

Marcello Cherchi's notes for Gross Anatomy

ABDOMEN

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(Please let me know of any errors! mchercl@uic.edu)

References:

- CH CHUNG, Kyung Won, *Gross Anatomy*, 3rd ed. Baltimore: Williams & Wilkins, 1995.
- CL CLEMENTE, Carmine, *Anatomy: A Regional Atlas of the Human Body*, 4th ed. Baltimore: Williams & Wilkins, 1997.
- GR WILLIAMS, Peter L. and Roger WARWICK (eds.), *Gray's Anatomy*, 36th British ed. Philadelphia: W.B. Saunders Co., 1980.
- Hosford <http://www.ptcentral.com/muscles>
- MA MOORE, Keith L. and Anne M. R. AGUR, *Essential Clinical Anatomy*. Baltimore: Williams & Wilkins, 1995.
- NE NETTER, Frank H., *Atlas of Human Anatomy*, 2nd ed. East Hanover, New Jersey: Novartis, 1998.
- RRK ROSS, Michael H., Lynn J. ROMRELL and Gordon I. KAYE, *Histology: A Text and Atlas*, 3rd ed. Baltimore: Williams & Wilkins, 1995.
- SA SADLER, Thomas W., *Langman's Medical Embryology*, 7th ed. Baltimore: Williams & Wilkins, 1995.
- Sapan <http://www.uic.edu/~sdesai4/>
- SH JACOBS, John J., *Shearer's Manual of Human Dissection*, 7th ed. New York: McGraw-Hill, Inc., 1989.

Also see:

The M1 home page for anatomy: http://www2.uic.edu/stud_orgs/prof/M1/

ABDOMEN, anterior wall

Muscle	Innervations	Blood supplies	Origins	Insertions	Actions
External oblique ("flat muscle")	Inferior six thoracic nn. and subcostal n.	(?)	External surfaces of 5th to 12th ribs	Linea alba, pubic tubercle, and anterior half of iliac crest	Compress and support abdominal viscera; flex and rotate trunk

Internal oblique ("flat muscle")	Ventral rami of inferior six thoracic nn. and first lumbar nn.	(?)	Thoracolumbar fascia, anterior two-thirds of iliac crest, and lateral half of inguinal ligament	Inferior borders of 10th- 12th ribs, linea alba and pubis via conjoint tendon	Ditto
Transversus abdominis ("flat muscle")	Ditto	(?)	Internal surfaces of 7th- 12th costal cartilages, thoracolumbar fascia, iliac crest, and lateral third of inguinal ligament	Linea alba with aponeurosis of internal oblique, pubic crest, and pecten pubis via conjoint tendon	Compress and support abdominal viscera
Rectus abdominis ("vertical muscle")	Ventral rami of inferior six thoracic nn.	Internal thoracic a., inferior epigastric a. (MA 88)	Pubic symphysis and pubic crest	Xiphoid process and 5th-7th costal cartilages	Flex trunk and compress abdominal viscera

The **cremaster m.** (or cremasteric m.) is innervated by the genital branch of the genitofemoral n. Its function is to elevate the testes. It is derived from the internal abdominal oblique m. (CL 182; MA 91) in two places, viz. a medial and a lateral origin (NE 243).

Note the following relationships between the thorax and abdomen:

<u>In the abdomen</u>	<u>is continuous with</u>	<u>in the thorax</u>
External abdominal oblique m.	...	external intercostal m.
Internal abdominal oblique m.	...	Internal intercostal m.
Transversus abdominis m.	...	transversus thoracis m.

In the abdomen, the **neurovascular plane** passes between the external abdominal m. (or aponeurosis) and the internal abdominal oblique m. (or aponeurosis).

Notes

The superior border of the abdominal cavity is the diaphragm. The diaphragm is attached to the xiphoid process, the lower six ribs and the lumbar vertebrae 1-3. The dome of the diaphragm on the right side lies as high as the 5th intercostal space because the liver is pushing up against it.

Clinical correlations

Portal hypertension (e.g. due to obstruction of the portal v., CL 161) causes gastrointestinal blood (which would normally drain through the hepatic portal venous system) to flow to the inferior vena cava. Four anastomosing channels permit this, one of which is in the area of the umbilicus (via the perforating veins between the paraumbilical and portal system). When these vessels become distended, the veins become visible and result in a condition called **caput medusae** (MA 124).

Between the membranous layer of superficial fascia (Scarpa's fascia) and the deep fascia of the rectus abdominis and external abdominal oblique mm. there is a potential space where fluid may accumulate (e.g. from a **ruptured urethra**, typically the spongy urethra). The fluid cannot spread into the thigh because the deep layer of fascia fuses with the deep fascia of the thigh along a line inferior and parallel to the inguinal ligament (MA 81; see also MA 178; CH 203). A rupture of the spongy urethra results in urine collecting between the tunica dartos scroti and the external spermatic fascia (according to Sapan).

Fascia

Camper's fascia is a fatty superficial layer.

Scarpa's fascia is a membranous deeper layer.

In the lateral inguinal region, Scarpa's fascia fuses with the fascia latae.

In the medial inguinal region, the two layers of superficial fascia (=Camper's and Scarpa's?) blend to form the **dartos layer of the scrotum** (or "**tunica dartos scroti**") and continue in the perineum as **Colle's fascia** (CL 160).

Inside all the above-mentioned layers of fascia there is the **transversalis fascia** (MA 81), which:

- Defines the abdominal cavity
- Lies posterior (deep) to the rectus abdominis mm. at all points (CL 168).
- Lies external (superficial) to the peritoneum.
- Evaginates (at the deep inguinal ring) to form the internal spermatic fascia.

Nerves

The **genital branch** of the genitofemoral n. (L1, L2) innervates cremaster m.

The iliohypogastric n. (from L1) and ilioinguinal n. (from L1) both pass between the transversus abdominis m. and the internal abdominal oblique m.

