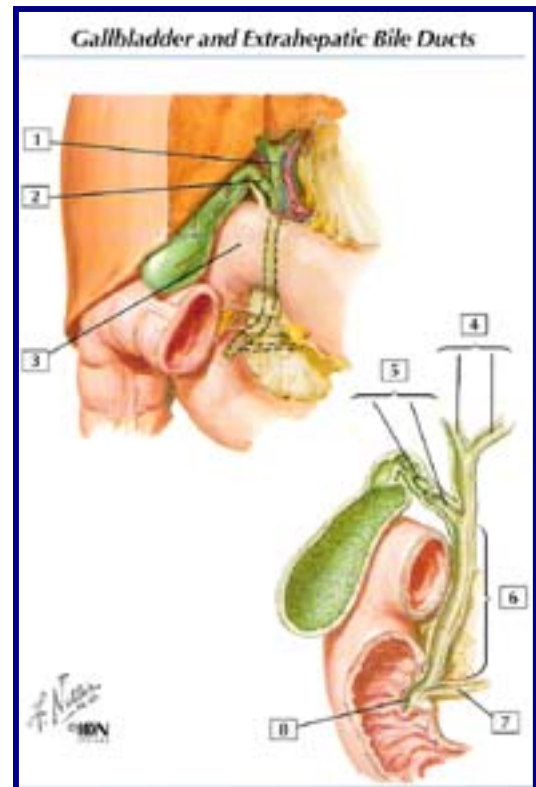


Objective 1)

Follow the course of bile from the liver into and out of the gall bladder and into the duodenum. Follow the course of exocrine pancreatic secretions from their source to the duodenum. Identify the parts of the pancreas and its relationship to other abdominal organs.

A). Course of bile:

- i. Hepatocytes secrete and secrete bile into the bile canaliculi formed by them.
- ii. The canaliculi drain into the small interlobular biliary ducts and then into large collecting bile ducts of the intrahepatic portal triad, which merge to form the right and left hepatic ducts.
- iii. The right and left hepatic ducts drain the right and left functional (portal) lobes of the liver, respectively.
- iv. Shortly after leaving the porta hepatis the right and left hepatic ducts for the common hepatic duct, which is joined on the right side by the cystic duct to form the bile duct.
 1. The cystic duct carries bile into and out of the gallbladder.
- v. The bile duct forms in the free edge of the lesser omentum and descends posterior to the superior part of the duodenum and lies in a groove on the posterior surface of the head of the pancreas or embeds in the parenchyma of the pancreas.
 1. The distal end of the bile duct has the sphincter of the bile duct that closes and doesn't let bile into the duodenum; hence, bile backs up and passes along the cystic duct into the gallbladder for storage and concentration.
- vi. On the left side of the descending part of the duodenum, the bile duct comes into contact with the main pancreatic duct.
- vii. The two ducts run obliquely through the wall of the descending part of the duodenum, where they unite to form the hepatopancreatic ampulla.

