NOTE: This set of dissection instructions is for three laboratory periods. There is sufficient time to perform a thorough study and review.

THE ABDOMINAL CAVITY

PERITONEUM AND PERITONEAL CAVITY

The **abdominal cavity** is the upper portion of a continuous **abdominopelvic cavity** bounded above by the respiratory diaphragm and below by the **pelvic diaphragm**, which separates the **pelvic cavity** from the **perineum** (**Fig. 1**; **G11** 2.22, 3.2; **G12** 2.19, 3.3; **N** 323). The abdominopelvic cavity contains a serous sac, the **peritoneum**, and the tissues around it inside a musculoaponeurotic and skeletal abdominal wall. The peritoneum has **visceral and parietal layers** enclosing a potential space, the **peritoneal cavity**, which normally contains only a small amount of serous fluid (**G11** 2.22, 2.23B; **G12** 2.20, 2.21; **N** 323, 327). This is the same basic arrangement that was seen in the pericardial and pleural cavities, with which the peritoneal cavity shares a developmental origin. The accumulation of excess fluid within the peritoneal cavity (**ascites**) can result from a number of pathological conditions (e.g., cirrhosis, cancer, infection). The peritoneal cavity may be punctured and some of the fluid aspirated for analysis or the excess fluid may be drained (**paracentesis**), e.g., to relieve respiratory distress.

The **visceral layer of peritoneum** forms the outer layer (serosa) covering some abdominal organs. The **parietal layer of peritoneum** lines the inside of the abdominal wall and the inferior surface of the respiratory diaphragm. Immediately outside the parietal peritoneum is a layer of **extraperitoneal connective tissue**. The largest amount of extraperitoneal connective tissue within the abdominal cavity is located posteriorly, the **retroperitoneum**, enclosing multiple organs (e.g., the kidneys, pancreas, aorta).

Parts of the peritoneum that connect two organs or connect organs to the abdominal wall are given special names. A **mesentery** is a double layer of peritoneum that suspends an organ (e.g., small intestine, transverse colon) from the abdominal wall because the organ had invaginated the peritoneal sac from behind during embryonic development (**Fig. 1**). Nerves and vessels that supply the suspended organ reach it through the mesentery. The more obvious mesenteries are the **mesentery** (proper) for the jejunum and ileum of the small intestine, the **transverse mesocolon** for the transverse colon, and the **sigmoid mesocolon** for the sigmoid colon.

An **omentum** is a double layer of peritoneum that connects the stomach to adjacent organs. The **greater omentum** (or more specifically its gastrocolic ligament component) is an apron-like peritoneal fold that usually hangs in front of the small intestine (**G11** 2.19, 2.20A; **G12** 2.18, 2.23; **N** 261, 267). Its anterior layer descends from the greater curvature of the stomach and its posterior layer ascends to fuse with visceral peritoneum on the transverse colon and with the

transverse mesocolon (**Fig. 1**; **G11** 2.22; **G12** 2.20; **N** 323). The **lesser omentum** passes from the lesser curvature of the stomach and the first part of the duodenum below to the liver above. The lesser omentum is correspondingly subdivided into **hepatogastric** and **hepatoduodenal ligaments** (**G12** 2.18B; **N** 267).

Organs that are suspended by a mesentery have a covering of visceral peritoneum and are classified as **intraperitoneal organs**. Some intraperitoneal organs have no obvious mesentery but nevertheless are enclosed by visceral peritoneum. These include the liver, gallbladder, and cecum.

Fig. 1
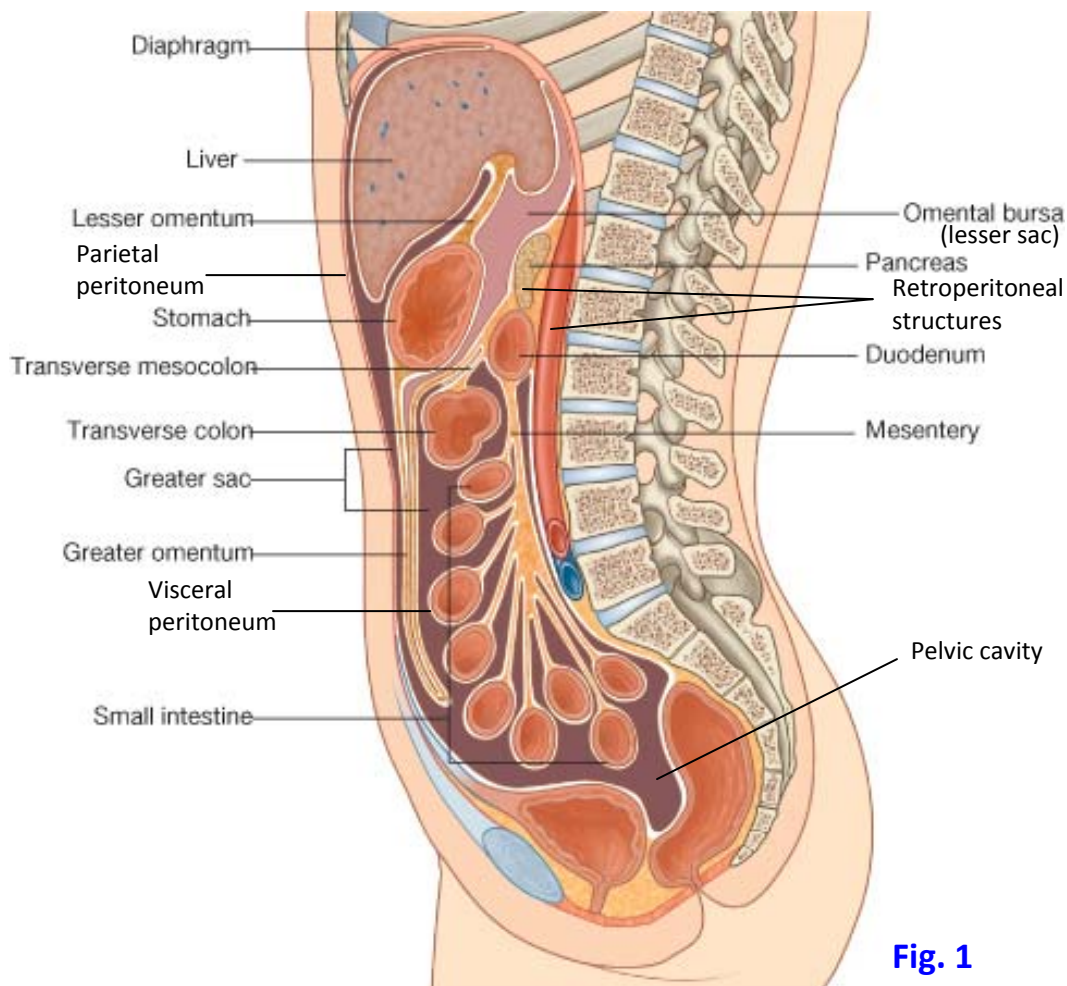
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Organs that remain behind the peritoneal sac and lack a mesentery are classified as **retroperitoneal organs**. They are covered with peritoneum only on their anterior surface. Retroperitoneal organs include most of the duodenum and pancreas, ascending and descending colons, kidneys and ureters, suprarenal glands, abdominal aorta, and inferior vena cava. Of these, the first four mentioned—duodenum, pancreas, ascending colon, and descending colon— were originally intraperitoneal during embryonic development and later became retroperitoneal

during rotation of the gut and fusion of various fasciae. The originally intraperitoneal organs that later became retroperitoneal—duodenum, pancreas, ascending colon, and descending colon—are said to be **secondarily retroperitoneal** (Fig. 2). The organs that were originally retroperitoneal and remained that way are said to be **primarily retroperitoneal**.

The **peritoneal cavity** is a closed sac in males. In females the open ends (ostia) of the **uterine tubes** connect the peritoneal cavity with the outside world via the uterine tubes, cavity of the uterus, and vagina. This provides a potential pathway for an external infection to enter the peritoneal cavity, resulting in **peritonitis**. The patency of the uterine tubes can be examined radiographically by injection of a radiopaque dye into the uterine cavity, from where it normally flows through the uterine tubes into the peritoneal cavity (**hysterosalpingography**) (G11 3.33B, G12 3.73).

The peritoneal cavity is subdivided into the small **lesser peritoneal sac** (**omental bursa**) behind the stomach and lesser omentum and the large **greater peritoneal sac**, which occupies the rest of the peritoneal cavity (**Fig. 1**; **G11** 2.22, 2.23B; **G12** 2.19, 2.20, 2.21; **N** 323, 327). The lesser and greater sacs communicate on the right side through the **omental** (epiploic) **foramen**, which is located posterior to the hepatoduodenal ligament above the first part of the duodenum (**G11** 2.20, 2.22, 2.23A; **G12** 2.23, 2.19, 2.21A; **N** 267, 323, 327).
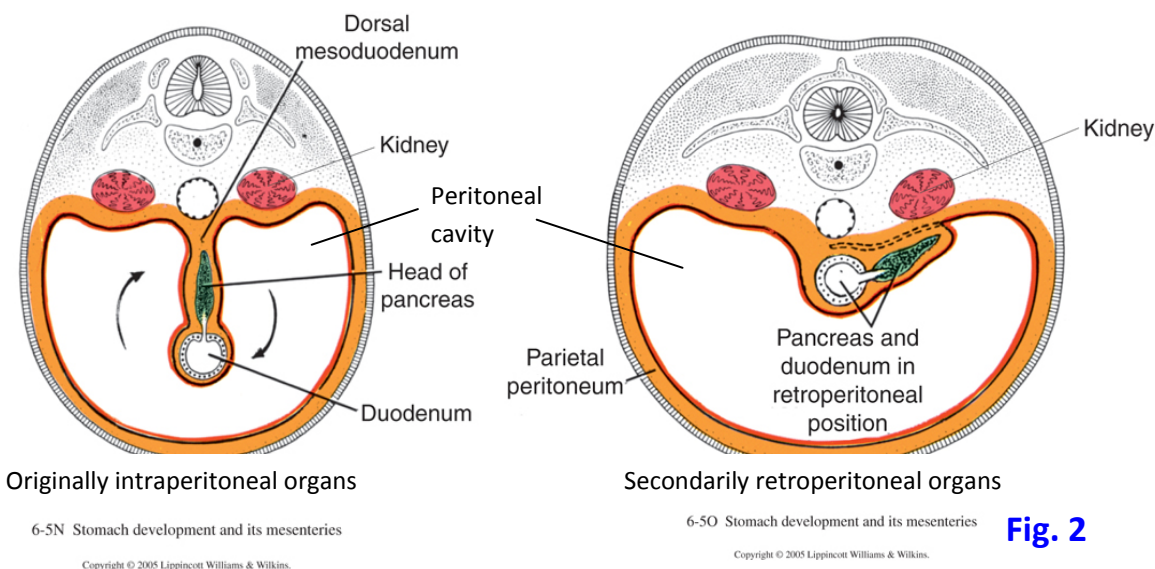

Fig. 2

The abdominal cavity will be opened in different ways by even-numbered and odd-numbered dissection groups.

