

# Gastrointestinal

“A good set of bowels is worth more to a man than any quantity of brains.”  
—Josh Billings

“Man should strive to have his intestines relaxed all the days of his life.”  
—Moses Maimonides

“All right, let’s not panic. I’ll make the money by selling one of my livers. I can get by with one.”

—Homer Simpson, *The Simpsons*

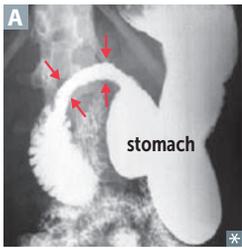
“The truth does not change according to our ability to stomach it emotionally.”

—Flannery O’Connor

When studying the gastrointestinal system, be sure to understand the normal embryology, anatomy, and physiology and how the system is affected by various pathologies. Study not only disease pathophysiology, but also its specific findings, so that you can differentiate between two similar diseases. For example, what specifically makes ulcerative colitis different from Crohn disease? Also, be comfortable with basic interpretation of abdominal x-rays, CT scans, and endoscopic images.

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### Pancreas and spleen embryology

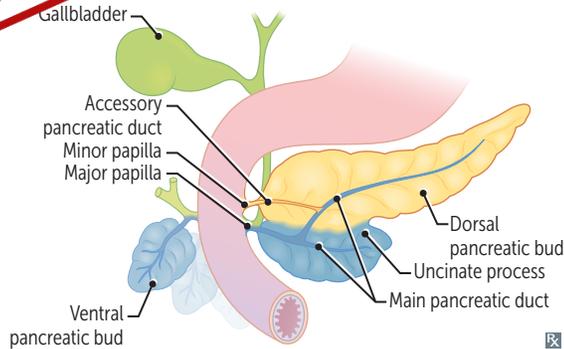


Pancreas—derived from foregut. Ventral pancreatic bud contributes to uncinete process and main pancreatic duct. The dorsal pancreatic bud alone becomes the body, tail, isthmus, and accessory pancreatic duct. Both the ventral and dorsal buds contribute to pancreatic head.

**Annular pancreas**—abnormal rotation of ventral pancreatic bud forms a ring of pancreatic tissue → encircles 2nd part of duodenum; may cause duodenal narrowing (arrows in **A**) and vomiting.

**Pancreas divisum**—ventral and dorsal parts fail to fuse at 7 weeks of development. Common anomaly; mostly asymptomatic, but may cause chronic abdominal pain and/or pancreatitis.

Spleen—arises in mesentery of stomach (hence is mesodermal) but has foregut supply (celiac trunk → splenic artery).



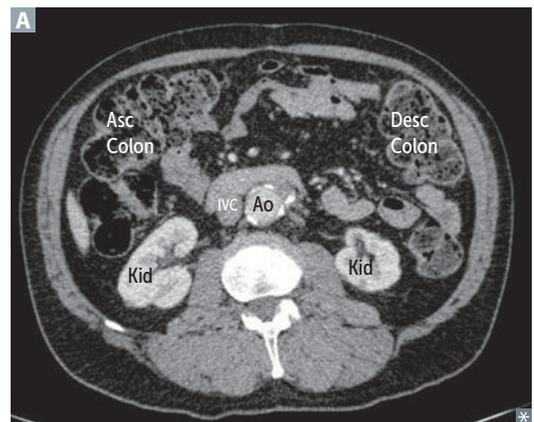
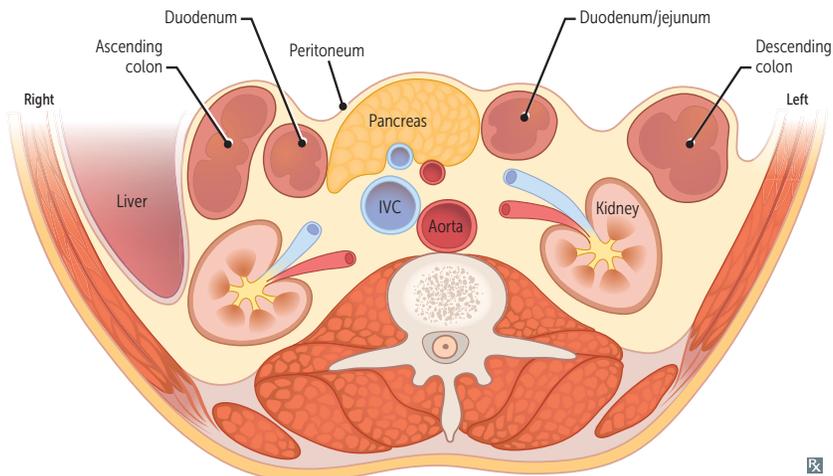
### ► GASTROINTESTINAL—ANATOMY

