

**Objective 1)**

**Identify the osseous landmarks and ligaments associated with the abdomen. Identify the fascial and muscular layers of the abdomen, emphasizing those passed through as a result of a surgical incision through the rectus sheath and rectus abdominis muscle above the umbilicus and/or just above the pubic symphysis.**

A). Boundaries of the abdomen:

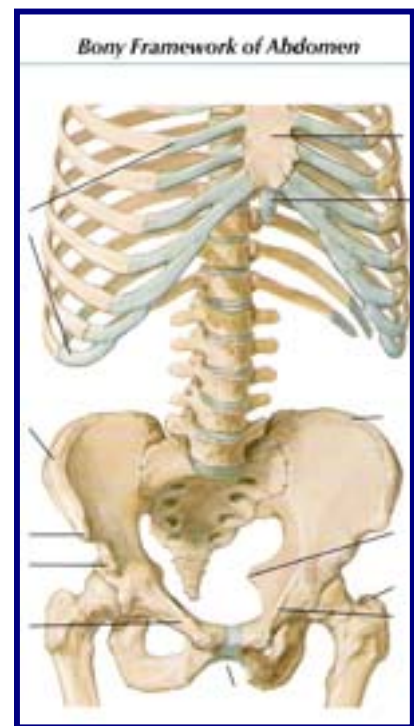
- i. Superior boundary: the diaphragm
- ii. Inferior boundary: pelvic cavity; the plane running through the pubic symphysis, along the iliopectineal line, and across the ala and promontory of the sacrum defines the inferior boundary of the abdomen
- iii. Posteriorly: the sacrum, pelvic bones, and the sacroiliac joints (near the ala of the sacrum)
- iv. Anteriorly: the pelvic bones articulating at the symphysis pubis
- v. Laterally: the pubic crests, pubic tubercles and the pectineal lines

B). Osseous landmarks:

- i. Iliac crests: their highest points are near the area of the spine of the L4 vertebra (an important region when performing spinal taps)
- ii. Umbilicus: generally lies in the T10 dermatome and marks the level of the intervertebral disk between L3 and L4
- iii. Xiphoid process of the sternum: linea alba extends from here
- iv. Fused cartilages of ribs 7-10
- v. Floating ribs 11 and 12
- vi. Pubic symphysis
- vii. Pubic bones
- viii. Iliac spines and crests

C). Ligaments associated with the abdomen:

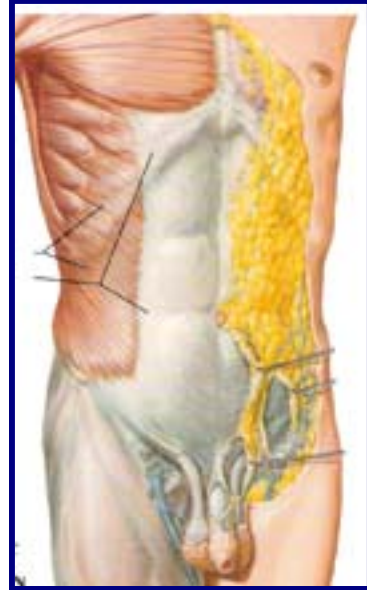
- i. Inguinal Ligament: part of the lower free margin of the aponeurosis of the external oblique muscle; extends from the anterior superior iliac spine to the pubic tubercle; attaches to fascia lata of thigh
- ii. Lacunar Ligament: runs between inguinal ligament and pectineal line; forms medial part of floor of inguinal canal
- iii. Pectineal Ligament: runs along pectineal line of pelvis; separates pelvic and abdominal cavities



- iv. Interfoveolar Ligament: medial thickening of transversalis fascia at deep inguinal ring
- v. Umbilical ligaments: remnants of the umbilical arteries
- vi. Median umbilical ligament: remnant of the urachus

D). Fascia layers:

