

## THE ABDOMEN

- [Clinical Examination of the Abdomen](#)
- [Anterior Abdominal Wall](#)
- [Inguinal Region](#)
- [Peritoneum](#)
- [Summary by Gut Derivatives](#)
- [Stomach](#)
- [Spleen](#)
- [Duodenum](#)
- [Pancreas](#)
- [Liver](#)
- [Gallbladder](#)
- [Small Intestine](#)
- [Large Intestine](#)
- [Abdominal Vasculature](#)
- [Nervous System](#)
- [Posterior Abdominal Wall](#)
- [Kidneys and Suprarenal Glands](#)
- [Lymphatic System](#)

### CLINICAL EXAMINATION OF THE ABDOMEN

Two kinds of pain:

- **Visceral Pain:** Deep, throbbing, delocalized pain, associated with the visceral organs.
- **Somatic Pain:** Sharp, piercing, pain localized to the abdominal wall.

Abdominal Medical History: (pqr)<sup>2</sup>st<sup>3</sup>

- P -- Provoking: What have you noticed that makes this pain worse?
- P -- Palliating: What relieves the pain?
- Q -- Quantity: How much pain are you having?
- Q -- Quality: What does the pain feel like?
- R -- Region: Where is the pain?
- R -- Radiation: Does the pain go (radiate) to any other locale?
- S -- Severity: How does it keep them from doing what they normally would do?
- T -- 3 time related questions
  - Did the pain just start (suddenly) or come on gradually?
  - Is the pain constant or does it come and go?
  - Is the first time you ever had this or have you noticed anything like this before?

OBSERVE: Watch patient walk to table. Look for visible pain and discomfort. Note vital signs, stretch marks, scars, vascular pattern, etc.

LISTEN (AUSCULTATE):

- Listen for fluid sounds -- mix of fluid and gas mixing by peristalsis.
  - If you hear nothing, listen up to five minutes before concluding there are no bowel sounds. It can take a while.
- Listen for blood flow. In some slender people you can hear turbulent flow.
- Listen for **Friction Rub**, which occurs when inflamed organs rub next to each other.
- Listen for transmission of sounds from chest.

PERCUSSION: Best way to examine liver is by percussion, to feel for borders. Can percuss for spleen to determine if it is enlarged.

PALPATE: Feel all major organs for inflammations, abnormalities, position, etc.

Four Quadrants:

- **Midsagittal Plane:** Vertical line going through the middle of the abdomen.
- **Transumbilical Plane:** Horizontal line going through the umbilicus.
- Four Quadrants based on those planes:
  - Right Upper Quadrant: RUQ
  - Right Lower Quadrant: RLQ
  - Left Upper Quadrant: LUQ
  - Left Lower Quadrant: LLQ

Nine Regions:

- Vertical lines of division: Left and Right Mid-Clavicular Lines
- Horizontal lines of division:
  - **Transpyloric Plane:** Sometimes used. It is halfway between the jugular notch and the pubic bone.
  - **Subcostal Plane:** Upper plane, passing through the inferior-most margin of the ribs.
  - **Transtubercular Plane:** The line transversing the pubic tubercle.
- Divisions:
  - Upper: **Right Hypochondriac, Epigastric, Left Hypochondriac**
  - Middle: **Right Lumbar, Umbilical, Left Lumbar**
  - Lower: **Right Inguinal, Hypogastric (Suprapubic), Left Inguinal**

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## ANTERIOR ABDOMINAL WALL

Boundaries of the Abdomen:

- Superior Boundary: The diaphragm. It extends to ICS-5 superiorly (at the median line; it is more inferior around the edges).
  - Hence the superior limit of the liver is also ICS5 since it push up into the diaphragm.
- Posterior Boundary: Lumbar Vertebrae, and Quadratus Lumborum and Transverse Abdominis muscles.
- Anterolateral Borders: The muscles of abdominal wall: transversus abdominis, and internal and external abdominal oblique.
- Inferior Borders: The **Pelvic Brim**

**PELVIC BRIM:** Inferior border of the abdomen.

- It consists of the Right and Left **Coxal Bones**.
  - Each coxal bone is made up of an **ilium, ischium, and pubic bone**.
- **Iliac Crest:** The superior portion of the iliac bone. The **Iliac Tubercles** are bony prominences on the iliac crest.
- **Anterior Superior Iliac Spine (ASIS):** The anterior most feature on the iliac crest.
- **Pubic Tubercle:** Lateral edge of pubic bone.
- **Inguinal Ligament:** Found between the ASIS and the pubic tubercle, running in the same direction as the ASIS.
  - The femoral vessels and the inguinal canal are both related to the inguinal ligament.
  - Formed from aponeurosis part of the external abdominal oblique.

**UMBILICUS:** Found between L3 and L4 in physically fit persons.

**Grandparents Like Pediatric Doctors Preventing Kids Sickness: One Transpyloric Plane** -- The Transpyloric plane passes through **L1** and contains the following structures:

- Gall-bladder

- Liver
- Pylorus of Stomach
- Duodenal Bulb (Duodenum I)
- Pancreas Body and Tail
- Kidneys
- Spleen

**Processus Vaginalis:** The portion of peritoneum that remains with the testes when they descend into the scrotum.

- Anything that pushes through the anterior abdominal wall will become invested with peritoneum.
- The testes push through the wall, but normally a piece of peritoneum is left behind as the processus vaginalis.
- When the testes descend, the peritoneum goes with it and then scales back. The portion of peritoneum that remains with the testes is called the processus vaginalis.

7 Layers of the Abdominal Wall:

- **Skin**
  - **Epidermis** -- the part we shed
  - **Dermis** -- contains nerves, capillaries, sweat glands, hair follicles.
    - Has collagen fibers that tend to be horizontal, forming the creasing of the skin. These are called **Langer's Lines**.
    - In surgery, you should cut with Langer's Line, the direction of the collagen, so as to minimize surgical scars.
- **Superficial Fascia** -- Connective tissue that is not aponeurosis, tendon, or ligament. This is the same thing as the hypodermis.
  - **Camper's Fascia:** Fatty layer, first of the two layers. It is found throughout.
  - **Scarpa's Fascia:** Lower layer, found in the lower 1/3 of the anterior abdominal wall. It has a restrictive location, defined by the extent of damage occurring with a **straddle injury**.
    - Limits:
      - The area is restricted to the anterior abdominal wall.
      - Lateral Limit: Basically the inguinal ligament, where it intersects with **fascia lata**, so that fluid does not pass into the thigh.
      - Inferior Limit = the base of the scrotum.
      - Posterior Limit = it goes back to the anus, and fills the pelvis in between.
    - The outlined region is called the **superficial perineal space**.
    - It is called different fascia at different places: *Dartos Fascia* in scrotum / labia majora, and *Colles Fascia* around perineum.
  - **Fundiform Ligament:** The **false suspensory ligament** of the penis or clitoris. It is an extension of superficial fascia.
- **Deep Fascia**
  - A **true suspensory ligament** occurs in the deep fascia layer, which extends into the penis / clitoris. So, we have both a true suspensory ligament (deep fascia) and a false one (fundiform ligament / superficial fascia).
  - Deep fascia encompasses all muscles of the entire body.
- **Muscles** -- Three flat muscles plus the longitudinal rectus sheath muscle.
  - **External Abdominal Oblique** -- muscle fiber direction is antero-inferior (like external intercostals -- hands in pocket).
    - Originate at border of Thoracic ribs T5 - T12
    - Extends to midline and attaches on linea alba. Also attaches to the iliac crest.
    - Again, the **aponeurosis** portion of the externals form the **inguinal ligaments**.
    - Also forms the **superficial inguinal ring**, which allows passage of the **spermatic cord** (male) or **round ligament** (female).
      - Superficial Inguinal Ring is made up of two components, **lateral crus** and **medial crus**. **Intercrural fibers** separate the two.
  - **Internal Abdominal Oblique**
    - Also has fibers that attach along the inguinal ligament to the pubic crest.
    - Direction of fibers tends to go outward, from medial to lateral and a little bit inferiorly (inferolaterally).
    - Borders on ribs 7 - 12.

