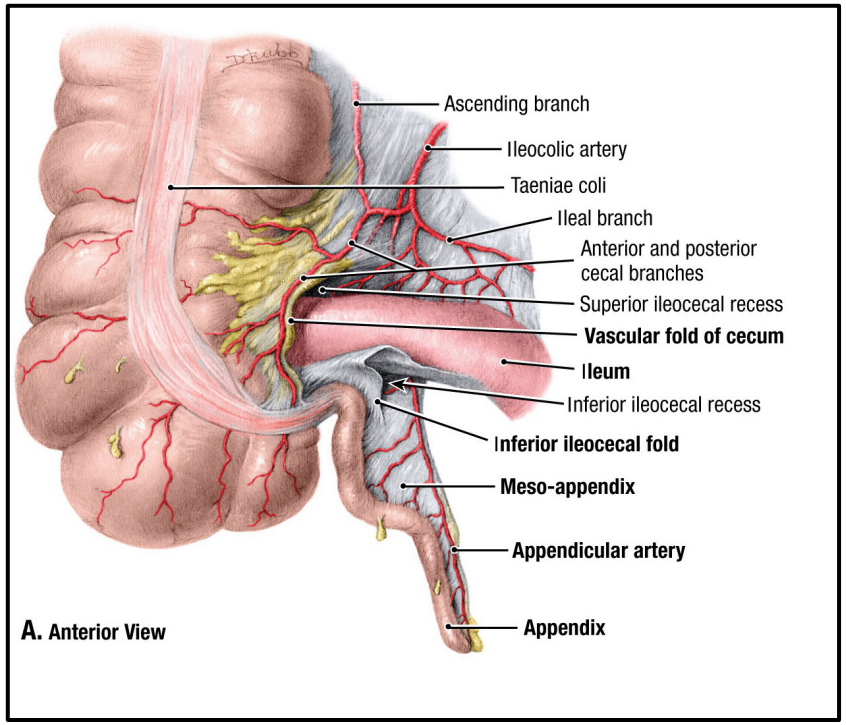


# Large Intestine: Continued

- The **haustra** (sing. haustrum) are pouches formed along the length of the colon by muscle tone exerted by the teniae coli. These structures may not appear in a cadaver due to a lack of smooth muscle tone.
- The outer longitudinal layer of the muscularis externa doesn't completely surround the colon; instead, it is organized into three bands of longitudinal muscle, called **teniae coli** that extend the length of the colon.
- **Epiploic appendages** are fatty structures that hang from the length of teniae coli. Their function is unknown.



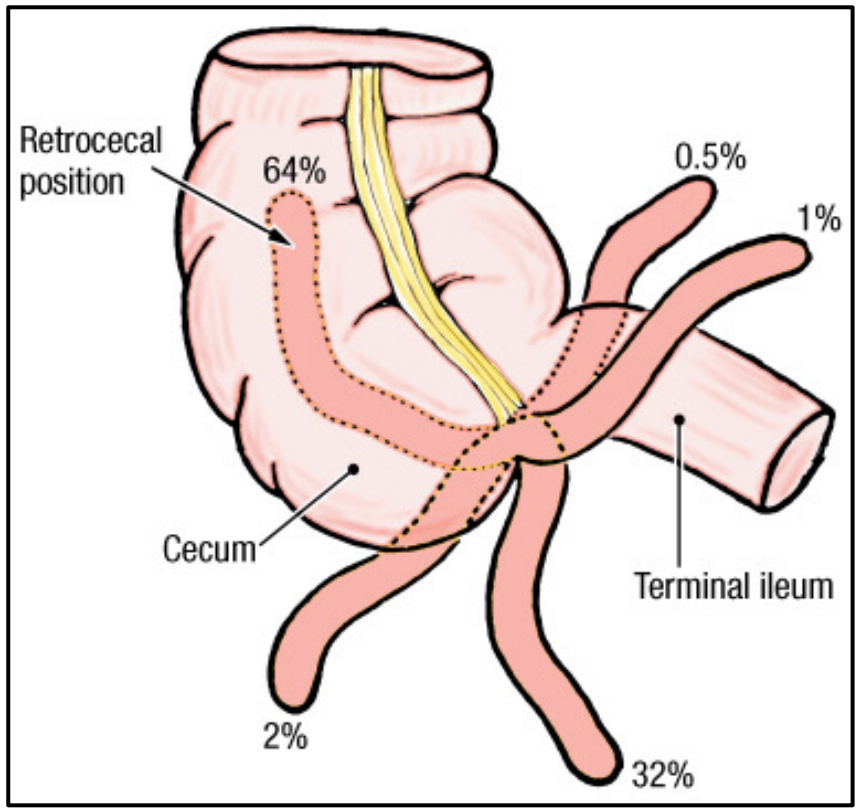



# Appendix

The appendix is a blind-ended tubing attached to the cecum which is highly variable in length, ranging between 2 to 20 cm. It is associated with its own mesentery that is called the mesoappendix. Its position is usually posterior to the cecum (64% of individuals), but variations exist.

**CLINICAL ANATOMY:** Acute inflammation of the appendix is a common cause of an **acute abdomen** (severe abdominal pain arising suddenly). The etiology of appendicitis depends on age. In the young, it is mostly due to an increase in **lymphoid tissue size**, which occludes the lumen. From 30 years old onwards, it is more likely to be blocked due a fecalith. The **pain of appendicitis** usually begins as a dull, vague pain (visceral) in the periumbilical region. Later, sharp (somatic) pain develops in the right lower quadrant due to irritation of the parietal peritoneum lining the abdominal wall. Digital pressure applied to McBurney's point registers the maximum abdominal tenderness.

- Early: inflammation of visceral peritoneum → visceral pain = poorly localized periumbilical pain
- Late: as inflammation progresses to involve parietal peritoneum → somatic pain = RLQ pain



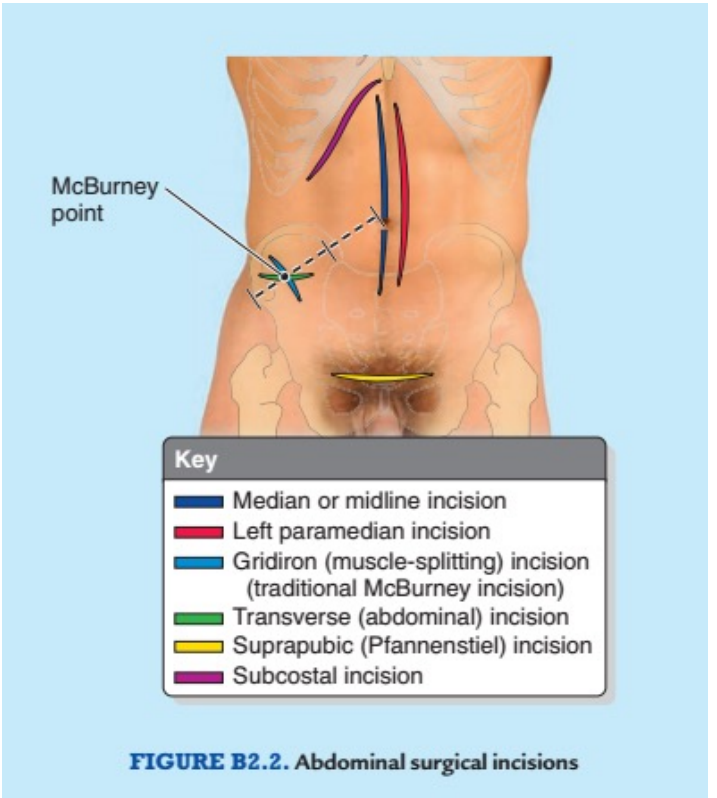
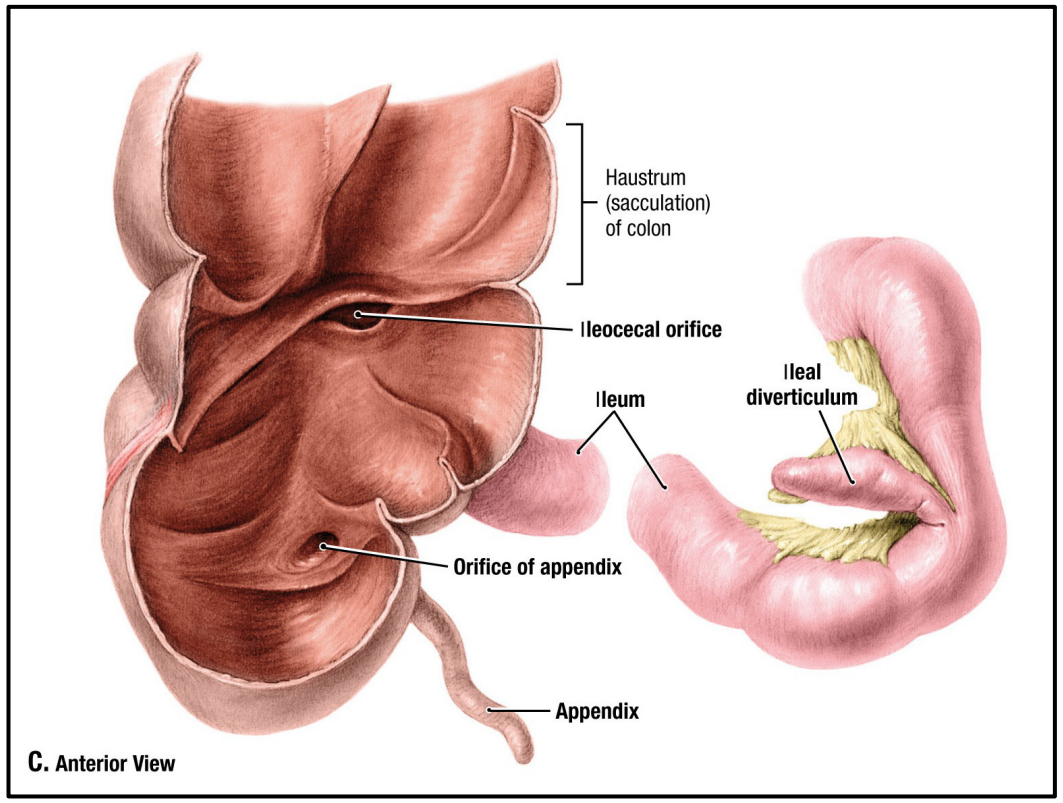
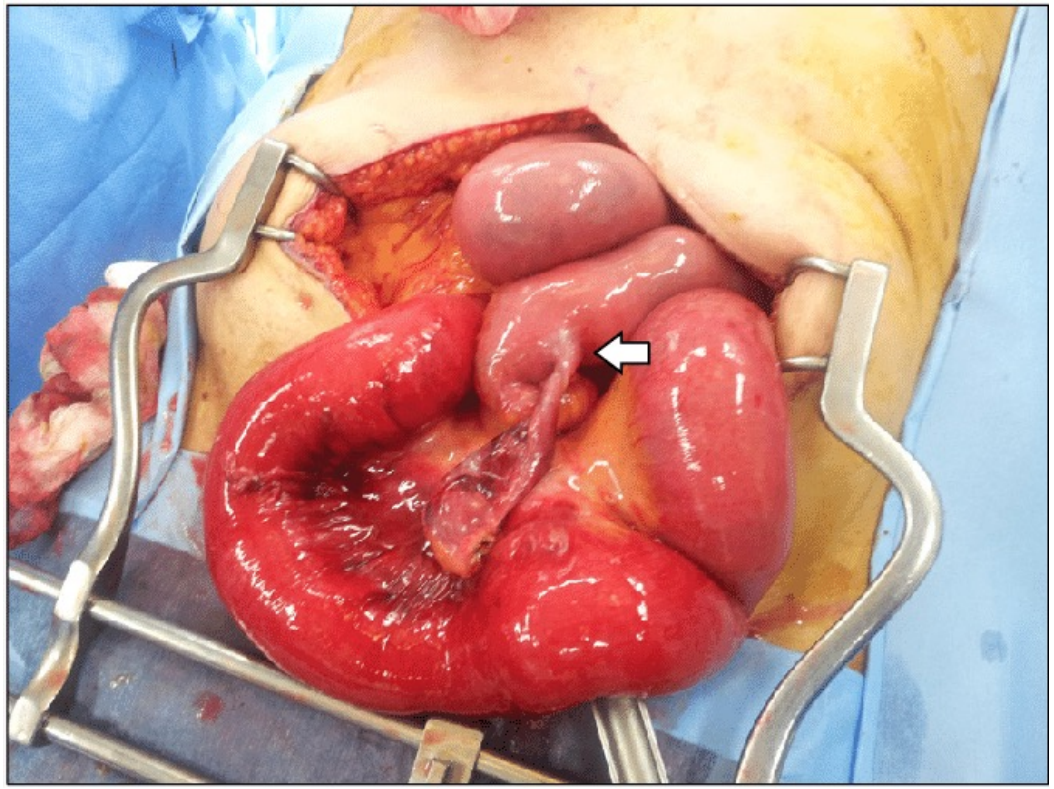




**FIGURE B2.2.** Abdominal surgical incisions

# Ileal Diverticulum of (Meckel)

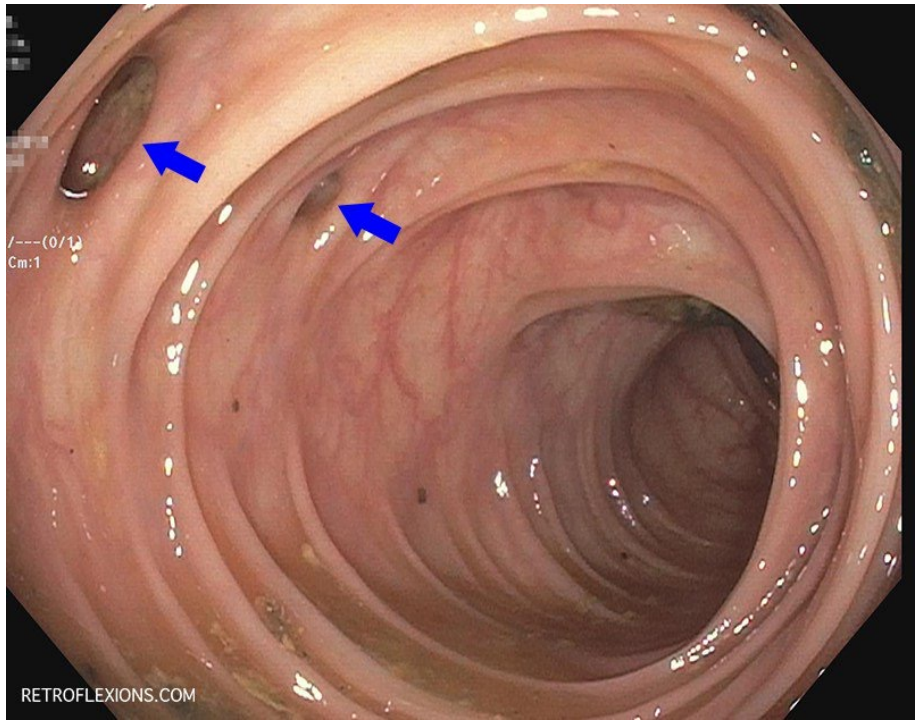
**CLINICAL ANATOMY:** An *ileal diverticulum (of Meckel)* is a pouch-like remnant of the proximal part of the *vitelline duct* of the embryo. This diverticulum is always located within 60-100 cm (*i.e.*, **2** feet) of the ileocecal junction and it is usually **2** inches in length. Approximately 2% of the population possesses an *ileal diverticulum* and of these individuals only **2**% are symptomatic. Symptoms usually present before the age of **2** and males are **2**x as likely to be affected.