#### Retroperitoneal structures

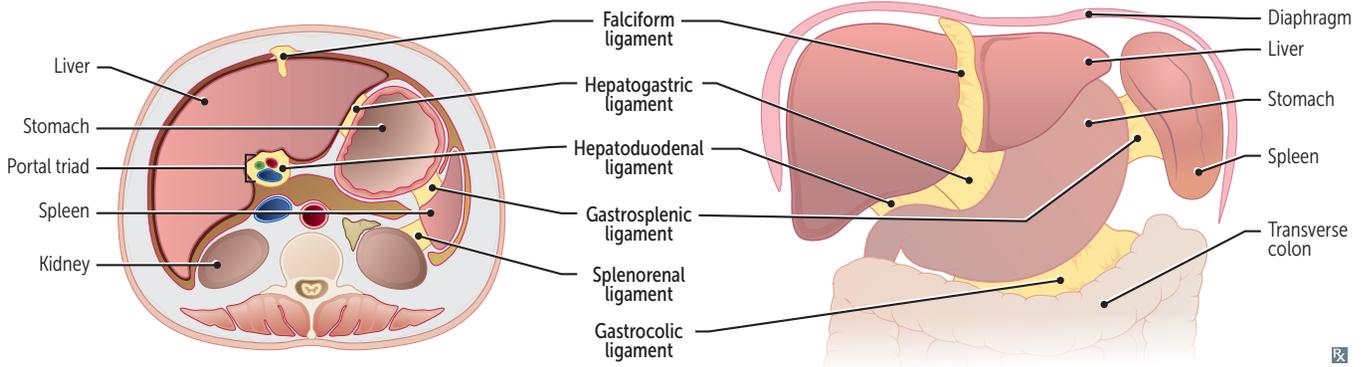
Retroperitoneal structures **A** are posterior to (and outside of) the peritoneal cavity. Injuries to retroperitoneal structures can cause blood or gas accumulation in retroperitoneal space.

#### SAD PUCKER:

- Suprarenal (adrenal) glands [not shown]
- Aorta and IVC
- Duodenum (2nd through 4th parts)
- Pancreas (except tail)
- Ureters [not shown]
- Colon (descending and ascending)
- Kidneys
- Esophagus (thoracic portion) [not shown]
- Rectum (partially) [not shown]



**Important gastrointestinal ligaments**



LIGAMENT	CONNECTS	STRUCTURES CONTAINED	NOTES
<b>Falciform ligament</b>	Liver to anterior abdominal wall	Ligamentum teres hepatis (derivative of fetal umbilical vein), patent paraumbilical veins	Derivative of ventral mesentery
<b>Hepatoduodenal ligament</b>	Liver to duodenum	Portal triad: proper hepatic artery, portal vein, common bile duct	Derivative of ventral mesentery Pringle maneuver—ligament is compressed manually or with a vascular clamp in omental foramen to control bleeding from hepatic inflow source Borders the omental foramen, which connects the greater and lesser sacs Part of lesser omentum
<b>Hepatogastric ligament</b>	Liver to lesser curvature of stomach	Gastric vessels	Derivative of ventral mesentery Separates greater and lesser sacs on the right May be cut during surgery to access lesser sac Part of lesser omentum
<b>Gastrocolic ligament</b>	Greater curvature and transverse colon	Gastroepiploic arteries	Derivative of dorsal mesentery Part of greater omentum
<b>Gastrosplenic ligament</b>	Greater curvature and spleen	Short gastrics, left gastroepiploic vessels	Derivative of dorsal mesentery Separates greater and lesser sacs on the left Part of greater omentum
<b>Splenorenal ligament</b>	Spleen to left pararenal space	Splenic artery and vein, tail of pancreas	Derivative of dorsal mesentery

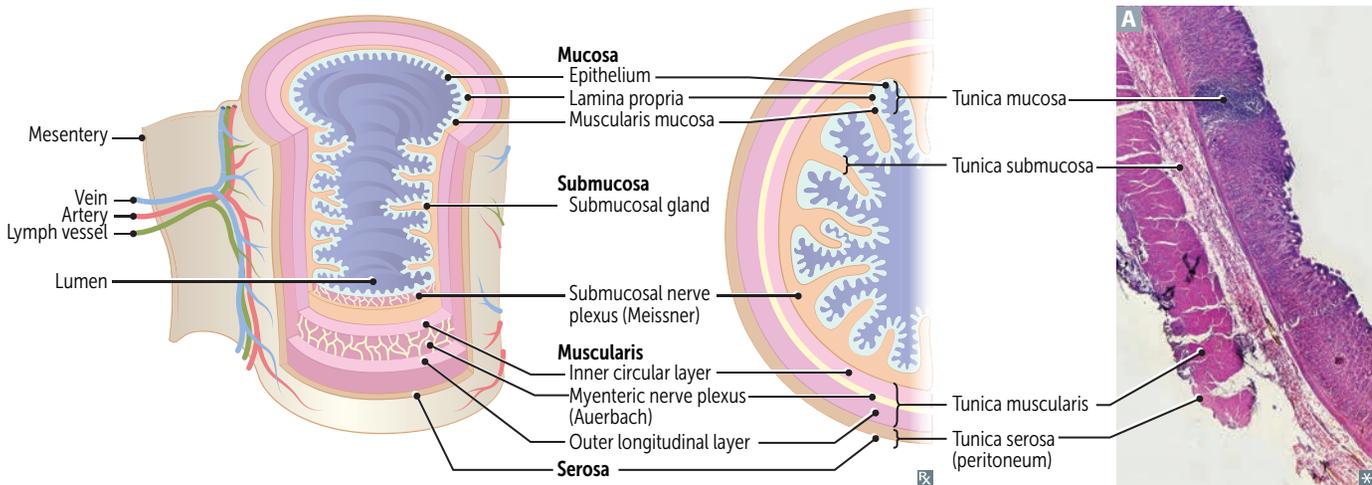
### Digestive tract anatomy

Layers of gut wall **A** (inside to outside—**MSMS**):

- **Mucosa**—epithelium, lamina propria, muscularis mucosa
- **Submucosa**—includes submucosal nerve plexus (Meissner), secretes fluid
- **Muscularis externa**—includes myenteric nerve plexus (Auerbach), motility
- **Serosa** (when intraperitoneal), adventitia (when retroperitoneal)

Ulcers can extend into submucosa, inner or outer muscular layer. Erosions are in mucosa only.