On **EVEN-NUMBERED TABLES**, using a Stryker saw, cut through the remaining ribs (most likely the 6th to 11th ribs) and intercostal spaces at the anterior axillary line on both sides to extend the vertical cuts used in

removing the anterior thoracic wall in previous dissections. Extend the cuts further inferiorly towards the iliac crests using scissors to cut through the three abdominal muscle layers in the midaxillary line. Be careful to cut only through the abdominal wall muscles and not into the parts of the colon in these areas! Then, extend the cuts anteriorly along the iliac crests towards the anterior superior iliac spines (ASIS) using your scalpel, cutting through the attachment of the three flat muscles to the iliac crest. Be careful not to cut farther anteriorly than the ASIS.

From the superior end of one vertical cut, use scissors or a scalpel to cut through the anterior attachments of the diaphragm about 2-3 cm posterior to the sternum and costal cartilages. Carefully pull the anterior abdominal wall attached to the lower part of the sternum and lower part of the anterior thoracic cage forward until you see a sagittally oriented peritoneal reflection attaching the upper part of the anterior abdominal wall to the liver. This is the falciform ligament (G11 2.18, 2.19; G12 2.17, 2.18; N 247, 277 [Anterior view]), which contains the ligamentum teres hepatis (round ligament of the liver) and paraumbilical veins within its inferior free edge. The ligamentum teres hepatis is the fibrous remnant of the umbilical vein. Cut the falciform ligament as close to the anterior abdominal wall as possible and reflect the abdominal wall forward.

If there is difficulty reflecting the anterior abdominal wall forward, it is probably due to adhesions. These basically are fibrous bands of scar tissue where the visceral peritoneum covering abdominal organs (e.g., small intestine) fuses to the parietal peritoneum lining the inside of the abdominal wall or where the visceral peritoneum covering two abdominal organs fuses. Such adhesions frequently form following abdominal surgery or inflammation of the peritoneum due to infection or other injury (peritonitis) and may cause pain and intestinal obstruction. If adhesions are present in the cadaver, they must be carefully torn by pulling the fused surfaces away from each other. If you have difficulty doing this, seek faculty assistance.

On ODD-NUMBERED TABLES, open the abdominal cavity by making the incisions in the abdominal wall indicated in Fig. 3:

A to B *Pull the anterior abdominal wall forward* and carefully make a transverse incision through it from 2 cm above one anterior superior iliac spine to 2 cm above the other. In making this incision, you will be cutting the transversus abdominis muscle of each side and, if they were not previously transected and reflected, the rectus abominis muscles. The cut

will also include the **linea alba** and **posterior layer of the rectus sheath** on each side of it, as well as **transversalis fascia, extraperitoneal connective tissue,** and **parietal peritoneum.**

C to D Next make a vertical incision through the abdominal wall above the level of the first incision just to the *left side* of the linea alba.

D to E Detach the left side flap from the costal arch in order to reflect it laterally.

D to F Before cutting the right side flap from the costal arch, it is necessary to cut the peritoneal ligament connecting the liver to the anterior abdominal wall above the umbilicus, the **falciform ligament** (**G11** 2.18, 2.19; **G12** 2.17, 2.18; **N** 247, 261, 277). Enclosed within its inferior free border is the fibrous remnant of the umbilical vein, the **ligamentum teres hepatis (round ligament of the liver)**, passing from the umbilicus to the liver. Cut the falciform ligament and ligamentum teres hepatis ≈1 cm behind the anterior abdominal wall. Then make the cut **D to F** and reflect the right side flap laterally.
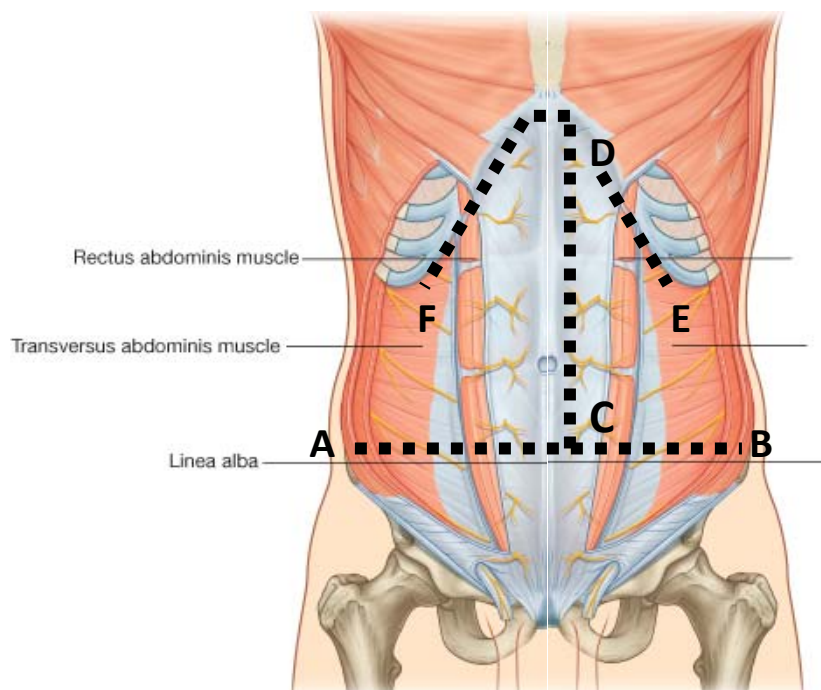
Fig. 3

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If there is difficulty reflecting the anterior abdominal wall forward, it is probably due to adhesions. These basically are fibrous bands of scar tissue where the visceral peritoneum covering abdominal organs (e.g., small intestine) fuses to the parietal peritoneum lining the inside of the abdominal wall or where the visceral peritoneum covering two abdominal organs fuses. Such adhesions frequently form following abdominal surgery or inflammation of the peritoneum due to infection or other injury (peritonitis) and may cause pain and intestinal obstruction. If adhesions are present in the cadaver, they must be carefully torn by pulling the fused surfaces away from each other. If you have difficulty doing this, seek faculty assistance. XXX

INTERNAL FEATURES OF ANTERIOR ABDOMINAL WALL

The internal (posterior) surface of the anterior abdominal wall is viewed during some laparoscopic surgeries (e.g, inguinal or femoral henia repair), and a physician needs to be familiar with its basic features. There are **five umbilical peritoneal folds** and associated depressions, the **peritoneal fossae**, on the internal surface. The umbilical peritoneal folds are the median, medial, and lateral umbilical folds. The **median umbilical fold** is parietal peritoneum raised over a fibrous remnant of the embryonic allantois, the **urachus**. The median fold extends upward from the apex of the **urinary bladder** to the **umbilicus** (**G11** 2.18, 3.13B; **G12** 2.17, 3.22B; **N** 247, 347). A patent urachus (**urachal fistula**) in a newborn may result in urine leaking from the umbilicus.

The **medial umbilical fold** on each side is parietal peritoneum raised over the **medial umbilical ligament**, which also ascends to the umbilicus. The medial umbilical ligament is the obliterated distal portion of the **umbilical artery**. Laterally on each side is the **lateral umbilical fold**. It is parietal peritoneum raised over the **inferior epigastric artery and vein**, which ascend medially to enter the **rectus sheath** at the **arcuate line**.
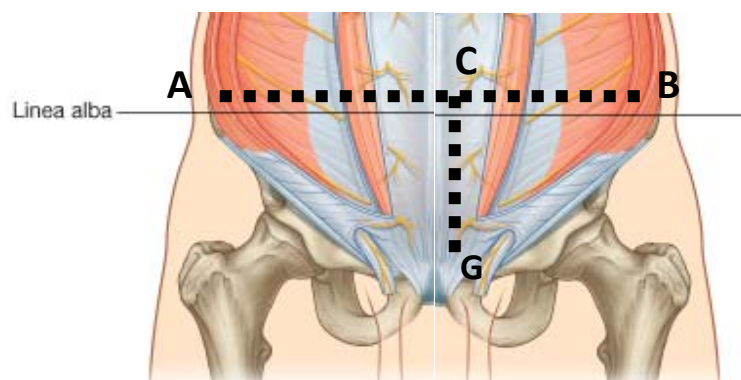

Linea alba

Fig. 4

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The **supravesical fossa** lies above the bladder between the median and medial umbilical folds. The **medial inguinal fossa** is bounded by the medial and lateral umbilical folds. The lower part of the medial inguinal fossa, lateral to the rectus abdominis and above the **iliopubic tract**, is the **inguinal** (Hesselbach's) **triangle**. The iliopubic tract is a thickening of **transversalis fascia** that parallels the internal surface of the inguinal ligament. The **inguinal triangle** is the site where a **direct inguinal hernia** leaves the abdominal cavity.