- The aponeurosis splits and goes both anteriorly (to merge with external aponeurosis) and posteriorly (to merge with transversus aponeurosis)
  - **Transversus Abdominis** Deep most layer of flat muscles.
    - Also borders on ribs 7 - 12. Extends down to the pubic crest and medially to the linea alba.
    - It creates a diagonal pathway for the spermatic cord or round ligament to pass through.
    - Fibers run transversely! -- horizontally from lateral to medial.
  - **Rectus Abdominis:** Straight muscle.
    - Passes from Xiphoid Process inferiorly to **pubic symphysis** (inferior center of pubic bone).
    - **Rectus Sheath** holds this rectus muscle in place. It is directly shallow to it, formed by the aponeuroses of the three flat muscles. It has a posterior and anterior layer, formed from the aponeuroses of the three flat muscles.
      - Upper 3/4 of Abdominal Wall: All three muscle layers converge on rectus sheath, and pass both anteriorly (external aponeurosis) and posteriorly (transversus aponeurosis).
        - This part of the wall is suturable in surgery.
      - Lower 1/4 of abdominal wall is transversalis fascia. Here, all three muscle layers pass anteriorly. Here it is called transversalis fascia.
        - This part of the wall is not suturable in surgery.
    - **Arcuate Line:** The line that divides the upper 3/4 of abdomen from lower 1/4, by the differences in the aponeurotic layers.
    - **Transversalis Fascia** -- Deep fascia on the interior (deep) surface of the transversus abdominis muscle.
      - Esp. found in the lower 1/4 of the abdomen.
  - It has several names, but it is one continuous plane of fascia, just outside the peritoneum.
  - As a continuous plane, it is also an avenue for infection.
- **Subserous Fascia**
- **Peritoneum:** A serous membrane that secretes fluid, thus allowing internal organs frictionless movement.

**Linea Alba:** The best place to make a surgical cut and not hit any nerves is straight down the linea alba.

NERVOUS SUPPLY of Anterior Wall: Ventral Rami of T7 - T12, and L1.

- **Dermatomes:** How nerves innervate the anterior abdominal wall -- in sections.
- Referred Pain: Example
  - T10 goes to umbilical region.
  - Appendicitis pain will go to sympathetic nervous system -----> refers back to T10. When rupture occurs, toxins are released and irritate the peritoneum, resulting in a localized effect.
- **Ilioinguinal Nerve:** Goes through the inguinal canal, with the spermatic cord (male) or round ligament (female).
  - Supplies scrotum (or labia majora) and medial aspect of thigh.
- **Iliohypogastric Nerve:** Directly superior to ilioinguinal nerve.
  - Innervates the suprapubic area.
- Both Ilioinguinal and Iliohypogastric may come off as a single nerve and branch later.

**McBurney's Point:** The point of surgical incision for an appendectomy.

- Is located on a line along the ASIS. The iliohypogastric nerve is right there, about 1cm superior to the ASIS, so that is the nerve that ya gotta be weary of when doing an appendectomy.

ARTERIAL SUPPLY of Anterior Wall:

- **Superior Epigastric Artery** -- Runs directly over rectus abdominis muscle.
- **Inferior Epigastric Artery**
- **Superficial Epigastric Artery**

VENOUS SUPPLY of Anterior Wall: The same as the veins above.

- When using a needle to drain peritoneal fluid, do not hit the Superior or Inferior epigastric veins! The result would be massive bleeding.

## INGUINAL REGION

**Inguinal Canal:** Formed from the aponeuroses of the three flat muscles.

- It a **diagonal passage**. Most tubular structures pass through membranes diagonally, as the ureters and fallopian tubes do.
  - This provides reinforcement on the wall of the structure being entered.
- Contents of Inguinal Canal
  - **Spermatic Cord** (male) or **Round Ligament** (female)
  - **Ilioinguinal Nerve**
  - Genital Branch of the **Genitofemoral Nerve**.

**Inguinal Triangle (Hesselbach's Triangle):** An area of weakness in the aponeurosis, where direct hernias can occur.

- Borders:
  - The lateral margin of the rectus muscle (aka **semilunaris**)
  - The **Inferior Epigastric Artery**
  - The **Inguinal Ligament**
- **CONJOINT TENDON:** The space of membrane where the transversus abdominis and internal oblique aponeuroses join into one. It is an *area of weakness* in the abdominal wall.

**HERNIAS:** The protrusion of intraperitoneal guts outside of the peritoneum (i.e. through the peritoneal wall).

- **DIRECT INGUINAL HERNIA:** Gut goes straight through the inguinal triangle, through the conjoint tendon.
  - It will be located *medial to the inferior epigastric artery*
- **INDIRECT INGUINAL HERNIA:** Hernia that passes through the inguinal canal and originates *lateral to the inferior epigastric artery*.
  - **Congenital Indirect:** The weakness was present at birth.
    - **Agenesis:** Absence of growth or closure of some part of the abdominal wall.
    - **Dysgenesis:** Incorrect or dysfunctional growth.
  - **Acquired Indirect:**
    - **Ascites** -- (fluid buildup in peritoneum)
    - Obesity
    - Pregnancy
    - Surgical Incisions
- Diaphragmatic Hernias:
  - **HIATAL HERNIA:** Distal end of the esophagus can draw itself back into the esophageal hiatus, pulling part of the stomach with it.
    - Referred pain from a hiatal hernia occurs in Epigastric region, around T7-T8.
  - **Semilunar Hernias:** Occur along the rectus sheath and arcuate lines, mostly.

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## PERITONEUM

**Spleen:** It is actually mesodermal in origin, not endodermal like the rest of the abdominal organs.

**Retroperitoneal Space:** The area behind (posterior to) the peritoneum. Any organs not completely (or almost completely) covered by peritoneum are considered retroperitoneal organs.

**Abdominal Cavity:** Everything but the lateral, posterior, and anterior body walls of the abdomen, including both the peritoneal cavity and the retroperitoneal space.

**Peritoneal Cavity:** That part of the abdomen invaginated by **peritoneum**.

- Peritoneum has visceral and parietal layers, just like the pleural cavity. It is analogous to the organs pushing themselves into the peritoneum, like a fist into a balloon.
  - **Visceral Peritoneum:** Peritoneum directly on the organs.
  - **Parietal Peritoneum:** Peritoneum surrounding the interior lining of the abdominal wall.
- MALES: The peritoneal cavity is CLOSED.
- FEMALES: The peritoneal cavity is OPEN. It opens out into the cervix and vagina, making it a potential space for pathogens to enter.
- Peritoneum should be considered a *potential space* for pathogens and fluids to build up.

**Subphrenic Recess:** The recess where the peritoneum reflects off the liver (right side) on the inferior surface of the diaphragm.

- It contains the **coronary ligament** of the liver.

OMENTA: Peritoneum surrounding the stomach

- **Lesser Omentum:** Peritoneum along the lesser curvature of the stomach, covering the pancreas. It is superior and medial to the stomach and posterior to parts of the liver, and anterior to pancreas.
  - **Lesser Omental Bursa / Lesser Peritoneal Sac:** The space between the stomach and the liver. The space anterior to the lesser curvature of the stomach and posterior to the liver.
- **EPIPLOIC FORAMEN:** A pathway that allows entrance from the lesser peritoneal sac to the greater peritoneal sac.
  - The Inferior Vena Cava goes directly posterior to it (*retroperitoneal*).
  - The portal triad is directly anterior to it, in the peritoneum, along the lesser curvature of the stomach.
- **Greater Omental Bursa:** The space between the stomach and anterior abdominal wall.
  - **Greater Omentum:** The space formed by the peritoneum on the anterior surface of the stomach and the anterior abdominal wall.
    - It attaches to the stomach and to the transverse colon.
    - Anterior Layer of Greater Omentum: The parietal peritoneum of the abdominal wall.
    - Posterior Layer of Greater Omentum: The visceral peritoneum along the greater curvature of the stomach.

**Superior Recess:** Where the Lesser Omentum stops at the **coronary ligament** of the liver and reflects back onto the liver. Essentially, the space between the stomach and

**Inferior Recess:** Along the greater curvature of the stomach, where the greater omentum reflects onto the transverse mesocolon. Essentially, the space between the stomach and transverse colon, inferior to the stomach.

Intra-Peritoneal Organs: Organs completely or almost completely enclosed by peritoneum.

- Stomach
- Liver
- Gall Bladder
- Transverse Colon: completely
- Jejunum
- Ileum
- Cecum (very start of ascending colon)

Retro-Peritoneal Organs: Organs that are located mostly or completely behind the posterior parietal peritoneum.

- Duodenum
- Ascending Colon (only 25-50% covered)
- Descending Colon (only 25-50% covered)
- Sigmoid Colon
- Pancreas
- Kidneys

- Great Vessels and their primary branches: Abdominal Aorta and Inferior Vena Cava, Celiac Trunk, and Superior and Inferior Mesenteric arteries and veins.

**Mesentery:** Two layers of peritoneum opposing each other. Vessels and nerves often lie in the mesentery, where they can easily reach the organ where the peritoneal layers separate and reflect off the organs.