Frequency of basal electric rhythm (slow waves), which originate in the interstitial cells of Cajal: duodenum > ileum > stomach.



### Digestive tract histology

#### Esophagus

Nonkeratinized stratified squamous epithelium. Upper 1/3, striated muscle; middle and lower 2/3 smooth muscle, with some overlap at the transition.

#### Stomach

Gastric glands **A**. Parietal cells are eosinophilic (pink, red arrow in **B**), chief cells are basophilic (black arrow in **B**).

#### Duodenum

Villi and microvilli ↑ absorptive surface. Brunner glands (bicarbonate-secreting cells of submucosa) and crypts of Lieberkühn (contain stem cells that replace enterocytes/goblet cells and Paneth cells that secrete defensins, lysozyme, and TNF).

#### Jejunum

Villi **C**, crypts of Lieberkühn, and plicae circulares (also present in distal duodenum).

#### Ileum

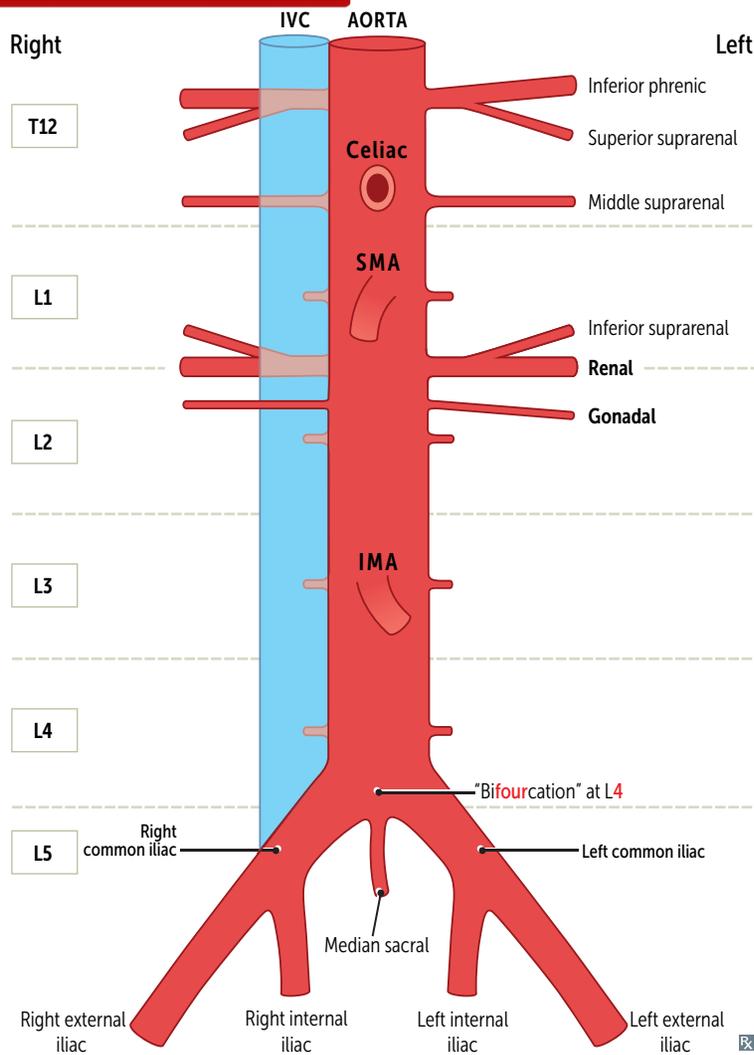
Villi, Peyer patches (arrow in **D**; lymphoid aggregates in lamina propria, submucosa), plicae circulares (proximal ileum), and crypts of Lieberkühn. Largest number of goblet cells in the small intestine.

#### Colon

Crypts of Lieberkühn with abundant goblet cells, but no villi **E**.



**Abdominal aorta and branches**



Arteries supplying GI structures are single and branch anteriorly.

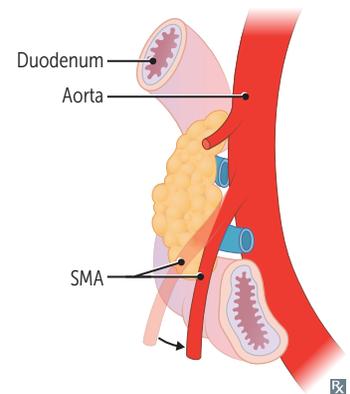
Arteries supplying non-GI structures are paired and branch laterally and posteriorly.

Two areas of the colon have dual blood supply from distal arterial branches (“watershed regions”) → susceptible in colonic ischemia:

- Splenic flexure—SMA and IMA
- Rectosigmoid junction—the last sigmoid arterial branch from the IMA and superior rectal artery

**Nutcracker syndrome**—compression of left renal vein between superior mesenteric artery and aorta. May cause abdominal (flank) pain, gross hematuria (from rupture of thin-walled renal varicosities), left-sided varicocele.

**Superior mesenteric artery syndrome**—characterized by intermittent intestinal obstruction symptoms (primarily postprandial pain) when SMA and aorta compress transverse (third) portion of duodenum. Typically occurs in conditions associated with diminished mesenteric fat (eg, low body weight/malnutrition).