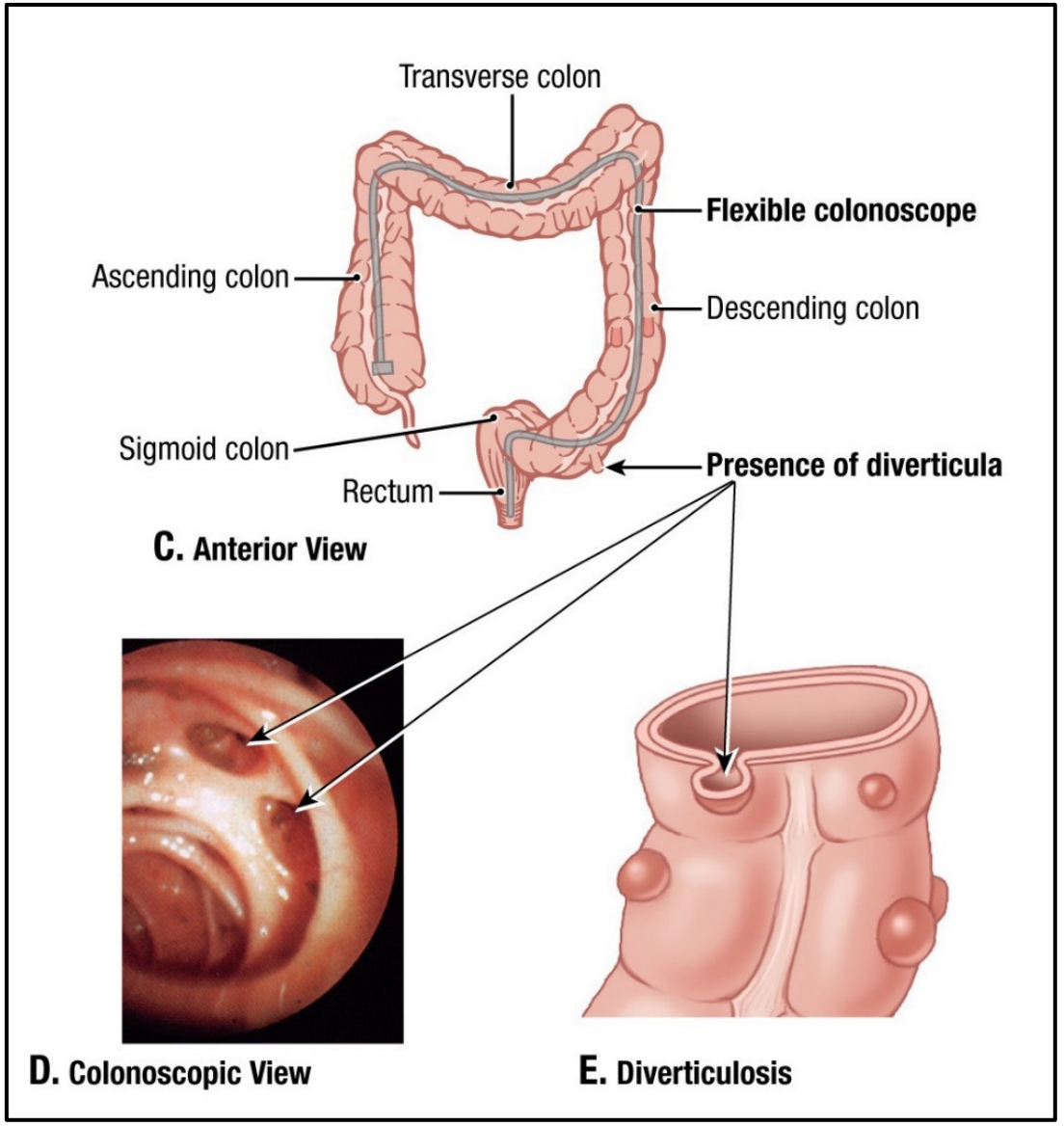


# Diverticulosis

**CLINICAL ANATOMY:** A diverticulum is a sac-like outpouching of the wall of the colon (Figure 4.1). These structures are common in elderly people and can become inflamed (**diverticulitis**) when their lumens accumulate fecal material. If an inflamed diverticulum ruptures, the infection can spread to the peritoneum (*peritonitis*). 75% of diverticula are found in the sigmoid colon.



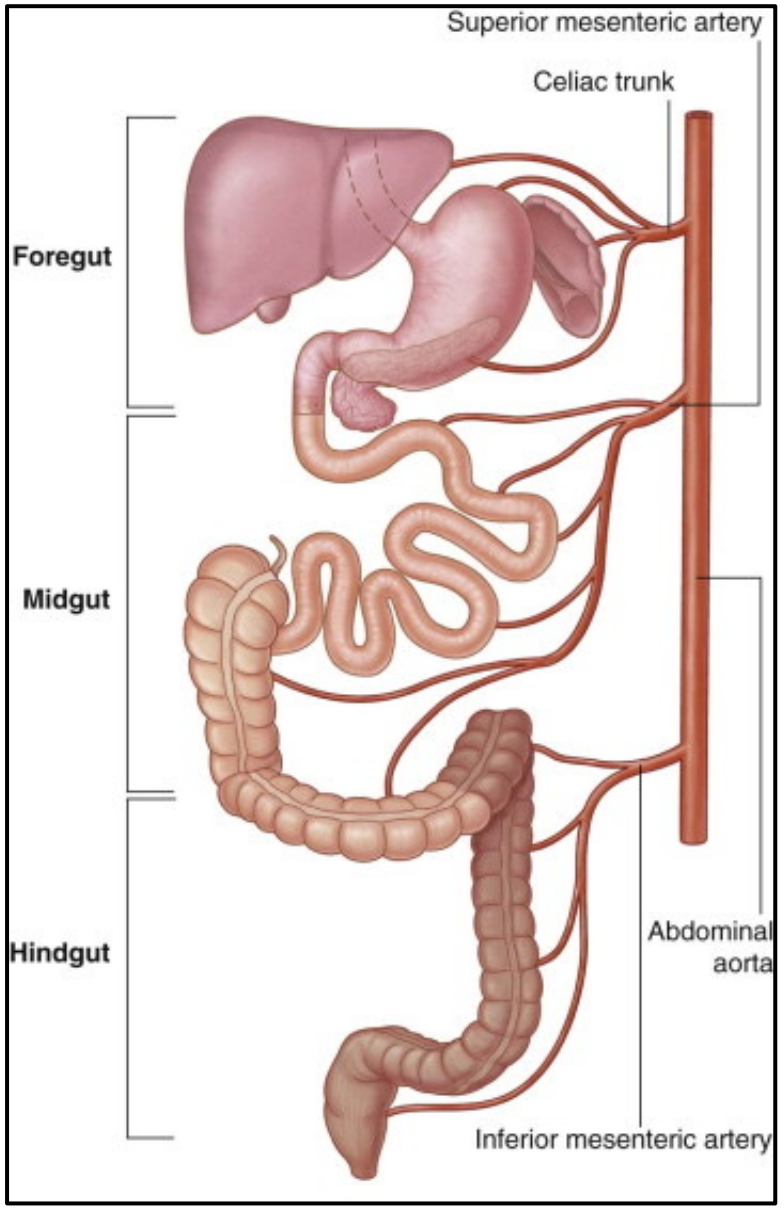



# Blood Supply: Midgut & Hindgut

Blood supply to the midgut and foregut is provided by the following anterior branches of the abdominal aorta.

- Midgut: **Superior mesenteric artery** (SMA)
  - Branches from aorta at the level of the L1 vertebra immediately inferior to the celiac trunk. It has some important anatomical relationships to other structures.
    - It is posterior to (crossed by) the following structures.
      - Pylorus of stomach
      - Splenic vein
      - Neck of pancreas
    - It is anterior to (crosses over) the following structures.
      - Uncinate process of pancreas
      - 3rd part of duodenum
      - Left renal vein
  - Supplies organs from the major duodenal papilla up to the last 1/3 of the transverse colon

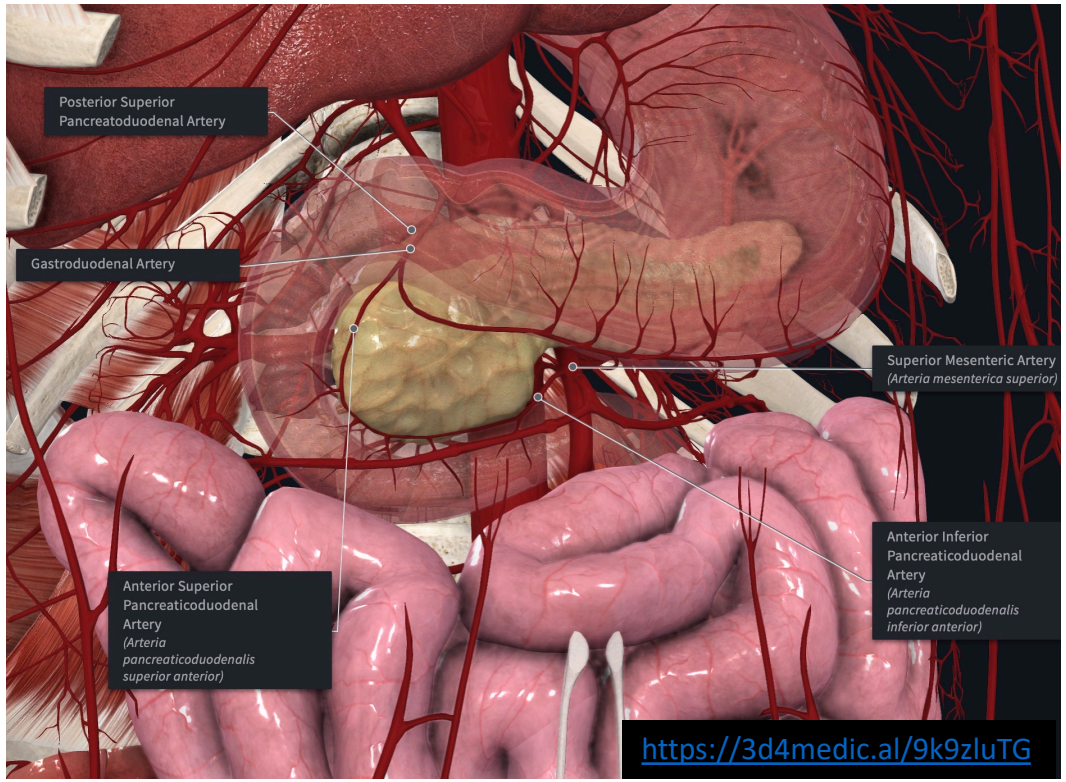
- Hindgut: **Inferior mesenteric artery (IMA)**
  - Branches from aorta inferior to SMA
  - Supplies the distal 1/3 of the transverse colon and the descending colon

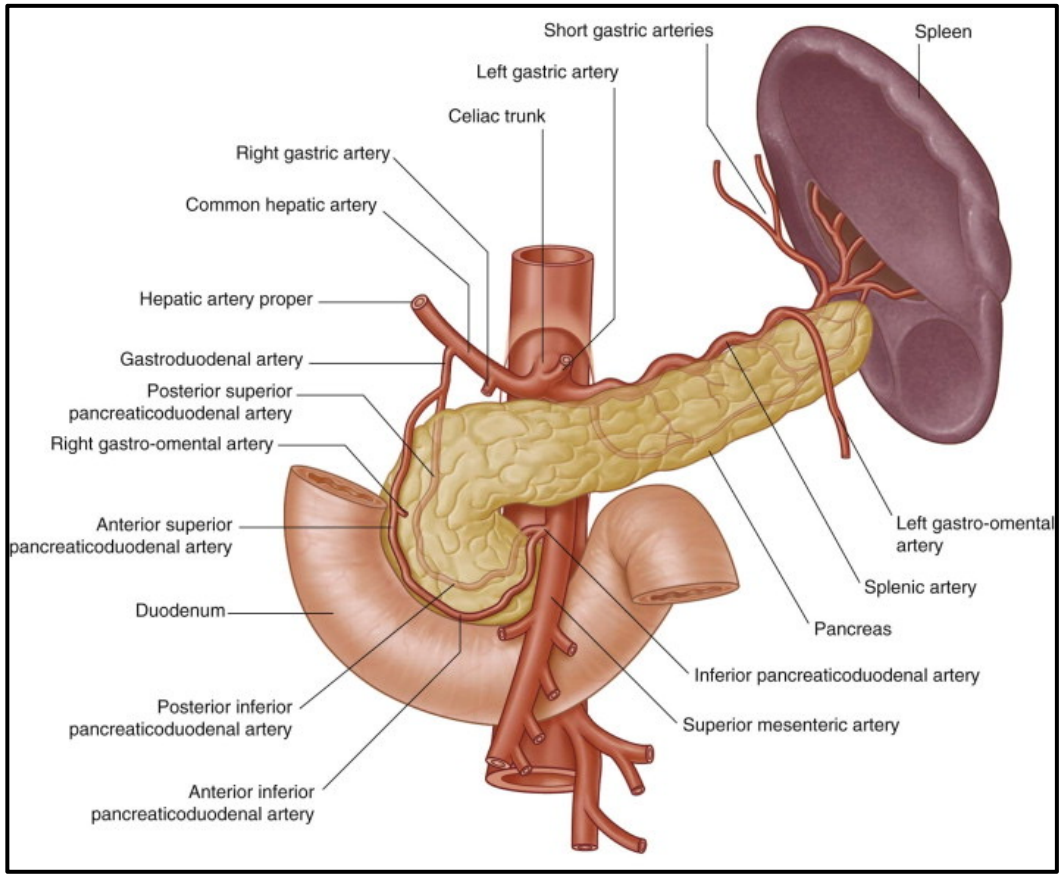


# Superior Mesenteric Artery (SMA): Branches

| ARTERY | ORIGIN | ORGANS SUPPLIED |
|---|---|---|
| Inferior pancreatoduodenal a | • 1st branch of SMA | • Head of pancreas<br>• Duodenum distal to major duodenal papilla<br>• Bifurcates into posterior and anterior aa.<br>• Forms anastomosis with superior pancreatoduodenal aa. |

The initial branches of the superior mesenteric artery distribute to the pancreas and the portion of the duodenum derived from the midgut. These inferior pancreaticoduodenal arteries, which are difficult to dissect, anastomose with superior branches derived from the gastroduodenal artery. The anastomosis between these arteries represents an anastomosis between the blood supply of the foregut and the blood supply of the midgut.