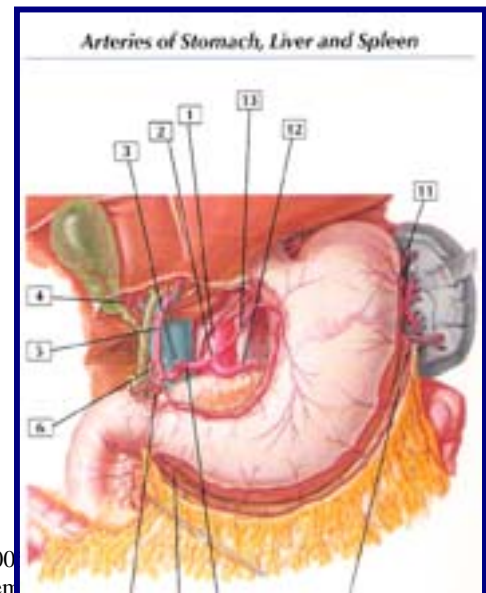


- viii. The distal end of the ampulla opens into the duodenum through the major duodenal papilla and has the hepatopancreatic sphincter to close the papilla.
- B). Course of exocrine pancreatic secretions:
- i. The exocrine secretions enter into the pancreatic duct, which begins at the tail of the pancreas and runs through the parenchyma of the pancreas to the head, where it turns inferiorly to merge with the bile duct.
 - 1. The sphincter of the pancreatic duct blocks pancreatic juice from entering the ampulla.
 - ii. The uniting forms the hepatopancreatic ampulla that opens into the major duodenal papilla.
 - iii. The accessory pancreatic duct drains the uncinete process and the inferior part of the head of the pancreas and opens into the duodenum at the minor duodenal papilla.
 - 1. Usually, the accessory pancreatic duct communicates with the pancreatic duct, but in some people it does not.
- C). Parts of the pancreas:
- i. Head – lies deep to the C-loop of the duodenum and anterior to the inferior vena cava and left renal vein
 - ii. Uncinate process (lingua) – small portion of the head that extends medially and is posterior to the superior mesenteric vessels.
 - iii. Neck – joins the head to the body and overlies the superior mesenteric vessels and the portal vein.
 - iv. Body – crosses the midline of the body and extends to the left, on top of the aorta, left renal vein, splenic vessels, and the termination of the inferior mesenteric vessels. It is to the left of the superior mesenteric vessels, and it is posterior to the transverse colon.
 - v. Tail: fascia of the tail connects the body with the fascia of the spleen. It is closely related to the hilum of the spleen and left colic flexure. It is mobile and passes b/ layers of the splenorenal ligament with the splenic vessels.

Objective 2)

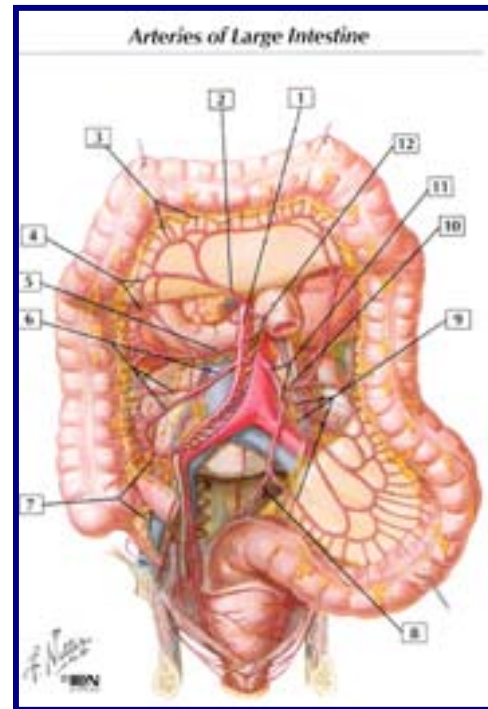
Trace the flow of blood (arterial & venous) for each of the major abdominal organs and indicate possible collateral vascular pathways.

- A). Arterial supply: The blood arrives in the abdomen via the abdominal aorta and supplies the viscera via several branches from top to bottom. The aorta has several bilateral branches and three singular branches.
- i. Celiac artery: From the abdominal aorta just distal to the aortic hiatus of the diaphragm. Soon divides into 3 arteries to supply the esophagus, stomach, duodenum, liver, biliary system, spleen, and pancreas.
 - 1. Left gastric artery: From the celiac trunk and ascends retroperitoneally to the esophageal hiatus where it passes b/ layers of hepatogastric ligament. It supplies the distal portion and the lesser curvature of