The **ilioinguinal n.** (from L1) innervates the anterior scrotum or anterior labium majus, the mons pubis (=the rounded mound of skin and adipose tissue anterior to the pubic symphysis, CL 274), and the adjacent medial aspect of thigh. It also innervates the internal abdominal oblique m. and transversus abdominis m. (MA 86).

Dermatomes: T5, T6=xiphoid process, T10=umbilicus, L1=just above the pubic symphysis.

Arteries (MA 88)

Superior epigastric a. (from internal thoracic a.) descends in the rectus sheath deep to the rectus abdominis m. Supplies the rectus abdominis m. and anterolateral abdominal wall (CL 170).

Inferior epigastric a. (from external iliac a.) runs superiorly and enters the rectus sheath; runs deep to the rectus abdominis m. Supplies the rectus abdominis and anterolateral abdominal wall (CL 170).

Deep circumflex iliac a. (from external iliac a.) runs on the deep aspect of the anterior abdominal wall, parallel to the inguinal ligament. Supplies the iliacus m. and inferior part of anterolateral abdominal wall (CL 171, 173).

Superficial circumflex iliac a. (from femoral a.) runs in superficial fascia along inguinal ligament. Supplies the superficial fascia and skin over the inferior portion of the anterolateral abdominal wall (CL 161, 175).

Superficial epigastric a. (from femoral a.) runs in superficial fascia towards umbilicus. Supplies the superficial fascia and skin over the suprapubic region (CL 170).

Ligaments

The **inguinal ligament (of Poupart)** is the tough, rolled-under inferior margin of the aponeurosis of the external abdominal oblique m. (CL 162).

The **lacunar ligament (of Gimbernat)** reflects onto the pecten pubis (CL 163, 273).

The **tendinous intersections** on the rectus abdominis m. (CL 165, 167; NE 233)

Lymphatics

Horizontal set of superficial inguinal lymphatic nodes (NE 249).

Landmarks

The **umbilicus** is at the level of the intervertebral disc between Lv3 and Lv4.

A **four-quadrant** schema for dividing the abdomen involves a vertical **median plane** and horizontal **transumbilical plane** through the umbilicus, thereby dividing the abdomen into right and left upper and lower quadrants.

A more detailed schema divides the abdomen into nine sectors via two horizontal planes (viz. the **subcostal plane** and the **transtubercular plane**) and two vertical planes (viz. the **midclavicular planes**), thereby rendering **hypochondriac, lumbar** and **inguinal** sections (on each side) and **epigastric, umbilical** and **suprapubic** sections in the center (MA 80; NE 251).

Linea alba at the vertical line passing through the umbilicus. Posterior to the linea alba is the **falciform ligament** (NE 235).

Linea semilunaris is at the lateral border of the rectus abdominis m. on each side.

The **arcuate line** is located between the upper 3/4 and lower 1/4 of the anterior abdominal wall (CL 167, 172-3). This is an important point for understanding the investitures of the rectus sheath (=those structures which envelop the rectus abdominis m.).

Above the arcuate line:

- The aponeurosis of the external abdominal oblique m. passes **anterior** to the rectus abdominis m.
- The aponeurosis of the internal abdominal oblique m. splits and passes both **anterior** and **posterior** to the rectus abdominis m.
- The aponeurosis of the transversus abdominis m. passes **posterior** to the rectus abdominis m.
- The inferior epigastric a. and v. course posterior to the rectus abdominis m. and anterior to the internal abdominal oblique aponeurosis.

Below the arcuate line:

- The aponeurosis of the external abdominal oblique, internal abdominal oblique and transversus abdominis mm. all pass **anterior** to the rectus abdominis m. (MA 84; CL 168; NE 235).
- The inferior epigastric a. and v. course posterior to the rectus abdominis m. and anterior to extraperitoneal connective tissue and parietal peritoneum.

The inferior epigastric a. and v. insinuate themselves into the rectus sheath above the arcuate line.

Note that the transversalis fascia lies posterior to the rectus abdominis mm. at all points (CL 168; NE 235, 238).

INGUINAL CANAL (MA 88 ff.)

The inguinal canal is 4-5 cm in length.

Through the inguinal canal there passes the spermatic cord (in the male) or the round ligament of the uterus (in the female).

Contents of the spermatic cord: (CL 307)

1. Ductus deferens (smooth m.)
2. Deferential a.
3. Testicular a. and v. (including the pampiniform plexus of veins)

4. Autonomic nerves
5. Lymphatics
6. Obliterated processus vaginalis (part of the peritoneum)

Boundaries of the inguinal canal (MA 88):

Floor

- Full length of the i.c.: **inguinal ligament**.
- Medial portion of the i.c.: supplemented by the **lacunar ligament** (which is an extension of the inguinal ligament, CL 163, 273).

Roof

- Full length of the i.c.: aponeurosis of the **internal abdominal oblique m.**
- Full length of the i.c.: aponeurosis of the **transversus abdominis m.**
(These two aponeuroses fuse medially (just posterior to the superficial inguinal ring) to form the **conjoint tendon** or **falx inguinalis**.)
- Transversalis fascia.

Anterior wall

- Full length of the i.c.: aponeurosis of the **external abdominal oblique m.**
- Lateral portion of the i.c.: supplemented by the aponeurosis of the **internal abdominal oblique m.**
(The transverse abdominal oblique m.'s aponeurosis does *not* contribute to the anterior wall of the i.c.)

Posterior wall

- Full length of the i.c.: aponeurosis of the **transversus abdominis m.**
- Medial portion of the i.c.: supplemented by the **conjoint tendon** (=internal abdominal oblique and transversus abdominis).
- Transversalis fascia.

The arching fibers of the **internal abdominal oblique m.** contribute to the following enclosures of the inguinal canal:

- Lateral part of anterior wall
- Medial part of posterior wall
- Full length of the roof

The roof and posterior wall are also formed by the **transversalis fascia**.

Although the **superficial inguinal ring** is called a “ring,” this opening is actually more “V” shaped, and is defined by the **medial crus** (which is attached to the body of the pubis) and **lateral crus** (which is attached to the pubic tubercle). The superficial inguinal ring lies *medially* to the inferior epigastric a.