### Gastrointestinal blood supply and innervation

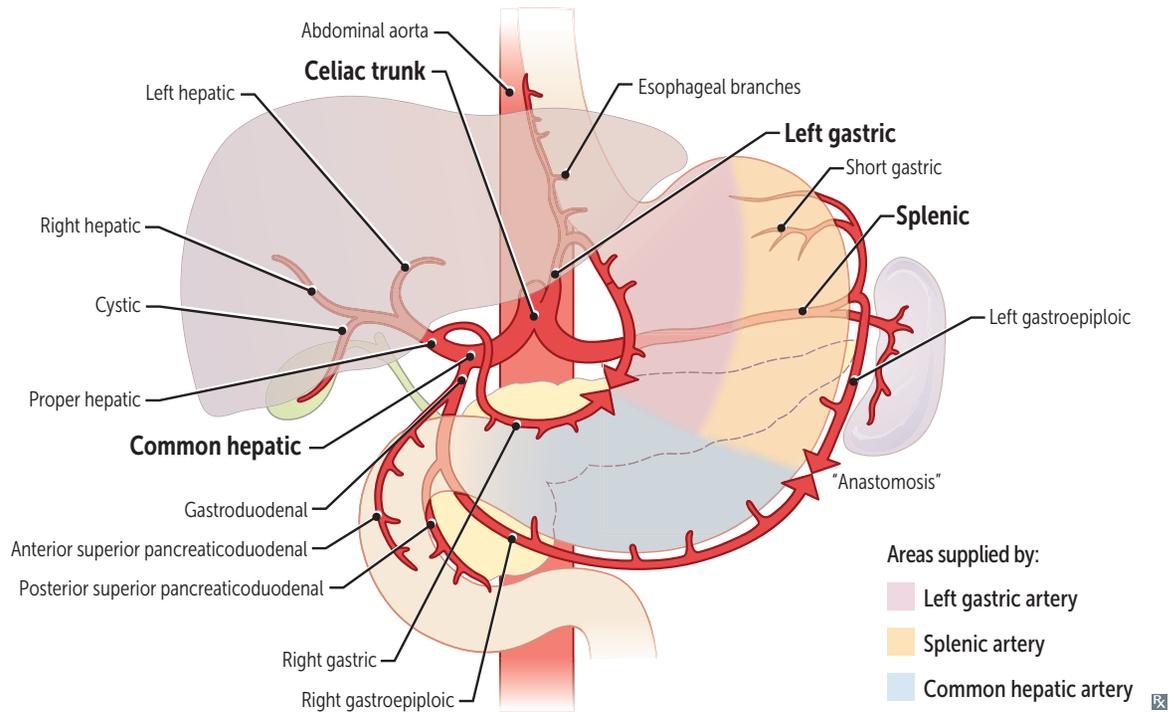
EMBRYONIC GUT REGION	ARTERY	PARASYMPATHETIC INNERVATION	VERTEBRAL LEVEL	STRUCTURES SUPPLIED
<b>Foregut</b>	Celiac	Vagus	T12/L1	Pharynx (vagus nerve only) and lower esophagus (celiac artery only) to proximal duodenum; liver, gallbladder, pancreas, spleen (mesoderm)
<b>Midgut</b>	SMA	Vagus	L1	Distal duodenum to proximal 2/3 of transverse colon
<b>Hindgut</b>	IMA	Pelvic	L3	Distal 1/3 of transverse colon to upper portion of anal canal

### Celiac trunk

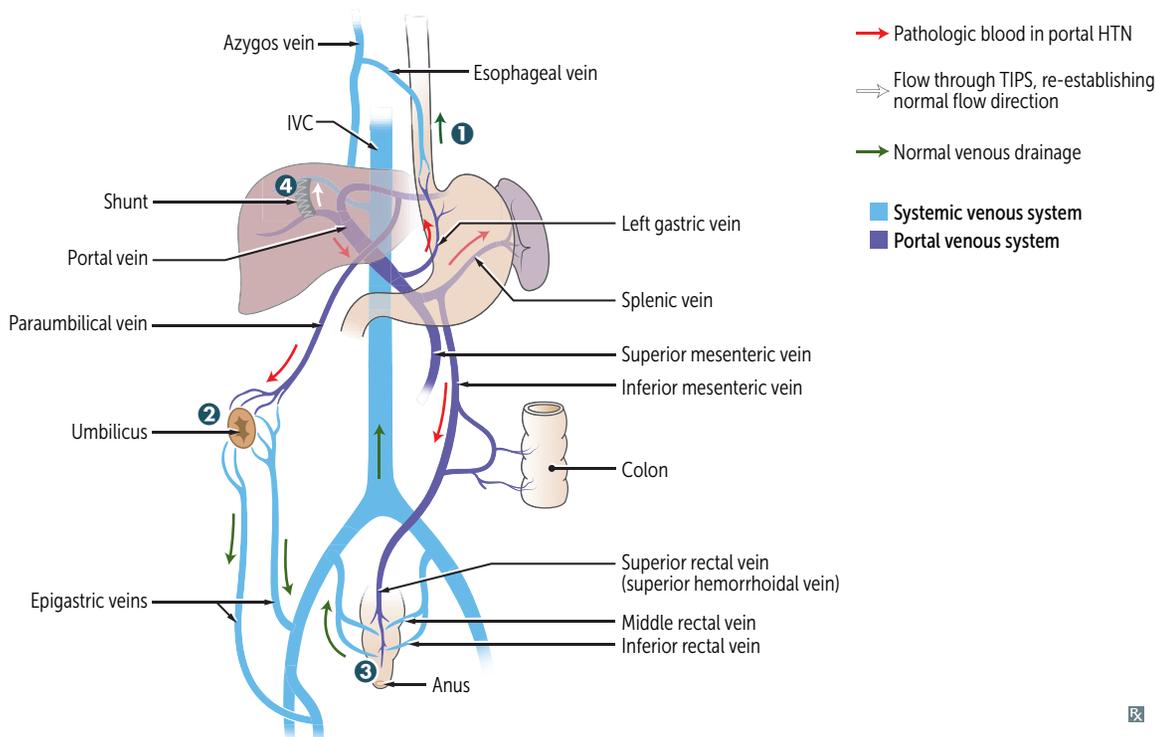
Branches of celiac trunk: common hepatic, splenic, and left gastric. These constitute the main blood supply of the foregut.