- i. Superficial Fascia - divided into two layers:
  1. Superficial fatty layer (Camper's Fascia) – contains adipose tissue and fuses with superficial fascia of thigh; cannot be used to suture
  2. Deep membranous layer (Scarpa's Fascia) – is more fibrous and contains very little adipose tissue; fuses with deep fascia at the inguinal ligament; continuous with the fascia lata of the thigh and with Colles' fascia (the superficial fascia of the perineum); better suturing material
- ii. Deep Fascia - thin layer over superficial abdominal muscles (epimysium); cannot be separated
- iii. Transversalis Fascia - lines most of abdominal wall; covers posterior surface of transversus abdominis muscle and aponeurosis; extends into thigh to form part of femoral sheath; forms part of covering (internal spermatic fascia) of spermatic cord
- iv. Just inside the transversalis fascia is the parietal peritoneum, a thin membrane which is separated from the transversalis fascia by endoabdominal (extraperitoneal) fat



E). Muscular Layers:

- i. Flat (lateral) Muscles - aid in rotation and lateral flexion of trunk to same side; protect viscera and increase intra-abdominal pressure. The muscles become aponeurotic sheets as they approach the midline before fusing at the linea alba.
  1. External Obliques - arise from lower eight ribs (5-12); fibers run downward and medially (like external intercostal muscles); part of aponeurosis forms inguinal ligament; forms part of anterior portion of rectus sheath
  2. Internal Obliques - arise from ribs 10-12, the thoracolumbar fascia, part of iliac crest, and a portion of the inguinal ligament; upper fibers run upwards and medially; intermediate fibers form part of rectus sheath before joining linea alba; lower fibers attach to pectineal line with fibers from transversus abdominis muscle forming conjoint tendon
  3. Transversus Abdominis - arise from costal cartilages 7-12, the thoracolumbar fascia, part of iliac crest, and portion of inguinal ligament; fibers run transversely to linea alba; lower fibers attach to pectineal line with internal obliques via the conjoint tendon.
- ii. Vertical Muscles - flex trunk against gravity; also protect viscera and increase intra-abdominal pressure

1. Rectus Abdominis - vertical muscle fibers on either side of linea alba; broad superiorly and more narrow inferiorly; attachments at costal cartilages 5-7, the pubic crests, and the symphysis pubis; separated into segments by three tendinous inscriptions (one at level of umbilicus, 2 above umbilicus); lateral borders defined by linea semilunaris
2. Pyrimidalis - small triangular muscle covering lower fibers of rectus abdominis that ; no known function

F). Rectus Sheath:

- i. The rectus sheath encloses the rectus abdominis muscles, the pyrimidalis muscles, and the superior/inferior epigastric arteries/veins.
- ii. The aponeurosis of the external oblique muscles **always** contribute to the **anterior** sheath
- iii. Above the costal margin, the sheath (anterior to posterior) is composed of external oblique aponeurosis, rectus muscle, and costal cartilage
- iv. The arcuate line is an important landmark approximately halfway between the umbilicus and the symphysis pubis. *The arcuate line is the point at which the posterior part of the rectus sheath is formed superiorly by aponeuroses and inferiorly by transversalis fascia.*
- v. B/ the arcuate line and the costal margin, the aponeurosis of the internal oblique muscle splits around the rectus abdominis muscle, contributing to **both** the **anterior** and **posterior** rectus sheath; in this region.
  1. The sheath is (anterior to posterior) external oblique aponeurosis, half of internal oblique aponeurosis, rectus muscle, half of internal oblique aponeurosis, transversus abdominis aponeurosis
- vi. Below the arcuate line, the aponeurosis of the internal oblique passes only anterior to the rectus abdominis, forming **only** the **anterior** portion of the rectus sheath.
  1. In this region, the sheath is (anterior to posterior) external oblique aponeurosis, internal oblique aponeurosis, transversus abdominis aponeurosis, rectus muscle, transversalis fascia
- vii. The aponeurosis of the transversus abdominis muscle forms the **posterior** rectus sheath **above** the arcuate line and forms part of the **anterior** sheath **below** the arcuate line; below the arcuate line, the posterior rectus sheath is formed by the transversalis fascia.