- **THE Mesentery:** The one that connects the small intestine to the posterior abdominal wall.
  - The **root** of the mesentery is where the Mesentery connects to the posterior wall.
- **Transverse Mesocolon:** Specific mesentery connecting the transverse colon to the posterior peritoneum.
- **Sigmoid Mesocolon:** Specific mesentery connecting the sigmoid colon to the posterior peritoneum.

The Anterior Surface of the Diaphragm:

- **Vena Caval Foramen:** Hole for the Inferior Vena Cava, where it passes to the liver.
  - Around **T8**
  - It is located in the **central tendon** (superior most part) of the diaphragm.
- **Eosophageal Hiatus:** Opening that admits the esophagus, guarded by two muscles **left crus** and **right crus**.
  - **Left Gastric Artery** and **Left Gastric Vein** also pass through the eosophageal hiatus.
  - Passes through at **T10**.
- **Aortic Hiatus:** Is actually posterior to the diaphragm -- not really a hole in the diaphragm.
  - **Thoracic Duct** goes posterior through this opening as well as aorta.
  - About Level 12, at lower most part of diaphragm.
- **Lumbocostal Arches:** Transversalis Fascia on the posterior wall of the diaphragm. Sympathetic Ganglia come through along these arches.

## SUMMARY ACCORDING TO THE GUTS

### FOREGUT:

- STRUCTURES:
  - Stomach
  - 1st two parts of the duodenum: Duodenal Cap and Descending Duodenum.
  - Liver
  - Gall Bladder
  - Pancreas
- ARTERIAL VASCULAR SUPPLY
  - Branches of the Celiac Trunk
- LYMPHATIC SUPPLY
  - Branches of the Celiac Nodes
- REFERRED PAIN: Occurs in the Epigastric Region.
- VENOUS RETURN: The portal vein.
- INNERVATION:
  - Parasympathetic: From Vagus nerve (C10). It is *perivascular* -- it follows the blood vessels.
  - Sympathetic: From the Greater Thoracic Splanchnic Nerves (T6-T10)

### MIDGUT:

- STRUCTURES:
  - Third and fourth parts of duodenum: Horizontal and Ascending Duodenum.
  - Jejunum
  - Ilium
  - Cecum

- Ascending Colon
- First 2/3 of Transverse Colon
- ARTERIAL VASCULAR SUPPLY
  - Branches of the Superior Mesenteric Artery
- LYMPHATIC SUPPLY: Branches of the Superior Mesenteric Nodes.
- REFERRED PAIN: Occurs in the Umbilical Region
- VENOUS RETURN: The Superior Mesenteric Vein.
- INNERVATION:
  - Parasympathetic: From Vagus nerve (C10). It is *perivascular* -- from the blood vessels.
  - Sympathetic: From the Lesser Thoracic Splanchnic (T9-T11,L1)

## HINDGUT:

- STRUCTURES:
  - Distal 1/3 of Transverse Colon
  - Descending Colon
  - Sigmoid Colon
  - Rectum
  - Upper portion of anal canal.
- ARTERIAL VASCULAR SUPPLY
  - Branches of the Inferior Mesenteric Artery
- LYMPHATIC SUPPLY: Branches of the Inferior Mesenteric Nodes.
  - Exception: The upper and lower rectum go to the Right and Left Common Iliac nodes, which then drains straight to the Lumbar Chain Nodes, and then to Thoracic Duct.
- REFERRED PAIN: Occurs in the Hypogastric (Suprapubic) region.
- VENOUS RETURN: The Inferior Mesenteric Vein.
- INNERVATION:
  - Parasympathetic: From Pelvic Splanchnic Nerves (S2-S4).
  - Sympathetic: From the Upper Lumbar Splanchnic (L1-L2)

## THE STOMACH

### DEVELOPMENT:

- Stomach begins as a mere dilation of the primitive gut tube.
- It undergoes two basic processes: differentiation and rotation.
- Initially tube attaches to dorsal and ventral walls via dorsal and ventral mesenteries.
  - **Ventral Mesentery** eventually becomes lesser omentum.
  - **Dorsal Mesentery (Dorsal Mesogastrium)** eventually becomes greater omentum.
- **Rotation:** Then the whole structure rotates 90 to the right, dragging the mesentery along with it.
  - The dorsal mesentery becomes the left side of the body, and the posterior of the stomach becomes the left lateral aspect.
- **Differential Growth:** Then differential growth produces the fundus, the greater curvature, and the lesser curvature of the stomach.

LOCATION: The pylorus of the stomach at the level of L1, in the transpyloric plane.

- Generally in the right epigastric region, but the location varies depending on position, weight, physiology, etc.

### EXTERNAL MORPHOLOGY:

- **Cardia:** Superior part nearest the esophagus.
- **Fundus:** That part of the stomach that is actually superior to the abdominal esophagus.



- Gastric Bubble is located here in radiographs, if person is upright.
- Cardiac Notch is a radiographic feature of being able to see the fundus part of the stomach.
- **Body:** The main part of the stomach consisting of the greater and lesser curvatures.
  - **Greater Curvature:** Inferior border of stomach body.
  - **Lesser Curvature:** Superior border of stomach body.
- **Pyloric Region:** The most distal part of the stomach, at level of L1, leading into duodenal cup.
- **Gastrocolic Ligament:** On greater curvature of stomach, attaching to transverse colon. It is part of the greater omentum.

#### INTERNAL MORPHOLOGY:

- **Gastric Canal:** Impression along the lesser curvature of the stomach, on the interior.
  - Rugae here are more longitudinal, to guide food to the pylorus.
- **Cardiac Opening:** The opening at the proximal end, aka the **esophogastric junction**.
  - No true sphincter here.
- **Rugae:** Mucosal folds of internal wall of stomach. They increase the surface area available for digestion.
- **Pyloric Antrum:**
- **Pyloric Canal:** The distal region of the body, in the pyloric zone, leading to pylorus.
- **Pyloric Sphincter:** At the pylorus, it is a true sphincter controlling flow of chyme into the duodenum.

#### RELATIONSHIPS:

- The left lobe of the liver overlies the anterior portion of the stomach.
- Spleen is lateral to the stomach, just off the greater curvature.
- The greater omentum is inferior to the stomach (just off greater curvature), and the transverse colon lies directly deep to it.
- Posterior to Stomach:
  - The lesser peritoneal sac.
  - The pancreas, with the duodenum surrounding it.
- **Bed of the Stomach:** Those organs upon which the stomach lies.
  - The pancreas, spleen, transverse colon, and a portion of the kidney and suprarenal glands.

#### CLINICAL CONSIDERATIONS:

- Gastric Bubble can be seen in stomach on X-rays, in the fundus region.
- Stomach Carcinoma is usually in the pyloric region or lower body, close to the pyloric lymph nodes.
- **Gastric (Peptic) Ulcers:** Acid secretion in stomach.
  - Gastroduodenal Artery, posterior to pyloric area, can be affected by an ulcer if the wall is eroded.

#### VASCULAR / LYMPH SUPPLY:

- Pyloric Lymph Nodes drain to the Celiac Nodes.
- **Right and Left Gastric Arteries** supply the lesser curvature of the stomach. They come off of the Celiac Trunk, via the common or proper hepatic arteries.
- **Right Gastroepiploic** supplies greater curvature, from the gastroduodenal, from the proper hepatic.
- **Left Gastroepiploic** supplies greater curvature, from the Splenic Artery, from the Celiac Trunk.

## THE SPLEEN

DEVELOPMENT: It is mesodermal -- not derived from gut (i.e. nongut)

- It grows within the two layers of peritoneum going to the posterior wall -- within the two folds defining the dorsal mesogastrium.
- As the stomach rotates, the spleen is moved to the left of the stomach (lateral to stomach)
- The dorsal mesogastrium in this region becomes the **gastrosplenic ligament**.

- Posterior part of mesogastrium adheres to the posterior wall, and the left kidney will then lie directly deep to it. This portion of the mesentery becomes the **splenorenal ligament**.

LOCATION: Upper left quadrant, left hypochondriac region, articulated with ribs 9-11 (laterally).

EXTERNAL MORPHOLOGY: It has three grooves (surfaces)

- **Renal Surface**
- **Gastric Surface**
- **Colic Surface:** Anterior / Inferior extremity.
- **Hilus:** Contains the splenic artery and vein, near the splenorenal ligament.

INTERNAL MORPHOLOGY:

RELATIONSHIPS:

- Kidney is deep to it, connected by splenorenal ligament.
- Stomach is medial to it, connected by gastrosplenic ligament.