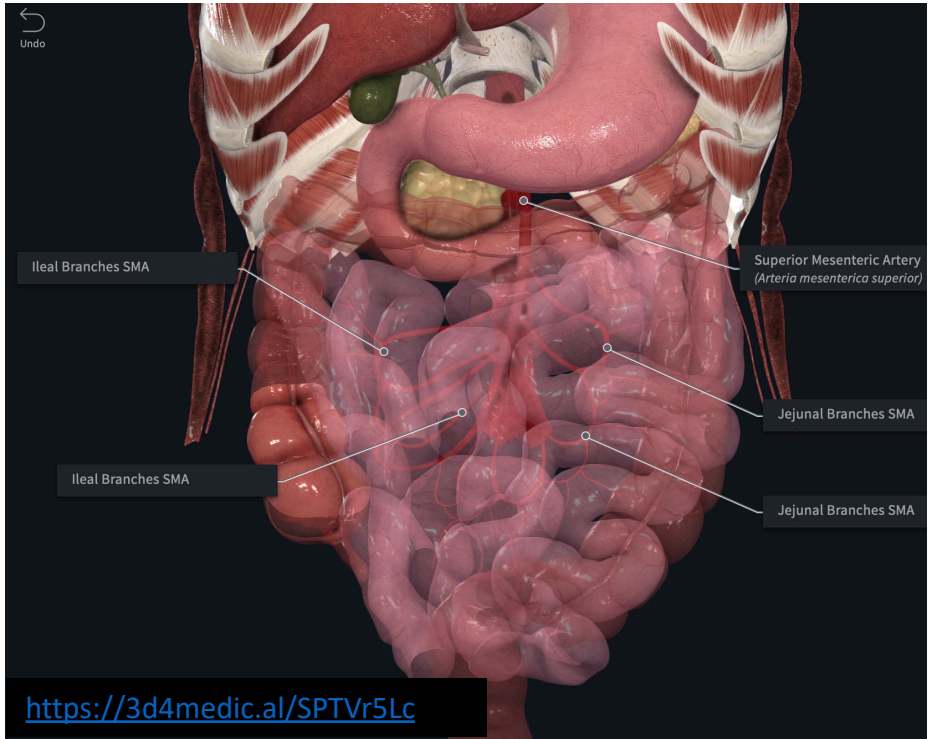



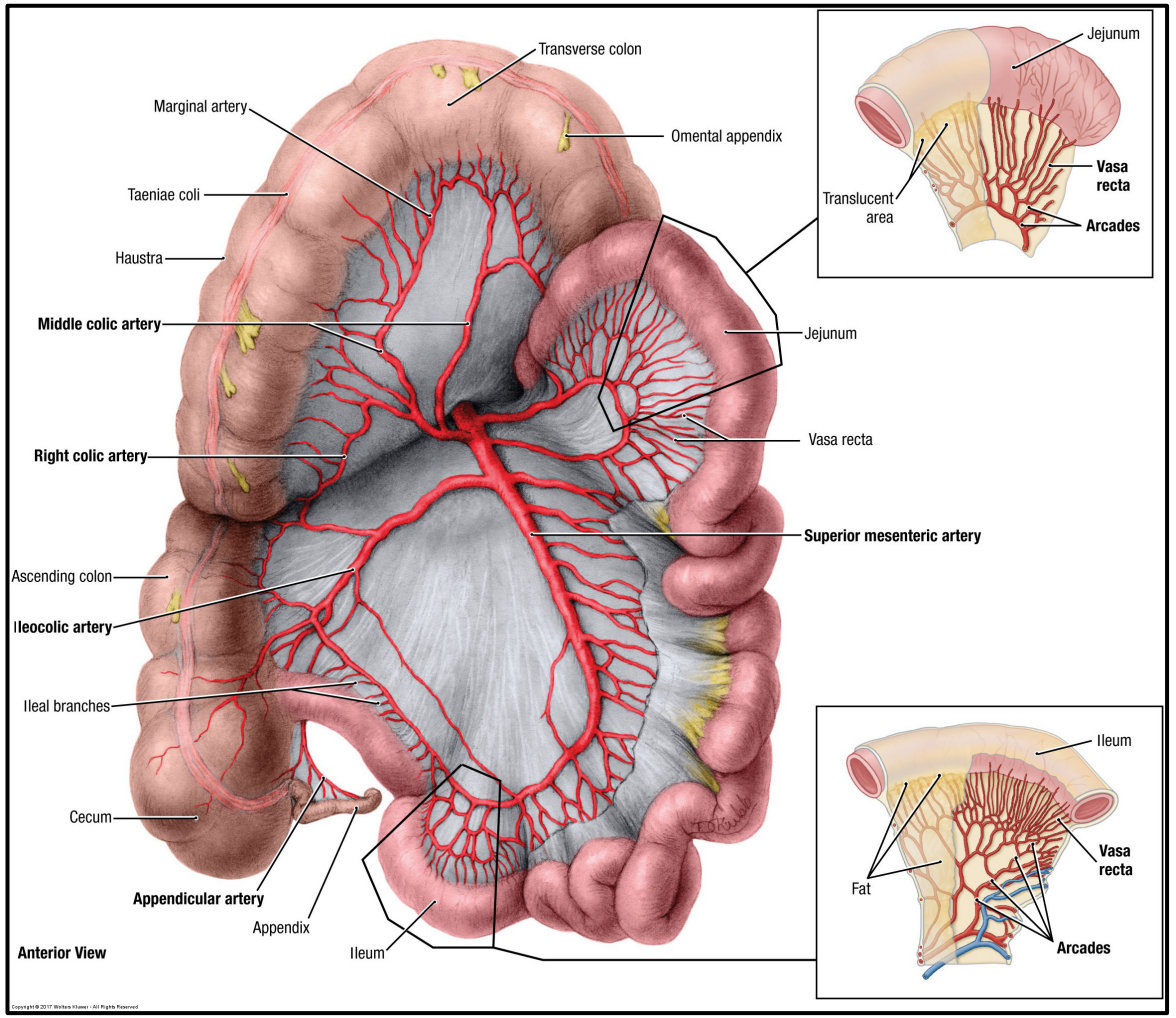
# Superior Mesenteric Artery (SMA): Branches

| ARTERY | ORIGIN | ORGANS SUPPLIED |
|---|---|---|
| Intestinal (jejunal and ileal) aa. | SMA | Jejunum and ileum via arcades and vasa recta |

The SMA courses between the layers of mesentery and forms many intestinal branches that supply the jejunum and ileum. Near the walls of these organs, the arteries anastomose to form loops called arterial arcades. Branches from the arcades form straight arteries called vasa recta that course to the wall of the organ. The arcade and vasa recta anatomy is slightly different in the jejunum as compared to the ileum.

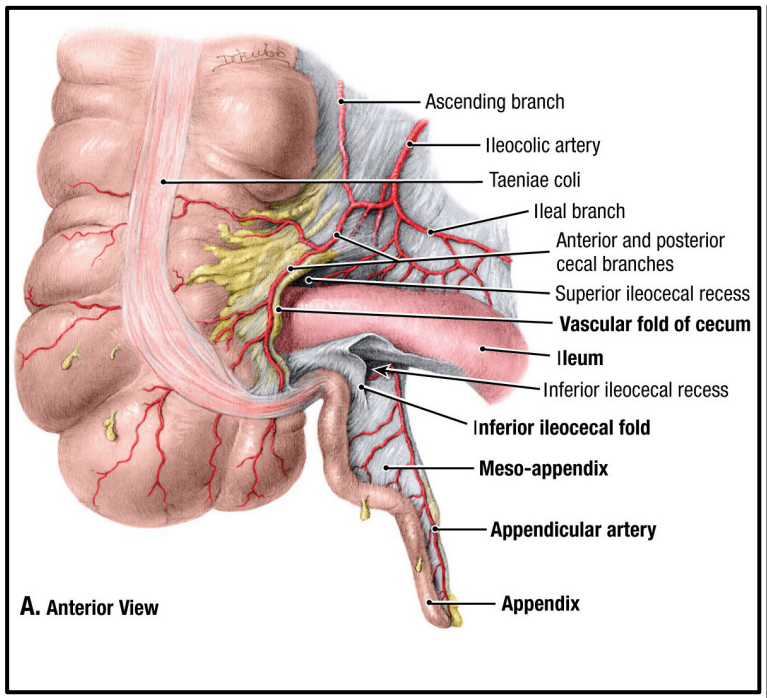
- In the proximal jejunum, the vasa recta are **long, and the arterial arcades are few**.
- In the distal ileum, the **vasa recta are short and arterial arcades are abundant**.

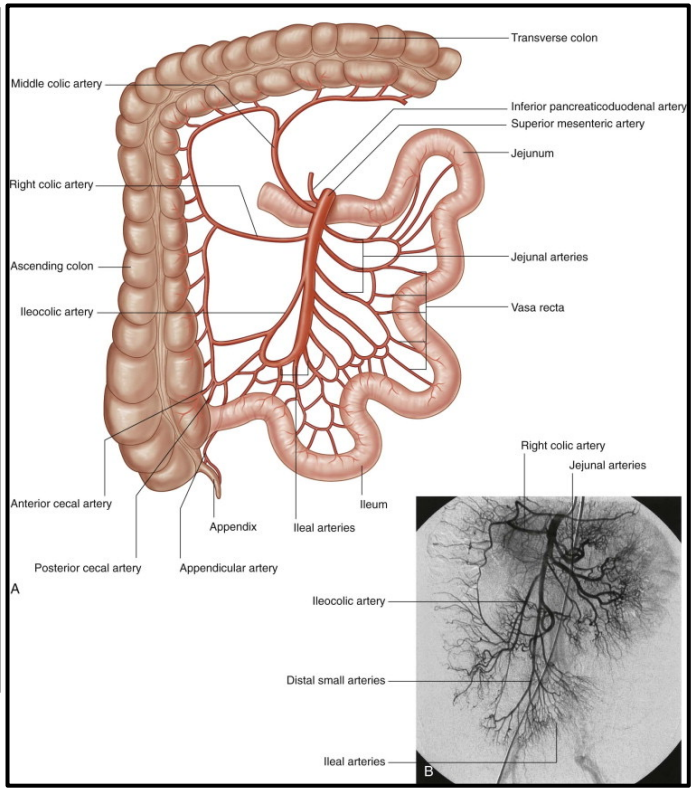


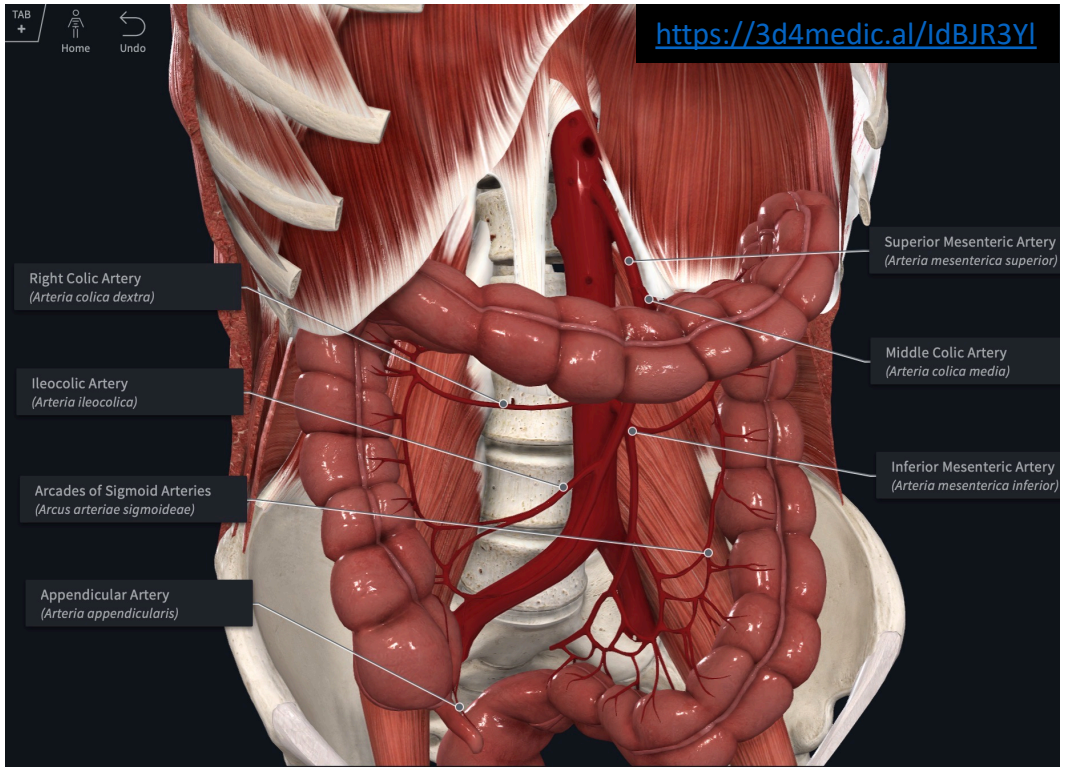



# Superior Mesenteric Artery (SMA): Branches

| ARTERY | ORIGIN | ORGANS SUPPLIED |
|---|---|---|
| Ileocolic a. | SMA | Cecum, ileum, appendix |
| Right colic a. | SMA | Ascending colon |
| Middle colic a. | SMA | Proximal 2/3 of transverse colon |
| Marginal a. Drummond | SMA and IMA | Forms anastomosis along margin of colon between ileocolic, right colic, middle colic, and left colic<br>Forms anastomosis with IMA at left colic (splenic) flexure between middle colic a. (SMA branch) and left colic a. (IMA) branch |