The **deep inguinal ring** is an outpouching of the transversalis fascia located just superior to the midpoint of the inguinal ligament and *lateral* to the inferior epigastric a. (see NE 243).

Femoral hernias are more common in women than in men. Inguinal hernias are more common in men.

Indirect inguinal hernias (also called “congenital hernias,” although this is a misnomer) are more common than direct ones. They occur when the neck (i.e. the source of the hernia; generally part of the intestine) follows the same path of a descended testis (in the male) or the round ligament of the uterus (in the female) by passing *laterally* to the inferior epigastric vessels and through the inguinal canal and possibly down into the scrotum (in the male).

The **inguinal triangle** (or **Hesselbach triangle**) has the following borders (NE 236, 243):

- The inguinal ligament inferiorly.
- The linea semilunaris medially.
- The inferior epigastric a. and v. laterally.

In the area of the inguinal triangle, the transversalis fascia is covered only by the external abdominal oblique, hence this triangle is a weak area of the abdominal wall. **Direct inguinal hernias** (also called “acquired hernias”) occur when the neck passes *medially* to the inferior epigastric vessels and presses up against the inguinal triangle (MA 92; NE 243).

Compare the correspondence between the layers of the abdomen and the scrotum (MA 89; CL 183):

	<u>Anterior abdominal wall</u>	<u>Coverings of testis</u>
Scrotum:	1. Skin 2. Superficial fascia (=Scarpa’s + Colle’s fasciae)	1. Skin 2. Dartos tunic (containing the dartos scroti m.)
Spermatic cord:	3. Fascia of external abdominal oblique m.	3. External spermatic fascia

- | | |
|---------------------------------------|------------------------------|
| 4. Internal abdominal oblique m. | 4. Cremaster muscle |
| 5. Fascia of transversus abdominis m. | 5. Cremasteric fascia |
| 6. Transversalis fascia | 6. Internal spermatic fascia |
| 7. Extraperitoneal fat | 7. Fatty layer |
| 8. Peritoneum | 8. Processus vaginalis |

Note that the superficial fascia (within which is found the dartos scroti muscle) has *no subcutaneous fat* (MA 93).

The **tunica vaginalis** is a peritoneal sac surrounding the anterior portion of the testis (and is a derivative of the embryonic *processus vaginalis*). Its parietal layer is adjacent to the internal spermatic fascia; its visceral layer is adherent to the testis and epididymis (MA 93).

Clinical correlations

The presence of excess fluid (secreted by the serous epithelia of the tunica vaginalis) is called a **hydrocele**. Blood (due to injury or inflammation) in the same region is called a **hematocele** (MA 93).

Cancer of the testes metastasizes to the lumbar and preaortic lymph nodes. Cancer of the scrotum metastasizes to the superficial inguinal nodes (MA 91). (See NE 249 for illustrations of these lymph nodes.)

ABDOMEN, peritoneal and retroperitoneal spaces

Notes

The **portal triad** consists of:

1. Portal v.
2. Bile duct
3. Common hepatic a.

Clinical correlations

Peritonitis is any inflammation of the peritoneum.

Fascia

The **retroperitoneal space** is the posterior potential space between the transversalis fascia and the peritoneum.

The **mesentery** is the double layer of the peritoneum. For a general view of the mesentery see NE 329, CL 195.

An **omentum** is a double-layered extension of visceral peritoneum that passes from the stomach and the proximal part of the duodenum to another organ or structure (MA 96).

The following are the components of the mesentery:

Section of mesentery	What it connects or envelops	Notes
I. Dorsal common mesentery		Posterior inferior part of abdomen
A. Mesentery proper		
B. Mesoappendix	Suspends the vermiform appendix from the mesentery of the terminal ileum (MA 109).	
C. Transverse mesocolon	Mobile mesentery of the transverse colon: The root of this mesentery is located along the inferior border of the pancreas and becomes continuous with the parietal peritoneum posteriorly (MA 111).	The transverse mesocolon has six layers of peritoneum (according to Sapan).
D. Sigmoid mesocolon	Envelops the sigmoid colon (MA 111).	
II. Dorsal mesogastrium		Posterior superior part of abdomen
A. Greater omentum (CL 192)		Contains four layers of peritoneum (CL 195).
1. Gastrophrenic ligament	Connects the stomach to the inferior surface of the diaphragm (MA 96).	
2. Gastrosplenic (gastrolial) ligament	Connects the spleen to the greater curvature of the stomach (MA 113).	In this ligament there courses the left gastroepiploic a. (GR 1328) and the short gastric aa. (according to Sapan).
3. Gastrocolic ligament	Connects the stomach to the transverse colon (MA 96).	
B. Splenorenal (lienorenal) ligament	Connects the spleen to the left kidney (MA 113).	The tip of the tail of the pancreas is ensheathed in this ligament (MA 114). The splenic a. (GR 1328) and splenic v. (GR 764) course in this ligament.

C. Phrenicocolic ligament	Attaches the left colic flexure to the diaphragm (MA 111; NE 267)	
III. Ventral mesogastrium		Anterior superior part of abdomen
A Lesser omentum (CL 202)		Encloses the portal triad (MA 119).
1. Hepatogastric ligament	Extends between the liver and the stomach (MA 119).	
2. Hepatoduodenal ligament	Extends between the liver and the duodenum.	Encloses the portal triad (MA 119).
3. Hepatocolic ligament		Absent in many individuals
B. Ligaments of liver		
1. Falciform ligament	Connects the liver to the anterior abdominal wall (MA 96).	Continuous with the round ligament of the liver (ligamentum teres hepatis) and divides the liver into R and L anatomical lobes.
2. Coronary ligament (MA 117)		
a. Right triangular ligament		At rightmost extreme of coronary ligament.
b. Left triangular ligament		At leftmost extreme of coronary ligament.

Various organs are “**peritonealized,**” i.e. are “enveloped” by the peritoneum. (Actually, nothing is really “inside” the peritoneum except some serous fluid. Rather, organs are “enclosed” by the peritoneum in the same way that a fist is inserted into an inflated balloon.)