The **lateral inguinal fossa** is lateral to the lateral umbilical fold. Note the **ductus deferens** and **testicular vessels** or the **round ligament of the uterus** entering the **deep inguinal ring** in the lower part of the lateral inguinal fossa. The **deep inguinal ring** is where an **indirect inguinal hernia** leaves the abdominal cavity.

Pull the anterior abdominal wall forward so that you can examine the lower part of its posterior surface (G11 2.18, 3.13B; G12 2.17, 3.22B; N 247, 347). This internal view of the anterior abdominal wall is the one seen during laparoscopic surgery. Identify the median, medial, and lateral umbilical folds. Note the slight depressions between the umbilical folds and identify these peritoneal fossae. They are the supravesical fossa, medial

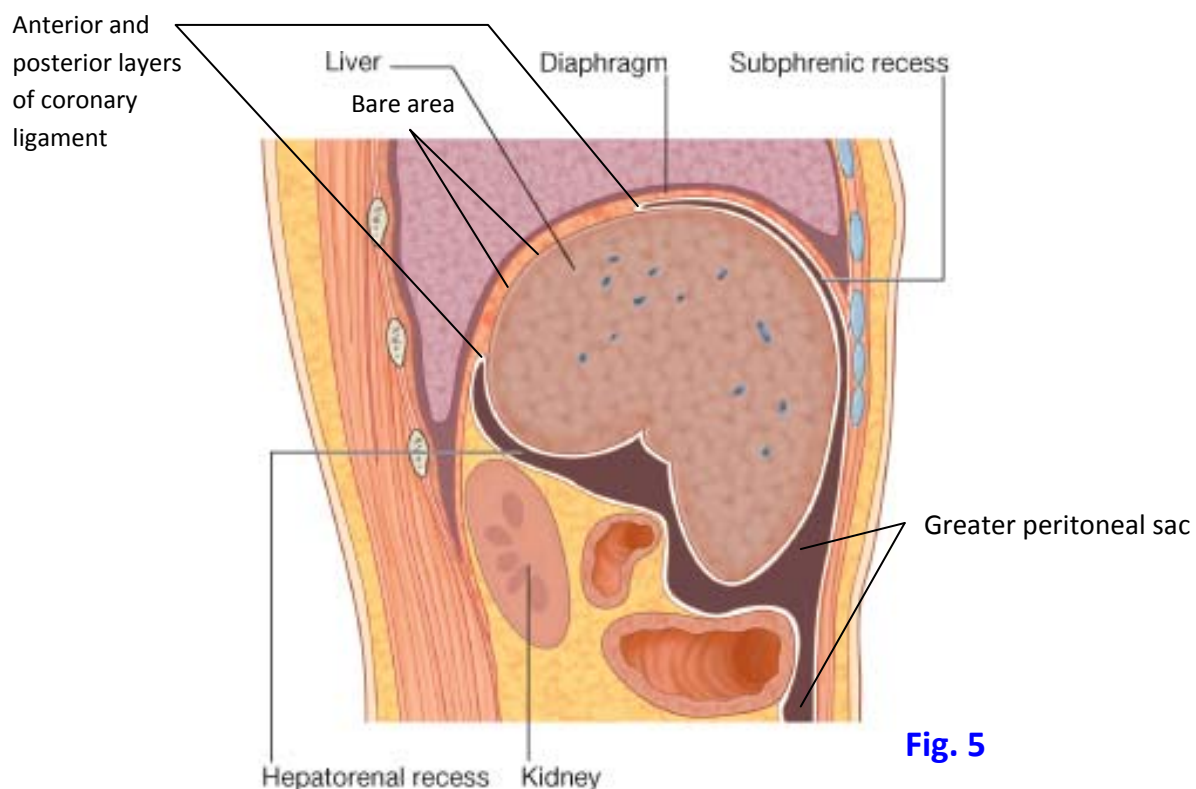Anterior and posterior layers of coronary ligament

Liver — Diaphragm   Subphrenic recess

Bare area

Greater peritoneal sac

Fig. 5

Hepatorenal recess   Kidney

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inguinal fossa, and lateral inguinal fossa.

For groups on **ODD-NUMBERED TABLES**, as shown in **Fig. 4, C to G** open the lower part of the anterior abdominal wall by making an incision just to the left side of the linea alba from the edge of the original transverse cut (**A-B**) down to the pubic bone. Reflect the flaps laterally and downward toward the inguinal canal.

ALL TABLES: The remaining instructions for this dissection apply to ALL TABLES.

The abdominal cavity should now be fully exposed (**G11** 2.19; **G12** 2.18; **N** 261). Explore the abdominal organs *in situ* visually and by palpation. It again may be necessary to break adhesions.

LIVER AND ASSOCIATED STRUCTURES

Examine the large liver, which is responsible for the right dome of the diaphragm and extends across the midline to near the left midclavicular line (**N 261, 277**). On the right side of the liver, projecting below its sharp inferior border, look for the fundus of the gallbladder, which usually is stained dark green by stored bile in the cadaver. Note that the surface projection of the fundus is at the tip of the *9th costal cartilage near the linea semilunaris*. The gallbladder may have been surgically removed (cholecystectomy) in some cadavers.

Find the ligamentum teres hepatis enclosed within the inferior free margin of the falciform ligament, which is the vertical peritoneal fold connecting the liver and the anterior body wall. It was cut earlier when the abdominal cavity was opened.

Insert your hand into the narrow space between the liver and diaphragm, beside the falciform ligament (**Fig. 5**). This space is the subphrenic recess, which is a common site for abscess formation within the peritoneal cavity. Now try to push your hand below and behind the right lobe of the liver into the hepatorenal recess or pouch (Morison's pouch) in front of the right kidney (**G11** 2.35; **G12** 2.51; **N** 317 [unlabeled], 327). **XXX**

In a supine patient the **hepatorenal recess** is the lowest part of the peritoneal cavity. Therefore, gravity may cause infectious fluids to drain into it from the **subphrenic recesses** or **omental foramen**. The subphrenic recesses are frequent sites of abscess formation, which may result in

In **Fig. 5** notice that the liver is suspended from the diaphragm by peritoneal reflections, the anterior and posterior layers of the **coronary ligament**. The liver is an intraperitoneal organ covered by visceral peritoneum except for a posterior **bare area**, which is in direct contact with the diaphragm.

STOMACH

The **stomach** is saclike dilatation of the digestive tract connecting the abdominal portion of the esophagus and the small intestine (**G11** 2.19, 2.20, 2.27A; **G12** 2.18, 2.23, 2.28B; **N** 261, 267-269). What was originally the left side of the embryo's stomach faces anteriorly in the adult due to the stomach's 90° clockwise rotation around a *longitudinal* axis (⟵) during development (**Fig. 6**). The stomach also rotates 90° around an *anteroposterior* axis (↓) during development.

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Langman's Medical Embryology, 10E
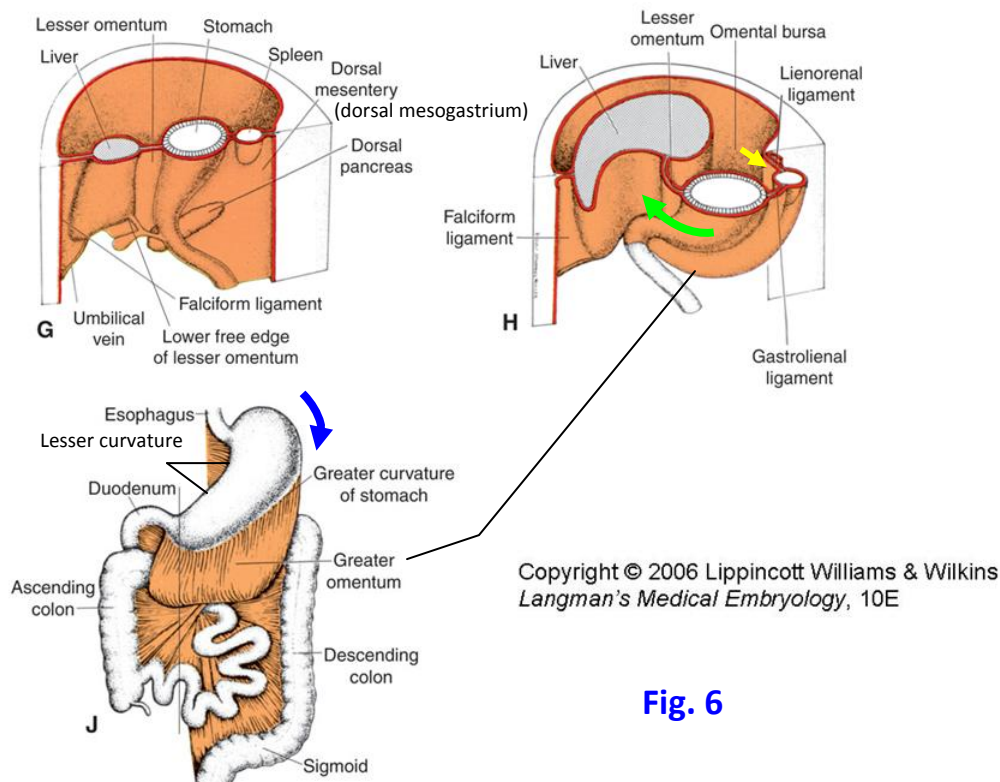
Fig. 6

The stomach has four parts (**G11** 2.27, 2.31B-D; **G12** 2.28, 2.32B-D; **N** 267, 268). The **cardia** (cardiac part) surrounds the **cardial orifice**, the opening into the stomach at the gastroesophageal junction. The **fundus** is the dilated superior part of the stomach to the left of the cardia. It is related to the left dome of the diaphragm and often contains gas in x-rays. The **body** forms the major part of the stomach. The **pyloric part** is the funnel-shaped outflow region of the stomach.