- the stomach, where it anastomoses with the right gastric artery.
2. Splenic artery: From the celiac trunk and runs retroperitoneally along the superior border of the pancreas; it then passes b/ the layers of the splenorenal ligament to the hilum of the spleen. It supplies the body of the pancreas, spleen, the adrenal glands and greater curvature of the stomach.
 - a. Left gastro-omental artery (gastroepiploic artery): From the splenic artery in the hilum of the spleen to supply the left portion of the greater curvature of the stomach and anastomose with the right gastro-omental artery.
 - b. Short gastric arteries (n = 4-5): From the splenic artery at the hilum of the spleen to supply the fundus of the stomach.
 3. Hepatic artery (common): From the celiac trunk and passes retroperitoneally to reach the hepatoduodenal ligament and passes b/ its layers to the porta hepatis, where it divides into the left and right hepatic arteries to supply the functional lobes of the liver. It supplies the liver, gallbladder, stomach, pancreas, and duodenum.
 - a. Cystic artery: From the hepatic artery within the hepatoduodenal ligament to supply the gallbladder and cystic duct.
 - b. Right gastric artery: Runs in the hepatogastric ligament to supply the right portion of the lesser curvature of the stomach and anastomose with the left gastric artery.
 - c. Gastroduodenal artery: From the hepatic artery and descends posterior to the gastroduodenal junction to supply the stomach, pancreas, first part of the duodenum, and the distal part of the bile duct. It will anastomose with the inferior duodenal artery.
 - i. Right gastro-omental artery (gastroepiploic artery): From the gastroduodenal artery to pass b/ the greater omentum to supply the right portion of the greater curvature of the stomach and anastomose with the left gastro-omental artery.
 - ii. Anterior and posterior superior pancreaticoduodenal arteries: From the gastroduodenal artery to descend to the head of the pancreas and supply the proximal portion of the duodenum and head of the pancreas. They will anastomose with the anterior and posterior inferior pancreaticoduodenal arteries.
 - ii. Superior mesenteric artery (SMA): From the abdominal aorta and runs in the root of the mesentery to the ileocecal junction to supply the part of the gastrointestinal tract derived from the midgut (distal duodenum, jejunum, ileum, cecum, ascending colon, part of the transverse colon).
 1. Anterior and posterior inferior pancreaticoduodenal arteries: From the SMA and ascend retroperitoneally to the head of the pancreas to supply the distal portion of the duodenum and head of the pancreas. They will anastomose with the anterior and posterior superior pancreaticoduodenal arteries.
 2. Intestinal arteries (n = 15-18): From the SMA passing b/ the two layers of the mesentery to supply the jejunum and ileum.

3. Ileocolic artery: From the SMA as its terminal branch to divide into the ileal and colic arteries to supply the ileum, cecum, and part of the ascending colon.
 - a. Appendicular artery: From the ileocolic artery and passes b/ layers of mesoappendix to supply the appendix.
 4. Right colic artery: From the SMA and runs retroperitoneally to supply the ascending colon. Anastomoses with the middle colic artery.
 5. Middle colic artery: From the SMA and runs retroperitoneally b/ the layers of the transverse mesocolon to supply the transverse colon. Anastomoses with the right and left colic arteries.
- iii. Inferior mesenteric artery (IMA): From the abdominal aorta and descends retroperitoneally to the left of the abdominal aorta to supply the area of the GI tract derived from the hindgut (descending colon, sigmoid colon, and rectum).
1. Left colic artery: From the IMA and passes retroperitoneally toward the left to supply the descending colon. Anastomoses with the middle colic artery.
 2. Sigmoid arteries (n = 3-4): From the IMA and passes retroperitoneally to the left to supply the descending colon and sigmoid colon.
 3. Superior rectal artery: The terminal branch of the IMA that descends retroperitoneally to supply the proximal part of the rectum. Anastomose with the other rectal arteries.
- iv. *Middle rectal artery: From the internal iliac artery to supply the middle of the rectum. Anastomose with the other rectal arteries.
- v. *Inferior rectal artery: From the internal pudendal artery to supply the inferior part of the rectum and anal canal. Anastomose with the other rectal arteries.
- vi. Middle suprarenal arteries: These are bilateral branches of the aorta that go directly to the adrenal (suprarenal) glands. They can be found about the level of the celiac trunk.
1. Superior suprarenal artery: from the inferior phrenic artery to the adrenal gland
 2. The renal arteries give off a branch to the adrenal glands as well – the inferior suprarenal arteries. This is the third artery that supplies the adrenal glands; the first is a branch of the inferior phrenic, the second is directly off the aorta, and the third is off the renal artery. The adrenal glands, therefore, are rarely starved for blood.



- vii. Renal arteries: Bilateral and leave at about the same level as the SMA, and supply the kidneys.
 - 1. The renal arteries split into segmental arteries that split into interlobar arteries that are b/ renal pyramids, and they split into arcuate arteries that surround the renal pyramids.
 - viii. Gonadal arteries: Bilateral and these are direct branches which go all the way down to the gonads.
- B). Venous Drainage: More venous drainage detail below in objective 3. In general, the venous drainage of the foregut, midgut and hindgut mimics arterial supply until it drains into the portal vein, which is the formation of the splenic vein and superior mesenteric vein. (The inferior mesenteric vein dumps into the splenic vein.) The portal vein takes this oxygen deficient, but nutrient rich blood to the liver. The portal vein then goes to the inferior vena cava (IVC). The adrenal vein goes to the IVC. The phrenic and renal veins drain into the IVC as well, along with the right gonadal vein and right suprarenal vein. The left gonadal vein drains into the left renal vein with the left suprarenal vein.