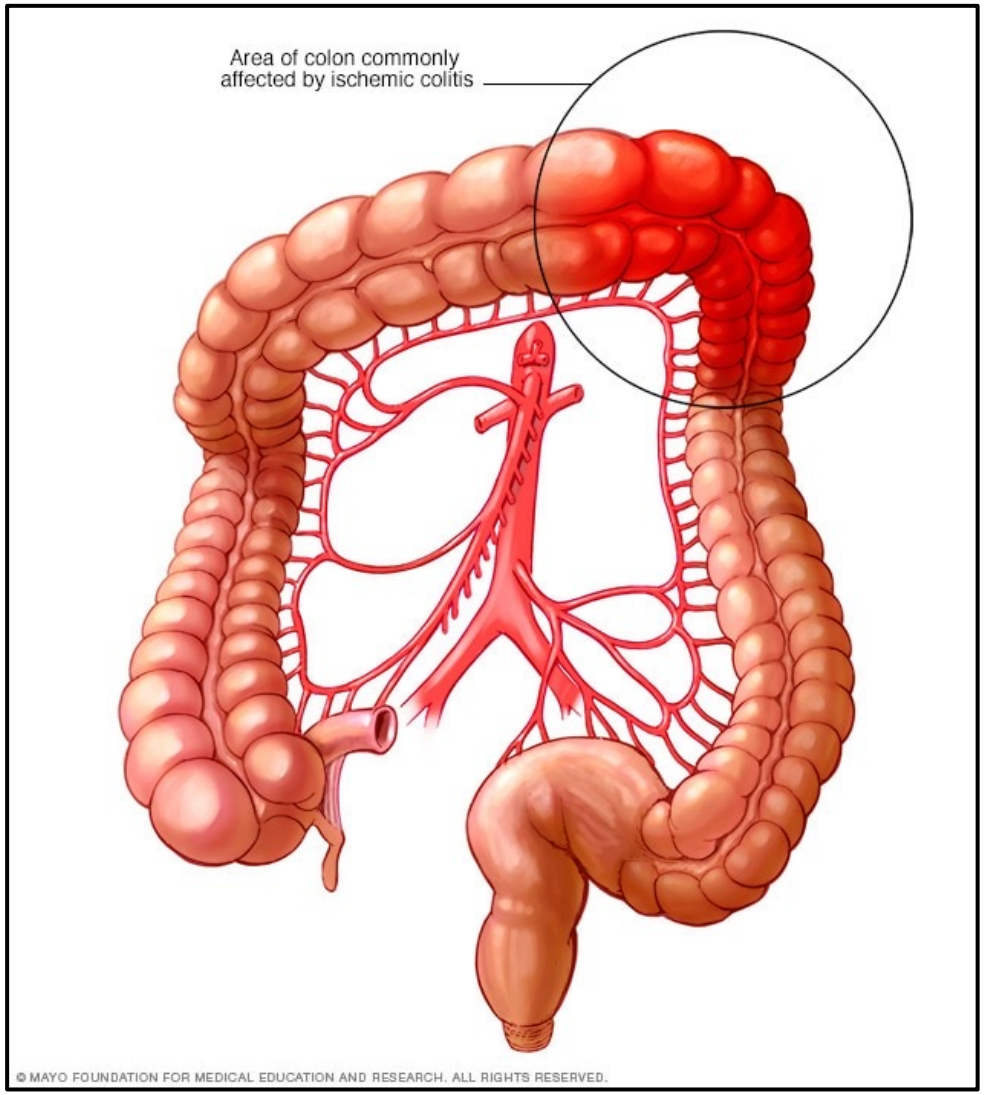



# Splenic Flexure Watershed Area

A **watershed area** is terminology that refers to a region of the body that receives a blood supply from two different vessels.

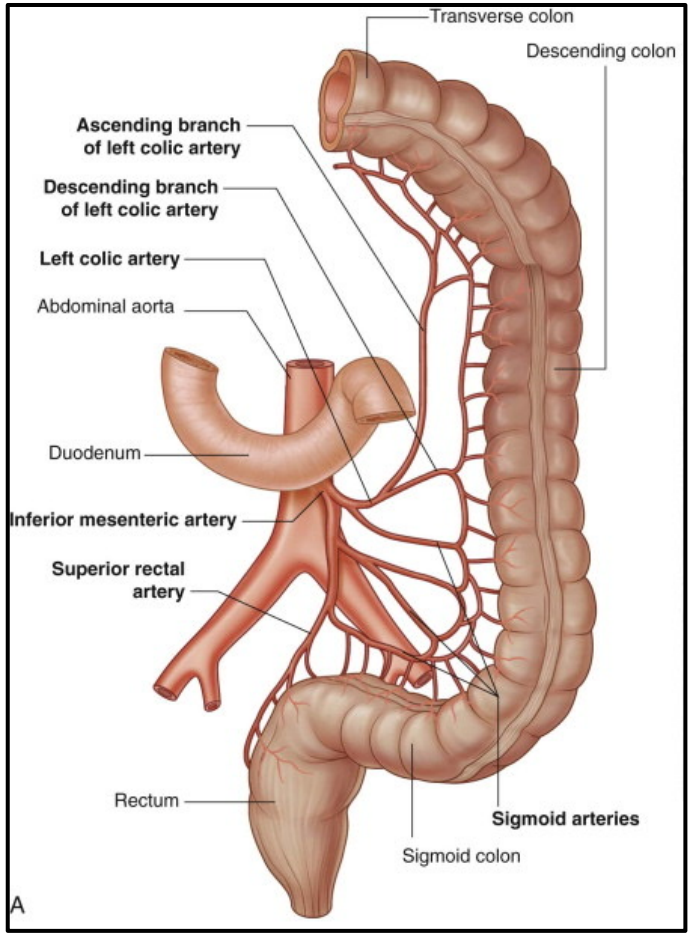
- A watershed area can be protected from ischemia if a blockage occurs in one of the vessels, but adequate flow is maintained in the other vessel.
- Watershed areas are vulnerable to ischemia if hypoperfusion occurs in both vessels, which can occur from a variety of conditions, such as hypotension, heart failure, vasoconstrictive drug use, sickle cell disease, or atherosclerosis. Since both vessels are the most distal segments of their vascular pathways, a decrease in the vessel's blood flow will result in inadequate perfusion to the site of anastomosis.

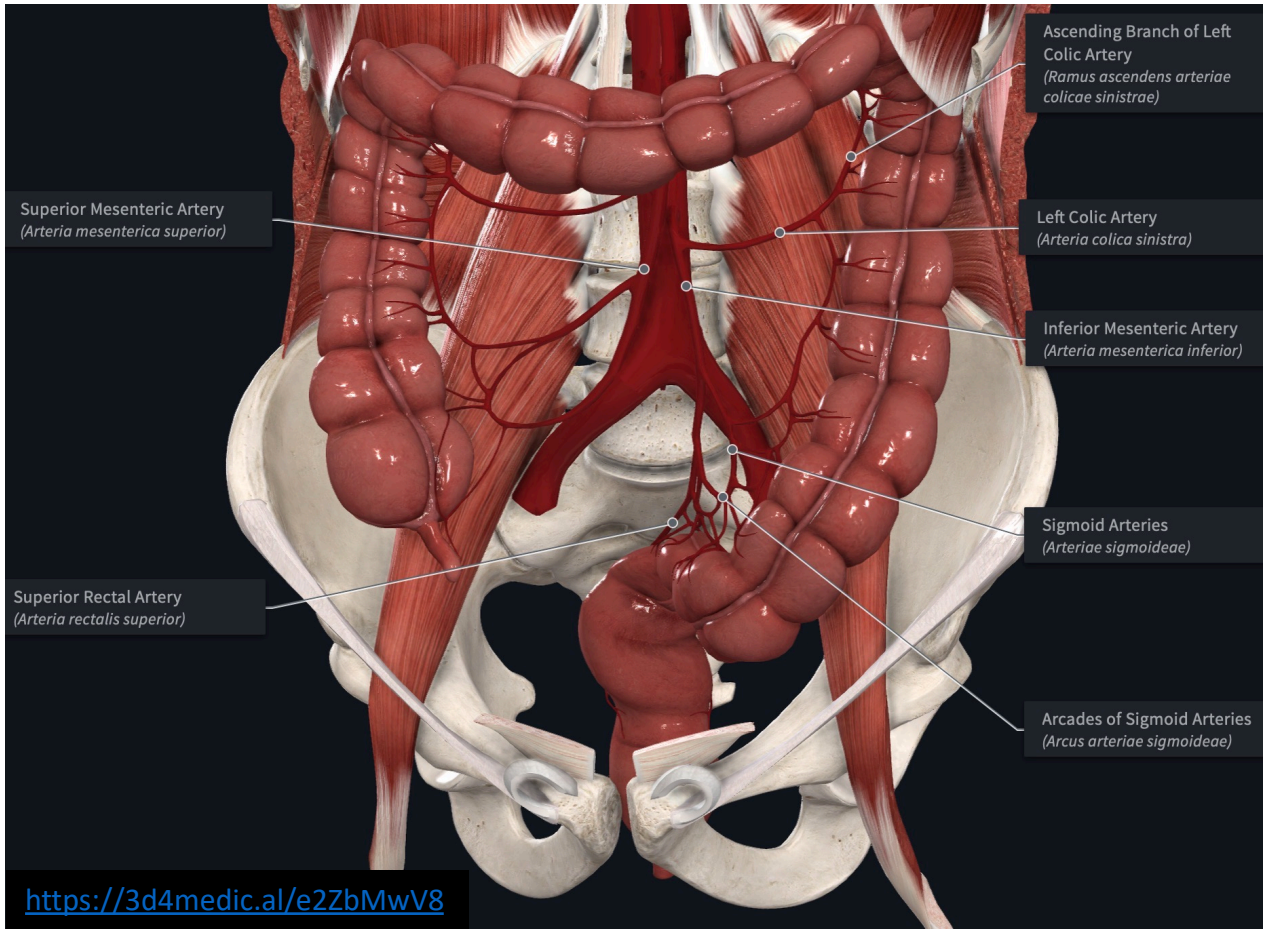
The **splenic flexure** is an important watershed area that is susceptible to ischemic colitis from either an occlusive or non-occlusive hypoperfusion.

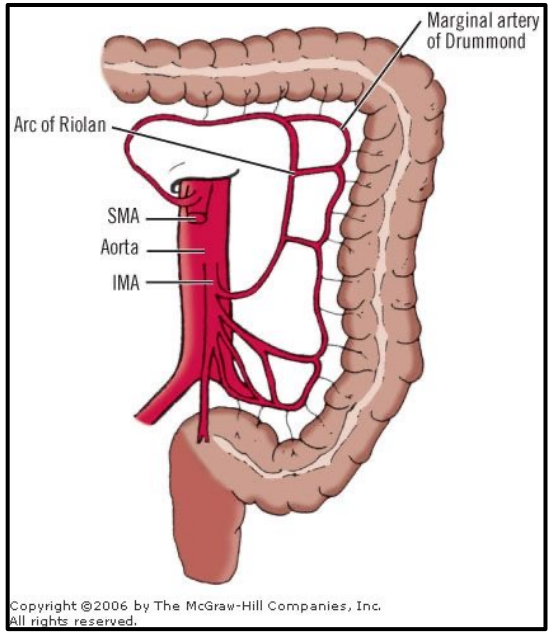


# Inferior Mesenteric Artery (IMA): Branches

| ARTERY | ORIGIN | ORGANS SUPPLIED |
|---|---|---|
| Left colic a. | IMA | Last 1/3 of transverse colon and descending colon |
| Sigmoid a. | IMA | Sigmoid colon |
| Superior rectal a. | IMA | Upper rectum |
| Marginal a. (of Drummond) | SMA and IMA | Forms anastomosis along margin of colon between ileocolic, right colic, middle colic, and left colic |
| Arc of Riolan | SMA and IMA | Forms anastomosis between left colic and middle colic at splenic flexure |