CLINICAL CONSIDERATIONS:

VASCULAR / LYMPH SUPPLY:

- **Splenic Artery** and **Splenic Vein** come into the hilus.

## THE DUODENUM

DEVELOPMENT: Duodenum is the dividing point between the foregut and midgut.

- It forms in response to the rotation of the stomach.

LOCATION: It is **retroperitoneal**. (The first portion is actually intraperitoneal, but we won't count that).

- Umbilical Region, and Medial parts of the Left and Right upper quadrants.

EXTERNAL MORPHOLOGY: It is a C-Shaped portion of the gut.

- **Duodenal Bulb (I)** (foregut) (at about the level of LV1 -- the transpyloric plane)
  - **Hepatoduodenal Ligament:** There is a ligament which is part of lesser omentum.
  - This ligament is the sign of peritoneum surrounding the duodenum, hence we will consider the whole duodenum as retroperitoneal.
- **Descending Duodenum (II)** (foregut) (LV2)
- **Horizontal Duodenum (III)** (midgut) (LV3)
- **Ascending Duodenum (IV)** (midgut) (LV2-3)
  - **Ligament of Treitz:** Attaches the fourth part of the duodenum to the right crus of the diaphragm. It goes posterior to the pancreas. Essentially attaches duodenum to posterior wall.
    - It is the Suspensory Muscle of the Duodenum -- function to hold duodenum opened / closed for passage of food into Jejunum.

## INTERNAL MORPHOLOGY:

- Duodenal Bulb is smooth internally, while the rest of it is rough with mucosal folds.
- **Plicae Circulares:** The name of the folds on the distal three parts of duodenum.
- **Hepatopancreatic Duct:** Anastomose of the common bile duct and pancreatic duct onto the duodenum. It joins at the second part of the duodenum.
- **Major Papilla:** The opening into the common bile and pancreatic ducts.
  - The pancreatic duct usually joins the common bile duct before it reaches the major papilla.
- **Minor Papilla:** Another duct opening.
- **Ampulla (of Vater):** Ductule right at the major papilla, which holds bile and pancreatic enzymes.

## RELATIONSHIPS:

- The pancreas lies in the internal curvature of the C-Shape.
- Duodenal bulb is in transpyloric plane.
- **Superior Mesenteric Artery** usually passes over the horizontal duodenum.
- **Renal Artery and Vein** passes posterior to the ascending (fourth part of) duodenum.
- **Aorta:** The fourth part of the duodenum lies on the Aorta. Aorta is posterior to duodenum.
- **Transverse Mesocolon:** Inferior aspect of transverse colon. It covers the pancreas, and crosses the duodenum at the fourth part (ascending, and most medial part).
- **Portal Triad:** Common Bile Duct, Portal Vein, Proper Hepatic Artery.
  - They are located posterior to the duodenal bulb.
  - They are within the free edge of the lesser omentum (hepatoduodenal ligament).
- **Pancreas:** Within the C-Shape of the duodenum. The head of the pancreas lies posterior to the descending and horizontal duodenum.

## CLINICAL CONSIDERATIONS:

- **Duodenal Atresia:** Lack of development of duodenum.
- **Duodenal Stenosis:** Clogging of duodenum.
- Vomiting: Look for bile as a sign of where the obstruction occurred. If there is bile, then it was the lower duodenum (distal to duodenal papilla), if not, then it was the proximal duodenum (proximal to papilla).
- **Duodenal Ulcer:** Posterior aspect of the duodenal bulb, if the wall is broken, hemorrhaging can occur as it invades the gastroduodenal artery.
  - Four times more prevalent than peptic ulcers.
- **Paraduodenal Hernia:** The **Paraduodenal Recess** lies just posterior to the fourth part of the duodenum. A portion of duodenum and ilium can herniate there.
  - The *inferior mesenteric vein* is right there, and can be ruptured as a result.
- **Enterogastrone:** Is released by duodenum to decrease the peristalsis and acidity of material coming from stomach.
- **Cholecystitis:** Inflammation of gall-bladder, where bile is stored. Duodenum can form adhesions, etc., from what was originally cholecystitis.
- **Referred Pain:** Pain referred in duodenum is generally referred to *umbilical region*, through the **greater thoracic splanchnic nerve**.

## VASCULAR / LYMPH SUPPLY:

- Supplied by both the Celiac Artery (foregut parts) and Superior Mesenteric Artery (Midgut parts).
- **Gastroduodenal Arteries:** Come from the celiac trunk ultimately.
  - Celiac Trunk -----> Common Hepatic -----> Gastroduodenal.
- **Hepatic Arteries:** Proper Hepatic and Left Hepatic come off of the Common Hepatic Artery.
- **Superior Mesenteric Artery and Vein** passes over last half (midgut portions) of the duodenum.

## THE PANCREAS

### DEVELOPMENT:

- Starts out with a dorsal and ventral **pancreatic bud** on either side of the duodenum.
- The ventral bud rotates 180 and joins the dorsal bud.
- The stalk to the ventral bud becomes the **major papilla**
- The main pancreatic duct is formed from *both dorsal and ventral buds*.
- **Annular Pancreas:** The pancreatic lobes migrate around duodenum in the wrong direction and fuse with each other, strangling the duodenum.
  - Can completely block or at best result in **stenosis** of duodenum.

### LOCATION: Retroperitoneal.

- Umbilical, Epigastric, and left hypochondriac regions.
- It traverses diagonally from the descending (second) duodenum all the way over to the spleen.

### EXTERNAL MORPHOLOGY:

- **Head** -- snug up against the second and third parts of duodenum.
  - Lower portion extending inferiorly from the head is the **uncinate process**.
- **Neck** -- directly anterior to superior mesenteric artery and veins, and the portal vein.
- **Body**
- **Tail:** The tail of the pancreas extends into the **splenorenal ligament**, associated with the spleen.

### INTERNAL MORPHOLOGY:

- There is a main **pancreatic duct** running down the center of the organ.

### RELATIONSHIPS: Also see external morphology

- The root of the **transverse mesocolon** runs along the longitudinal axis of the pancreatic, directly anterior to it. (So the transverse colon lies on top of it).
- Left Adrenal Gland and Left Kidney are just posterior to the body and tail of the pancreas.

### CLINICAL CONSIDERATIONS:

- Referred epigastric pain could be the pancreas or the gallbladder. If the pain wraps around the the posterior, too, then the bile duct is probably compressed (stenosis) which could be more serious than just gallbladder.
- **Pancreatitis:** causes
  - Gallstones can block the major papilla in the duodenum. This would cause *bile* to backflow into the pancreas.
  - A stenosis in the pancreaticohepatic duct can cause *acid chyme* to backflow into the pancreas.
  - The stones may block both common bile and pancreatic ducts above, causing both to backflow into pancreas.

### VASCULAR / LYMPH SUPPLY:

- **Superior Pancreaticoduodenal Arteries (Anterior and Posterior):** These come off of the common hepatic, in turn off of the Celiac Trunk.
  - They also anastomose with the Right Gastroepiploic.
  - They supply the head, generally.
- **Great Pancreatic Artery, and Inferior Pancreatic Artery,** come off the Splenic Artery, from the Celiac Trunk.
  - Supplies body and tail.

## THE LIVER

DEVELOPMENT: Foregut, closely associated with primitive cystic and pancreatic ducts.

- Starts out as the **hepatic diverticulum**.
- Hepatic Duct elongates throughout development and joins with cystic duct to form **common bile duct** in the adult.
- The liver elongates into the **septum transversum** during development.
  - It continues to grow into the diaphragm later, to create the *bare area* of the liver -- the part that has no peritoneum covering it.
- The **omental foramen** is a free border of the lesser omentum. The portal triad travels through this hole.
- The **ventral mesentery** in the embryo reduces to become the **falciform ligament** in the adult.
- PRENATAL CIRCULATION: The liver is basically bypassed.
  - **Ductus Venosus**: In the embryo, it connects the **umbilical vein** with the hepatic vein and inferior vena cava. It shunts blood going through the liver so that it really doesn't perfuse the liver, but rather bypasses right to the inferior vena cava.
  - Blood going through much of the embryonic portal vein system is shunted through the ductus venosus.
  - After birth, the ductus venosus closes and its remnants become the **ligamentum venosum**, the ligament on the inferior, posterior aspect of the liver.
  - The **Round Ligament** is what remains of the umbilical vein. It hangs down from the falciform ligament.

LOCATION:

- The liver is not covered in the area of the falciform ligament attachment.
- Highest point is the right lobe. It rises to the 5th intercostal space.