It consists of the **pyloric antrum** leading into the narrow **pyloric canal**. The **angular incisure** on the lesser curvature indicates the junction between the body and pyloric antrum. The **pylorus** is the opening of the stomach into the first part of the duodenum, the **pyloric orifice**, surrounded by the thick, circular smooth muscle of the **pyloric sphincter**. Relaxation of the pyloric sphincter under parasympathetic control of the **vagus nerves** (anterior vagal trunk) allows emptying of the stomach.

The stomach has two curvatures. The **lesser curvature of the stomach** faces superiorly and to the right. The lesser curvature and the first part of the duodenum are attached to the liver by the **hepatogastric** and **hepatoduodenal ligaments**, respectively, which are parts of the **lesser omentum**.

The **greater curvature of the stomach** faces inferiorly and to the left. A double-layered fold of peritoneum laden with fat, the **greater omentum**, hangs down from the greater curvature of the stomach to cover the intestine (**G11** 2.19, 2.22; **G12** 2.18, 2.19, 2.20; **N** 261, 267, 323). As shown in **Fig. 6**, the greater omentum is formed by a ballooning to the left (➡) of the **dorsal mesentery** (dorsal mesogastrium) that accompanies rotation of the stomach. The greater omentum is a mobile structure and is important in part because it "walls off" areas of localized infection (e.g., during appendicitis) by forming **adhesions** around them. This sometimes prevents the spread of infection throughout the peritoneal cavity with the development of a potentially fatal general **peritonitis**. Its mobility also means that the position of the greater omentum in the cadaver is somewhat variable.

SPLEEN

The **spleen** is the largest of the lymphatic organs. It lies deep to ribs 9-11 on the left side with its long axis roughly parallel to the 10th rib. Despite this seemingly protected position, the living spleen is relatively fragile and it is the most frequently injured abdominal organ. It rests on the shelf of peritoneum (**phrenicocolic ligament**) that suspends the angled junction of the transverse and descending colons (**splenic**, or **left colic**, **flexure**) from the diaphragm. The spleen is positioned between the stomach and left kidney by two other peritoneal ligaments, the **gastrosplenic** (gastrolienal) **ligament** and the **splenorenal** (lienorenal) **ligament** (**Fig. 6H; G11** 2.23B; **G12** 2.22A, 2.23B; **N** 264, 327).

Pay particular attention to the relationships of the spleen on the left side and of the liver on the right side (**G11** 2.20A, 2.21, 2.63; **G12** 2.23A, 2.24, 2.63; **N** 242, 267, 278, 308). Each organ lies deep to the lower ribs but is separated from them by the diaphragm and the **costodiaphragmatic recess** of its side. The **liver** and **spleen** may be damaged by blunt abdominal trauma with or without **fractures the lower ribs**. During **biopsies** of the spleen and liver, care must be taken not to damage a lung or its pleura. During a **liver biopsy**, a trocar or needle inserted through the right 9th or 10th intercostal space in the midaxillary line would penetrate, in order, the skin and superficial fascia; intercostal muscles; endothoracic (extrapleural) fascia; costal pleura, costodiaphragmatic recess, and diaphragmatic pleura; diaphragm; diaphragmatic peritoneum, subphrenic recess, and visceral peritoneum; and the liver. In patients with ascites or increased risk of bleeding a **transjugular approach** may be used to perform the liver biopsy: internal jugular vein➔brachiocephalic vein➔superior vena

<mark>cava→right atrium→inferior vena cava→hepatic vein→liver. Thus, any resultant bleeding is back into the venous system.</mark>

✎ **Examine the stomach. Identify the fundus, body, pyloric part, and pylorus. Squeeze the pylorus to appreciate the thickness of the pyloric sphincter. Lift the left lobe of the liver to better see the lesser curvature of the stomach facing superiorly and to the right. Is the angular incisure apparent? Note the hepatogastric and hepatoduodenal ligaments.**

Put your hand inside the left costal margin and follow the curvature of the ribs posteriorly to near the midaxillary line, where you should feel a hard organ deep to ribs 9-11. This is the spleen. Understand how fractures of the lower ribs on the left side can cause lacerations and hemorrhaging from the spleen. XXX

SMALL INTESTINE AND MESENTERY

The stomach opens into the **small intestine**, which is the primary site for the absorption of nutrients (**G11** 2.26; **G12** 2.27). The small intestine consists of the duodenum, jejunum, and ileum. All of the **duodenum**, except the first couple of centimeters, is **retroperitoneal** and will be studied later. The junction of the duodenum and jejunum, the **duodenojejunal junction**, is where the small intestine again becomes an intraperitoneal organ. The jejunum and ileum are **intraperitoneal**.

The small intestine opens into the **large intestine** at the **ileocecal junction** (**G11** 2.26; **G12** 2.27; **N** 273, 274). The large intestine is a site for water absorption and the temporary storage of the resulting semisolid feces until its elimination. The large intestine comprises the cecum and appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum, and upper part of the anal canal.

✎ **Lift the greater omentum superiorly and drape it over the sternum and costal cartilages, breaking any adhesions that may hamper its reflection (G11 2.39, 2.40; G12 2.35, 2.36; N 261). Note that the portions of the small intestine now visible, the jejunum and ileum, are framed on three sides by large intestine. XXX**

The **mesentery** that suspends the jejunum and ileum from the posterior abdominal wall has a fan-shaped structure. Its attachment on the abdominal wall, the **root of the mesentery**, extends from the duodenojejunal junction to the ileocecal junction, a length of about **15 cm** (6 inches) (**G11** 2.23A; **G12** 2.21; **N** 266, 270). The much longer intestinal side of the mesentery, attached to the jejunum and ileum, averages about **7 m** (21 feet). Therefore, the small intestine is highly coiled.

Distinguishing the jejunum from the ileum may be difficult, especially if adhesions are present. The **jejunum** forms the proximal two-fifths of their combined length and lies mainly in the left upper quadrant. The **ileum** makes up the distal three-fifths and is mostly in the right lower quadrant.

There is a gradual transition in structure between jejunum and ileum, but the *proximal jejunum* can be distinguished from the *distal ileum* by the amount of fat in the mesentery and the arrangement of its arterial supply (**G11** 2.43; **G12** 2.39; **N** 272). The mesentery of the proximal jejunum usually contains little fat and may be translucent, while the mesentery of the distal ileum is laden with fat (**G11** 2.43, insets; **G12** 2.39, insets). The proximal jejunum also is characterized by only 1-2 **arterial arcades** (anastomotic loops) and long **vasa recta** (straight arteries) in its mesentery, while the distal ileum typically has 3-5 arterial arcades and short vasa recta. The jejunum and ileum develop from the embryonic **midgut** and, therefore, the arterial supply is from the **superior mesenteric artery** (**G11** 2.43, 2.44; **G12** 2.39, 2.40; **N** 287).

✎   **Bluntly dissect the arterial arcades and vasa recta in the mesentery along several centimeters of the proximal jejunum and the distal ileum. Notice the relative amounts of fat that you need to remove in each location to expose the vessels. The proximal jejunum characteristically has fewer arterial arcades and longer vasa recta than the distal ileum. The origin of the arterial supply from the superior mesenteric artery will be dissected later. XXX**
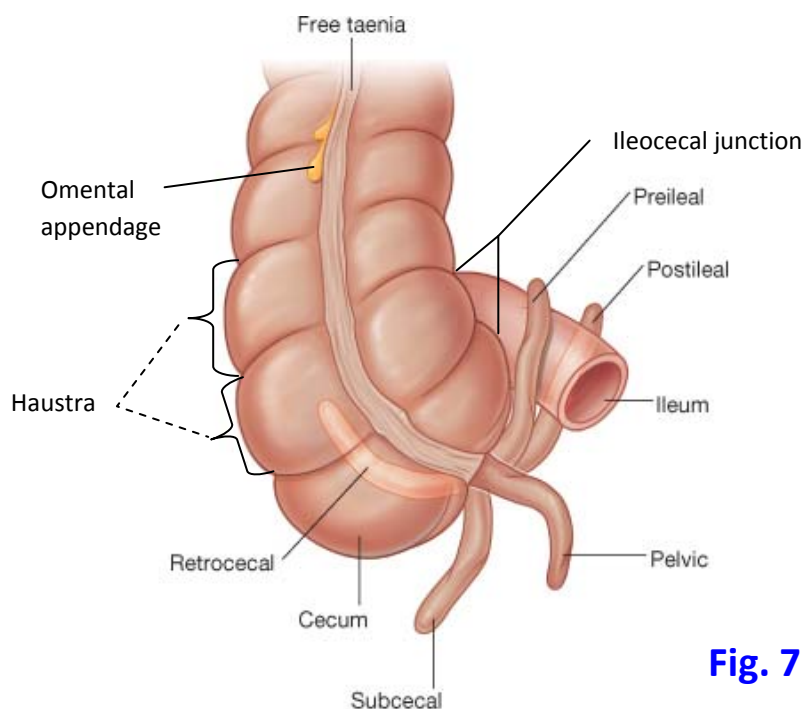

Fig. 7

Free taenia
Ileocecal junction
Omental appendage
Preileal
Postileal
Haustra
Ileum
Retrocecal
Pelvic
Cecum
Subcecal

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LARGE INTESTINE

The jejunum and ileum are framed by the **cecum** and **ascending colon** on the right side, the **transverse colon** above, and the **descending colon** on the left side (**G11** 2.26, 2.39, 2.41; **G12** 2.27, 2.35, 2.37; **N** 261, 263). The **large intestine** is approximately **1.7 m** (5 feet) in length and has features, aside from position, that usually make it easy to distinguish from the small intestine.

The **outer longitudinal layer of smooth muscle** in the **large intestine** is incomplete and arranged in three narrow bands, the **teniae coli** (**G11** 2.42, 2.43, 2.47; **G12** 2.38, 2.39, 2.43; **N** 273, 276). The **appendix**, **rectum**, and **upper portion of the anal canal** are exceptions and have a complete longitudinal layer of smooth muscle. ***This fact may be used to find an elusive appendix by tracing the convergence of the three teniae coli toward its base.*** The teniae coli are slightly shorter than the rest of the colon, drawing its wall into a series of sacculations, the **haustra**. Also characteristic of the large intestine is the presence of fat-filled pouches of visceral peritoneum, the **omental** (epiploic) **appendices**, suspended from it.