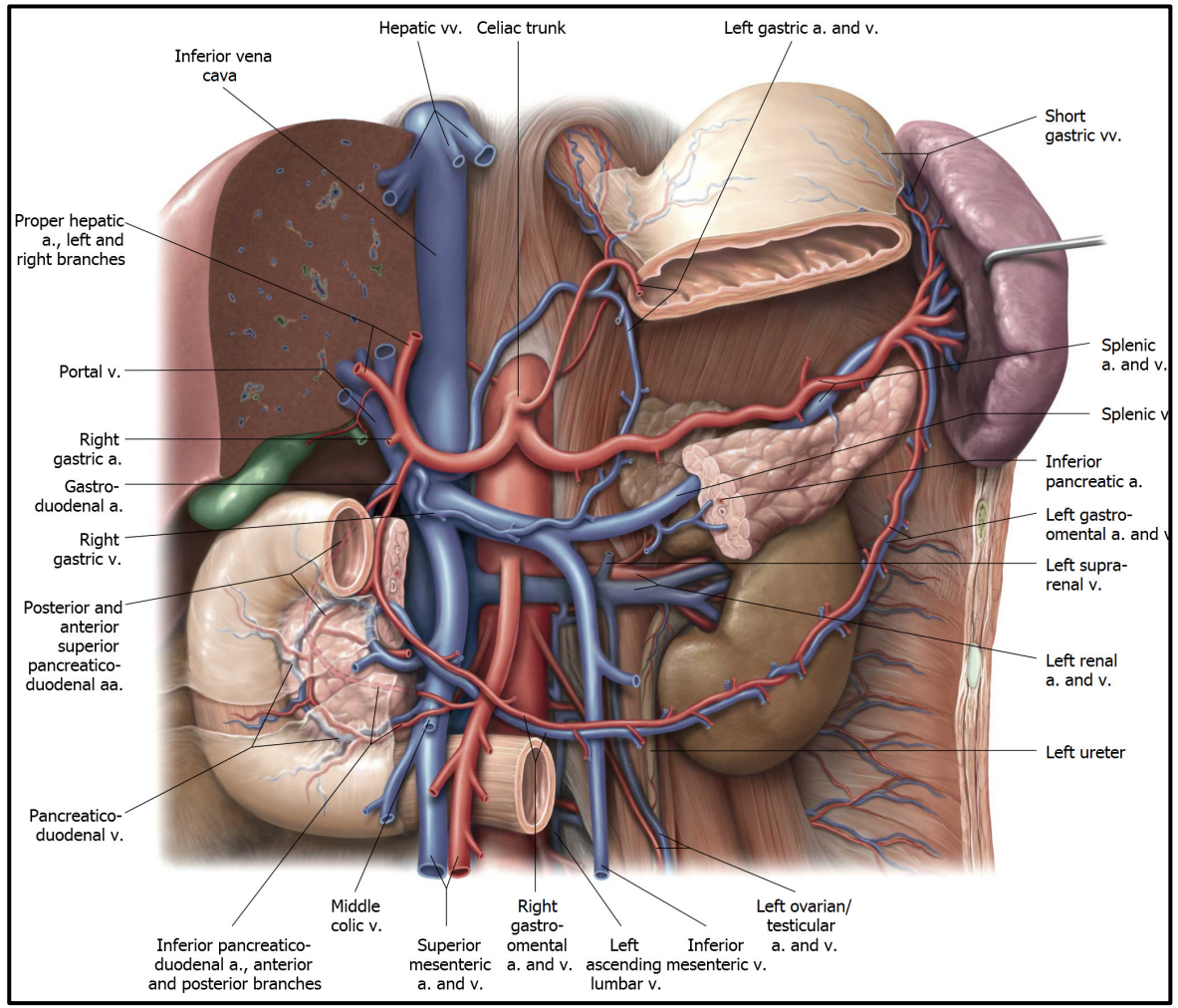



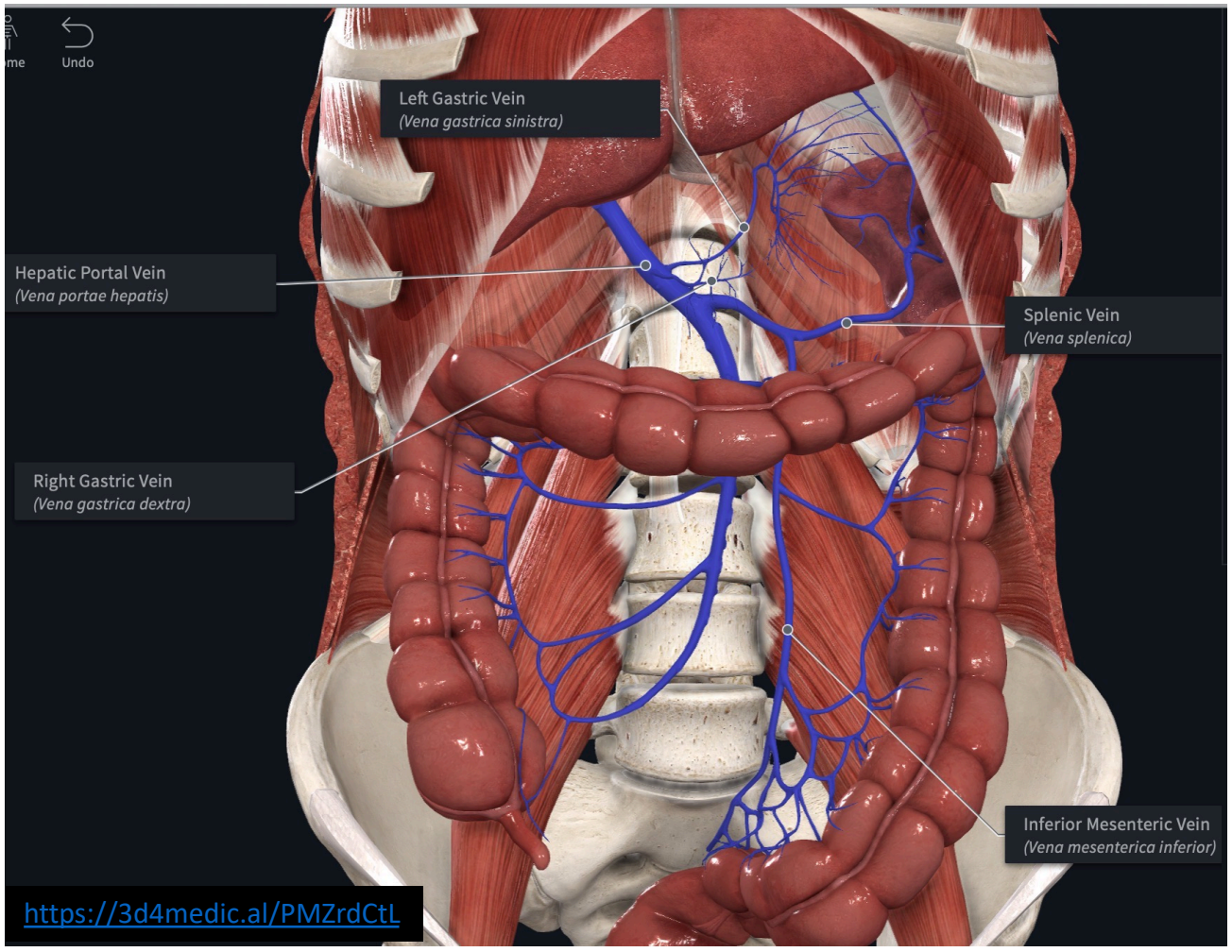



# Tributaries of the Hepatic Portal Vein

All of the following veins drain into the hepatic portal vein.

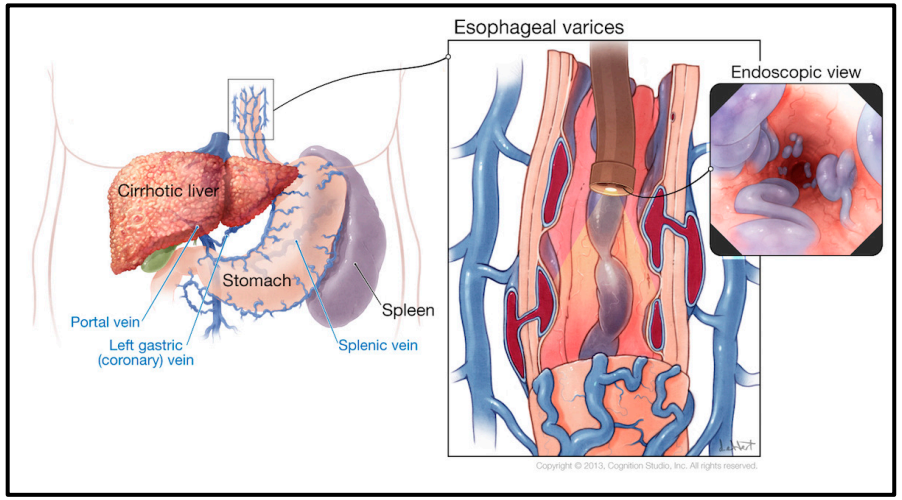
| VEIN | DRAINS INTO | ORGANS DRAINED |
|---|---|---|
| Splenic v | Joins superior mesenteric vein to form hepatic portal v. | Last 1/3 of transverse colon and descending colon |
| Superior mesenteric v.. | Joins splenic vein to form hepatic portal v. | Midgut and part of foregut (greater curvature of stomach via greater omental veins) |
| Inferior mesenteric v. | Splenic vein (sometimes SMA) | Hindgut including proximal third of rectum |
| Gastric veins (left and right) | Hepatic portal v. | Lesser curvature of stomach |

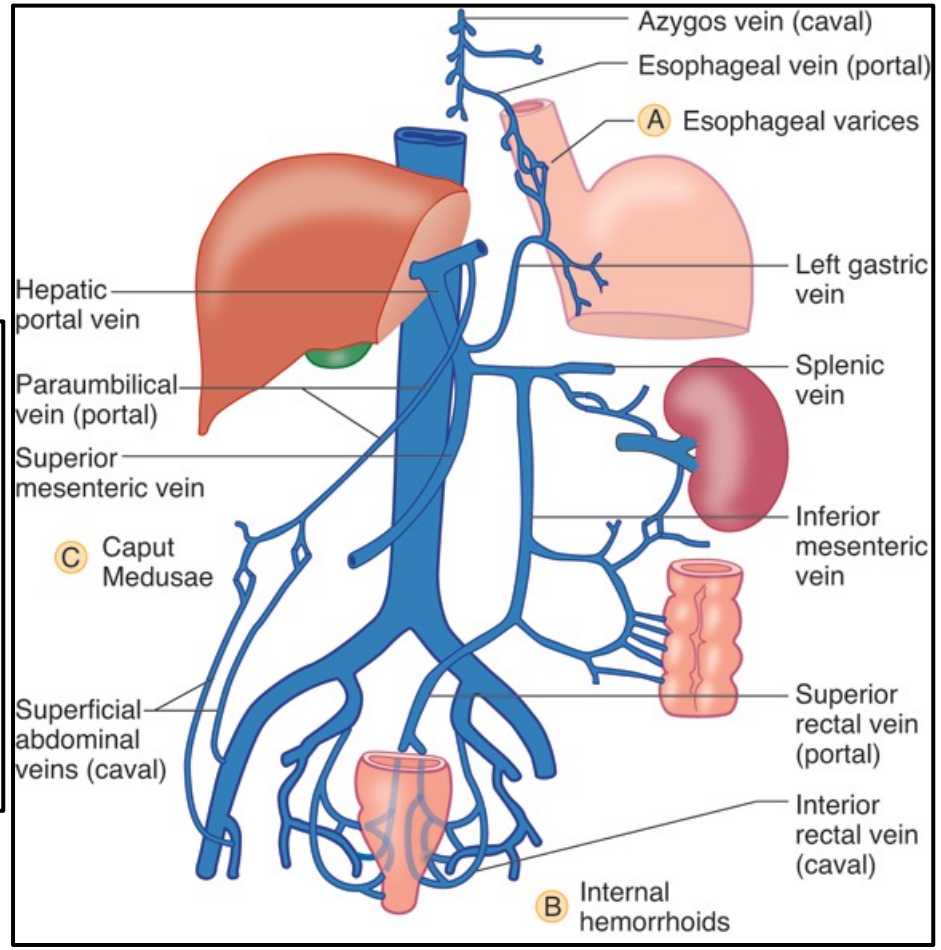


# Review: Portacaval Anastomosis

- **Hepatic portal venous system** refers to the ”nutrient-rich” venous blood that is transported from the foregut, midgut, and hindgut to the liver.
- **Caval (venous) system** refers to veins from the lower limbs, pelvis, and posterior abdominal wall that transport venous blood directly to the inferior vena cava.
- A **portacaval anastomosis** is a junction between areas drained by BOTH the portal and caval systems. The clinically important portal-caval anastomoses include the following junctions. In severe cases of portal hypertension, these regions become engorged with blood.
  - Anterior abdominal wall (Figure = Letter C): Results in caput medusae
    - Superficial epigastric veins (skin around umbilicus) → paraumbilical veins → hepatic portal
    - Superficial epigastric veins (skin around umbilicus) → epigastric veins → venous circulation
  - Distal esophagus (Figure = Letter A): Results in esophageal varices
    - Esophagus → azygos vein → superior vena cava
    - Esophagus → left gastric v.→ hepatic portal v.
  - Rectum (Figure = Letter B): Results in internal hemorrhoids
    - Superior rectal v. → portal circulation
    - Middle and inferior rectal v. → inferior vena cava



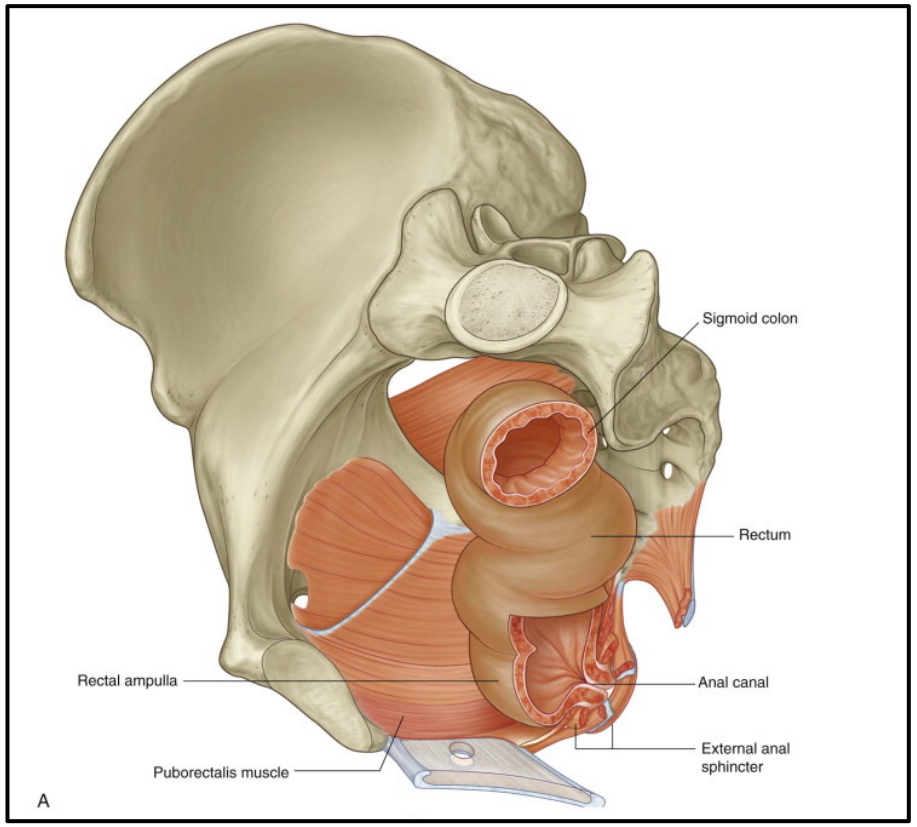



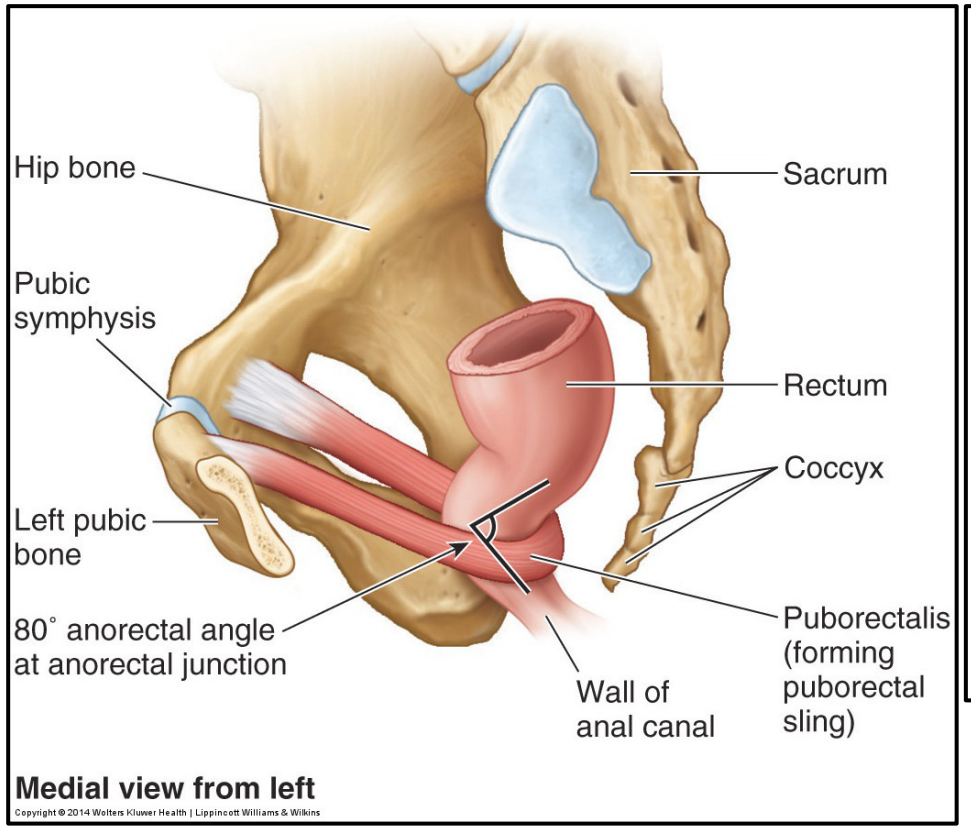
# Rectum

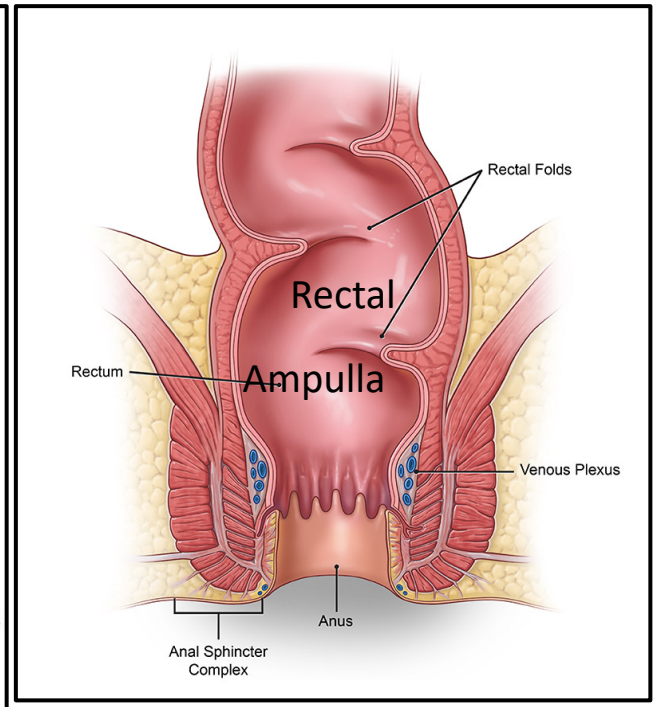
The rectum is the portion of the digestive tract located within the pelvic cavity. It is the segment of large intestine between the sigmoid colon proximally, and the anal canal distally.