EXTERNAL MORPHOLOGY:

- Ligaments:
  - **Coronary Ligament**: Reflection of peritoneum off the posterior surface of the liver, with the diaphragm.
    - A **bare area** is created by the reflection of the coronary ligaments on the diaphragm. The bare area touches the diaphragm.
  - **Right and Left Triangular Ligaments**: Part of the Coronary Ligament. Formed by the two layers of peritoneum extending laterally.
  - **Falciform Ligament**: Liver's reflection of peritoneum with anterior wall. The primitive ventral mesentery.
  - **Round Ligament** (Ligamentum Teres Hepatis) hangs down from the falciform ligament, on the anterior side.
  - **Ligamentum Venosum**: Posterior side of liver, separating the two lobes. It continues superiorly (on the posterior side) all the way to the superior margin of the liver.
- Lobes: The two lobes are separated by the falciform ligament.
  - **Left and Right Lobes**: The functional lobes of the liver, demarcated by an imaginary line going between the **inferior vena cava** (superior part) and the **gall bladder** (inferior part).
    - The right lobe is the larger lobe, extending superiorly to the fifth ICS when supine.
    - The left lobe is the smaller lobe.
  - **Caudate and Quadrate Lobes**: Both on the posterior side, surrounding the porta hepatis (i.e. portal triad).
    - **Caudate Lobe** is directly superior to the porta hepatis. Part of the functional left lobe of the liver.
      - It is closest to the vena cava.
    - **Quadrate lobe** is directly inferior to the porta hepatis, also part of the left lobe of the liver.
      - It is closest to the gall bladder.
- Peritoneal Reflections
  - **Subphrenic Recess**: Recess created by coronary ligament reflecting off the diaphragm.
  - **Hepatorenal Recess**: Recess between the right lobe of the liver and right kidney.
- Surfaces:
  - **Diaphragmatic Surface**: The surface of the liver facing the diaphragm. Smooth.
  - **Visceral Surface**: The posterior and left surfaces facing the stomach, duodenum, gall bladder, and pancreas.

#### INTERNAL MORPHOLOGY:

- **Porta Hepatis:** The hole going through the posterior side of the right lobe, containing the **portal triad** of vessels:
  - **Portal Vein**
  - **Common Bile Duct**
  - **Proper Hepatic Artery.**
- Difference between functional (surgical) and anatomical lobes: anatomic lobes are divided by the falciform ligament. Functional lobes (as above) are divided by the imaginary line between the gall bladder and IVC.
  - Each functional lobe is supplied by different vessels.

#### RELATIONSHIPS:

- **Inferior Vena Cava:** Goes over the reflection of the coronary ligament, through the **bare area**, on the superior posterior aspect of the liver.

#### CLINICAL CONSIDERATIONS:

- **Subphrenic Recess:** Air can collect in there as a result of surgeries.
- **Hepatorenal Recess:** This is the lowest area for fluid to collect in the upper abdominal cavity, *when the patient is in supine position.*

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## THE GALLBLADDER

#### DEVELOPMENT:

LOCATION: Located in the gallbladder fossa of the liver, on visceral (posterior side), medial-left lobe.

EXTERNAL MORPHOLOGY: A pear-shaped sac, containing concentrated gallbladder bile.

- Small or large amount of mesentery surrounding sac.
- Composed of:
  - **Fundus**
  - **Body**
  - **Neck**

#### INTERNAL MORPHOLOGY:

- Duct system on inside is made of spiral grooves. It joins the **common hepatic duct** to form the **common bile duct**, which dumps out on the major papilla of the duodenum.

#### RELATIONSHIPS:

- The body of the gall bladder is directly superior to the first part of the duodenum.
- It is adjacent to the Quadrate Lobe (lower posterior lobe) of the liver.

#### CLINICAL CONSIDERATIONS:

- Small or large amounts of mesentery may be present around the sac. The mesentery commonly has vessels. So surgical removal of the gallbladder can cause massive hemorrhaging if a lot of mesentery is present.\
- **Cholecystokinin** is the hormone that stimulates the release of gallbladder bile.
- **Biliary Colic** = expansion of the gall bladder or **cystic duct**, resulting in pain in the right upper quadrant.
- Has many stretch receptors, so it is sensitive to swelling. However, it is relatively insensitive to a direct cut.

- **Cholecystitis:** The infection of the gall bladder. It is clinically determined by palpating along the right costal margin, along the liver. This is **Murphy's Sign**.
- 

## THE SMALL INTESTINE (JEJUNUM / ILIUM)

DEVELOPMENT: Small intestine develops as a herniation into the umbilical region.

- Bowel spins 90 counterclockwise during growth, so that the distal end is to the left of the proximal end.
- Then, in the *Return Phase*, there is a 180 rotation, which places the cecum just inferior to the liver. Then the Cecum usually descends somewhat, but in some people it doesn't, and is thus termed a **subhepatic cecum**.
- **Fixation** occurs lastly: Organs become retroperitoneal secondarily. They start with peritoneum surrounding them, then they implant on the posterior wall, then they lose their peritoneum.
  - At this point, what was once visceral peritoneum is now parietal.
  - This secondary fixation occurs with all retroperitoneal organs except the rectum, which never has peritoneum in the first place.

LOCATION: It occupies most of the left upper quadrant and right lower quadrant of the abdomen.

- Jejunum Mostly in the umbilical region.

EXTERNAL MORPHOLOGY:

- 18-20 feet in length, but the mesentery holding it is only 4 feet long because it is scrunched up.
- Jejunum Proximal to the Ileum.
- **THE Mesentery** is the peritoneum surrounding the small intestine.

INTERNAL MORPHOLOGY:

- Jejunum has many **circular folds** on the inside lining, in the mucosa.
  - It has a thicker wall.
- The Ileum is smoother and has **solitary lymph follicles** (little spots) on inside lining.
  - It has a thinner wall.

RELATIONSHIPS:

CLINICAL CONSIDERATIONS:

- **Meckel's Diverticulum:** A portion of the bowel along the Ileum that may be left over from development.
  - Rule of Twos: In 2% of population, 2 feet from the distal end of the Ileum, and 2 inches long.
  - It creates a pouch which can collect unwanted waste and materials.

VASCULAR / LYMPH SUPPLY:

- **Arteriae Rectae** come off the superior mesenteric artery and supply the **Jejunum**, throughout the Mesentery. They run perpendicular to the superior mesenteric artery.
- **Arterial Arcades** have a more web-like pattern coming off the Superior Mesenteric Artery, and supply the **Ileum**.

## THE LARGE INTESTINE (COLON)

### DEVELOPMENT:

- Cecum, Ascending Colon, and Proximal 2/3 of Transverse Colon are midgut.
- Distal 1/3 of Transverse Colon, Splenic Flexure, Sigmoid Colon, Rectum, and Proximal Anal Canal are hindgut.
- **Cloacal Membrane:** At the distal end of the hindgut in the embryo.
- **Allantois:** Posterior part of the yolk sac. It will become the **Urogenital Sinus** and primitive urogenital system.
- Invasion of the Folds:
  - **Tourneaux's Fold:** A wedge of mesoderm that invades the hindgut region along the midsagittal plane.
  - At same time, lateral **Rathke's Folds** invade along the frontal plane.
- These two folds come together such that the hindgut is *separated from the primitive urogenital sinus*.
- **Perineal Body:** The tissue in between the two primitive tubes formed by the Rathke's and Tourneaux's Folds. It will form the future Urogenital region.
  - The perineal body divides two tubes, which are:
    - **Anorectal Canal**
    - **Urogenital Sinus:** This will be future **perineum** of the adult -- the region below the abdomen and superior to the pelvic bones, medial to the thighs.
  - Perineal body is the common attachment site for future muscles in the region:
    - Anal Sphincter.
    - Muscles associated with the pelvic and urogenital diaphragms.
    - In females it provides the primary support for reproductive organs.
- **Proctodeum:** Distal portion of hindgut, still covered by cloacal membrane. The cloacal membrane will eventually perforate, resulting in the anal opening.
- **PECTINATE LINE:** The division of hindgut (endodermal) anal canal, and ectoderm from invagination of the skin. They are both supplied by different vessels, nerves, etc.
  - Upper Anal Canal, superior to pectinate line, is endodermal hindgut.
  - Lower Anal Canal, inferior to pectinate line, is ectoderm.
  - The Pectinate Line can be identified by looking for the **anal columns**, longitudinal folds of mucosa that demarcate the upper anal canal.
- **COLLATERAL CIRCULATION:** Due to the pectinate line, there are two alternative circulations in the area.
  - **Caval System** of vessels supplies the ectodermal lower anus: Rectal Veins -----> Iliac Veins -----> Caval System
  - **Portal System** of vessels supplies the endodermal upper anus: Superior Rectal Veins -----> Inferior Mesenteric Vein -----> Portal Vein System
  - Because of the anastomosis, if there is an occlusion in one system, blood can get back to the circulation via the *collateral system*.