Strong anastomoses exist between:

- Left and right gastroepiploics
- Left and right gastrics



**Portosystemic anastomoses**



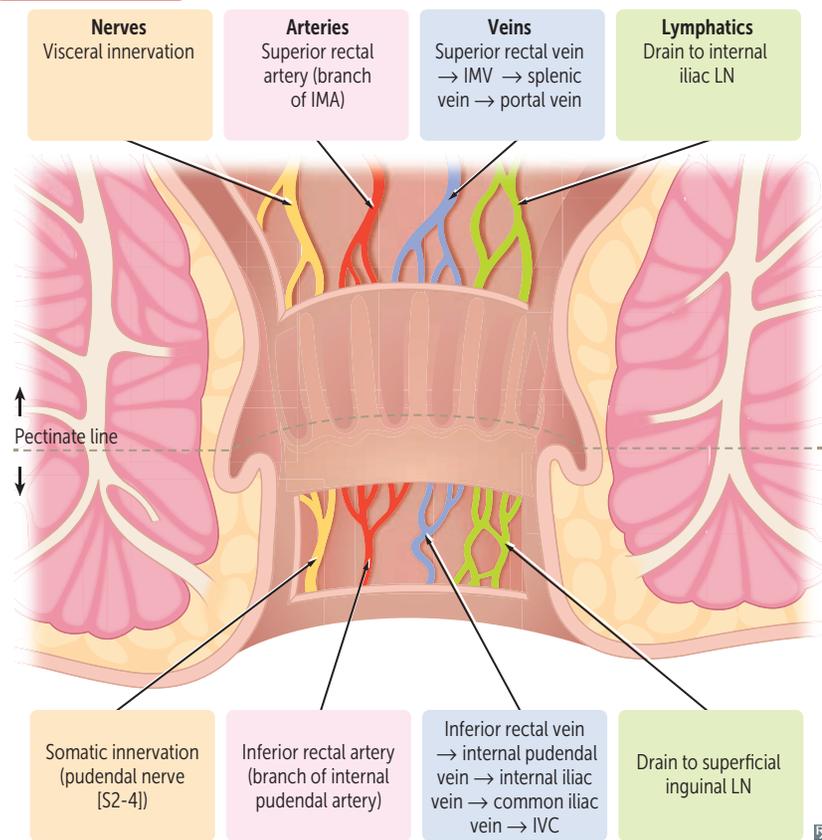
SITE OF ANASTOMOSIS	CLINICAL SIGN	PORTAL ↔ SYSTEMIC
1 Esophagus	Esophageal varices	Left gastric ↔ esophageal (drains into azygos)
2 Umbilicus	Caput medusae	Paraumbilical ↔ small epigastric veins of the anterior abdominal wall.
3 Rectum	Anorectal varices	Superior rectal ↔ middle and inferior rectal

Varices of **gut**, **butt**, and **caput** (medusae) are commonly seen with portal hypertension.

4 Treatment with a **T**ransjugular **I**ntrahepatic **P**ortosystemic **S**hunt (**TIPS**) between the portal vein and hepatic vein relieves portal hypertension by shunting blood to the systemic circulation, bypassing the liver. TIPS can precipitate hepatic encephalopathy due to ↓ clearance of ammonia from shunting.

**Pectinate line**

Also called dentate line. Formed where endoderm (hindgut) meets ectoderm.



**Above pectinate line:** internal hemorrhoids, adenocarcinoma.

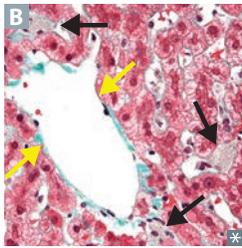
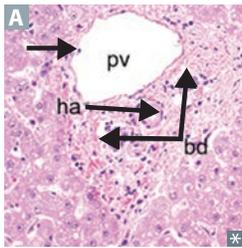
Internal hemorrhoids receive visceral innervation and are therefore **not painful**.

**Below pectinate line:** external hemorrhoids, anal fissures, squamous cell carcinoma.

External hemorrhoids receive somatic innervation (inferior rectal branch of pudendal nerve) and are therefore **painful** if thrombosed.

**Anal fissure**—tear in anoderm below pectinate line. **P**ain while **p**ooping; blood on toilet **p**aper. Located in the **p**osterior midline because this area is **p**oorly perfused. Associated with low-fiber diets and constipation.