- The rectosigmoid junction is located anterior to the S3 vertebra.
- The anorectal junction is located at approximately the top of the coccyx. In this location, the **puborectalis muscle** wraps around the anorectal junction causing the lumen to be pulled into an 80° angle. The puborectalis muscle is innervated by perineal nerve branch of the **pudendal nerve**.
- The **rectal ampulla** is the dilated distal portion of the rectum.
- **Transverse rectal folds** are located along the wall of the rectum. These folds function to slow down the movement of feces toward the anal canal.

**FUNCTIONAL ANATOMY:** The 80° (approximately) anorectal flexure is an important mechanism for fecal continence, being maintained during the resting state by the tonus of the puborectalis muscle, and by its active contraction during peristaltic contractions if defecation is not to occur.



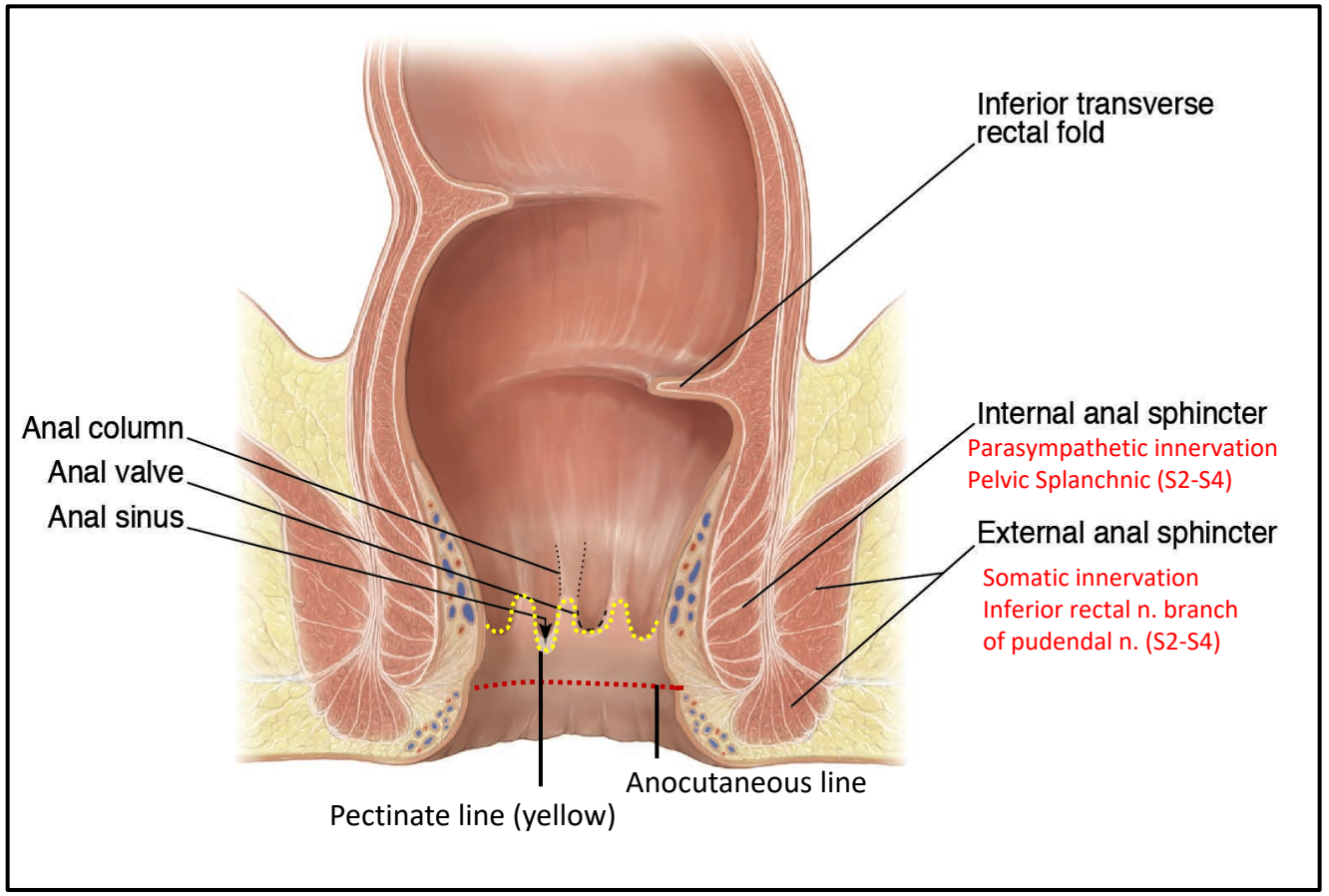



# Anal Canal

The anal canal is approximately 4 cm long and is divided into an upper and lower canal by the **pectinate line**.

- The upper anal canal extends from the anorectal junction to the pectinate line. The following structures are associated with the upper anal canal.
  - The mucosa consists of folds called **anal columns (of Morgagni).**
  - Anal columns are continuous with each other at their inferior ends to form **anal valves**.
  - The space just superior to each valve is an **anal sinus**.
  - Collectively, the anal valves form a circle around the anal canal, which defines the **pectinate line.** The pectinate line divides the nerve and blood supply to, and the lymphatic drainage from, the proximal and distal parts of the anal canal.
- The lower anal canal extends from the pectineal line to the anocutaneous line. This junction represents the location where stratified squamous epithelium transitions to keratinized stratified squamous epithelium.




**FUNTIONAL ANATOMY:** The anal sinuses contain glands that exude mucus when compressed by feces. This mucus aids in evacuation of feces from the anal canal.

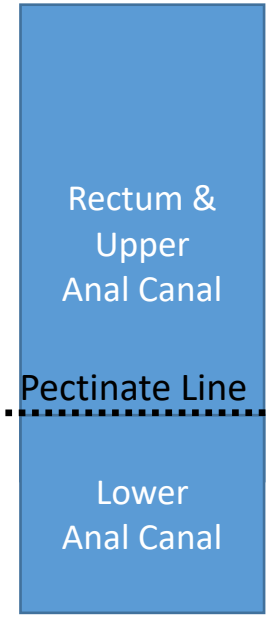
The anal canal is surrounded by muscle.

- The **internal anal sphincter** consists of smooth muscle surrounding the superior two-thirds of the anal canal. The smooth muscle of the internal anal sphincter is a thickened region of the muscularis externa's circular layer that is continuous throughout the GI tract. This muscle is controlled by the **parasympathetic nervous system** and is contracted most of the time, but relaxes during defecation.
- The **external anal sphincter** consists of skeletal muscle surrounding the inferior two-thirds of the anal canal. The skeletal muscle of the external anal sphincter blends superiorly with the puborectalis muscle. This muscle is controlled voluntarily by the **somatic nervous system**. Voluntary relaxation results in defecation.

# Summary of Anal Canal Innervation, Arterial Supply, and Lymph and Venous Drainage

| **Rectum & Upper Anal Canal** |
|---|
| Arterial Supply:<br>Inferior mesenteric a. →Superior rectal a. |
| Venous Drainage:<br>→ Superior rectal v.→ inferior mesenteric v. →hepatic portal v. (internal hemorrhoids: no pain) |
| Parasympathetic Innervation (Visceral motor) = Motor to internal anal sphincter<br>• Pelvic splanchnic n. (S2-S4) →Inferior hypogastric plexus → ganglia wall of organ |
| Sympathetic Innervation = Vasomotor<br>• Lateral horn (T12-L2) →Least/lumbar splanchnic (T12-L2)→preaortic ganglia → hypogastric plexuses |
| Visceral sensory innervation<br>• Neurons course alongside parasympathetic pelvic splanchnic neurons to spinal cord S2-S4 |
| Lymph Drainage<br>• →internal iliac lymph nodes |

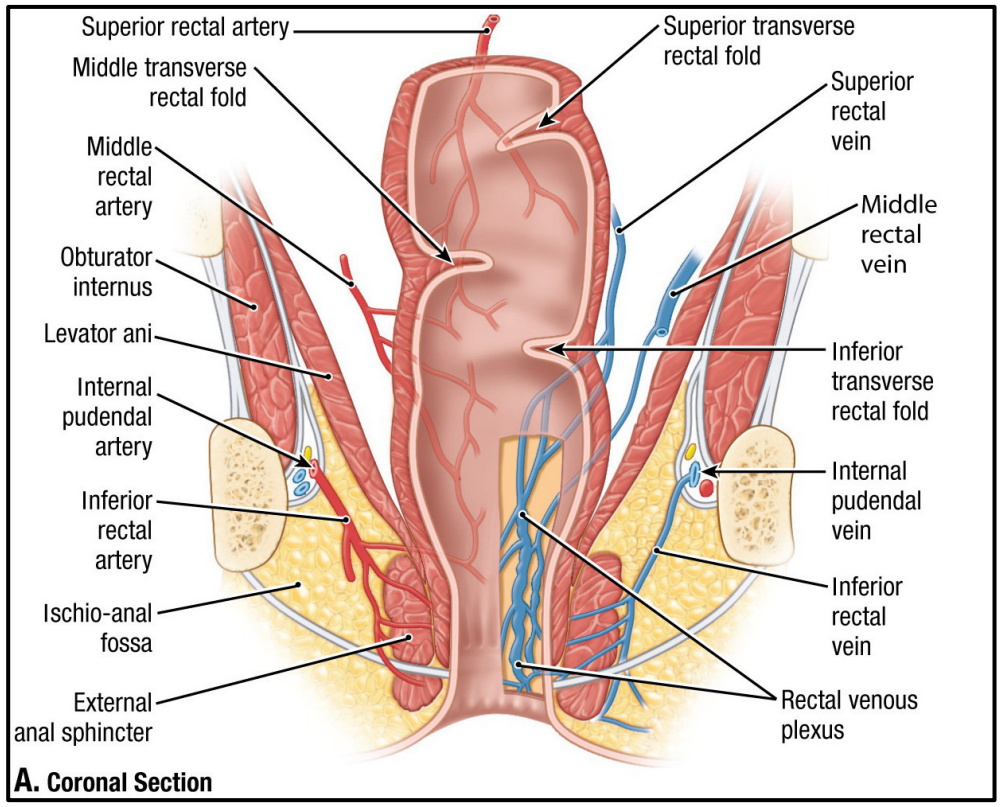
| **Lower Anal Canal** |
|---|
| Arterial Supply:<br>• Internal iliac a. → Internal pudendal a. →Inferior rectal a. |
| Venous Drainage:<br>• → Inferior rectal v. → internal pudendal v. → internal iliac v. → IVC (external hemorrhoids: painful) |
| Somatic Motor (motor to external anal sphincter)<br>• Ventral horn S2-S4→pudendal n→ inferior rectal n |
| Somatic Sensory<br>• Neurons course within inferior rectal n.→ pudendal n.→ dorsal horn spinal cord S2-S4 |
| Sympathetic Innervation (vasomotor)<br>• Lateral Horn Lumbar Region → Paravertebral ganglia S2-S4 Vertebral Level →pudendal n→ inferior rectal n |
| Lymph Drainage:<br>• →Superficial inguinal lymph nodes |

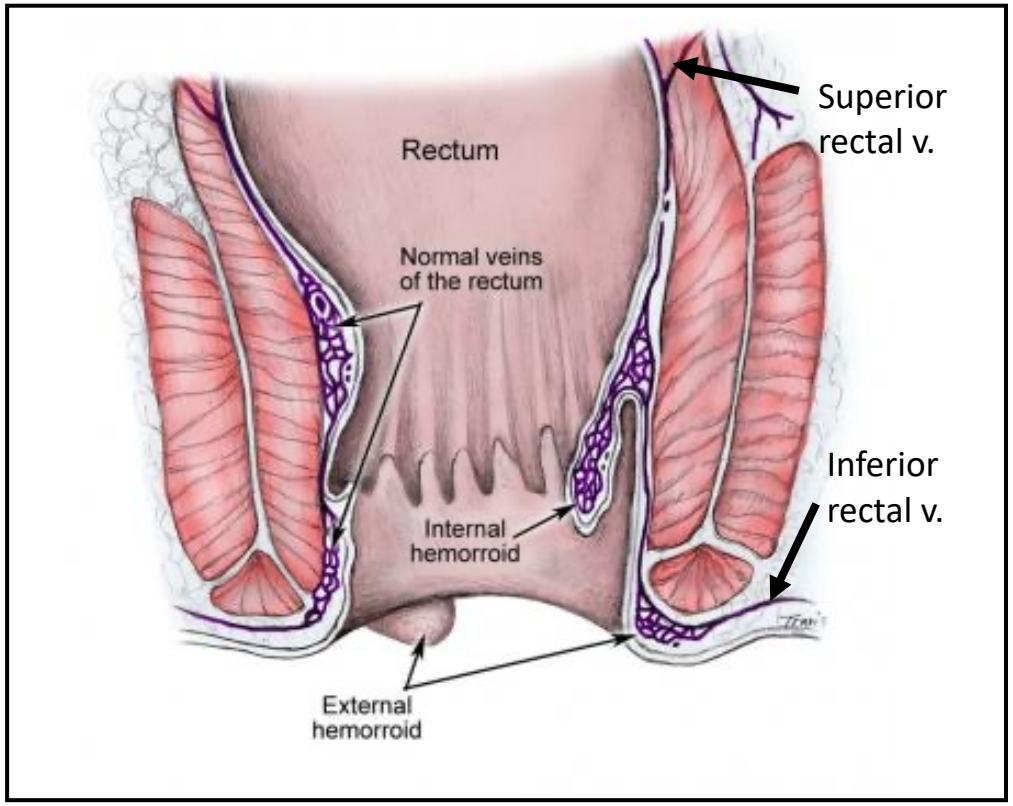


# Hemorrhoids

**CLINICAL ANATOMY:** Hemorrhoids are varicosities in the rectal veins.

- Internal hemorrhoids are varicosities of superior rectal veins above the pectinate line that prolapse into the lumen of the anal canal. Internal hemorrhoids may also prolapse through the anus. Because the mucosa above the pectinate line is derived from endoderm and, therefore, is innervated by autonomic fibers, there is no pain associated with internal hemorrhoids.
- External hemorrhoids are varicosities of the inferior rectal veins that typically result from the presence of thromboses within them. External hemorrhoids are located in the superficial fascia around the anus. Because this region of the anal canal is derived from somatic tissues and is innervated by somatic nerves, significant pain is associated with external hemorrhoids.