G). Surgical Incision

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| <ol style="list-style-type: none"> <li>i. <u>Above the arcuate line:</u> <ul style="list-style-type: none"> <li>skin</li> <li>superficial fascia (Camper's and Scarpa's)</li> <li>deep fascia</li> <li>external oblique aponeurosis</li> <li>internal oblique aponeurosis</li> <li>rectus abdominis muscle</li> </ul> </li> </ol> | <ol style="list-style-type: none"> <li><u>Below the arcuate line:</u> <ul style="list-style-type: none"> <li>skin</li> <li>superficial fascia</li> <li>deep fascia</li> <li>external oblique aponeurosis</li> <li>internal oblique aponeurosis</li> <li>transversus abdominis</li> </ul> </li> </ol> |
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aponeurosis

internal oblique aponeurosis  
transversus abdominis aponeurosis  
transversalis fascia  
peritoneum

pyrimidalis muscle in inferior  
rectus abdominis muscle  
transversalis fascia  
peritoneum

## Objective 2)

**Identify the dermatome segments of the anterior abdominal wall. Contrast the anatomical organization of the cutaneous innervation and vascular supply of the abdominal and thoracic walls in terms of: their segmental organizations and the relationship of nerves to muscle layers.**

### H). Dermatomes:

- i. The abdominal wall is divided into horizontal dermatomes supplied by ventral rami of spinal nerves.
- ii. T7, T8, T9 innervate the skin superior to umbilicus.
- iii. T10 innervates the skin around the umbilicus.
- iv. T11, subcostal nerve (T12), iliohypogastric nerve (L1), and the ilioinguinal nerve (L1) supply the skin inferior to the umbilicus.

### I). Nerve organization:

- i. Lateral cutaneous branches innervate the lateral portions of the abdomen while anterior cutaneous branches innervate the midline
- ii. Muscles of the abdomen are also innervated by the 7th through 12th intercostal nerves which run between the internal oblique and transversus abdominis along the neurovascular plane
- iii. Nerves actually pierce the rectus sheath (arteries do not)
- iv. L1 nerve splits to iliohypogastric and ilioinguinal nerves which innervate the lower internal oblique and transversus abdominis
- v. This is very similar to the organization of the thoracic cutaneous nerves.
- vi. Relationship of nerves to muscle layers: pierce the rectus sheath a short distance from the median plane after the rectus muscle has been supplied and lie superficial to muscular layer.

### J). Vascular organization (arteries and veins):

- i. Generally organized in the vertical direction.
- ii. Different from thoracic wall, which has horizontal vessels from vertical vessels.
- iii. Veins drain into the azygos system.
- iv. 10<sup>th</sup>, 11<sup>th</sup> posterior intercostals, subcostal arteries: lie superficial to transversus abdominis and deep to rectus abdominis
- v. Internal thoracics (branch of subclavian) branches into
  1. Musculophrenics – gives off the 7th through 9th intercostal arteries; these along with the lumbar arteries supply the lateral portion of the abdomen
  2. Superior epigastrics – direct continuation of the internal thoracic and enter the rectus sheath its posterior layer to supply the upper part of the rectus abdominis. Artery anastomoses with the inferior epigastric artery.
- vi. External iliacs:
  1. Inferior epigastrics: Arises from the external iliacs just proximal to its passage under the inguinal ligament. Runs superiorly in the transversalis fascia to enter the rectus sheath inferior to the arcuate

- line. Its branches enter the lower rectus abdominis and anastomose with the superior epigastric artery around the umbilicus.
- 2. Deep circumflex iliacs: runs on deep aspect of anterior abdominal wall, parallel to inguinal ligament
- vii. Femoral artery and great saphenous vein:
  - 1. Superficial circumflex iliacs: runs in superficial fascia along inguinal ligament
  - 2. Superficial epigastrics: runs in superficial fascia toward umbilicus
- viii. Anterior and collateral branches of the posterior intercostal vessels in 10<sup>th</sup> and 11<sup>th</sup> spaces
- ix. Anterior branches of subcostal arteries and veins
- x. Branches of the musculophrenic vessels from internal thoracic arteries and veins