**Liver tissue architecture**



The functional unit of the liver is made up of hexagonally arranged lobules surrounding the central vein with portal triads on the edges (consisting of a portal vein, hepatic artery, bile ducts, as well as lymphatics) **A**.

Apical surface of hepatocytes faces bile canaliculi. Basolateral surface faces sinusoids. Kupffer cells (specialized macrophages) located in sinusoids (black arrows in **B**; yellow arrows show central vein) clear bacteria and damaged or senescent RBCs.

Hepatic stellate (Ito) cells in space of Disse store vitamin A (when quiescent) and produce extracellular matrix (when activated). Responsible for hepatic fibrosis.

Zone I—periportal zone:

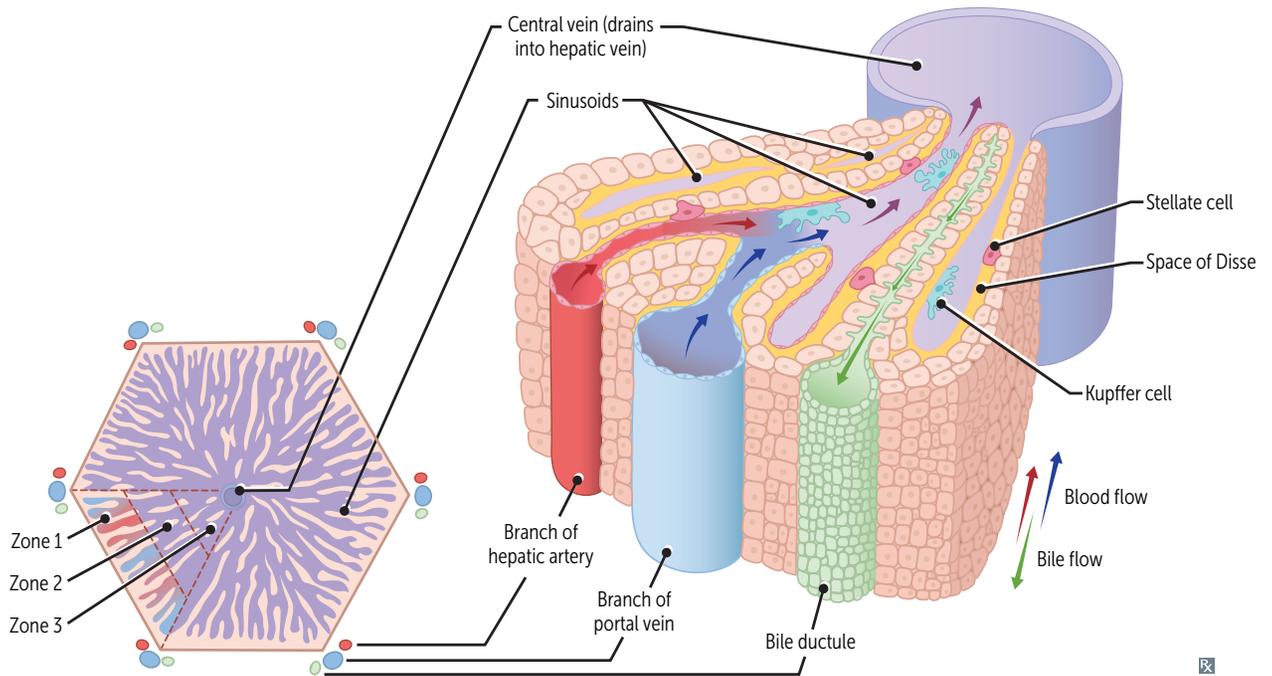
- Affected 1st by viral hepatitis
- Best oxygenated, most resistant to circulatory compromise
- Ingested toxins (eg, cocaine)

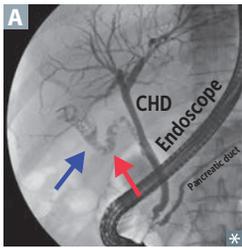
Zone II—intermediate zone:

- Yellow fever

Zone III—pericentral (centrilobular) zone:

- Affected 1st by ischemia (least oxygenated)
- High concentration of cytochrome P-450
- Most sensitive to metabolic toxins (eg, ethanol, CCl<sub>4</sub>, halothane, rifampin, acetaminophen)
- Site of alcoholic hepatitis

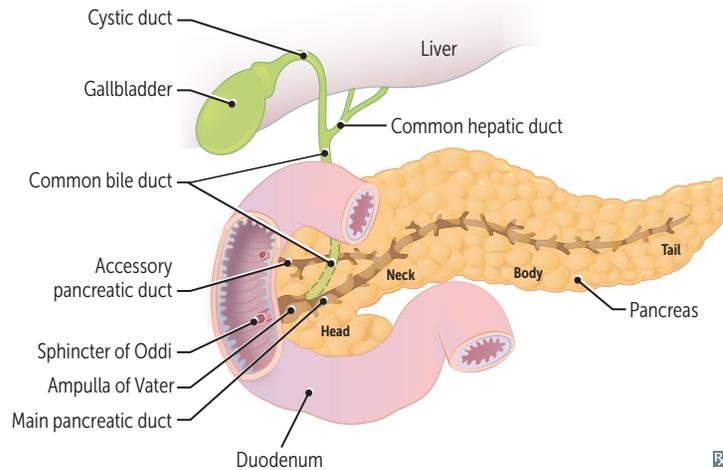


**Biliary structures**

Cholangiography shows filling defects in gallbladder (blue arrow in **A**) and cystic duct (red arrow in **A**).