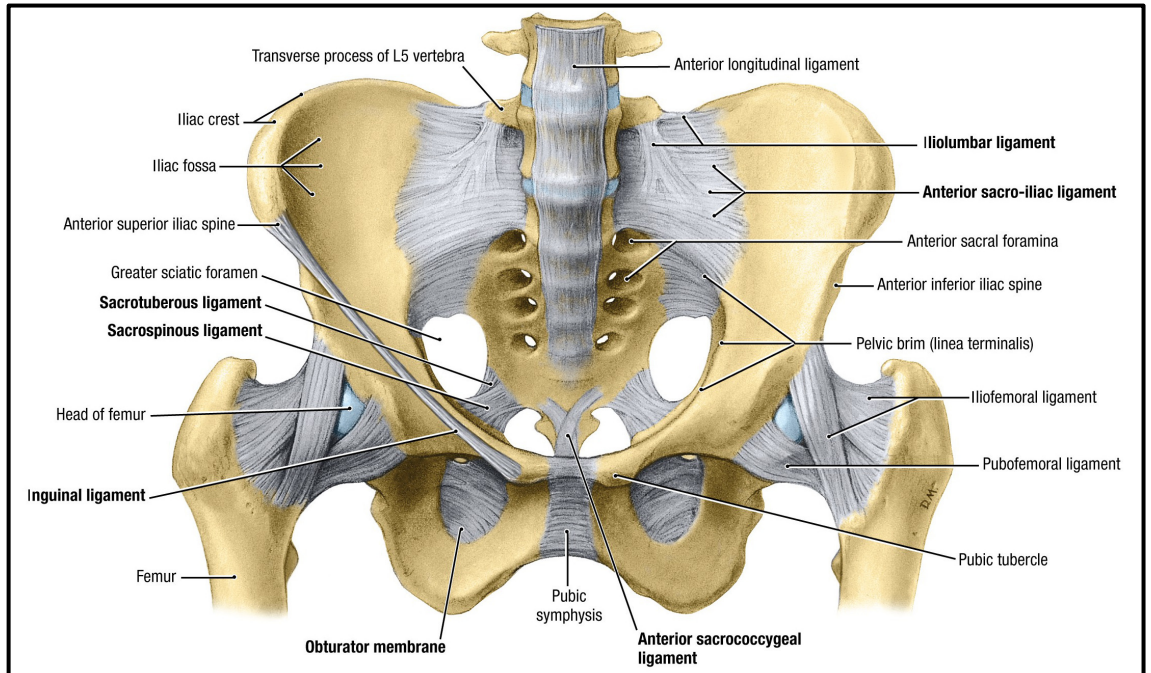


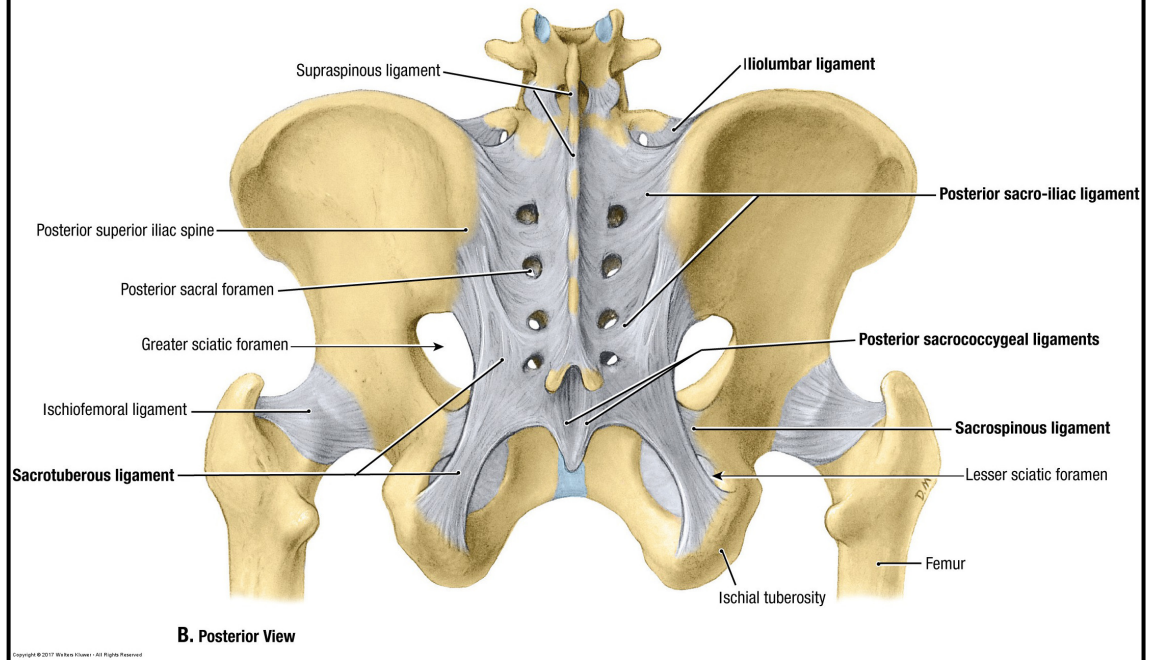



# Pelvic Ligaments, Osseous Features, & Spaces

Review the following osseous features, ligaments, and spaces of the pelvis.

- **Inguinal ligament**
- **Lacunar ligament**
- **Ischial spine**
- **Ischial tuberosity**
- **Sacrospinous ligament**
- **Sacrotuberous ligament**
- **Greater sciatic foramen**
- **Lesser sciatic foramen**
- **Obturator foramen**
- **Obturator membrane**

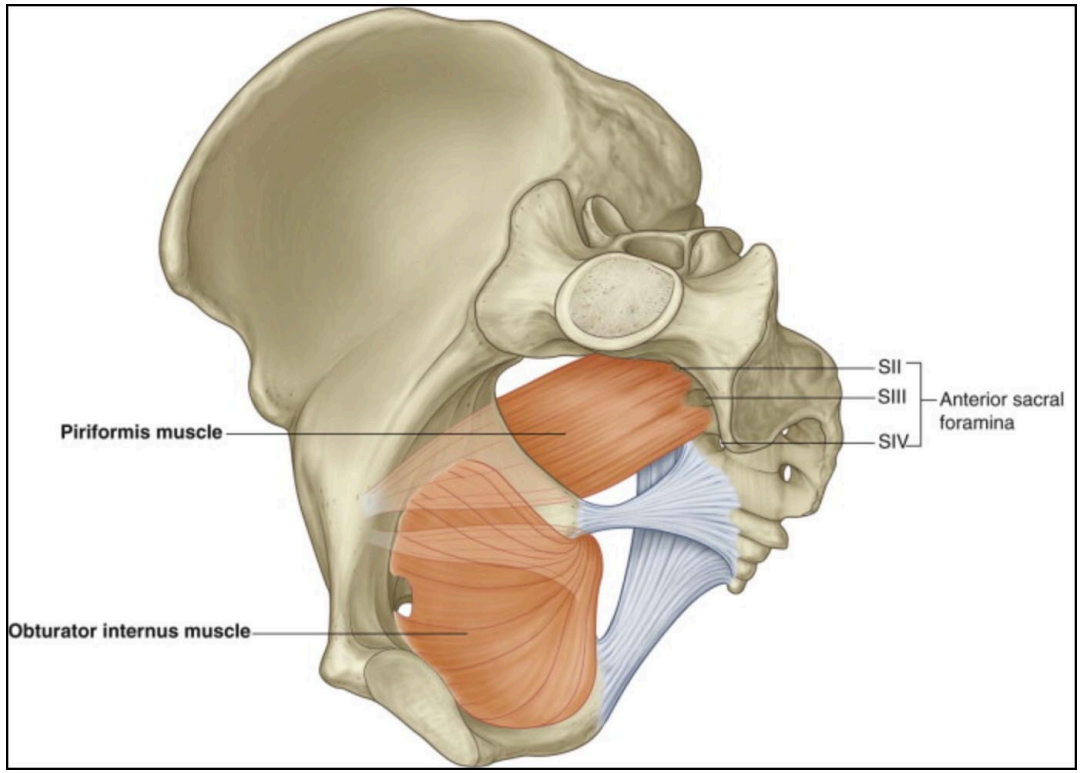


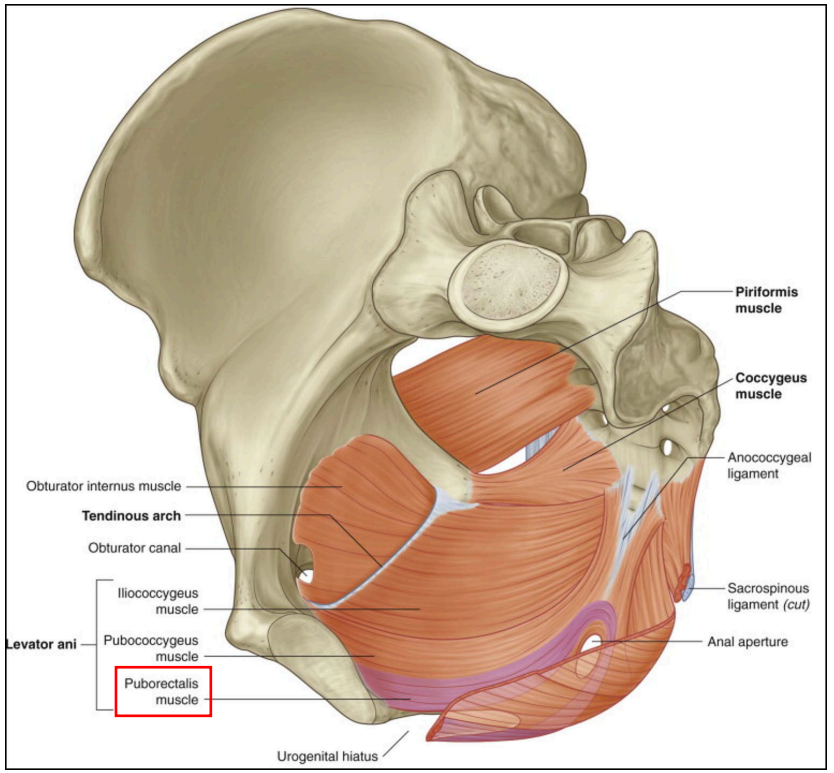



# Pelvic Cavity Boundaries

Because the distal end of the digestive tract passes through the pelvis, it is important to have a basic understanding of the pelvic cavity.

- Lateral walls: **obturator internus muscle**: The obturator interns muscle inserts on the internal surface of the obturator membrane and passes through the lesser sciatic foramen to insert on the greater trochanter of the femur. Within the pelvis, the obturator internus muscle is covered in thick fascia called the obturator fascia.
- Posterior walls: **piriformis muscle**: The proximal attachment of the piriformis muscle is on the anterior aspects of the S2-4 vertebral segments and passes through the greater sciatic foramen to its distal attachment on the greater trochanter of the femur.
- Floor: **The pelvic diaphragm (pelvic floor)** is a funnel-shaped, muscular structure that supports pelvic organs, including the rectum. It consists of the the **levator ani** and the **coccygeus (ishiococcygeus)** muscles.
    - The levator ani muscle is composed of 3 muscles: **puborectalis**, pubococcygeus, and iliococcygeus. The most important muscle in this unit is the **puborectalis** muscle because it forms a U-shaped muscular "sling" around the rectum.
    - The coccygeus muscle's superior border is adjacent to the inferior border of the piriformis muscle. Its origin is on the ischial spine and the pelvic surface of the sacrospinous ligament. It inserts onto the lateral margin of coccyx and the most inferior portion of sacrum.



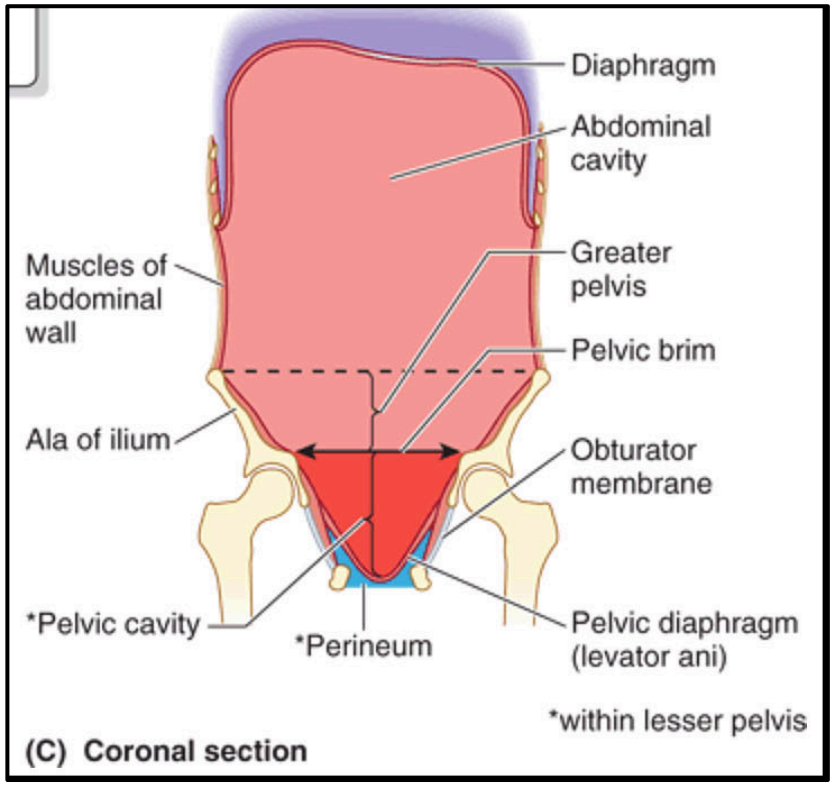
# Perineum

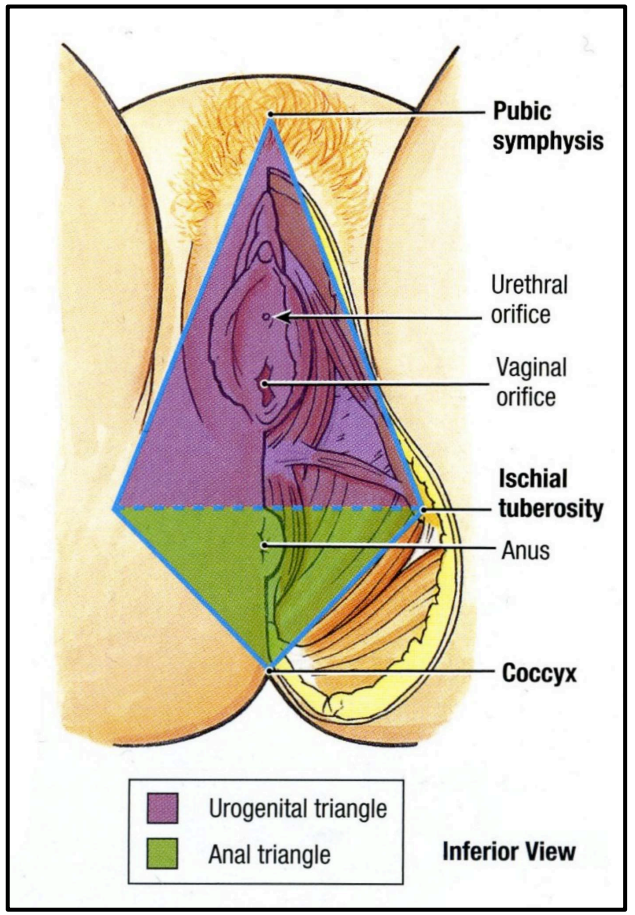
The **perineum** is the anatomical term for the region of the body wall located inferior to the pelvic diaphragm. The perineum is the diamond-shaped region of the body wall inferior to the pelvic diaphragm between the buttocks and thighs.