- Stomach (between greater and lesser omenta)
- Liver (MA 117)
- Gallbladder (MA 122)
- Duodenum (1st part, very end of 4th part)
- Jejunum
- Ileum
- Cecum (most of it)
- Appendix

- Transverse colon
- Sigmoid colon (in the sigmoid mesocolon)
- Spleen (MA 113)
- Portal triad (in hepatoduodenal ligament)

Other organs are “**retroperitoneal**,” i.e. lie outside of the peritoneum.

The following are **primarily formed** in the retroperitoneum:

- Great vessels
- Kidneys (MA 125)

The following are **secondarily formed** in the retroperitoneum. (Embryonically they are initially in the peritoneum, but subsequently they move to the posterior wall and the peritoneum fuses anterior to them, leaving behind a thin sheet of fascia called fusion fascia: “Organs[...] that are originally covered by peritoneum but later fuse with the posterior body wall to become retroperitoneal are referred to as being secondarily retroperitoneal,” SA 250.)

- Duodenum (2nd part, 3rd part, most of 4th part)
- Pancreas (except for the tip of the tail)
- Cecum (a small portion thereof)
- Ascending colon (MA 111)
- Descending colon (MA 111)
- Rectum

Subdivisions of the peritoneal cavity (MA 96):

- I. **Greater sac** is divided by the transverse mesocolon into
 - A. Supracolic compartment containing the stomach, liver and spleen
 - B. Infracolic compartment containing the small intestine and ascending and descending colon. This compartment lies posterior to the greater omentum and is further subdivided by the mesentery of the small intestine into right and left infracolic spaces.
- II. **Lesser sac (=omental bursa)** lies posterior to the stomach and lesser omentum (CL 203; NE 270). It contains:
 - A. A superior recess that is limited superiorly by the diaphragm and the posterior layers of the coronary ligament of the liver
 - B. An inferior recess between the superior part of the layers of the greater omentum

The omental bursa communicates with the greater peritoneal sac through the **omental (epiploic) foramen (of Winslow)**, which can usually admit two digits. (For a good illustration see NE 256; CL 221) The borders of this foramen are (MA 96):

- Anteriorly, the portal triad (viz. portal vein, hepatic artery and common bile duct)

- Posteriorly, the inferior vena cava and right crus of the diaphragm
- Superiorly, the caudate lobe of the liver
- Inferiorly, the superior part of the duodenum, portal vein, hepatic artery and bile duct.

Ligaments

In the peritoneum, “ligaments” are really areas of the serous membrane; they are not ligaments in the traditional sense of connecting bone to bone.

Landmarks

The **umbilicus** is at the level of the intervertebral disc between Lv3 and Lv4.

The long axis of the **spleen** lies in the line of the 10th rib (MA 116; NE 251, 269).

The **transpyloric plane (TPP)** eclipses Lv1 (MA 116; CL 3). It passes through the pylorus of the stomach. It is about halfway between the suprasternal notch and the superior border of the pubic symphysis. It is also about halfway between the xyphoid process and the umbilicus.

From medially to laterally (NE 236; CL 187, 242, 298; GR 1322):

1. The median umbilical fold (of peritoneum) is the urachus (CL 192), which is the obliterated allantois of the fetus (SA 283-4).
2. Supravesical fossa
3. The medial umbilical fold (of peritoneum) is due to the medial umbilical ligament (=obliterated umbilical artery).
4. Medial inguinal fossa
5. The lateral umbilical fold of peritoneum is due to the inferior epigastric a. and v.
6. Lateral inguinal fossa

STOMACH

Notes

Note the following areas of the stomach: (MA 99-100; NE 258)

Cardia = orifice between esophagus and stomach.

Fundus = most superior part of stomach.

Body of stomach = its main part.

Lesser curvature = rightmost curve (embryonically was anterior). Lesser omentum attaches here.

Greater curvature = leftmost curve (embryonically was posterior). Greater omentum attaches here.

Angular incisure (or **angular notch**) = notch at the inferior edge of the lesser curvature which delineates the separation between the body of the stomach and the **pyloric antrum**.

Pylorus = funnel-shaped distal part of the stomach (at the level of Lv1) in which there is the **pyloric sphincter** which controls discharge of the stomach contents through the **pyloric orifice** into the duodenum

The stomach consists of four layers (from innermost to outermost):

1. Mucosa (rugae are only here, not in deeper layers)
2. Submucosa
3. Muscular layer
 - a. Inner (circular)
 - b. Outer (longitudinal)
4. Serosal surface (=visceral peritoneum)

Netter (p. 260) seems to imply that there are *three* muscular layers to the stomach, viz.: innermost oblique, middle circular and outer longitudinal.

When not distended, **rugae** (gastric folds in the mucosa) are visible on the inside of the stomach (NE 259).

The **stomach bed** consists of the structures posterior to the stomach:

- Pancreas
- Diaphragm
- Celiac trunk
- Left adrenal gland
- Pole of left kidney
- Spleen
- Transverse mesocolon
- Splenic flexure

Nerves

The *parasympathetic* nerve supply of the stomach is from the anterior and posterior vagal trunks and their branches. The *sympathetic* nerve supply from T6 to T9 segments of the spinal cord passes to the **celiac plexus** (=solar plexus) and is distributed through the plexuses around the gastric and gastrointestinal arteries.

Arteries

For a good illustration of the arterial supply to the stomach see CL 198.

Four “unpaired arteries” (MA 137) branch off the abdominal aorta:

1. The **celiac trunk** branches from the abdominal aorta at the lower border of Tv12. (This supplies that part of the abdomen corresponding to the *foregut* of the embryonic primitive gut.) The celiac trunk branches off the abdominal aorta retroperitoneally, but then becomes peritonealized (since it must supply peritonealized structures). It has three branches:
 - a. Splenic a. (in retroperitoneal space)
 - b. Left gastric a.
 - c. Common hepatic a.
2. **Superior mesenteric a.** branches off at the level of Lv1. (This supplies that part of the abdomen corresponding to the *midgut* of the embryonic primitive gut.)
3. **Inferior mesenteric a.** branches off at the level of Lv3. (This supplies that part of the abdomen corresponding to the *hindgut* of the embryonic primitive gut.)
4. **Middle (or median) sacral a.**

Veins

Venous return from all abdominal organs is via the **portal vein** (CL 201; NE 293) which passes into the capillary bed of the liver (thereby constituting a portal system).