Gallstones that reach the confluence of the common bile and pancreatic ducts at the ampulla of Vater can block both the common bile and pancreatic ducts (double duct sign), causing both cholangitis and pancreatitis, respectively.

Tumors that arise in head of pancreas (usually ductal adenocarcinoma) can cause obstruction of common bile duct → enlarged gallbladder with painless jaundice (Courvoisier sign).

**Femoral region**

## ORGANIZATION

**Lateral to medial: nerve-artery-vein-lymphatics.** You go from **lateral to medial** to find your **navel**.

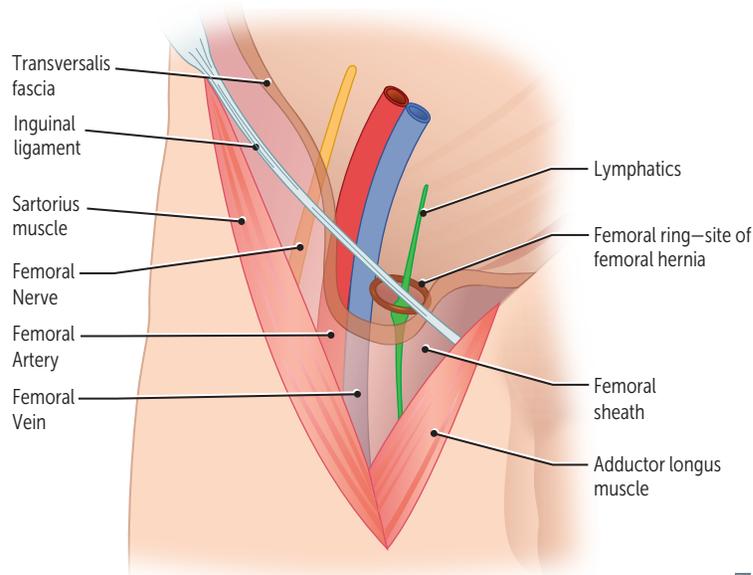
**Femoral triangle**

Contains femoral nerve, artery, vein.

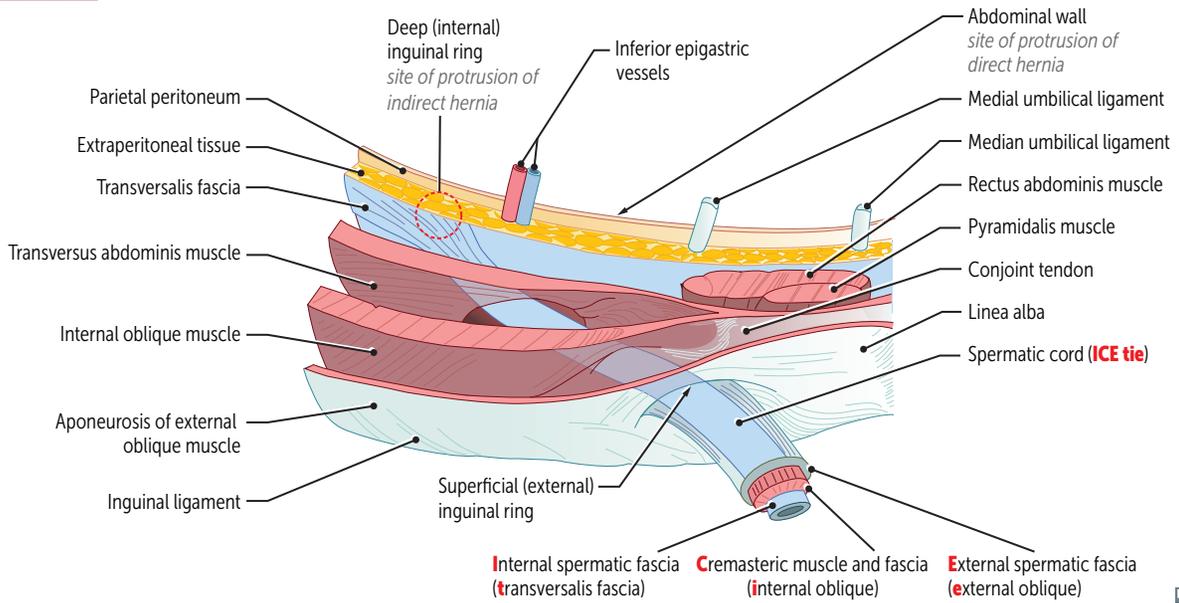
**Venous** near the **penis**.

**Femoral sheath**

Fascial tube 3–4 cm below inguinal ligament.  
Contains femoral vein, artery, and canal (deep inguinal lymph nodes) but not femoral nerve.