Objective 3)

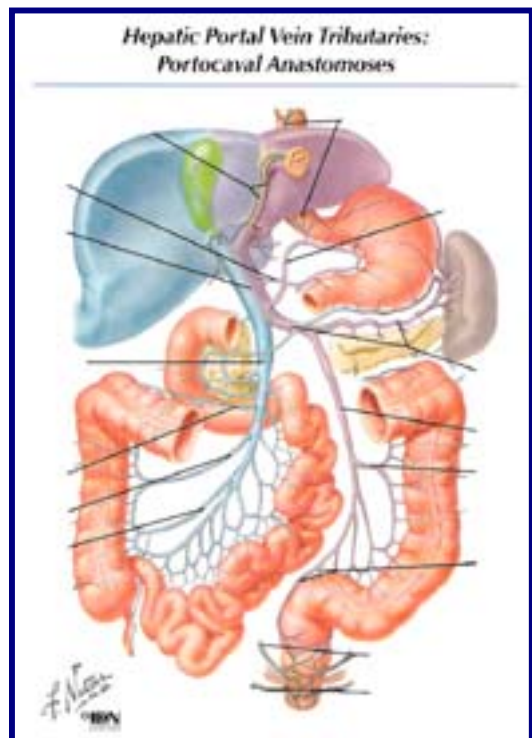
Contrast the caval and portal venous pathways draining the abdomen and indicate sources of communication between them. Follow the course of lymphatic drainage in the abdomen and identify the major sites of lymph node aggregations (whether or not they are present in your cadaver).

C). Portal system:

- i. The portal system begins with nutrient rich venous blood from the fusion of the splenic vein and the superior mesenteric vein (SMV) to form the portal vein to the liver.
- ii. The portal veins or its tributaries receive blood from the other abdominal organs including the GI tract, gallbladder, pancreas, and spleen.
- iii. Once in the liver, the blood branches into the venous sinusoids of the liver.

D). Caval system:

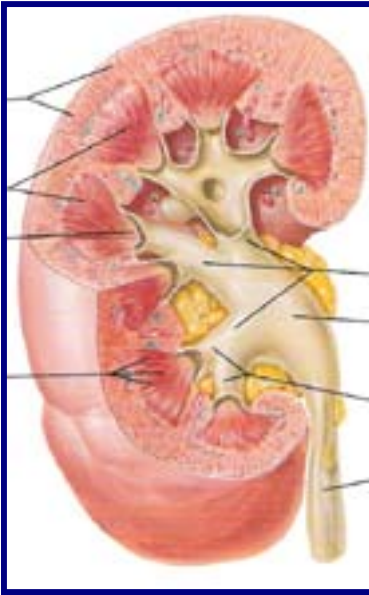
- i. The caval system consists of the inferior vena cava (IVC) and its tributaries.
- ii. It receives de-O₂ from the lower limbs, most of the back, the abdominal walls, and the abdominopelvic viscera from the hepatic veins after passing through the portal system.
- iii. Tributaries of the IVC include: common iliac veins, 3rd and 4th lumbar veins, right gonadal vein, renal veins, ascending lumbar veins (azygos/hemiazygos) veins, right suprarenal vein, inferior phrenic vein, and hepatic veins.