INTESTINES

Clinical correlations

In the initial phases of appendicitis, the **referred visceral pain** is perceived paraumbilically (see MA 137) in dermatome T10.

Notes

Sections of the intestine: (see CH 160-162)

I. Small intestine

A. Duodenum, the “C”-shaped tube surrounding the head of the pancreas (NE 261-2).

1. Superior (first) part is peritonealized. At the level of **Lv1** (NE 251).
2. Descending (second) part is retroperitoneal. At the level of **Lv2**. Here begin the plicae circulares (folds).
3. Transverse (third) part is retroperitoneal. At the level of **Lv3**.
4. Ascending (fourth) part is mostly retroperitoneal, although the very end is peritonealized. At the level of **Lv2**.

B. Jejunum

C. Ilium is characterized by the presence of Peyer’s patches in the lower portion

II. Large intestine (NE 267)

A. Cecum, the “blind pouch” of the large intestine (CL 222)

B. Appendix (or “vermiform appendix”) (NE 265)

C. Colon

1. Ascending colon is retroperitoneal. On its lateral and medial sides there are *paracolic gutters*.
2. Transverse colon is ensheathed in transverse mesocolon
3. Descending colon is retroperitoneal. On its lateral and medial sides there are *paracolic gutters*.
4. Sigmoid colon is ensheathed in sigmoid mesocolon (NE 267)

D. Rectum and anal canal

Distinguishing characteristics of jejunum and ilium (MA 108):

Characteristic	Jejunum	Ilium
Color	Deeper red	Paler pink
Caliber	2-4 cm	2-3 cm
Wall	Thick and heavy	Thin and light
Vascularity	Greater	Less
Vasa recta	Long	Short
Number of intestinal arteries	More	Fewer
Arcades (converse to # of intestinal aa.!)	A few large loops	Many short loops
Fat in mesentery	Less	More
Circular folds (plicae circulares)	Large, tall and closely packed	Low and sparse; absent in distal part
Lymphoid nodules (Peyer’s patches)	Few	Many

Characteristics of large intestine (MA 109)

The longitudinal muscle is coalesced into three bands called **teniae coli**. The sacculations (outpouchings) between the teniae coli are called **haustra**. Small pouches of omentum filled with fat are called **omental (epiploic) appendages** (NE 267).

Note that the **appendix** is completely enclosed in the smooth muscle from the teniae coli.

The bend in the rightmost part of the transverse colon is called the **right (hepatic) colic flexure**.

The bend in the leftmost part of the transverse colon is called the **left (splenic) colic flexure** (NE 267).

The rectum has only two bands of muscle (as opposed to the three bands of teniae coli of the large intestine).

Arteries

The **celiac trunk** supplies the derivatives of the embryonic foregut, viz.: stomach and duodenum (proximal to the entrance of the bile duct).

The **superior mesenteric a.** supplies the derivatives of the embryonic midgut, viz.: duodenum (distal to the entrance of the bile duct) and up to and including the middle third of the transverse colon.

The **inferior mesenteric a.** supplies the derivatives of the embryonic hindgut, viz.: the distal third of the transverse colon, the upper part of the anal canal.

Concerning the *small intestine*: The various **intestinal aa.** (e.g. jejunal, ileal, ileocolic) have anastomosing **arcades** which connect them. From these arcades there branch **vasa recta** which actually supply the intestine (NE 286).

Concerning the *large intestine*: Along the inner side of the large intestine there courses the **marginal a.**, which is contributed to by the **right colic a.** (which has ileal, cecal and appendicular bb.), **middle colic a.** (which has L and R bb.) and the **left colic a.** (which has ascending and descending bb.) (NE 287). There are variations in this arrangement (NE 289).

Veins

Concerning the *small intestine*: Straight veins (**venae rectae**) bring blood back from the intestines. These are tributaries to **anastomotic loops**, which in turn are tributaries to (jejunal and ileal) **intestinal veins**, which empty into the **superior mesenteric v.** (NE 291-3).

Concerning the *large intestine*: the ileocolic, right colic, middle colic vv. empty into the superior mesenteric v. (NE 291-3).

Ligaments

The **suspensory muscle (=ligament of Treitz)** suspends the small intestine at the juncture between the duodenum and jejunum (MA 105; NE 253).

The **phrenicocolic ligament** suspends the leftmost part of the transverse colon at the left (splenic) colic flexure (MA 111).

Landmarks

The base (or “root”) of the appendix lies deep to **McBurney’s point**, which is between the lateral third and middle third of the oblique line joining the right anterior superior iliac spine to the umbilicus (MA 109; NE 266). Another way of locating this point is at the intersection between the R linea semilunaris and the imaginary line between the two ASIS tubercles. However, note that the position of the appendix can vary widely (CL 223).

The transition between the sigmoid colon and the rectum occurs at the level of Sv3.

DERIVATIONS OF EMBRYONIC GUT**Notes**

The division between the embryonic foregut and midgut occurs at the greater duodenal papilla (SA 258).

The division between the embryonic midgut and hindgut occurs between the 2nd part and 3rd part of the transverse colon (SA 268).

The following are the derivatives of the embryonic gut:

1. Embryonic **foregut** gives rise to: esophagus, stomach, duodenum (proximal to the entrance of the bile duct), liver, gallbladder, pancreas (SA 245, 247, 253, 254, 256, 270).
2. Embryonic **midgut** gives rise to: duodenum (distal to the entrance of the bile duct) all the way up to and including the middle third of the transverse colon (SA 258, 270).
3. Embryonic **hindgut** gives rise to: everything from (and including) the final third of the transverse colon, the upper part of the anal canal (SA 268, 271).