Study the cecum and appendix. The **cecum** is a blind pouch located in the iliac fossa of the right lower quadrant. It receives the ileum at the **ileocecal junction**, which is guarded by an **ileocecal valve** (**Fig. 7**; **G11** 2.1A, 2.26, 2.41-2.43, 2.47; **G12** 2.1A, 2.27, 2.37-2.39, 2.43; **N** 273, 274, 276). The ileocecal valve prevents the reflux of chyme into the terminal ileum. The valve may be obstructed by a gallstone (**gallstone ileus**) that has entered the lumen of the intestine (the superior part of the duodenum) via a fistula with the gallbladder (**cholecystenteric fistula**). The cecum has no distinct mesentery but in most bodies it is enveloped by peritoneum and, therefore, is mobile. It is classified as an **intraperitoneal** organ.

The **appendix** (vermiform appendix) is a diverticulum of the posteromedial wall of the cecum below the ileocecal junction (**G11** 2.42; **G12** 2.38; **N** 273-275). Usually it is short, 6-10 cm, but occasionally it may be 20 cm or more in length. The appendix has a short mesentery, the **mesoappendix**, derived from the mesentery of the terminal ileum. Although the base of the appendix occupies a relatively constant position one-third of the distance along a line drawn from the **right anterior superior iliac spine** to the **umbilicus** (**McBurney's point**), the orientation of the appendix is variable (**Fig. 7**). The majority of the time (≈65%) the appendix extends superiorly behind the cecum toward the right colic flexure (**retrocecal position**). The variability in anatomical position is important because it determines the signs and symptoms as an inflamed appendix *(***appendicitis***)* irritates contiguous structures. Typically appendicitis presents with vague periumbilical pain which later shifts to become severe right lower quadrant pain. The initial vague pain is due to visceral afferent (GVA) innervation, while the subsequent sharp, localized right lower quadrant pain results from irritation of the parietal peritoneum, which is innervated by somatic afferent (GSA) nerve fibers. Flexing the right thigh without resistance may relieve the patient's pain by relaxing the iliopsoas muscle, but flexing the thigh against resistance or extending it may increase pain due to the irritation resulting from inflammation (**positive psoas/iliopsoas sign**). Vomiting, when it occurs, characteristically follows the onset of appendicitis pain, whereas vomiting that precedes pain suggests another cause, such as intestinal obstruction.

Find the ileocecal junction. Study the cecum and appendix. Verify that the cecum occupies the iliac fossa of the right lower quadrant. What is the orientation of the appendix in your cadaver, or has it been surgically removed (appendectomy)? If the appendix is still present, look for the short mesoappendix derived from the mesentery of the terminal ileum. The appendicular artery, a branch of the ileocolic artery or its posterior cecal branch, enters the mesoappendix by passing posterior to the terminal ileum. XXX

The **ascending colon** passes superiorly from the cecum along the right side of the abdominal cavity toward the **right lobe of the liver** (**G11** 2.26, 2.39, 2.41, 2.47; **G12** 2.27, 2.35, 2.37, 2.43; **N** 261, 263). There it has an angled junction with the transverse colon at the **hepatic (right colic) flexure**. The ascending colon is **secondarily retroperitoneal**. A deep vertical groove, the **right paracolic gutter**, lies between the lateral aspect of the ascending colon and the abdominal wall.

The **transverse colon** is the longest part of the large intestine and crosses the abdominal cavity from right to left. It has a mesentery, the **transverse mesocolon**, and hangs down a variable distance toward the pelvis (**G11** 2.39, 2.41; **G12** 2.35, 2.37; **N** 261). The attachment of the transverse mesocolon on the posterior abdominal wall crosses the descending (2nd) part of the duodenum and the inferior border of the pancreas (**G11** 2.23A, 2.62A; **G12** 2.21A, 2.62A; **N** 266, 270).

The transverse colon is continuous with the **descending colon** at the **splenic (left colic) flexure**, which is usually somewhat posterior and superior to the hepatic flexure (**G11** 2.26, 2.39, 2.41; **G12** 2.27, 2.35, 2.37; **N** 270, 276). The descending colon descends along the left side of the abdominal cavity to become continuous with the sigmoid colon in the left iliac fossa. Like the ascending colon, the descending colon is **secondarily retroperitoneal**. The **left paracolic gutter** is located on its lateral aspect.

Located lateral to the ascending and descending colons are vertical grooves lined with parietal peritoneum. These **right** and **left paracolic gutters**, respectively, provide pathways for the movement of **infectious fluid** or **cancer cells** into the pelvic cavity in the upright patient. In fact, patients with peritonitis may be propped in a seated position to facilitate the flow of infectious fluid into the pelvis, where the absorption of toxins is slower than it is nearer to the diaphragm. Since the ascending and descending colons are secondarily retroperitoneal organs with a mesentery that fused to the posterior abdominal wall on their *medial* side during development, the paracolic gutters also provide an approach for **surgical mobilization** of the ascending and descending colons that doesn't endanger their nerve and blood supplies.

The **sigmoid colon** is an S-shaped segment of colon of variable length. It is continuous above with the descending colon in the iliac fossa and below with the **rectum** in the pelvis in front of the **third sacral vertebra** (Sv3). The sigmoid colon is suspended by the **sigmoid mesocolon** from its attachment on the posterior abdominal wall, the **root of the sigmoid mesocolon** (**G11**

2.23A; **G12** 2.21A; **N** 263, 266). The root is roughly in the form of an inverted V with the apex over the terminal division of the left common iliac artery. The sigmoid colon is the most common site of **volvulus** resulting from twisting of the colon around its mesentery with **intestinal obstruction** and possible **necrosis** due to loss of the blood supply (e.g., see http://www.learningradiology.com/notes/ginotes/sigmoidvolvpage.htm). The sigmoid colon is also the most frequent location for the development of outpouchings of the intestinal mucosa (**diverticulosis**), which commonly occurs in middle-aged and elderly individuals, probably due to a lifetime of insufficient fiber in the diet. Diverticula are prone to infection and **inflammation** (**diverticulitis**), **hemorrhage**, and **perforation** (producing **peritonitis**). For example, see http://digestive.niddk.nih.gov/ddiseases/pubs/diverticulosis/   The rectum will be studied with other pelvic organs.

FOLLOWING THE VASCULATURE

During this next section, the study of the abdominal portion of the digestive tract will be approached by following its blood supply. To truly understand the abdomen, one must learn its vasculature in some detail.

OMENTAL BURSA AND OMENTAL FORAMEN

Once again review the organization of the peritoneal cavity. It consists of a greater peritoneal sac and a lesser peritoneal sac, or **omental bursa**. The omental bursa (lesser sac) communicates with the greater sac only at the **omental** (epiploic) **foramen** (**G11** 2.20, 2.22, 2.23B, 2.24; **G12** 2.23, 2.19, 2.20, 2.23B, 2.25; **N** 265, 267, 323, 327).

The **omental foramen** is bounded anteriorly by the **hepatoduodenal ligament**, which is the free right edge of the lesser omentum. The ligament contains the **bile duct**, **proper hepatic artery**, and **portal vein** (**G11** 2.23, 2.35, 2.36; **G12** 2.21, 2.51; **N** 265, 266, 278, 283, 327). The posterior boundary of the omental foramen is the **inferior vena cava** behind parietal peritoneum, the superior boundary is the **caudate lobe of the liver**, and the inferior boundary is the **first (superior) part of the duodenum**. The omental foramen may be the site of an **internal hernia** if a loop of small intestine becomes entrapped there. Fluid sometimes accumulates within the omental bursa (e.g., following a perforation through the posterior wall of the stomach). Injury and **inflammation of the pancreas (pancreatitis)** can result in an encapsulated collection of pancreatic fluid, usually in the posterior wall of the omental bursa (**pancreatic pseudocyst**) (e.g., see http://www.emedicine.com/radio/topic576.htm).

BLOOD SUPPLY OF THE ABDOMINAL DIGESTIVE TRACT

The blood supply to the abdominal portion of the gastrointestinal system from three unpaired ventral branches of the aorta reflects its embryonic origin (**Fig. 8**). Derivatives of the embryonic **caudal foregut**, which extends from the distal esophagus to the entrance of the (common) bile duct into the second, or descending, part of the duodenum, are supplied by branches of the **celiac trunk** (celiac artery). **Midgut** derivatives extend from just distal to the bile duct entrance to near the splenic (left colic) flexure and are supplied by branches of the **superior mesenteric artery**.

The **hindgut** extends from just proximal to the splenic flexure to the middle of the anal canal and is supplied by branches of the **inferior mesenteric artery**.

Note that the **abdominal aorta** is a **retroperitoneal** structure, and so the celiac trunk, superior mesenteric artery, and inferior mesenteric artery arise in a retroperitoneal position. Some of their branches, however, enter a mesentery to supply **intraperitoneal** organs. The celiac trunk arises in front of vertebra **Tv12**, the superior mesenteric artery at the **Lv1** level, and the inferior mesenteric artery at the **Lv3** level. Pay particular attention to the fact that *the autonomic innervation of the gastrointestinal tract follows the blood vessels that supply it. Since the* ***general visceral afferent nerve fibers that accompany sympathetic fibers carry pain*** *from visceral organs, knowledge of their arrangement provides a basis for understanding* **pain referred** *to the body wall* (**G11** 2.77, Table 2.7 [p. 169], **G12** 2.80).