### Objective 3)

**Identify the muscular and ligamentous components of the inguinal canal in both males and females. Be able to demonstrate the surface projections of the abdominal muscles, inguinal rings, inguinal canal, and bony pelvis.**

#### K). Inguinal canal:

- i. Oblique, inferomedially directed passage through the inferior part of anterior abdominal wall.
- ii. Lies parallel and just superior to the medial half of the inguinal ligament.
- iii. Spermatic cord in males and round ligament of uterus in females mainly occupies it. Also contains blood, lymphatic vessels, and ilioinguinal nerve in both sexes.
- iv. From deep inguinal ring to superficial inguinal ring.

#### L). Superficial inguinal ring – Exit from the inguinal canal above the pubic tubercle; ring created by splitting of external oblique fiber/aponeurosis

- i. Bordered by the lateral and medial crura; base formed by pubic crest
- ii. Spermatic cord and/or round ligament of uterus exit inguinal canal through this ring.

#### M). Deep inguinal ring – Entrance to the inguinal canal and formed by outpouching of the transversalis fascia (sometimes thickened to form interfoveolar ligament)

- i. The ductus deferens, testicular arteries and veins, and the genital branch of the genitofemoral nerve pass through the deep inguinal ring

#### N). Boundaries:

- i. Anterior wall – formed by external oblique aponeurosis throughout the length of the canal with the anterior wall of the lateral part of the canal being reinforced by fibers of internal oblique
- ii. Posterior wall – formed by transversalis fascia with medial part reinforced by merging of pubic attachments of the internal oblique and transverse abdominis aponeuroses into the conjoint tendon
- iii. Roof – formed by arching fibers of internal oblique and transverse abdominal muscles
- iv. Floor – formed by superior surface of the inguinal ligament and an infolding of the thickened inferior border of the external oblique aponeurosis; the most medial part of the floor is formed by part of the inguinal ligament that attaches to the superior pubic ramus as the lacunar ligament rather than attaching to the pubic tubercle.

- O). Muscular components of inguinal canal
  - i. Anterior wall
    - 1. External oblique aponeurosis:
    - 2. Internal oblique: reinforces anterior wall of lateral part of canal
  - ii. Posterior wall
    - 1. Transversalis fascia
    - 2. Internal oblique & transverse abdominal aponeurosis (join to form conjoint tendon)
  - iii. Roof: Internal oblique and transverse abdominis muscles
  - iv. Floor: superior surface of inguinal ligament & lacunar ligament
- P). Ligaments of inguinal canal
  - i. Inguinal ligament
  - ii. Lacunar ligament
- Q). Inguinal Ring
  - i. Deep (internal ring): entrance to inguinal canal—outpouching of transversalis fascia; lies superior to middle of inguinal ligament, lateral to inferior epigastric vessels
  - ii. Superficial external inguinal ring: exit from inguinal canal; opening between aponeurosis of external oblique (superolateral to pubic tubercle)
  - iii. Lateral & medial margins of ring: lateral & medial crura
- R). Surface projections of inguinal canal:
  - i. Oblique inferomedially directed passage through the inferior part of anterior abdominal wall
  - ii. Contains spermatic cord or round ligament of uterus and also ilioinguinal nerve (both sexes)
- S). Surface projections of bony pelvis
  - i. Iliac crest
  - ii. Anterior & Posterior superior iliac spine
  - iii. Iliac tubercle
- T). Pubic tubercle & Pubic crest

#### Objective 4)

**Follow the course of the testes as they descend from the posterior abdomen into the scrotum. Indicate the structures passed through and identify the homologies between scrotal and abdominal structures. Perform a similar analysis of the descent of the ovaries into the pelvis in females.**