Nerves

See the diagram in NE 305-6 concerning the innervation of the gut.

Section of gut	Parasympathetic innervation (=craniosacral)	Location of preganglionic cell bodies	Sympathetic innervation (=thoracolumbar)	Location of postganglionic cell bodies
Foregut	Vagus n. (CN X)	Brain	Greater thoracic splanchnic nn (T5-T9)	Celiac ganglia (at celiac trunk)
Midgut	Vagus n. (CN X)	Brain	Greater thoracic splanchnic nn (T5-T9)	Superior mesenteric ganglia (inferior to celiac ganglia)
Hindgut	Pelvic splanchnic nn. (S2, S3, S4)	In the respective cord levels	Lumbar splanchnic nn. (L1, L2)	Inferior mesenteric ganglion

Arteries

Derivatives of the embryonic **foregut** are supplied by the **celiac trunk**.

Derivatives of the embryonic **midgut** are supplied by the **superior mesenteric a.**

Derivatives of the embryonic **hindgut** are supplied by the **inferior mesenteric a.**

PANCREAS

Notes

Parts of pancreas: (NE 279)

1. Head, with uncinate process (from ventral primordium)
2. Neck
3. Body
4. Tail (only the tip thereof is peritonealized)

Most of the pancreas is secondarily retroperitoneal; only its tip is peritonealized as it passes between the layers of the splenorenal (lienorenal) ligament with the splenic vessels and contacts the hilum of the spleen (MA 114).

The **main pancreatic duct (of Wirsung)** (NE 279) begins in the tail of the pancreas (MA 114) (i.e. in what was embryonically the *dorsal primordium*) and enters the small intestine through the **greater duodenal papilla** (in the posteromedial wall between the 2nd

and 3rd segments of the second part of the duodenum). Usually the main pancreatic duct unites with the bile duct, forming a short, dilated hepatopancreatic ampulla (MA 114), though there are anatomical variations in this (NE 278; CL 208, 211). Sometimes the main pancreatic duct and the common bile duct fuse (before entering the duodenum) and form what is known as the **ampulla of Vater** (NE 262, 276, 278). The orifice controlling the release from this duct into the duodenum is called the **sphincter of hepatopancreatic ampulla** or **sphincter of Oddi** (NE 278, 309; RRK 508).

In 9% of people, the **accessory pancreatic duct (of Santorini)** (NE 279) begins in the uncinata process (MA 114) (i.e. in what was embryonically the *ventral primordium*) enters the small intestine through the **lesser duodenal papilla** (in the anteromedial wall between the 1st and 2nd segments of the second part of the duodenum) separately from the main pancreatic duct (MA 114). Usually the main pancreatic duct and accessory pancreatic duct are separate, but there are anatomical variations (NE 280).

Arteries

The pancreas is supplied by the dorsal pancreatic a. and the artery pancreatica magna (both of which are branches from the splenic a., which in turn is a branch from the celiac trunk).

SPLEEN

Notes

The spleen is the largest of the lymphatic organs. It has smooth muscle which, under stress, can contract in order to mobilize blood reserves (MA 113).

Clinical correlations

The spleen is enclosed by a thin capsule which is easily torn by trauma (MA 114).

Arteries

The splenic a. traverses the splenorenal ligament (GR 1328).

Veins

The splenic v. traverses the splenorenal ligament (GR 764).

Landmarks

The long axis of the spleen normally lies in the line of the 10th rib (MA 116).

LIVER

Notes

The liver is the largest gland in the body. It is covered with peritoneum except posteriorly in its “bare area” (MA 117).

The liver is divided along anatomical and functional lines (MA 117, 119; NE 272)

The liver is divided into left and right “**anatomical**” lobes by the falciform ligament.

The liver is divided into four “**functional**” lobes (left, right, quadrate [anteriorly], caudate [posteriorly]) by a more elaborate system. The *left* functional lobe includes all of the quadrate lobe and the left half of the caudate lobe (NE 272) (which is counterintuitive, because the caudate lobe and quadrate lobe belong to the *right* anatomical lobe).

The bile from the liver exits the hilum through the left and right hepatic ducts, which meet at the **common hepatic duct** (NE 276). The common hepatic duct and the cystic duct (from the gallbladder) meet and form the common bile duct (or ductus choledochus) (NE 276).

Clinical correlations

Although the portocaval anastomoses help bypass blockage of the inferior vena cava, other problems can result. For instance, bleeding from esophageal varices (MA 125), which can be fatal, or hemorrhoids (MA 182).

Arteries

The blood supply to the liver is 30% from the hepatic a., 70% from the portal v. (MA 119). There are anatomical variations in their arrangement (NE 294).

Veins

There are four sites of portocaval anastomoses: (NE 293; MA 124, 174, 182)

1. Esophageal vv. & left gastric v.
2. Paraumbilical vv. & epigastric vv.
3. Superior rectal v. & middle and inferior rectal vv.
4. Retroperitoneal venous channels

If the IVC (inferior vena cava) is blocked or ligated, blood can still return to the heart by several routes (MA 138):

If the IVC is blocked *above* the tributaries from the azygos v., then the blood can return to the heart by flowing through the following route: tributaries to azygos v. → arch of the azygos v. → superior vena cava.

If the IVC is blocked *below* the tributaries from the azygos v., then the blood can return to the heart by flowing through the following anastomotic pathway: femoral v. → superficial epigastric v. → thoracoepigastric v. → lateral thoracic v. → axillary v. → subclavian v. → R brachiocephalic v. → superior vena cava.

Note that the portal system of veins is valveless (RRK 501).

Ligaments

The **round ligament of the liver** (=ligamentum teres hepatis) is the remnant of the embryonic umbilical v. (CL 192, 187, 207; MA 118).

GALLBLADDER

Notes

The gallbladder is completely peritonealized; its neck is applied to the liver (MA 122).