LOCATION: All four quadrants. In the nine-region system, it is located in the bottom six regions -- not the epigastric / hypochondriac regions.

### EXTERNAL MORPHOLOGY:

- Order of Sections:
  - **Cecum / Ileocecal Junction:** Intraperitoneal, for the most part.
    - **Vermiform Appendix:** Can be intraperitoneal or retro. The appendix extends down over the pelvic brim.
  - **Ascending Colon:** Retroperitoneal.
  - **Transverse colon:** Intraperitoneal, covered by transverse mesocolon. Hence it is mobile.
  - **Descending Colon:** Retroperitoneal
  - **Sigmoid Colon:** Intraperitoneal, covered by sigmoid mesocolon. Hence it is mobile.
- **Tenia Coli:** Three longitudinal muscles that run the length of the large intestine.
  - **Rectosigmoid Junction:** A complete expansion of the longitudinal muscles at the end of the colon, where it can have a muscular force.
- **Sulci:** Periodic indentations in the large intestine, on the external surface.



- **Haustra:** The "sections" of intestine created by the semilunar folds.
- **Epiploic Appendices:** The fatty appendages along the length of the large bowel. Their presence or absence is related to the diet of the individual.

#### INTERNAL MORPHOLOGY:

- There are no mucosal folding, like the small intestine.
- There are **semilunar folds**, the internal markings of the sulci on the outside. They are much further apart than in the jejunum.
- **Diverticula:** Outpocketings of the bowel, at the location of the semilunar folds. Food and popcorn can get stuck in there.

#### RELATIONSHIPS:

- **Transverse Mesocolon:** The mesentery connecting the transverse colon to the pancreas, stomach, and duodenum.
  - Transverse mesocolon covers the pancreas. Hence pancreatitis can spread to the transverse colon.
- **Sigmoid Mesocolon:** The mesentery connecting the sigmoid colon to the posterior abdominal wall.
- **Hepatic Flexure:** Turning point of the ascending -----> transverse colon on the right side, just inferior to the liver.
- **Splenic Flexure:** Turning point of the transverse -----> descending colon on the left side, just anterior to the left kidney.
- **Phrenicocolic Ligament:** Attaches the transverse colon to the left crus of the diaphragm, at the location of the splenic flexure.
  - It is right next to the spleen.
  - It inhibits the passage of fluid into the **left paracolic gutter**, and prevents fluid from getting into the supracolic (above mesocolon) area.

#### CLINICAL CONSIDERATIONS:

- **Pancreatitis** can spread to the transverse colon, via the transverse mesocolon.
- **Diverticula** can cause problems. See popcorn.
- **Volvulus:** is twisting of the sigmoid colon. It can lead to a strangulation of the vessels and eventual necrosis.

#### VASCULAR / LYMPH SUPPLY: Colic arteries have variations.

- **Right Colic Artery:** Comes off of the superior mesenteric artery, superior to the **ileocolic artery**, and supplies the ascending colon.
  - It divides into the Arterial Arcades
- **Middle Colic Artery:** Comes off the superior mesenteric artery and supplies the Transverse Colon. It divides off right anterior to the duodenum.
- **Left Colic Artery:** Comes off the inferior mesenteric artery and supplies the descending colic.
- **Sigmoid Arteries:** Come off the inferior mesenteric and supply the sigmoid colon.

## THE ABDOMINAL VASCULATURE

### Abdominal Aorta:

- Enters the **Aortic Hiatus** between the **right crus** and **left crus** of the diaphragm at the level of T12.
- Extends retroperitoneally along the anterior surface of the vertebrae (slightly to the left), until the level of L4.
- **Bifurcation of the Abdominal Aorta:** It bifurcates at L4, into the **Left Common Iliac** and **Right Common Iliac Arteries**.
- RELATIONS:
  - Goes posterior to the Uncinate Process and Body of the pancreas.
  - Goes posterior to the horizontal (third portion of) duodenum.
  - Goes posterior to the Left Renal Vein.
    - The left renal vein passes *over* (anterior to) the Aorta.

- The left renal vein passes *under* (posterior to) the superior mesenteric artery.
  - The Inferior Vena Cava is to the right and slightly more anterior than the abdominal aorta.
    - At the bifurcation, the inferior vena cava passes *posterior* to the Aorta.
- Principle Branches:
  - Celiac Trunk
  - Superior Mesenteric Artery
  - Inferior Mesenteric Artery
  - Renal Arteries
  - Gonadal Arteries -- gonadal arteries pass to a region in the *upper abdomen*, not lower.

**Celiac Trunk:** Located just inferior to Aortic Hiatus.

- Branches:
  - Splenic
    - Splenic -----> Left Gastroepiploic
  - Common Hepatic
    - Common Hepatic -----> Proper Hepatic -----> Gastroduodenal -----> Right Gastroepiploic.
    - Right Gastroepiploic -----> Gastroduodenal Arteries
    - Right Gastroepiploic -----> Superior Pancreaticoduodenal Arteries
  - Left Gastric
    - **CLINICAL:** If the left gastric is occluded, blood can be rerouted through the right gastric. With gastro-esophageal cancer, the left gastric can be ligated, and the right gastric will still supply blood.

**Superior Mesenteric Artery:**

- Branches:
  - SMA -----> Inferior Pancreaticoduodenal Arteries
  - SMA -----> Middle Colic -----> (transverse colon)
  - SMA -----> Right Colic -----> (ascending colon)
  - SMA -----> Ileocolic -----> Ileal and Colic
- **Marginal Artery:** Comes off the Left Colic Artery and can supply the medial aspect of the large intestine in the absence of a middle colic.

**Inferior Mesenteric Artery:**

- IMA -----> Left Colic
- IMA -----> Sigmoid Artery
- IMA -----> Rectosigmoid
- IMA -----> Superior Rectal

**Pancreaticoduodenal Arcade:** An alternative route for blood flow through the branches of the celiac, if there should be an occlusion in the celiac trunk.

- Superior Pancreaticoduodenal Arteries come from the Hepatic branch of the Celiac.
- Inferior Pancreaticoduodenal Arteries come from the SMA.

**Lumbar Arteries:** Supply the posterior abdominal wall.

- **1st - 4th Lumbar Arteries** come off of the Aortic Trunk directly.
- **5th Lumbar Artery** comes off of the *Median Sacral Artery*, below the bifurcation of the Aorta.

**PORTAL VENOUS SYSTEM:** Takes blood from the entire abdomen and dumps it into the liver for processing -----> out the Suprahepatic Inferior Vena Cava.

- Abdominal venous drainage ends in the **hepatic sinusoids** in the liver.