- U). Testicular descent:
  - i. Embryologically, the testes develop retroperitoneally in the superior lumbar region on the posterior abdominal wall (near the kidneys) and must therefore traverse the lateral abdominal muscles.
  - ii. Descend during the 9<sup>th</sup> to 12<sup>th</sup> fetal weeks to the deep inguinal canal with the movement caused by the growth of the vertebral column and pelvis.
  - iii. Testes are guided through the inguinal canal and into the scrotum by the gubernaculum testes which become the gubernaculum ligaments - cords that extend from the caudal pole of the testes to the scrotum.
  - iv. Testes are preceded in their descent posterior to the processus vaginalis, a sac of peritoneum.
  - v. The processus vaginalis covers the anterior and lateral testes with a double layer of peritoneum (both visceral and parietal peritoneum).

- vi. Once the peritoneal sac pinches off from the abdominal peritoneum, the sac becomes known as the tunica vaginalis.
  - vii. The testicular arteries are branches of the abdominal aorta and accompany the testes in their descent with nerves, veins, lymphatics, and the ductus deferens.
- V). Ovarian descent:
- i. Embryologically, the ovaries also originate retroperitoneally on the posterior abdominal wall in the superior lumbar region.
  - ii. The ovaries start descent at the 12<sup>th</sup> fetal week and do not descend past the pelvic cavity.
  - iii. The descent of the ovaries is also guided by the gubernaculum, which attaches from the caudal pole of the ovary to the labia majora, attaching en route to the uterus.
  - iv. The gubernaculum becomes:
    - 1. Ovarian ligament - connects the ovary and the uterus
    - 2. Round ligament of the uterus - connects the uterus and the labia majora; this is the portion that passes through the inguinal canal
  - v. There is a processus vaginalis formed as part of the peritoneum pinches off during fetal development, but it is normally obliterated.
- W). Homologous Structures: (see Table 3.4, page 134)

<ul style="list-style-type: none"> <li>i. <u>Abdominal Structures:</u> <ol style="list-style-type: none"> <li>1. skin</li> <li>2. subcutaneous tissue (superficial fascia)</li> <li>3. external oblique aponeurosis</li> <li>4. internal oblique muscle</li> <li>5. fascia for both superficial and deep surfaces of the internal oblique</li> <li>6. transversalis fascia</li> <li>7. peritoneum</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li><u>Scrotal Structures:</u> <ol style="list-style-type: none"> <li>skin</li> <li>superficial (Dartos)</li> <li>external spermatic fascia</li> <li>cremaster muscle</li> <li>cremasteric fascia</li> <li>internal spermatic fascia</li> <li>tunica vaginalis</li> </ol> </li> </ul>
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### Objective 5)

**Identify parietal and visceral peritoneum, their major reflections and the boundaries of their surface projections.**

- X). Peritoneum: continuous, glistening, transparent serous membrane that consists of two layers:
- i. Parietal peritoneum: Lining the internal surface of the abdominopelvic wall
    - 1. Innervated by the intercostal nerves and the phrenic nerve.
  - ii. Visceral peritoneum: Investing viscera such as spleen and stomach
    - 1. No sensory supply
  - iii. Peritoneal cavity: potential space between parietal and visceral peritoneum that has lubricating peritoneal fluid to allow viscera to move smooth during digestion.
    - 1. There are no organs in the peritoneal cavity.
    - 2. The peritoneal fluid contains WBCs and antibodies to prevent infection.
    - 3. Completely closed in males but open through uterine tubes, uterus, and vagina in females.