The venous drainage of the abdominal portion of the gastrointestinal tract and spleen differs fundamentally from that of the rest of the body. *The abdominal digestive tract is drained by the* ***portal system of veins***, which carries the nutrient-rich blood to the liver rather than directly to the systemic circulation as represented by the inferior vena cava (**G11** 2.60; **G12** 2.60; **N** 292). In the liver nutrients are extracted from the blood and stored, while toxins are extracted and broken down, and **bile** is produced for transport in the bile duct to the duodenum. The secreted bile both neutralizes acid in the chyme leaving the stomach and emulsifies fat to facilitate its digestion. Only the larger tributaries of the portal vein will be dissected.

The **celiac trunk** (celiac artery) is the first branch of the abdominal aorta to be studied. It has **three branches**—the **left gastric**, **common hepatic**, and **splenic arteries** (**Fig. 9**; **G11** 2.28, 2.30, 2.34; **G12** 2.29, 2.31, 2.34; **N** 283, 284).
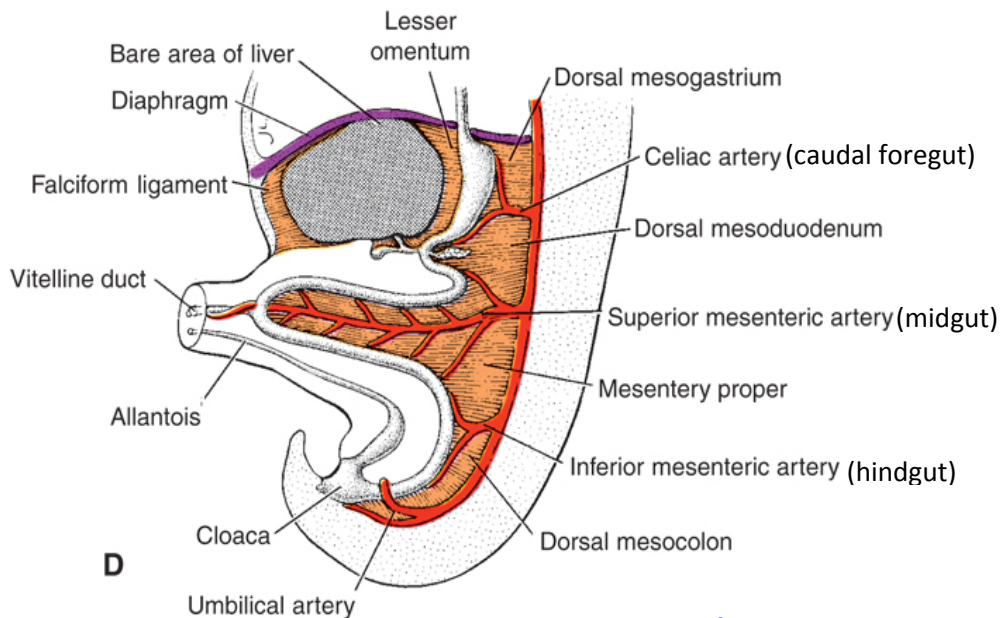
Lesser omentum
Bare area of liver
Diaphragm
Falciform ligament
Vitelline duct
Allantois
Cloaca
Umbilical artery
Dorsal mesogastrium
Celiac artery (caudal foregut)
Dorsal mesoduodenum
Superior mesenteric artery (midgut)
Mesentery proper
Inferior mesenteric artery (hindgut)
Dorsal mesocolon

D

3-8D Mesenteries

Fig. 8

The **left gastric artery** ascends briefly toward the esophageal hiatus of the diaphragm, giving off **esophageal branches** before arching downward and descending to the right along the lesser curvature of the stomach. It anastomoses with the right gastric artery.

The **common hepatic artery** courses to the right from its origin to divide into **proper hepatic** and **gastroduodenal arteries** near the pylorus. The proper hepatic artery usually gives origin to the **right gastric artery**, then ascends within the **hepatoduodenal ligament**. It bifurcates into **right** and **left hepatic arteries** to their respective lobes of the liver. The **cystic artery** to the gallbladder typically arises from the right hepatic artery, but variations are common **(Fig. 10**; **G11** 2.57; **G12** 2.57; **N** 283, 284). The cystic artery typically arises within a triangle bounded on the left side by the **common hepatic duct**, on the right side by the **cystic duct**, and above by the **liver (cystohepatic/hepatocystic triangle)**. This is an important relationship during the surgical removal of the gallbladder **(cholecystectomy)**. The triangle contains a lymph node (Calot's node), which is enlarged during inflammation of the gallbladder **(cholecystitis)** or bile ducts **(cholangitis)**.

The **gastroduodenal artery** descends behind the first part of the duodenum to divide into the **superior pancreaticoduodenal** and **right gastro-omental arteries (Fig. 9**; **G11** 2.28, 2.33, 2.34; **G12** 2.29, 2.33, 2.34; **N** 283, 284). In this position the gastroduodenal artery may **hemorrhage** due to a **peptic ulcer** that erodes through the posterior wall of the **first part of the duodenum**, the most common location for a peptic ulcer. Alternatively, a duodenal ulcer may erode inferiorly into the pancreas, producing **pancreatitis**, or anteriorly into the peritoneal cavity, causing **peritonitis**, both potentially life-threatening conditions.

A

Common hepatic artery
Hepatic artery proper
Esophageal branches
Left hepatic artery
Right hepatic artery
Left gastric artery
Short gastric arteries
Gastroduodenal artery
Spleen
Right gastric artery
Left gastro–omental artery
Splenic artery
Right gastro–omental artery
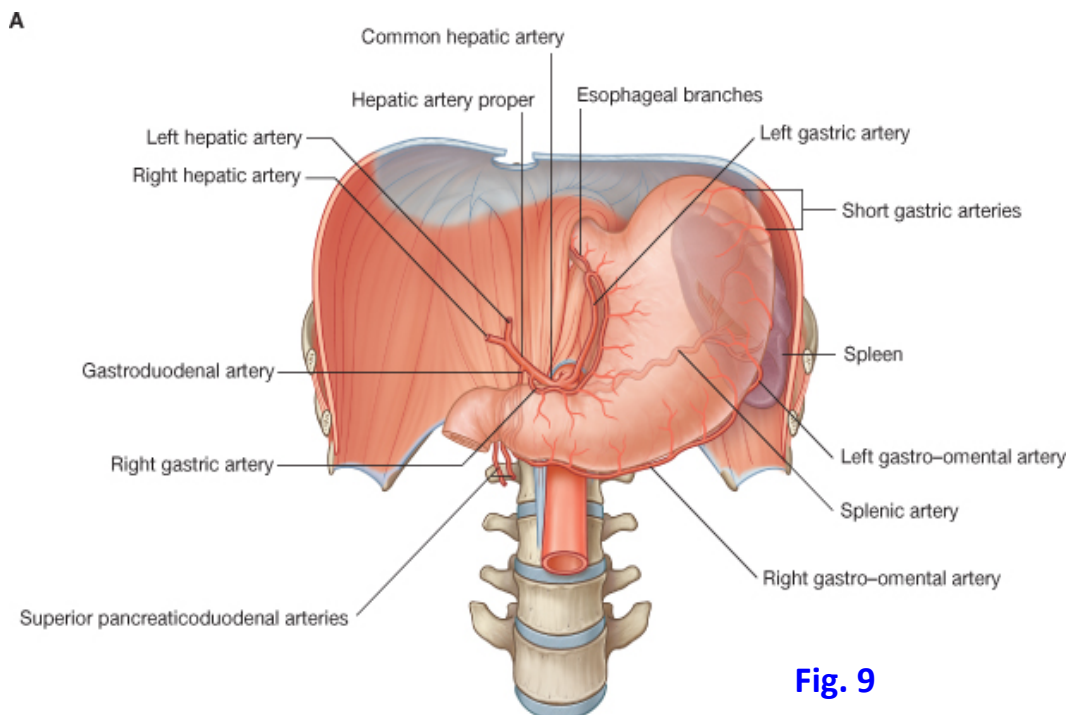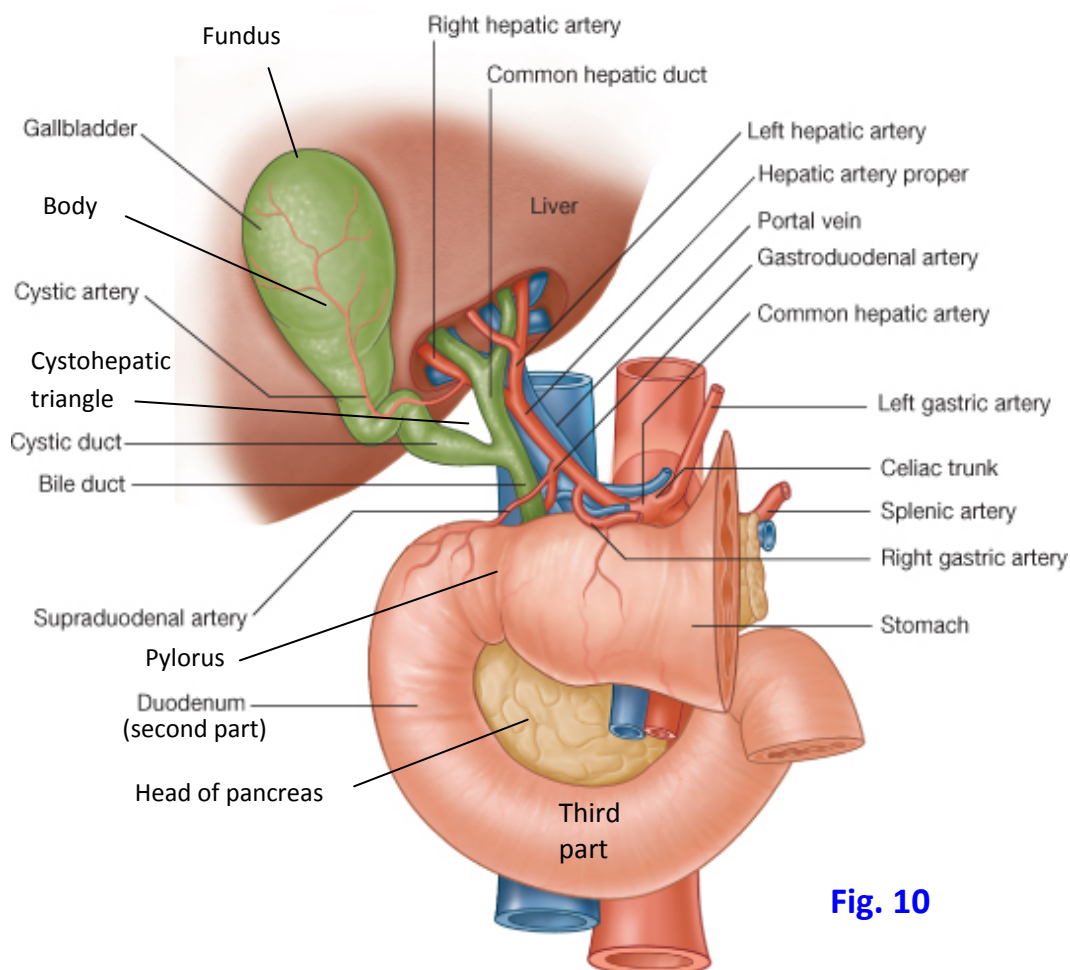Superior pancreaticoduodenal arteries