1. The left suprarenal and gonadal veins drain into the left renal vein before draining into the IVC.
 2. The ascending lumbar and azygos veins connect to the IVC and superior vena cava directly or indirectly.
- E). Collateral connections b/ the 2 systems:
- i. B/ the esophageal veins draining into either the azygos (caval system) or the left gastric vein (portal system).
 - ii. Anastomoses at the rectal veins → middle and inferior rectal veins that drain into the IVC (caval system) and the superior rectal vein drains into the IMV (portal system)
 - iii. Anastomoses of the paraumbilical veins of the anterior abdominal wall (portal system) with the superficial epigastric veins (systemic system)
 1. Dilation of these veins causes varicose veins from umbilicus → caput medusae
 - iv. Anastomoses of twigs of the colic veins (portal system) and the retroperitoneal veins (systemic system)
- F). Lymphatic drainage:
- i. Lymphatic vessels follow the course of the arteries that supply the organs, and the nodes are named by there location, so the lymph drains towards the celiac, superior mesenteric, or inferior mesenteric, according to their respective arterial supply, before they drain into the chyle cistern.
 - ii. Lymph node aggregations:
 1. Celiac
 2. Gastro-omental
 3. Gastric
 4. Cystic
 5. Hepatic
 6. Pyloric
 7. Pancreaticoduodenal
 8. Pancreaticosplenic
 9. Superior mesenteric
 10. Mesenteric
 11. Ileocolic
 12. Appendicular
 13. Epicolic
 14. Intermediate colic (left, right, and middle colic)
 15. Paracolic
 16. Inferior mesenteric
 17. Lumbar or Lateral aortic
 - a. Receives lymph from the kidney and adrenal plexuses and common iliac lymph nodes (lymph from lower portion of body)
 18. Chyle cistern
 - iii. Some of the lymph of the liver drains into the phrenic lymph nodes, which drain into the posterior mediastinal lymph nodes, which drain into the thoracic duct.

Objective 4)

Trace the flow of urine from inside of the kidney to the bladder, indicating the relationship of the left and right ureters to the peritoneum, posterior abdominal vasculature and musculature. Identify the surface projections of the kidneys and ureters.



3. Urine flow: Blood travels to the kidney through the renal artery. This blood is filtered in the kidney and returned to the body through the renal vein. Necessary salts and water are reabsorbed in the cortex. The concentrated urine and wastes that remain pass into the collecting tubules (you can't see these). From the collecting tubules, the urine passes into the renal pyramids and into the minor calyces, then to the major calyces, and then into the renal pelvis. The urine will then travel inferiorly to the bladder through the ureter.

4. Ureter:

- A). Begin posterior to the renal blood vessels, and as they descend, travel over the psoas major muscles
- B). Run inferomedially along the transverse processes of the lumbar vertebrae.
- C). Cross the external iliac artery beyond the common iliac bifurcation.

- i. Then run along the lateral wall of the pelvis.

- ii. Both ureters travel posterior to the peritoneum, the jejunum, the ileum, the transverse colon, the gonadal vessels, and the colic vessels.

- iii. The right ureter passes deep to the duodenum as well.

D). Surface anatomy of the kidneys and ureters:

- i. Kidneys: The kidneys are located on the posterior abdominal wall, usually encased in a well-defined renal fascia surrounded by fat. The right kidney is usually slightly lower than the left because the liver pushes it down. The kidneys span from T-11 to L-3 with protection from the 11th and 12th ribs. The hilum of the left kidney lies near the transpyloric plane, while the transpyloric plane transects the superior pole of the left kidney.

- ii. Ureters: Run inferomedially along the transverse processes of the lumbar vertebrae.

Objective 5)

Identify the components of the lumbosacral nerve plexus and indicate the segmental source of origin and the peripheral distribution of each. Follow the courses of autonomic nervous impulses to the abdominal organs. Indicate the source of both pre- and postganglionic elements.

E). Lumbar plexus: This nerve network is composed of the anterior rami of L1 through L4 nerves and is located in the posterior part of the psoas major. All rami receive gray rami communicantes from sympathetic trunks, and the superior two send white rami communicantes to these trunks.

- i. Branches of the lumbar plexus:
 1. Obturator nerve (L2-L4): emerges from the medial border of the psoas major and passes through the pelvis to the medial thigh supplying adductor muscles.
 2. Femoral nerve (L2-L4): emerges from the lateral border of the psoas major and innervates the iliacus and passes deep to the inguinal ligament to the anterior thigh, supplying the flexors of the hip and extensors of the knee.
 3. Lumbosacral trunk (L4, L5): passes over the ala of the sacrum and descends into the pelvis to participate in the formation of the sacral plexus along with anterior rami of S1 through S4.
 4. Ilioinguinal and iliohypogastric nerves (L1): enter the abdomen posterior to the medial arcuate ligaments and pass inferiolaterally, anterior to the quadratus lumborum. They pierce the transverse abdominal muscles near the anterior superior internal and external oblique muscles to supply the skin of the suprapubic and inguinal regions and nervous supply to abdominal musculature.
 5. Genitofemoral nerve (L1, L2): pierces the anterior surface of the psoas major and runs inferiorly on it deep to the psoas fascia; it divides lateral to the common and external iliac arteries into the femoral and genital branches that supply the skin of the medial thigh and the innervates the skin of the external genitalia and, in the male, the skin over the cremaster muscle, respectively.
 6. Lateral femoral cutaneous nerve (L2, L3): runs inferiolaterally on the iliacus muscle and enters the thigh posterior to the inguinal ligament, just medial to the anterior superior iliac spine; it supplies the skin on its anterolateral surface of the thigh.