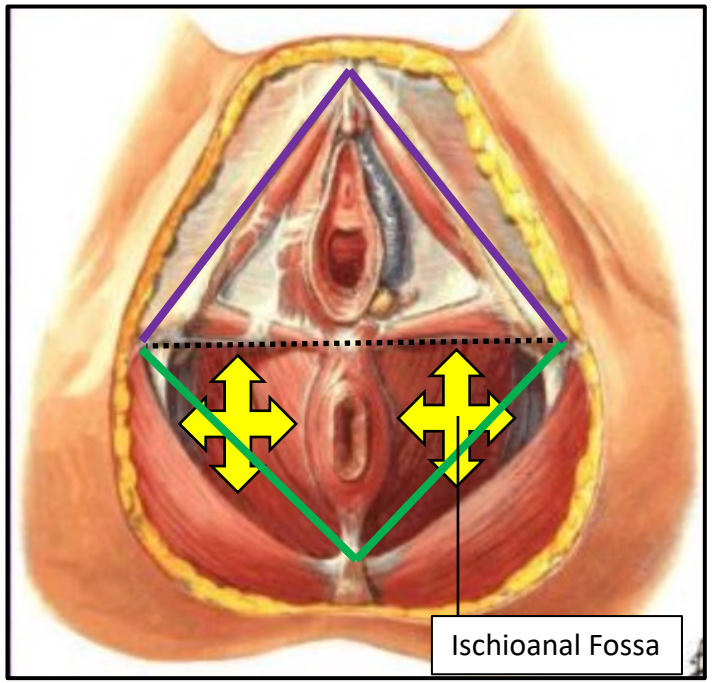
- Anterior: inferior border of pubic symphysis
- Anteriolateral margin: ischiopubic ramus
- Posteriolateral margin: sacrotuberous ligament
- Posterior: tip of coccyx

The diamond-shaped perineum can be further subdivided into two triangular regions by an imaginary line connecting the two ischial tuberosities.

- The anal triangle contains the anus and the **ischioanal fossa**. The ischioanal fossae are large fat-filled spaces on either side of the anal canal.
- The urogenital triangle contains the external genitalia.

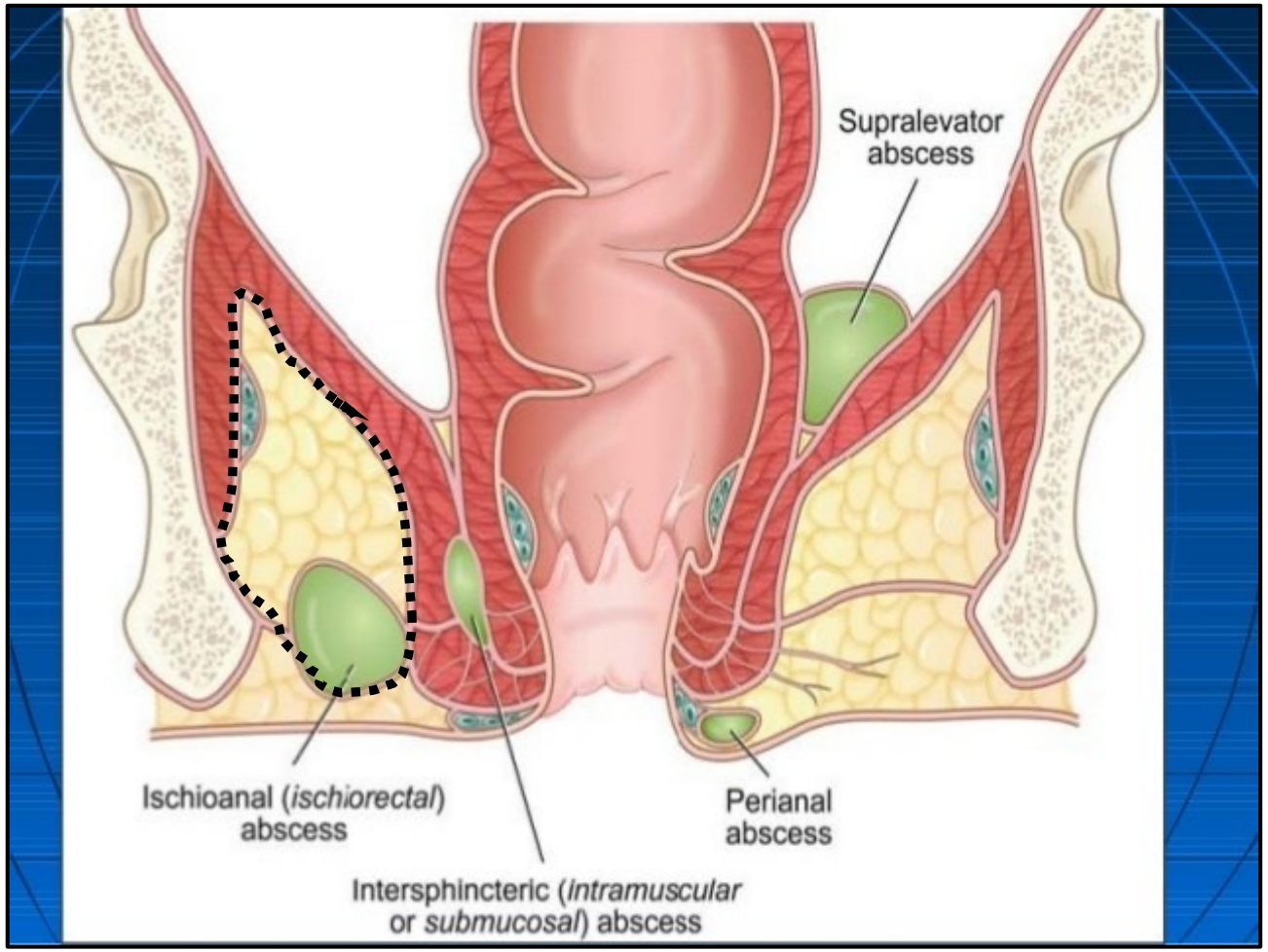


# Ischio-anal Fossa

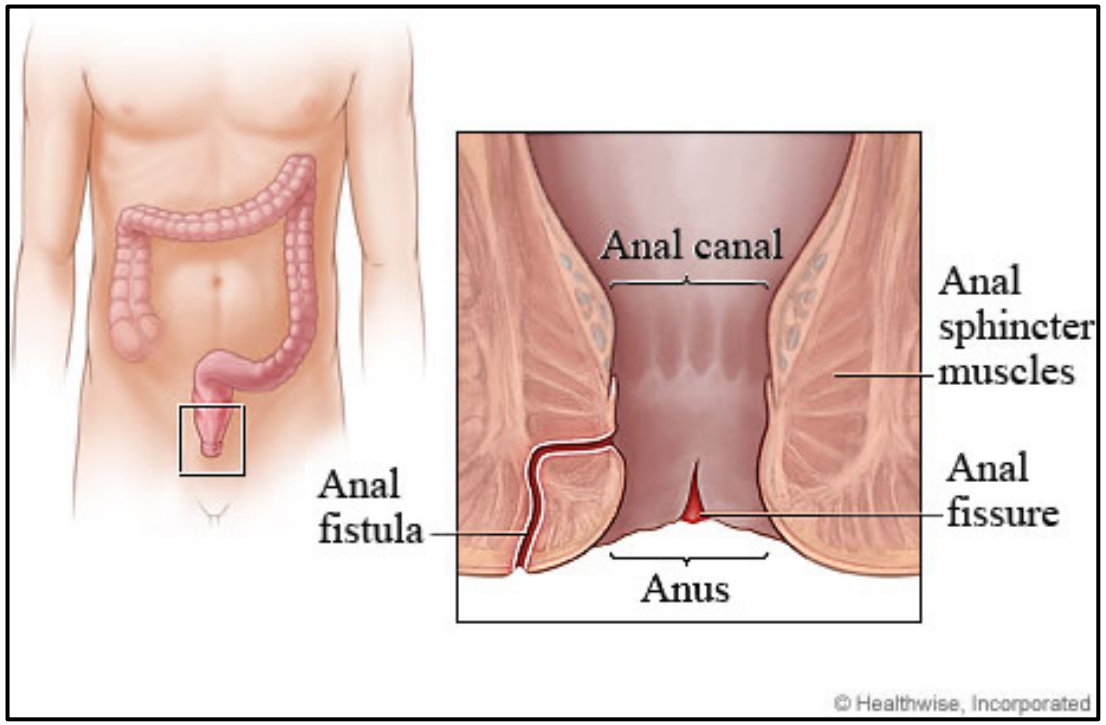
**CLINICAL ANATOMY:** The ischio-anal fossae are filled with fat that is continuous with the fat of the subcutaneous fascia. Infections within the ischio-anal fossae (ischio-anal abscesses) are quite painful and are indicated by fullness and tenderness between the anus and the ischial tuberosity.



# Anal Fistulas and Fissures

**CLINICAL ANATOMY:** Anal fistula versus anal fissure

- An **anal fissure** is a short longitudinal tear in the anal mucosa. They may be restricted to the epithelium of the mucosa or involve the entire thickness of the mucosa. Anal fissures are commonly caused by hard stools as they pass through the lower anal canal. Physiological changes, such as hypertonicity and hypertrophy of the internal anal sphincter can occur in response to anal fissures. Constipation and hypertrophy of the internal sphincter leads to increased pressure within the anal canal, which compresses the stool against the epithelium making the pain worse with each bowel movement.
- A **peri-anal fistula** is a communication between the anal canal and the perianal skin. They often occur secondary to a perianal abscess that develops a drainage tunnel to the perianal skin.



# Summary of Abdominal/Inguinal Innervations

## Summary of the innervation of the abdomen and inguinal region

| NERVE | COMPONENT(S) | MAJOR DISTRIBUTION |
|---|---|---|
| Intercostals (T7-T11)<br>Subcostal (T12)<br>Iliohypogastric (L1) | GSA | skin of the abdominal wall |
| | GSE | muscles of the anterior abdominal wall |
| Ilioinguinal (L1) | GSA | skin of medial thigh, scrotum/labia majora |
| | GSE | muscles of the anterior abdominal wall |
| Genital branch of genitofemoral | GSA | scrotum/labia majora |
| | GSE | cremaster muscle |
| Muscular branches of lumbar plexus | GSE | muscles of posterior abdominal wall |
| Greater splanchnic | GVA | pain/sensation from foregut organs |
| | GVE sympathetic | foregut organs, suprarenal medulla |
| Lesser and least splanchnics | GVA | pain/sensation from midgut organs, kidney, ureter |
| | GVE sympathetic | midgut organs, kidney, ureter |
| Lumbar splanchnics | GVA | pain/sensation from hindgut organs, ureter |
| | GVE sympathetic | hindgut organs, ureter |
| Vagus | GVA | pain/sensation from foregut and midgut organs |
| | GVE parasympathetic | foregut and midgut organs |
| Pelvic splanchnics | GVA | pain/sensation from hindgut organs |
| | GVE parasympathetic | hindgut organs |

## Visceral motor innervation of the abdomen

| | Pre-fiber cell bodies | Pre-fiber axon | Post-fiber cell bodies (synapse) | Post-fiber axon location | Organs innervated |
|---|---|---|---|---|---|
| Sympathetic | T5-T9<br>spinal levels | Exits sympathetic chain as greater splanchnic | celiac ganglia | travels with branches of celiac trunk | foregut<br>suprarenal medulla |
| | T10-11<br>spinal levels | Exits sympathetic chain as lesser splanchnic | superior mesenteric, renal ganglia | travels with branches of superior mesenteric and renal arteries | midgut<br>kidney<br>ureter |
| | T12<br>spinal level | Exits sympathetic chain as least splanchnic | | | |
| | L1-L2<br>spinal levels | Exits sympathetic chain from L1-L5 as lumbar splanchnics | inferior mesenteric ganglia | travels with branches of inferior mesenteric a. | hindgut<br>ureter |
| Para-sympathetic | brain | vagus nerve | abdominal ganglia (on organ) | on organ | foregut<br>midgut |
| | S2-S4<br>spinal levels | pelvic splanchnics | abdominal ganglia (on organ) | on organ | hindgut |

Key of Acronyms:

- GSA = General Somatic Afferent Neurons
- GSE = General Somatic Efferent Neurons
- GVA = General Visceral Afferent Neurons
- GVE = General Visceral Efferent Neurons

# Summary of Abdominal Blood Supply

| ARTERY | ORIGIN | MAJOR STRUCTURES SUPPLIED |
|---|---|---|
| Superior epigastric | Internal thoracic artery | abdominal wall |
| Inferior epigastric | External iliac artery | abdominal wall |
| Intercostals/lumbar | Abdominal aorta | abdominal wall |
| Gonadal | Abdominal aorta | testis and ovary |
| Celiac | Abdominal aorta | foregut organs |
| Superior mesenteric | Abdominal aorta | midgut organs |
| Inferior mesenteric | Abdominal aorta | hindgut organs |
| Renal | Abdominal aorta | kidney |
| Suprarenal<br>(superior, middle, inferior) | Inferior phrenic, aorta, and<br>renal arteries respectively | suprarenal gland |