Fig. 9

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The **superior pancreaticoduodenal artery** divides into **anterior** and **posterior branches** that anastomose with corresponding branches of the **inferior pancreaticoduodenal artery** from the superior mesenteric. As the name suggests, the pancreaticoduodenal arteries supply the head of the pancreas and adjacent duodenum.

The **right gastro-omental artery** follows the greater curvature of the stomach within the greater omentum. It anastomoses with the **left gastro-omental branch of the splenic artery**.

The **splenic artery** is the third branch of the celiac trunk. It branches from the left side of the celiac trunk and passes posterior to the stomach along the superior border of the pancreas. In this position it may be the cause of fatal **hemorrhage** following the rare erosion of a **peptic ulcer** through the posterior wall of the **stomach**. Fatal hemorrhage also may result from the rupture of a **splenic artery aneurysm**, while an unruptured aneurysm may cause severe epigastric pain and vomiting (emesis) (e.g., see http://shortreports.rsmjournals.com/content/1/3/24.full   ).

Fundus
Right hepatic artery
Common hepatic duct
Gallbladder
Body
Liver
Left hepatic artery
Hepatic artery proper
Portal vein
Gastroduodenal artery
Common hepatic artery
Cystic artery
Cystohepatic triangle
Cystic duct
Bile duct
Left gastric artery
Celiac trunk
Splenic artery
Right gastric artery
Stomach
Supraduodenal artery
Pylorus
Duodenum (second part)
Head of pancreas
Third part

Fig. 10

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Along with the **tail of the pancreas**, the **splenic artery** enters the **splenorenal ligament** to reach the **hilum of the spleen** (**Fig. 9**; **G11** 2.28, 2.32, 2.34; **G12** 2.29, 2.33, 2.34; **N** 281-284). The splenic artery gives branches to the pancreas, **short gastric arteries** to the fundus of the stomach, and the **left gastro-omental artery** to the greater curvature. Pancreatic branches regularly include a **dorsal pancreatic artery** given off near the origin of the splenic artery and a **great pancreatic artery** near the middle of the **body of the pancreas** (**N** 284, 286).

✎   Study the omental foramen. Its anterior boundary is the hepatoduodenal ligament. Place your index finger into the omental foramen and your thumb anterior to the hepatoduodenal ligament and squeeze the hepatoduodenal ligament to palpate the three structures traversing it: the portal triad comprised of the bile duct, proper hepatic artery, and portal vein. Surgeons sometimes use this Pringle maneuver to compress the proper hepatic artery or portal vein to control bleeding (e.g., from a severed cystic artery).

Clean the celiac trunk and its branches. The lesser omentum and the parietal peritoneum in the posterior wall of the omental bursa will have to be removed piecemeal to expose the celiac trunk. Start by elevating the liver and pulling the stomach downward. Find the left and right gastric arteries within the lesser omentum along the lesser curvature of the stomach.

Follow the left gastric artery proximally to where it branches from the celiac trunk, looking for small esophageal branches of the left gastric artery that ascend on the distal esophagus. Expect the arteries to be enclosed within a dense plexus of autonomic nerve fibers (celiac plexus), which will have to be removed carefully to avoid damaging the vessels.

Clean the common hepatic artery, either by following it distally from the exposed celiac trunk or by following the right gastric and proper hepatic arteries proximally toward it. Examine the bifurcation of the common hepatic artery into the proper hepatic and gastroduodenal arteries.

Follow the proper hepatic artery through the hepatoduodenal ligament toward the liver. The artery typically lies to the left of the bile duct and anterior to the portal vein in the ligament (Fig. 10).

Find the division of the proper hepatic artery into right and left hepatic arteries near the transverse fissure (porta hepatis), where structures enter and leave the liver.

Identify the cystic artery supplying the gallbladder. It typically arises from the right hepatic artery within the cystohepatic triangle and courses to the right to reach the gallbladder. Variations are common. A discrete cystic vein may be missing because sometimes all of the veins of the gallbladder drain directly into the liver (G11 2.54C; G12 2.52B). Note that the cystic duct from the gallbladder joins the common hepatic duct from the liver to form the (common) bile duct (G11 2.37, 2.54B-C; G12 2.52A-B, 2.54; N 280, 284). XXX

Occasionally the **right hepatic artery** arises from the **superior mesenteric artery** and/or the **left hepatic artery** arises from the **left gastric artery** (labeled "**aberrant**" or "**accessory**" **hepatic arteries** depending on whether or not they are the sole blood supply or a supplemental blood supply, respectively, to that lobe of the liver) (G11 2.55; G12 2.53). Be aware of these possible variations.

Trace the gastroduodenal artery inferiorly behind the first part of the duodenum. Find its division into superior pancreaticoduodenal and right gastro-omental arteries. Approaching from the *right* (lateral) side, mobilize the descending (second) part of the duodenum and the head of the pancreas from the right kidney and related structures and retract them anteriorly (G11 2.36; G12 2.51C; N 286).

Clean the anterior and posterior branches of the superior pancreaticoduodenal artery, which anastomose in front of and behind the head of the pancreas, respectively, with the corresponding branches of the inferior pancreaticoduodenal artery. These anastomoses are described as forming arches (arterial arcades). The posterior superior pancreaticoduodenal artery often branches from the gastroduodenal artery proximal to its division into anterior superior pancreaticoduodenal and right gastro-omental arteries.

Follow the right gastro-omental artery along the greater curvature of the stomach in the greater omentum to where it anastomoses with the left gastro-omental artery (G11 2.28; G12 2.29; N 283).

Cut through the greater omentum just inferior to the gastro-omental arteries and elevate the stomach and transverse colon (G11 2.21, 2.34; G12 2.24, 2.34; N 264). Continue removing parietal peritoneum from the posterior wall of the omental bursa to dissect the tortuous splenic artery as it courses along the *superior border* of the pancreas (G11 2.21, 2.34; G12 2.24. 2.34;

N 281, 284). Find the short gastric and left gastro-omental branches of the splenic artery.

Clean the splenic vein as it passes medially *posterior* to the body and tail of the pancreas. It usually receives the inferior mesenteric vein as a tributary. The splenic vein unites with the superior mesenteric vein behind the neck of the pancreas to form the portal vein, which enters the hepatoduodenal ligament en route to the liver. Try to find the beginning of the portal vein. XXX

ABDOMINAL DIGESTIVE ORGANS SUPPLIED BY THE CELIAC TRUNK

Study the organs supplied by the blood vessels just dissected. The **stomach** consists of a cardial portion, fundus, body, and pyloric portion (G11 2.27; G12 2.28; N 267, 268). The **cardia** surrounds the cardial orifice at the **gastroesophageal junction**. A physiologic **lower esophageal sphincter**, formed in part by the diaphragmatic musculature of the esophageal hiatus, prevents regurgitation into the esophagus. Chronic **reflux of gastric contents** into the lower esophagus may cause **metaplastic change** of the mucosa, **ulceration**, and **stricture formation**. This **Barrett's esophagus** predisposes to the development of **esophageal adenocarcinoma**.

The **fundus** is the dilated upper portion of the stomach below the left dome of the diaphragm and often contains gas bubbles, which are apparent on a radiograph. The **body** forms the major portion of the stomach. It is continuous at a notch on the lesser curvature (**angular incisure**) with the pyloric part. The **pyloric part** consists of the wide **pyloric antrum** leading into the narrow **pyloric canal**. The pyloric canal ends at the **pyloric orifice** connecting the stomach with the duodenum. The pyloric orifice is guarded by a thickened circular layer of smooth muscle under **parasympathetic control** by the **vagus nerves** (anterior vagal trunk), the **pyloric sphincter**.