- Approx 67% of the liver's blood is venous blood from the portal vein. The other 33% comes from the hepatic arteries.
- BLOOD IN THE LIVER:
  - *Venous Blood Going into the liver:* portal vein branches to **left portal vein** and **right portal vein**, to go to the respective functional lobes of the liver. Then it further subdivides until it gets to the hepatic sinusoids.
  - *Venous blood leaving the liver:* **Central Vein** -----> **Sublobar Veins** -----> **Left and right Hepatic Veins** -----> **Inferior Vena Cava.**
- BRANCHES
  - *Blood going to the portal vein:* The anastomose of the **splenic vein** and **superior mesenteric vein.**
  - **Inferior Mesenteric Vein:** Joins with the Splenic Vein, 60% of the time, and with the Superior Mesenteric Vein, 40% of the time.
- RELATIONS
  - Right at the anastomoses of SMV and Splenic Vein, the portal vein passes *posterior to the neck of the pancreas.* (CLINICAL) Hence tumors in the head and neck of the pancreas can occlude the portal vein.
  - Passes posterior to the common hepatic artery, just south of the liver.
- PORTAL TRIAD: Duh. Portal Vein, Proper Hepatic Artery, and Common Bile Duct, going through the Porta Hepatis on the posterior side of the liver, between the caudate and quadrate lobes.
- **PORTAL HYPERTENSION:** Increased blood flow in hepatic portal system, creating increased pressure in the rest of the venous system.
  - Occlusion can be **prehepatic, intrahepatic, or posthepatic**, depending on where the occlusion occurs.
  - THE PORTAL VENUS SYSTEM DOES NOT HAVE VALVES.
  - Because the portal system has no valves, the blood can flow back on itself, causing an increase in pressure.
  - Blood tries to get back to the heart and winds up taking collateral channels, which creates a dilation *outside the portal system*, causing **varicose veins**. (this is only one cause of varicose veins).
  - **CAPUT MEDUSAE:** Varicosity of the paraumbilical veins, due to severe portal hypertension. They look like somewhat like small snakes on the skin. They radiate in a wheel-like fashion.
  - **Ascites:** Increased fluid in the peritoneal cavity. Can result from the liver's inability to handle increased blood pressure.
  - **Hemorrhoids:** Varicose veins in the anal regions.
  - COUGH UP BLOOD: Blood backflow into esophageal plexus could make you cough up (or vomit) blood from portal hypertension. Important clinical diagnostic sign.
- COLLATERAL VENOUS PATHWAYS: In the event of portal hypertension or portal stenosis.
  - **Paraumbilical Pathway:** The paraumbilical vein feeds into the portal vein, in the left lobe the liver.
    - These are usually closed off after birth, but in the event of portal hypertension, they can recanalize.
    - Umbilical Veins (recanalized) -----> Inferior Epigastric Veins -----> Superficial Epigastric Veins -----> IVA / SVC.
  - **Esoophageal Pathway:** Blood back flows into the left gastric and eventually makes its way back to the azygos vein.
    - Left Gastric Vein -----> Esophageal Vein (plexus) -----> Inferior Thyroid Veins (one on each side) ----> Azygos system of veins
  - **Caval/Portal Pathway:** At the pectinate line is another collateral pathway.
    - Upper portion of anal canal drains via **Superior Rectal Vein** -----> IMV
    - Lower Portion of anal canal drains via **Middle and Inferior Rectal Veins** -----> **Caval System.**
    - **PECTINATE LINE:** The two venous systems anastomose with each other, so backflow can take the alternative route at that location.
  - HEMORRHOIDS:
    - **INTERNAL HEMORRHOIDS:** Hemorrhoids in the upper anal canal caused by varicosities of the superior rectal vein. They are innervated by autonomic nerves and hence are not painful.
    - **EXTERNAL HEMORRHOIDS:** Varicosities of the inferior and middle rectal veins. They are innervated by somatic nerves and are painful.

## THE NERVOUS SYSTEM

CNS: The brain and the spinal chord.

**Peripheral Nervous System:** All other nerves, consisting of the **Autonomic Nervous System (ANS)** and **Somatic Nervous System (SNS)**. **Autonomic Nervous System:** Involuntary innervation of visceral structures.

- Innervates smooth (involuntary) muscle, cardiac muscle, and glands.
- **GVE: General Visceral Efferent** -- Responsible for motor function to visceral tissues.
  - "Efferent" refers to flow from CNS to tissues, so that they will stimulate or *effect* a response.
- **GVA: General Visceral Afferent** -- responsible for sensory function from visceral tissues.
  - "Afferent" refers to flow from the tissues back to the CNS, so they carry the impulse *away* from the stimulus.
  - These are made up primarily of **stretch receptors**, so that inflammation or distension of organs can be sensed.

**Somatic Nervous System:** Voluntary innervation of somatic structures (skeletal muscles and skin).

- **GSE: General Somatic Efferent** -- responsible for motor function to somatic tissues.
- **GSA: General Somatic Afferent** -- responsible for sensory function from somatic tissues.

Types of Nerves fibers: There are many types of nerve fibers in a single nerve **bundle**.

- Motor Fibers
- Sensory Fibers
  - Pain receptors -- originating from somatic structures.
  - Temperature -- originate from somatic structures.
  - Stretch receptors -- originating from visceral structures. These are important to visceral structures, as they constitute the main sensory input from the organs.

**MIXED NERVE:** Nerves such as vagus and phrenic carry both afferent and efferent fibers, and both somatic and autonomic. Therefore they are mixed nerves.

**REFERRED PAIN:** The interpretation of dermatomal layers in the brain is responsible for the concept of referred pain.

- Sensory input from the visceral organs is interpreted by the brain as originating from one of the dermatomal segments. The brain oversimplifies the stimulus as coming from a cutaneous layer.
- Take Appendicitis as an example:
  - Inflamed appendix sends an impulse to T10, which is then sent to brain to be processed.
  - Umbilical cutaneous dermatomal region also goes to T10, and in the past the brain has received more info from this region, so it "assumes" that the appendix signal is coming from such a region.
  - So, there is an initial *referred dull (visceral) pain in the umbilical region*.
  - Then if the appendix inflames enough to pierce or press against the anterior wall, it will stimulate pain-afferent nerves in the lower right quadrant, so that will create a *sharp (somatic) pain in the region of the appendix*.
  - These two signs together could be taken as signs of appendicitis.

STRUCTURE OF PARAVERTEBRAL GANGLIA:

- **Dorsal Root Ganglion:** They have afferent (incoming sensory) nerves.
  - Two afferent nerves come in -- one from the peripheral tissues and one from the central canal.
- **Ventral Root Ganglion:** Carries efferent fibers out to the periphery.
- **Spinal Nerves** form where these two roots come together, to form both sensory and motor fibers in the same nerve.
  - All spinal nerves are mixed nerves!
  - Soon after forming, the spinal nerve divides into two nerves -- the pre-ganglionic nerves.
  - **dorsal primary ramus** -- innervates muscles and skin of back.
  - **ventral primary ramus** -- innervates lateral and anterior.
- Ventral Primary Ramus goes to the **White Rami Communicans** on the sympathetic chain.
  - So the White Rami carries the efferent pre-ganglionic nerves.

- Once the nerve-fiber reaches the sympathetic trunk, it has several options:
  - It can *synapse* with a **Grey Rami Communicans** and continue as a sympathetic spinal nerve going out to target viscera.
  - It can *ascend* to a higher level in the sympathetic chain.
  - It can *descend* to a lower level in the sympathetic chain.
  - It can *pass through and out* of the paravertebral ganglion without synapsing, and then continue onto a target organ as a **splanchnic nerve** -- to go to visceral target organ and form a visceral **plexus** -- or branch somewhere nearby, like celiac or superior mesenteric arteries.

	SYMPATHETIC	PARASYMPATHETIC
Spinal Chord Origin	<b>Thoracolumbar: T5-T12, L1-L2</b>	<b>Craniosacral: C10 (Vagus Nerve), S2-S4.</b>
Effects	Widespread, low precision	Specific, discrete, local, acute.
Location of cell bodies	Along the spinal chord, at the <b>sympathetic chain ganglia.</b>	Adjacent to or in the target organ.
	Plexuses are found along the <i>midline</i> of the body -- <b>pre-aortic ganglia, mesenteric plexuses.</b>	
Pre-Ganglionic Fiber	Short	Long
Post-Ganglionic Fiber	Long	Short
Pre-Ganglion : Post-Ganglion fiber ratio	Low ratio -- one pre-ganglion spreads to lots of post-ganglion, hence the effect is widespread and imprecise	High Ratio -- 1:1 or near 1:1, hence the effect is more localized.
Neurotransmitter	Acetylcholine at pre-synapse terminals  Norepinephrine at post-synapse terminals	Acetylcholine
General energy use and metabolism	Fight or flight -- expenditure of energy.	Intake and conservation of energy

#### The Vagus Nerve: Foregut and Midgut innervation

- In the thorax, the right vagus runs posterior to the esophagus, and the left vagus runs anterior to it.
- Around the esophageal hiatus (T10), the two vagus nerves mix, and then they separate again, to form the right and left vagal trunks.
- **Left (Anterior) Vagal Trunk:** Gives off **Hepatic Branch** and **Principle Anterior Gastric Branch.**
- **Right (Posterior) Trunk:** Forms the **Celiac Plexus** -----> **Superior Mesenteric Plexus.**
- These nerves are **perivascular** -- they follow the course of the arteries.

#### Pelvic Splanchnic Nerves: Hindgut innervation

- The Pelvic Splanchnic Nerves are parasympathetic Sacral spinal nerves S2-S4.
- They form **Pelvic Plexuses** -----> **Inferior Hypogastric Plexus** -----> Pelvic viscera, and separately, the hindgut.
- These nerves are **Non-Perivascular.** They *do not* follow the arteries, but instead crisscross the arteries. The nerves are still located in mesentery.
- The lower anus (below pectinate line) is innervated by *somatic nerves* -- the **puddendal nerve** -- not parasympathetic pelvic splanchnic.