The gallbladder stores, concentrates and releases bile. The bile passes through the **cystic duct** (which consists of a spiral part and a smooth part) and meets the common hepatic duct, thereby forming the common bile duct (or ductus choledochus) (NE 276).

Clinical correlations

The distal end of the hepatopancreatic ampulla is the narrowest part of the biliary passage and is the common site for impaction of a gallstone (MA 124).

Arteries

The gallbladder and cystic duct are supplied by the **cystic artery** (← R hepatic a. ← proper hepatic a. ← common hepatic a. ← celiac trunk ← abdominal aorta) (NE 284; MA 104).

Landmarks

The gallbladder peeks out from underneath the liver at the level of the 9th right costal cartilage (NE 269; CL 188).

DIAPHRAGM

There are three hiati (or “foramina”) in the diaphragm (see CL 236-7):

Hiatus (or “foramen”)	Formed by	Level	Vessels (MA 132)
Inferior vena caval	Central tendon	Tv8	Inferior vena cava, terminal branches of R phrenic n.
Esophageal	Split within the R crus	Tv10	Esophagus, vagal trunks, esophageal branches of L gastric vessels
Aortic	L and R crura	Tv12	Aorta, thoracic duct, azygos v.

Clinical correlations

Hiatal hernias (e.g. of the cardiac of the stomach through the esophageal hiatus) can occur due to weakening of the muscle of the diaphragm around the esophageal hiatus (MA 101).

Nerves (MA 132; NE 182)

The motor supply to all of the diaphragm is from the **phrenic nn.** (C3-5).

Sensory innervation from the central part of the diaphragm is from the **phrenic nn.**

Sensory innervation from the peripheral part of the diaphragm is from the **intercostal nn.** (T5-T11) and the **subcostal nn.** (T12).

Arteries

The diaphragm is supplied by three pairs of arteries (MA 132):

1. Musculophrenic a. (from the internal thoracic a.)
2. Pericardiophrenic a. (from the internal thoracic a.)
3. Superior phrenic a. (from the thoracic aorta)
4. Inferior phrenic a. (from the abdominal aorta)

Ligaments

The diaphragm is attached to the vertebral column by the longer **right crus** (which attaches to Lv1-Lv3) and the shorter **left crus** (which attaches to Lv1-Lv2), which unite in the **median arcuate ligament**. The right posterior side of the diaphragm has a **medial arcuate ligament**, while the left posterior side has a **lateral arcuate ligament**. The central part of the diaphragm has a tendinous area called the **central tendon** (MA 129, 131; CL 237; NE 181).

Mnemonics

Motor supply of the diaphragm: “C three, four, five keep the diaphragm alive.”

ABDOMINAL AORTA

There are thirteen branches from the abdominal aorta (MA 137-8). From superior to inferior they are:

Nine paired branches

1. Inferior phrenic a.
3. Middle suprarenal aa.
4. 1st lumbar aa.
6. Renal aa.
7. Ovarian/testicular aa.
8. 2nd lumbar aa.
10. 3rd lumbar aa.
11. 4th lumbar aa.
13. Common iliac aa. (at **Lv4**)

Four unpaired branches

2. Celiac trunk [supplies foregut] (at lower level of **Tv12**)
5. Superior mesenteric a. [supplies midgut] (at **Lv1**)
9. Inferior mesenteric a. [supplies hindgut] (at **Lv3**)
12. Middle (or median) sacral a.

VEINS of the posterior abdominal wall

Most of the vv. of the posterior abdominal wall are tributaries to the IVC. The exception is the left testicular/ovarian vv., which is tributary to the L renal vv. (MA 138). From superior to inferior they are (MA 138-9):

1. Hepatic vv. (L, middle and R) (which bring blood from the portal system).
2. Inferior phrenic vv.
3. Suprarenal vv.
4. Renal vv.
5. R testicular/ovarian v.
6. Third & fourth lumbar vv.
7. Common iliac vv.

The L renal v. courses anterior to the aorta.

The IVC bifurcates (into the common iliac vv.) at the level of Lv4 or Lv5.

ABDOMEN, posterior wall

Muscle	Innervations	Blood supplies	Origins	Insertions	Actions
Psoas major	Lumbar plexus via ventral branches of L2-L4	medial femoral circumflex artery (Hosford)	Transverse processes of lumbar vertebrae; sides of bodies of T12-L5 vertebrae and intervening intervertebral discs	By a strong tendon to the lesser trochanter of the femur	Flexion at hip joint
Iliacus	Femoral n. (L2-L4)	(?)	Superior two-thirds of iliac fossa, ala of sacrum, and anterior sacroiliac ligaments	Lesser trochanter of femur and shaft inferior to it, and to psoas major tendon	Flex thigh and stabilize hip joint. Acts with psoas major.

Quadratus lumborum	Ventral branches of T12 and L1-L4	(?)	Medial half of inferior border of 12th rib and tips of lumbar transverse processes	Iliolumbar ligament and internal lip of iliac crest	Extend and laterally flex vertebral column. Fixes 12th rib during inspiration.
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Nerves

From superior to inferior the following nerves come off of the vertebral column (CL 240-1; NE 250, 463). Note that all of these nerves are external to the transversalis fascia.

Nerve	Cord levels	Course	Distribution
Subcostal	T12	Emerges just inferior to the 12th rib. Crosses the anterior surface of the quadratus lumborum m. (MA 134).	Innervates lowest slip of external oblique m. and skin over ASIS and hip (MA 86).
Iliohypogastric	L1	Pierces the transversus abdominis m. near the ASIS (MA 135). Penetrates the aponeurosis of the external abdominal oblique m. just above the superficial inguinal ring (CL 180).	Supplies skin of hypogastric region and over the iliac crest; internal oblique and transversus abdominis mm. (MA 86).
Ilioinguinal	L1	Pierces the transversus abdominis m. near the ASIS (MA 135).	Innervates skin of scrotum or labium majus, mons pubis, and adjacent medial aspect of thigh, internal oblique and transversus abdominis mm. (MA 86).
Genitofemoral	L1, L2	Pierces the anterior surface of the psoas major m. (MA 135).	Femoral br. supplies skin over femoral triangle; genital br. supplies scrotum or labia majora (MA 236).
Lateral femoral cutaneous	L2, L3	Runs inferolaterally on the iliacus m. and heads towards the anterior superior iliac spine (MA 135).	Supplies skin on anterior and lateral aspects of thigh (MA 236).
Femoral	<i>posterior divisions of</i> L2, L3, L4	Emerges from the lateral border of the psoas major and innervates the iliacus m. and the extensor mm. of the knee (MA 135).	Innervates anterior thigh muscles, hip and knee joints, and skin on anteromedial side of thigh (MA 236).