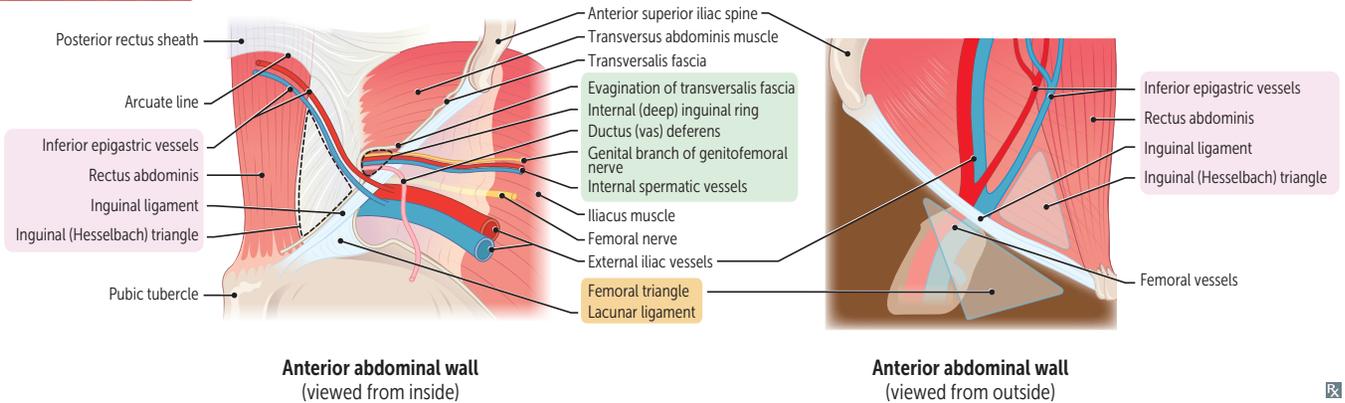


**Inguinal canal**



FX

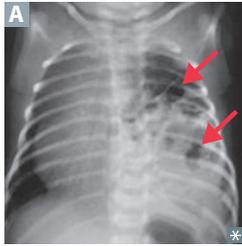
**Abdominal wall**



FX

**Hernias**

Protrusion of peritoneum through an opening, usually at a site of weakness. Contents may be at risk for incarceration (not reducible back into abdomen/pelvis) and strangulation (ischemia and necrosis). Complicated hernias can present with tenderness, erythema, fever.

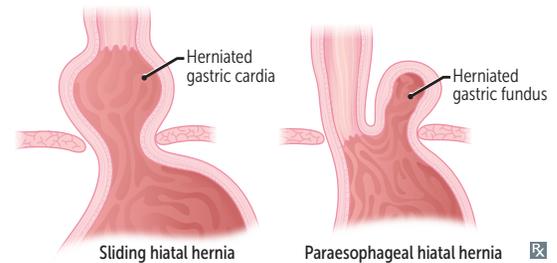
**Diaphragmatic hernia**

Abdominal structures enter the thorax. Most common causes:

- Infants—congenital defect of pleuroperitoneal membrane → left-sided herniation (right hemidiaphragm is relatively protected by liver) **A**.
- Adults—laxity/defect of phrenoesophageal membrane → **hiatal hernia** (herniation of stomach through esophageal hiatus).

**Sliding hiatal hernia**—gastroesophageal junction is displaced upward as gastric cardia slides into hiatus; “hourglass stomach.” Most common type. Associated with GERD.

**Paraesophageal hiatal hernia**—gastroesophageal junction is usually normal but gastric fundus protrudes into the thorax.



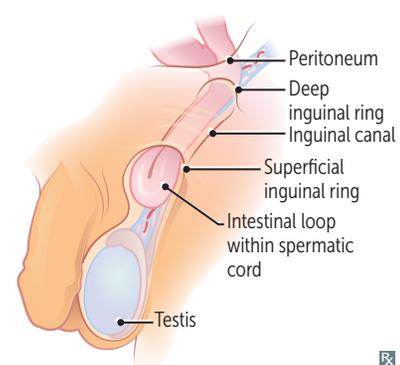
Sliding hiatal hernia

Paraesophageal hiatal hernia

**Indirect inguinal hernia**

Goes through the internal (deep) inguinal ring, external (superficial) inguinal ring, and into the groin. Enters internal inguinal ring lateral to inferior epigastric vessels. Caused by failure of processus vaginalis to close (can form hydrocele). May be noticed in **infants** or discovered in adulthood. Much more common in males **B**.

Follows the pathway of testicular descent.  
Covered by all 3 layers of spermatic fascia.



Bx

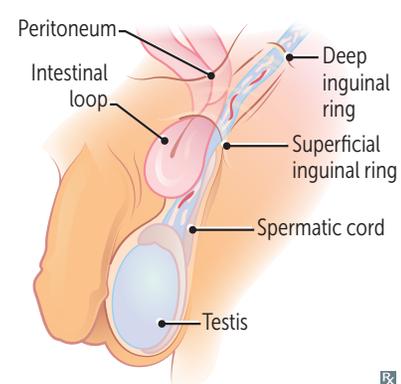
**Direct inguinal hernia**

Protrudes through inguinal (Hesselbach) triangle. Bulges directly through parietal peritoneum medial to the inferior epigastric vessels but lateral to the rectus abdominis. Goes through external (superficial) inguinal ring only. Covered by external spermatic fascia. Usually occurs in older males due to acquired weakness of transversalis fascia.

**MDs don't lie:**

**M**edial to inferior epigastric vessels = **D**irect hernia.

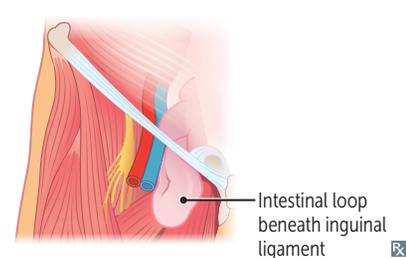
**L**ateral to inferior epigastric vessels = **i**ndirect hernia.



Bx

**Femoral hernia**

Protrudes below inguinal ligament through femoral canal below and lateral to pubic tubercle. More common in **females**, but overall inguinal hernias are the most common. More likely to present with incarceration or strangulation (vs inguinal hernia).



Bx