#### Greater Thoracic Splanchnics: T6-T9. Sympathetic spinal nerves supplying the foregut and midgut.

**Lesser Thoracic Splanchnic:** T10-T11. Sympathetic spinal nerves supplying the hindgut, generally.

**Least Thoracic Splanchnic:** T12. It supplies the Renal Plexus.

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## POSTERIOR ABDOMINAL WALL

Three Hiatuses of the Diaphragm:

- **Caval Hiatus:** Passage for Vena Cava, T8. The highest, most central hiatus, in the central tendon.
- **Eosophageal Hiatus:** T10.
- **Aortic Hiatus:** The Descending Aorta passes through the diaphragm most posteriorly and inferiorly. T12.

**Diaphragmatic Crura:** Left and Right Crus of the diaphragm, on posterior wall.

- **Thoracic Splanchnic Nerves** go through the left and right crura of the diaphragm, to enter the abdomen.

**LUMBOCOSTAL ARCHES (ARCUATE LIGAMENTS):** The ligaments connecting the diaphragm to the posterior wall. They are condensations of transversalis fascia.

- **Median Arcuate Ligament:** Passes anterior to the Aorta as it goes through the diaphragm. It creates the Aortic hiatus.
  - **CLINICAL:** At times it can compress the Celiac trunk, below the diaphragm. In this event blood can still circulate via the pancreaticoduodenal arcade.
- **Medial Arcuate Ligament:** Overlies the psoas muscle, lateral to the median arcuate ligament.
  - It may also be called the *psoas fascia*.
  - **RELATION:** The sympathetic trunks enters the abdomen immediately *posterior* to the medial arcuate ligaments.
- **Lateral Arcuate Ligament:** Ligament around the Quadratus Lumborum muscle. Extends from the transverse fascia of L1 to the 12th rib.

Muscles of the Posterior Abdominal Wall:

- **Psoas Major Muscle:** Chief flexor of the thigh and trunk
  - Passes all along vertebral column starting at T12.
  - Passes deep to the inguinal ligament and attaches to the lesser trochanter of the femur.
  - Innervated by L2-L4.
  - Contraction: Pulls the body toward the leg, or the thigh toward the body.
- **Iliacus Muscle:** Aids the psoas major in flexing the thigh and trunk
  - Attaches to the iliac fossa (anterior surface of the iliac bone).
  - Inserts into psoas tendon, and hence the two muscles together are often called the **iliopsoas muscle**.
- **Quadratus Lumborum:** Stabilizes the 12th (floating) rib during inspiration. Inserts on the 12th rib.

**Thoracolumbar Fascia:** Actually an extension of the aponeuroses of the transversus abdominis and external abdominal oblique muscles.

- It divides into an anterior plane and posterior plane. It thus serves to compartmentalize the muscles, which lies in between the two planes.
  - Anterior plane attaches to the transverse process of the lumbar vertebrae.
  - Posterior plane attaches to joins with the other muscles in the back.

## Nerves of the Posterior Wall:

- Things common to all the nerves: CLINICAL
  - They are all related to the psoas muscle. Psoas pathology will irritate those nerves. A patient that relieves pain upon relaxation of the psoas muscle may have retroperitoneal pathology.
  - All of the nerves pass from the posterior to wall laterally to the anterior wall.
    - Subcostal and lumbar plexus pass through the transversalis fascia and then go in-between the transversus abdominis and internal oblique muscles.
- **Subcostal Nerve:** T12
  - Associated with the 12th (floating) rib. This nerve is immediately posterior to the kidney and overlies quadratus lumborum muscle.
  - It is the only nerve of the lower posterior wall not associated with the lumbar plexus.
- **Lumbar Plexus:** L1-L3, and the upper half of L4. These are spinal nerves, so they have somatic and autonomic branches.
  - Somatic Components: Supply iliopsoas and quadratus lumborum muscles.
  - Autonomic Components: The lumbar splanchnic nerves.
  - Location: The plexus itself is located deep within the psoas muscle.
  - Distribution: Lower abdominal wall, genitalia, upper portion of the lower limb. It contains the following nerves:

## Nerves of the lumbar plexus:

- **Iliohypogastric Nerve:** T12-L1.
  - Runs superomedial to the Anterior Superior Iliac Spine.
  - CLINICAL: Passes over **McBurney's Point** -- the point of surgical entry for an appendectomy (about 1/4 of the way between the ASIS and umbilicus). It can thus be damaged from an appendectomy.
  - In the suprapubic region, it divides into two portions: Iliac Branch and Hypogastric Branch.
  - Distribution:
    - Iliac branch gets sensory info from hip.
    - Hypogastric branch innervates the suprapubic region.
  - Passes posterior to kidney and overlies quadratus lumborum muscle.
  - Sometimes it will be joined with the ilioinguinal nerve from their origin at L1, and sometimes it won't.
- **Ilioinguinal Nerve:** L1
  - Same location as the iliohypogastric. It passes through the inguinal canal and emerges out of the inguinal ring.
  - Distribution:
    - Innervates the anterior scrotum / labia majora, and the upper and medial thigh.
  - CLINICAL: If you want to anesthetize the pubic area, this is one of the nerves you have to block. Anesthesia would probably be placed in the inguinal canal.
  - It maybe joined with genitofemoral nerve.
  - Passes posterior to kidney and overlies quadratus lumborum muscle.
- **Lateral Femoral Cutaneous Nerves:** L2-L3
  - Assoc with the lateral aspect of the psoas muscle.
  - Considered to be a part of the posterior division of the plexus. Has nothing to do with the abdominal cavity.
  - Innervates the posterior and lateral thigh.
- **Femoral Nerve:** L2-L4
  - By far the largest branch of the lumbar plexus.
  - Location: Located in the cleft between the psoas and iliacus muscles.
  - Runs posterior to inguinal ligament and carries fascia with it -- the **femoral sheath**.
  - Distribution: Motor innervation of psoas and iliacus; innervation of the thigh and lower extremities.
- **Genitofemoral Nerve:** L1-L2
  - Location: Anterior surface of the psoas muscle. Very fine string, "ribbon."
  - Distribution: Branches into the genital and femoral branches.
    - Genital branch goes through inguinal nerve to inguinal canal. It innervates the **cremaster muscle**.
    - Femoral Branch: Innervates skin in upper portion of the thigh.
  - CLINICAL: **Cremaster Reflex:** Gently touch the medial portion of the thigh, and see if the scrotum pulls the testes up. This is a simple way of testing the functionality of the lumbar plexus.
- **Obturator Nerve:** L2(?), L3-L4
  - Deep, medial border of the psoas muscle. Very tight chord that passes along the lateral part of the pelvic wall.



## Lumbosacral Trunk: L4-L5

- Deep and medial to psoas and obturator nerve.
  - Distribution = sensory, to the gluteal region, thigh, leg.
  - Not part of the lumbar plexus.
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## KIDNEYS AND SUPRARENAL GLANDS

### Suprarenal Glands:

- Multiple arterial branches supply it with blood, but only one vein empties it. **VENOUS DRAINAGE:**
  - Right Adrenal Gland: **Inferior Vena Cava**.
  - Left Adrenal Gland: **Left Renal Vein**.
- **NERVE SUPPLY:** Only sympathetic (hence adrenaline). They are *only innervated by pre-ganglionic fibers, no post-ganglions*.
  - The fibers originate from the sympathetic trunk -- **Greater Thoracic Splanchnic Nerves**.

### KIDNEYS:

- Location: Retroperitoneum, T12-L4, in the **perirenal space**.
  - **Hilus:** Renal Artery, Renal Vein, and Renal Pelvis (ureters) enter at the hilus.
  - **RELATIONS:**
    - **Right Kidney** related to Morrison's Pouch.
    - **Left Kidney** related to tail of the pancreas.
  - Retroperitoneal Spaces:
    - **Perirenal Space:** The space containing the kidney's, bordered by Gerota's Fascia.
    - **Anterior Pararenal Space:** Contains the other retroperitoneal organs -- part of the duodenum, pancreas, ascending and descending colon.
    - **Posterior Pararenal Space:** Doesn't contain jack shit.
    - Because of the division of retroperitoneal spaces, pathology escapes down into the pelvis, before it goes right or left.
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## LYMPHATIC SYSTEM

### General stuff about the Lymphatic System:

- Functions:
  - Return extracellular fluid back to circulation
  - immunity
  - Clean up debris, general housekeeping
- Appearance = usually clear but can be cloudy when it contains fat
- Circulation: Percolates through lymph nodes. Lymph nodes are added to the fluid at lymph nodes.
  - Muscular contraction squeezing lymphatic channels is the primary contributor to its movement. Filtration pressure and arterial pulsing also contribute.

**Thoracic Duct:** Carries most of the lymph from the abdomen. All things empty into the thoracic duct.

**Lymphadenitis:** Infections within the lymph node(s).

**Lymphangitis:** Infections within lymph vessels.