Obturator	<i>anterior divisions of L2, L3, L4</i>	Emerges from the medial border of the psoas major (MA 135).	Anterior br. supplies adductor longus, adductor brevis, gracilis and pectineus mm.; posterior br. supplies obturator externus and adductor magnus (MA 236).
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Note that the femoral n. is from the *posterior divisions* of L2-4, while the obturator n. is from the *anterior divisions* of L2-4. For an illustration of this see NE 464.

The sympathetic portion of the autonomic nervous system consists of (MA 135):

- Thoracic splanchnic nn. from the thoracic sympathetic trunk
- Lumbar splanchnic nn. from the lumbar sympathetic trunk

The parasympathetic portion consists of:

- Anterior and posterior vagal trunks
- Pelvic splanchnic nn.

Mnemonics

“Sacral splanchnic are sympathetic, Pelvic splanchnic are parasympathetic” (see NE 306).

KIDNEY

Notes

The kidneys are not in a coronal plane; their hila are angled anteromedially.

The R kidney is slightly lower than the left due to the large R lobe of the liver (MA 125).

Superiorly each kidney is related to the diaphragm that separates it from the pleural cavity and the 12th rib (MA 125).

The kidneys' vertical extent is from Tv12 to Lv3. The superiormost part of the L kidney extends above the level of the 11th rib; that of the R kidney extends up to the 11th rib (CL 229; NE 312).

The hilum of the L kidney lies in the transpyloric plane (at the level of Lv1), about 5 cm from the median plane (MA 125).

The vessels course through the hilum. Around the hilum is a space called the **renal sinus**, which is usually filled with adipose tissue.

At the hilum, the **ureter** is the most posterior structure (i.e. posterior to the renal a. and v.) and it is directed inferiorly (NE 313; CL 232). The **renal pelvis** constitutes the beginning of the ureter.

The kidney may display **fetal lobulations**, giving it the appearance of lumps of clay mashed together (SA 277; NE 313). The ureter has abundant smooth muscle in its walls. Peristalsis (alternating from one ureter to the other) empties urine into the bladder. The ureter passes retroperitoneally, traversing the pelvic brim, and passing anteriorly to the iliac a. (at the point where the common iliac a. branches into the internal and external iliac aa.).

Urine is produced in the nephrons and courses along the following path (RRK 586):

Urine is produced:

- I. Renal corpuscle
 - A. Glomerulus
 - B. Bowman's capsule
- II. Renal tubule
 - A. Proximal thick segment
 - 1. Proximal convoluted tubule
 - 2. Descending limb of Henle's loop
 - B. Thin segment
 - C. Distal thick segment
 - 1. Ascending limb of Henle's loop
 - 2. Macula densa
 - 3. Distal convoluted tubule

Urine is excreted:

- III. Collecting duct
- IV. Papilla (at the apex of the pyramid; MA 126; NE 313) with its duct of Bellini (RRK 563)
- V. Minor calyx (RRK 579)
- VI. Major calyx
- VII. Renal pelvis
- VIII. Ureter
- IX. Urinary bladder
- X. Urethra

Clinical correlations

Ureteric calculi¹ (“kidney stones”) can cause complete or intermittent obstruction of urinary flow (MA 156). The pain from kidney stones is referred (through the lumbar splanchnic nn.) to the thighs.

Fascia

The kidney is enclosed by **renal fascia**. Between the kidney and this fascia there is **perirenal fat**. Outside of this fascia there is **pararenal fat** (MA 125). There is actually one continuous sheet of renal fascia which encloses both kidneys, but the kidneys are not in communication with each other because this fascia fuses with the adventitia of the renal vessels.

Arteries

At the hilum, the renal artery is posterior and superior with respect to the renal vein.

The longer R renal artery passes posterior to the IVC (MA 128).

Sometimes supernumerary (accessory) arteries (i.e. arteries in excess of the renal arteries) may branch directly off the abdominal aorta and supply lobes of the kidney (SA 282).

Veins

At the hilum, the renal vein is anterior and inferior with respect to the renal artery.

The L renal v. passes anterior to the abdominal aorta.

Landmarks

The ureter crosses the common iliac artery at the point at which it branches into the external and internal iliac aa. (NE 372).

SUPRARENAL GLANDS**Notes**

The **suprarenal (or adrenal) glands** (which have a medulla and cortex) are applied to the superomedial surface of the kidney, and are closely associated with the celiac ganglion, and the adrenal glands are in fact “quasi-neuronal” (as they are derived from embryonic

¹ Calculi? Isn't calculus a branch of mathematics? “The word ‘calculus’ is a Latin word that means ‘pebble’. The use of pebbles in early counting systems led to the adoption of the word ‘calculus’ to mean a method for computing” (Keith DEVLIN, *Mathematics: The Science of Patterns*, p. 79, New York: Scientific American Library, 1997).

neural crest cells). The adrenal medulla secretes epinephrine and norepinephrine. The adrenal cortex secretes glucocorticoids and mineralocorticoids.

Arteries

These glands are richly vascularized, and receive blood from three **suprarenal** arteries:

- Superior suprarenal a. (which is a branch from the inferior phrenic a.)
- Middle suprarenal a. (which is a branch off of the abdominal aorta)
- Inferior suprarenal a. (which is a branch off of the renal a.)

Veins

The short **right suprarenal vein** drains into the inferior vena cava, while the longer **left suprarenal vein** is tributary to the left renal vein (MA 128).