F). Sympathetic innervation:

- i. The preganglionic nerves of the sympathetic nervous system have their cell bodies in the intermediolateral column of the thoracic and lumbar portions of the spinal cord. These preganglionic fibers then travel out ventral horns of the spinal cord to the paravertebral ganglia where they synapse, travel up or down the chain of ganglia before synapsing, or leave the sympathetic chain of ganglia altogether and synapse at prevertebral ganglion in the body. The fibers in the last category leaving at one level collect to form splanchnic nerves that innervate the abdominal organs. The following preganglionic nerves will travel to a ganglion and synapse on a postganglionic nerve cell body, and their nerve fibers will ride the arteries to the target organs:
 1. Greater Splanchnic nerve – composed of fibers from T-5 through T-9 and travels to the celiac ganglion where the preganglionic fibers synapse. Its postganglionic fibers innervate those organs that are supplied with blood by the branches of the celiac trunk.
 - a. The organs supplied by postganglionic fibers from the celiac ganglion are the stomach, duodenum, spleen, pancreas, liver, gallbladder, adrenal glands (also thoracic splanchnic nerves that are preganglionic until they reach the medulla), jejunum, and ileum.
 2. Lesser splanchnic nerve – T-10 through T-11. Travels to superior mesenteric ganglion; innervates organs supplied by the SMA.

- a. The organs supplied by postganglionic fibers from the superior mesenteric ganglion are the duodenum, pancreas, jejunum, ileum, cecum, appendix, ascending colon, and transverse colon.
 - 3. Least splanchnic nerves – composed of fibers from all the lumbar roots, some of which travel to the inferior mesenteric ganglion and the genitalia, via the hypogastric plexus. These are the nerves involved with sexual function, micturition, and defecation.
 - ii. The organs supplied by postganglionic fibers from the inferior mesenteric ganglion are the kidney, transverse colon, descending colon, and sigmoid colon.
- G). Parasympathetic innervation:
 - i. The parasympathetic cell bodies are found in the brain (the vagus nerve and other brain centers) and in the sacral region, S-2 through S-4. The preganglionic fibers for the gut, not including the hindgut (so up until the left colic flexure) travel via the vagus nerve (CN X). The hindgut and the genitalia receive parasympathetic preganglionic input via the pelvic splanchnic nerves. These nerves travel to the organs along the blood vessels and synapse near or in the organ. Thus, the postganglionic fibers will never, ever be dissected.
 - 1. The preganglionic fibers of the posterior vagal trunk to the stomach and intestines synapse in the myenteric and submucous plexuses that are in the intestinal walls. The postganglionic fibers come from there.
 - a. The descending and sigmoid colons receive their preganglionic parasympathetic innervation from the pelvic splanchnic nerves.
- H). Abdominal autonomic plexuses: (both parasympathetic and sympathetic plexuses)
 - i. Celiac plexus: (solar plexus): made of celiac ganglion and irregular right and left celiac ganglia surround the celiac trunk. Receives preganglionic sympathetic innervation from the greater and lesser splanchnic nerves. The parasympathetic root is from the posterior vagal trunk.
 - ii. Superior mesenteric plexus: made of superior mesenteric ganglia surrounding the SMA. Connects the celiac and inferior mesenteric plexuses (through the intermesenteric plexus) and receives preganglionic sympathetic innervation from the lesser and least splanchnic nerves.
 - iii. Intermesenteric plexus: part of aortic plexus of nerves b/ the superior and inferior mesenteric arteries. It gives rise to the renal, gonadal, and ureteric plexuses.
 - iv. Inferior mesenteric plexus: made of inferior mesenteric ganglion that is inferior to the root of the IMA or surrounds it. Gets preganglionic sympathetic innervation from the lumbar ganglia of the paravertebral trunks.
 - v. Superior hypogastric plexus: continuation of the para-aortic plexus inferior to the bifurcation of the aorta. Supplies the uterine/testicular plexuses and plexus on each common iliac. Has the right and left hypogastric nerves joining it to the inferior hypogastric plexus.
 - vi. Inferior hypogastric plexus: situated on the sides of the rectum, uterine cervix, and urinary bladder. Right and left from the right and left hypogastric nerves. Get fibers from superior sacral ganglia (sympathetic) and pelvic