- iv. Mesentery: a double layer of peritoneum reflecting away from the abdominal wall to enclose part or all of one viscera.
  - 1. Constitutes a continuity of visceral and parietal peritoneum that provides a means for neurovascular communication b/ the organ and the body wall.
  - 2. Has core of connective tissue containing blood vessels, lymphatics, nerves, and fat.
  - 3. Viscera with mesentery are mobile with motility depending on length of mesentery.
- v. Peritoneal ligament: consists of a double layer of peritoneum that connects an organ with another organ or abdominal wall
  - 1. Falciform ligament: connects the liver to the anterior abdominal wall
  - 2. Gastrophrenic ligament: connects the stomach to the inferior surface of the diaphragm
  - 3. Gastrosplenic ligament: connects the spleen to the stomach.
  - 4. Lesser omentum (gastrohepatic and gastroduodenal ligaments): connects the lesser curvature of the stomach and the proximal part of the duodenum to the liver.
    - a. Gastrohepatic ligament: continues with and membranous part of the lesser omentum that connect the stomach to the liver.
    - b. Gastroduodenal ligament: continues with and membranous part of the lesser omentum that connect the duodenum to the liver.
  - 5. Hepatoduodenal ligament: thickened free edge of the lesser omentum that conducts the portal triad.
  - 6. Greater omentum (gastrocolic ligament): Hangs down from the greater curvature of the stomach and proximal part of the duodenum, descends, and folds back to attach to the transverse colon and its mesentery.
- vi. Omentum: broad, double-layered sheet of peritoneum passing from the stomach to another abdominal organ.
  - 1. Greater omentum hangs from the greater curvature of the stomach and proximal duodenum down and comes back up to connect to transverse colon.
  - 2. Lesser omentum connects the lesser curvature of the stomach and proximal duodenum to the liver.

Y). Boundaries and surface projections:

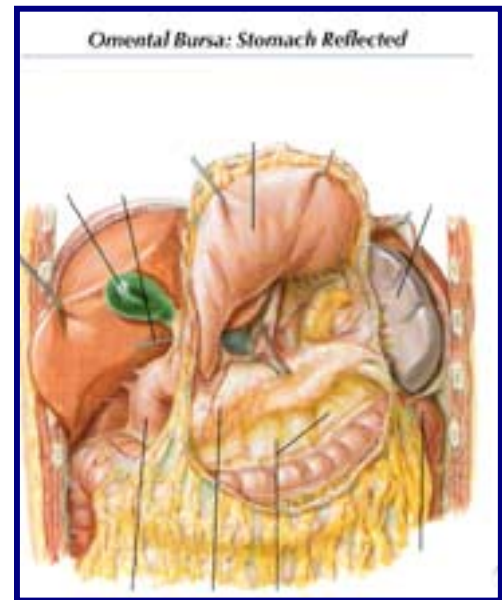
- i. Liver: sharp lower border can be palpated occasionally
- ii. Gall bladder: normally not palpable unless enlarged
- iii. McBurney's point: 1/3 the distance from Right anterior superior iliac spine to navel (vermiform appendix)
- iv. Spleen: parallel to left ribs 9-11. Does not project more forward than mid-axillary line (can only feel it when it is 2-3 times its normal size)

**Objective 6)**

**Identify the boundaries of the omental bursa, its communication with the abdominal cavity and organs in anterior, posterior, superior, and inferior relation to it. Indicate which of the abdominal organs are interperitoneal or retroperitoneal. Identify the surface projections of each of the organs. Identify the parts and peritoneal coverings of the liver.**

Z). Omental bursa: (see Fig 3.11 on page 142) – an extensive saclike cavity, is in the smaller part of the peritoneal cavity that lies posterior to the stomach and adjoining omenta

- i. Omental bursa is the same as the lesser peritoneal sac
- ii. Divided into two recesses:
  1. Superior recess: limited superiorly by the diaphragm and the posterior layer of the coronary ligament of the liver
  2. Inferior recess: b/ the superior part of the greater omentum; often a potential space because of b/ the two layers of the greater omentum, which often adhere together
- iii. Borders (superior recess):
  1. Anterior: the stomach and part of the liver
  2. Posterior: the pancreas, kidneys, part of the liver, the spleen, the major vessels (aorta, inferior vena cava), and the transverse colon
  3. Lateral: portions of the liver and spleen, the gastrocolic (stomach to colon) and lienorenal (spleen to kidney) ligaments
  4. Superior: the liver and diaphragm
  5. Inferior: the small intestine and the remainder of the colon
- iv. Omental foramen (epiploic foramen): omental bursa communicates with the greater sac through this opening situated posterior to the free edge of the lesser omentum forming the hepatoduodenal ligament