parasympathetic splanchnic nerves. Sends autonomic innervation to the pelvis.

Objective 6)

Identify the diaphragm, note the different portions, hiatuses, ligaments, crura and structures passing through, and the other muscles comprising the posterior abdominal wall and indicate their surface projections.



5. Diaphragm:

A). The muscular part of the diaphragm is situated peripherally with its fibers that converge radially on the trifoliate central aponeurotic part – the central tendon. The tendon has no bony attachments and is closer to the anterior part of the thorax. The surrounding muscular sheet is continuous, but it is divided into 3 parts for description:

1. Sternal part: two muscular slips that attach to the posterior aspect of the xiphoid process (may not be always present)
 2. Costal part: wide muscular slips that attach to the internal surfaces of the inferior six costal cartilages and their adjoining ribs on each side. This part forms the domes of the diaphragm.
 3. Lumbar part: arising from two aponeurotic arches – the medial and lateral arcuate ligaments – and three lumbar vertebrae (L1, L2, L3). The lumbar part forms the right and left muscular crura that ascend to the central tendon.
- ii. The crura of the diaphragm are musculotendinous bundles that arise from the anterior surfaces of the bodies of the superior lumbar vertebrae, the anterior longitudinal ligament, and the IV discs.
1. The right crus, larger and longer than the left, arises from the first three or four lumbar vertebrae, whereas the left crus arises from only the first two or three.
 2. The crura are united by the median arcuate ligament, which passes over the anterior surface of the aorta.
 3. The diaphragm is also attached on each side to the medial and lateral arcuate ligaments, which are thickenings of the fascia covering the psoas and quadratus lumborum muscles, respectively.
- iii. Apertures:
1. Caval opening: Aperture in the central tendon primarily for the IVC.
 - a. Also allows terminal branches of right phrenic nerve and lymphatics from liver to phrenic and mediastinal lymph nodes through.

- b. Located to the right of the median plane of the central tendon.
 - c. At the level of the IV disc b/ T8 and T9.
 - d. Respiratory movement of the diaphragm changes its size and facilitates the movement of blood back to the heart from the IVC.
 - 2. Esophageal hiatus: Oval opening in the muscle of the right crus for the esophagus.
 - a. At the T10 vertebra level.
 - b. Also transmits the anterior and posterior vagal trunks, esophageal branches of the left gastric artery, and a few lymphatics.
 - c. In most cases, a superficial muscular bundle from the left crus contributes to the formation of the right margin of the hiatus.
 - 3. Aortic hiatus: Opening in the posterior diaphragm that transmits the aorta, azygos vein, thoracic duct.
 - a. Located b/ the crura at the T12 vertebra level.
 - b. Aorta does not pierce the diaphragm, so diaphragmatic movements do not influence aortic blood flow.
 - 4. *Sternocostal foramen: small opening b/ the sternal and costal attachments of the diaphragm.
 - a. Transmits lymphatic vessels from the diaphragmatic surface of the liver and superior epigastric vessels.
 - 5. *Two apertures appear in each crus to transmit the greater and lesser splanchnic nerves bilaterally.
- B). Posterior abdominal muscles: These muscles help to flex the hip joint.
- i. Psoas major – arises from the lateral part of the vertebrae T-12 to L-4 and travels down to insert into the lesser trochanter of the femur.
 - ii. Psoas minor – is the smaller muscle that arises just from T-12 and L-1; travels over the major where it becomes a tendon that inserts into the pectineal line.
 - iii. Iliacus – arises from the inner portion of the iliac bone; is a fan-shaped muscle, which eventually inserts into the lesser trochanter.
 - iv. Quadratus lumborum – lies laterally to the upper part of the psoas and runs between the upper lumbar vertebrae and the iliac crest.