AA). Intraperitoneal and Retroperitoneal Organs

i. Organ:

1. stomach
2. first inch of duodenum
3. remainder of duodenum
4. jejunum/ileum (remainder of small intestine)
5. cecum/appendix
6. ascending colon
7. transverse colon
8. descending colon
9. sigmoid colon
10. rectum
11. liver
12. gall bladder
13. spleen
14. kidneys
15. pancreas
16. aorta/IVC

Location:

- intraperitoneal  
 intraperitoneal  
 retroperitoneal  
 intraperitoneal  
 intraperitoneal  
 retroperitoneal  
 intraperitoneal  
 retroperitoneal  
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BB). Surface Projections

- i. abdomen can be divided into 9 regions by left and right midclavicular lines, transtuberular plane, and subcostal plane:
  1. upper left and right = left and right hypochondriac regions
  2. upper middle = epigastric region
  3. middle = umbilical
  4. left and right middle = left and right lateral regions
  5. lower middle = hypogastric region (suprapubic)
  6. lower left and right = left and right inguinal regions
- ii. stomach is below the diaphragm on the left side in left hypochondriac region; crosses the midline to the umbilical/epigastric regions
- iii. liver is below the diaphragm on the right side in right hypochondriac region; extends down to right lateral region and crosses midline to epigastric region
- iv. gall bladder is behind liver on the lateral edge of the rectus abdominis
- v. pancreas is on posterior abdominal wall below duodenum; falls in lower epigastric/upper umbilical region
- vi. spleen behind stomach on left side of body in left hypochondriac region
- vii. duodenum surrounds pancreas and is continuous between stomach and jejunum; near midline from epigastric to umbilical region
- viii. jejunum and ileum covers umbilical and hypogastric regions
- ix. cecum/appendix beginning of large intestine; lower right lateral and right inguinal regions
- x. transverse colon from ascending colon on right to descending colon on left
- xi. descending colon in left lateral and left inguinal regions
- xii. sigmoid colon/rectum ends in hypogastric region from descending colon

CC). Liver:

- i. Parts:
  1. Portal lobes: right and left divided by an imaginary sagittal plane passing through the gall bladder fossa and the fossa for the IVC on the visceral surface of the liver.
    - a. Each portal lobe had its own blood supply from the hepatic artery and portal vein and its own venous and biliary drainage.
    - b. The portal lobes of the liver are further subdivided into 8 segments.
    - c. Left portal lobe includes anatomical left lobe, caudate lobe, and most of the quadrate lobe.
  2. Anatomical lobes: 4 total
    - a. Left lobe is demarcated from the caudate and quadrate lobes by the fissure for the round ligament (ligamentum teres, remnants fetal umbilical vein) of the liver and the fissure for the ligamentum venosum (remnant of fetal ductus venosus) on the visceral surface and by the attachment of the falciform ligament on the diaphragmatic surface.
    - b. Two smaller lobes, the caudate lobe and the quadrate lobe, are found to the right of the falciform ligament but are functionally part of the left lobe (receiving blood supply from left hepatic vessels).
- ii. Peritoneal coverings:
  1. Falciform ligament: separates subphrenic space into left and right spaces.

- a. Prevents the liver from being displaced to the right
  - b. Left and right triangular ligaments are continuations of the falciform ligament along the superior border of the liver to left or right
- 2. Hepatorenal recess: recess of peritoneal cavity on right side inferior to the liver and anterior to the kidney and suprarenal gland
- 3. Bare area: area on diaphragmatic surface not covered with peritoneum
- 4. Visceral surface of the liver is covered in peritoneum except for the bed of the gallbladder and porta hepatis (where vessels and ducts enter and leave the liver)
- 5. Peritoneal ligaments
  - a. Falciform
  - b. Hepatoduodenal
  - c. Gastrohepatic
  - d. Coronary
- iii. Lesser omentum links liver to stomach and duodenum
- iv. Coronary ligament - region b/ the falciform ligament and right triangular ligament