Attempt to find the anterior and posterior vagal trunks continuing from the esophagus onto the stomach (G11 1.72, 2.76; G12 1.79C, 2.76; N 298-300). They coalesce from the esophageal plexus of the thorax with most fibers from the left vagus nerve entering the anterior vagal trunk and most fibers from the right vagus nerve entering the posterior trunk. XXX
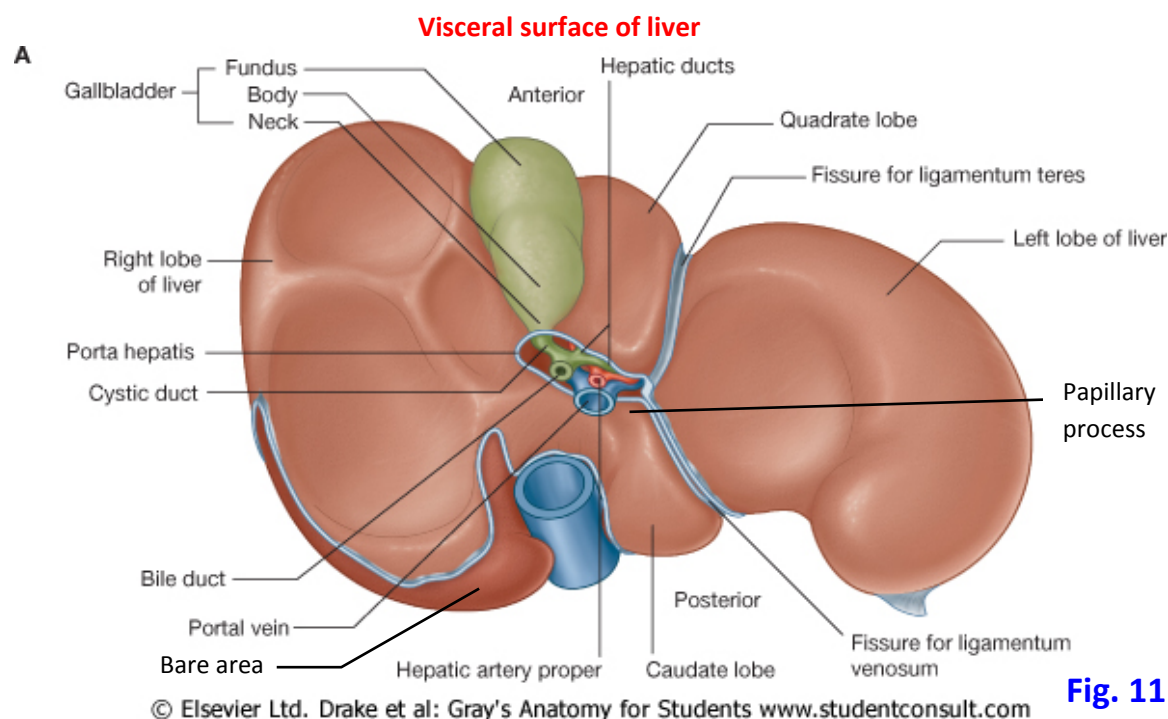
The **liver** is the largest gland in the body. It has **diaphragmatic** and **visceral surfaces** separated anteriorly by a sharp **inferior border** (**Figs. 5, 11**; G11 2.22, 2.24, 2.49, 2.50A; G12 2.19, 2.25, 2.45, 2.46A; N 267, 277, 278).

Posteriorly the diaphragmatic surface has a **bare area** where the liver isn't covered by visceral peritoneum and is in direct contact with the **diaphragm**. The **inferior vena cava** traverses the **groove for the inferior vena cava** in the bare area (**Fig. 11**). The bare area is bordered by peritoneal reflections that suspend the liver from the diaphragm, the **anterior** and **posterior**

layers of the coronary ligament. These layers meet laterally to form the **right** and **left triangular ligaments** on their respective sides of the falciform ligament.

The **liver** is subdivided into *functional right and left lobes* by a sagittal line joining the **fossa for the gallbladder** and the **groove for the inferior vena cava**. The **functional right lobe** of the liver is a single large lobe. The **functional left lobe** includes the smaller **caudate** and **quadrate lobes**, which are located medially and separated from the main portion of the left lobe by the **fissure for the ligamentum teres hepatis** (round ligament of the liver) and the **fissure for the ligamentum venosum**. The caudate and quadrate lobes are separated from each other by a transverse fissure, the **porta hepatis**, where the **portal vein**, **hepatic arteries**, **hepatic ducts**, and associated **lymphatic vessels and nerves** enter or leave the leave **(G11** 2.50, 2.55A; **G12** 2.46, 2.53A; **N** 277, 283, 284). The large **portal vein** carries 75% of the blood to the liver.

Some authors consider the **caudate lobe** to be a separate lobe functionally distinct from the right and left lobes. The caudate lobe may have a **papillary process** projecting toward the porta hepatis. A **caudate process** extends to the right between the inferior vena cava and the porta hepatis, connecting the caudate and right lobes **(G11** 2.50A; **G12** 2.46A).

Visceral surface of liver

© Elsevier Ltd. Drake et al: Gray's Anatomy for Students www.studentconsult.com **Fig. 11**

The **ligamentum teres hepatis (round ligament of the liver)** is a fibrous remnant of the fetal **left umbilical vein** (usually simply referred to as the "umbilical vein") **(Fig. 11**; **G11** 2.50; **G12** 2.46; **N** 267, 277). The left umbilical vein carried well oxygenated blood from the placenta to the fetus before birth. The **ligamentum venosum** is a fibrous remnant of the fetal **ductus venosus**. The ductus venosus shunted much of the oxygenated blood from the left umbilical vein to the inferior vena cava, bypassing the hepatic sinusoids of the liver.

The **liver** is often divided for descriptive purposes into *anatomical right and left lobes*. The large **anatomical right lobe** is separated from the **anatomical left lobe** by the fissures for the ligamentum teres hepatis and ligamentum venosum. Thus, the caudate and quadrate lobes would be considered part of the anatomical right lobe of the liver.

The **gallbladder** is an elongated thin-walled sac occupying the **gallbladder fossa** on the visceral surface of the liver. The gallbladder stores and concentrates bile and is usually stained green in the cadaver. Visceral peritoneum envelops the gallbladder and helps bind it to the liver. The gallbladder consists of a fundus, body, and neck **(Figs. 10, 11**; **G11** 2.37, 2.50, 2.58; **G12** 2.54, 2.46, 2.58; **N** 277, 280). The **fundus** is the wide end of the organ that projects slightly below the inferior border of the liver. Its surface projection is near the junction of the tip of the **right 9th costal cartilage** and the **linea semilunaris** (i.e., about the midclavicular line). A patient with an inflamed gallbladder (**cholecystitis**), which often results from **gallstones**, experiences pain at this site and abruptly stops inspiration with the pressure of palpation (Murphy's sign). Alternatively, the inflamed gallbladder may irritate diaphragmatic peritoneum, **referring pain** to the *right* shoulder. An inflamed gallbladder may adhere to the superior part of the duodenum with development of a **cholecystenteric fistula**. A gallstone entering the duodenum through such a fistula may pass distally and obstruct the **ileocecal junction** (**gallstone ileus**). Instead of the superior part of the duodenum, an inflamed gallbladder may adhere to the transverse colon and develop a cholecysteneric fistula with it. Would this result in gallstone ileus?

The **body of the gallbladder** occupies the gallbladder fossa of the liver. The **neck** is the tapered S-shaped portion of the gallbladder, which is connected by the **cystic duct** to the **common hepatic duct**. The cystic duct is kept open by a **spiral fold** (spiral valve) of mucosa **(G11** 2.37A; **G12** 2.54A; **N** 280), facilitating the passage of bile. The cystic duct joins the common hepatic duct to form the **bile duct**. A pouchlike dilatation of the neck of the gallbladder (**Hartmann's pouch**) may develop as a pathological change and be a site of gallstone accumulation.

The gallbladder and cystic duct are supplied by the **cystic artery**, which usually branches from the **right hepatic artery**, but variations occur **(G11** 2.57; **G12** 2.57; **N** 283, 284). Small **cystic veins** directly enter the liver from the fundus and body of the gallbladder and sometimes from the neck and cystic duct. A cystic vein from the neck of the gallbladder and cystic duct rarely is a direct extrahepatic tributary of the portal vein.

✎ **Now carefully remove the liver. Cut any remnants of the lesser omentum and structures entering or leaving the porta hepatis as follows. Cut the bile duct just *distal* to the union of the cystic duct and common hepatic duct. Cut the falciform ligament, the anterior and posterior layers of the coronary ligament, and the right and left triangular ligaments. Cut the inferior vena cava superiorly between the liver and diaphragm. Cut the inferior vena cava inferiorly as close to the liver as possible. Lift the liver from the abdominal cavity.**

Study the isolated liver with the attached gallbladder (if it hasn't been surgically removed), identifying each of the features described in the preceding paragraphs. Identify the diaphragmatic and visceral surfaces of the liver separated by its sharp inferior border. Find the bare area of the liver, which isn't covered by visceral peritoneum. It is outlined by the cut edges of the anterior and posterior layers of the coronary ligament, which continue laterally into the right and left triangular ligaments on those respective sides of the liver (G11 2.49B; G12 2.45B; N 277). Look inside the lumen of the superior part of the hepatic portion of the inferior vena cava and identify the hepatic veins, which drain blood from the liver into the systemic circulation.

On the visceral surface of the liver find the fossa for the gallbladder and the groove for the inferior vena cava. An imaginary sagittal line joining the two fossae indicates the division of the liver into *functional* right and left lobes. Find a second sagittal line formed by the fissure for the ligamentum teres hepatis and the fissure for the ligamentum venosum, which subdivides the functional left lobe. Clean the ligamentum teres hepatis, a remnant of the fetal left umbilical vein. Verify that it is a fibrous cord enclosed within the inferior free margin of the falciform ligament. Bluntly dissect into the fissure for the ligamentum venosum to find the ligamentum venosum, a fibrous remnant of the fetal ductus venosus.

The transversely oriented porta hepatis connects the two sagittal lines described in the preceding paragraph and separates the quadrate and caudate lobes. The quadrate and caudate lobes are part of the functional left lobe, although some authors classify the caudate lobe as a functionally distinct lobe. Identify the right and left branches of the portal vein, right and left hepatic arteries, and right and left hepatic ducts at the porta hepatis.

Identify the fundus, body, and neck of the gallbladder if it wasn't surgically removed. Palpate the gallbladder to check for the presence of gallstones, which may have been asymptomatic. Follow the cystic duct to its union with the common hepatic duct to form the (common) bile duct. Clean the small cystic artery and trace it to its origin, usually from the right hepatic artery within the surgically important cystohepatic triangle formed by the cystic duct, common hepatic duct, and the liver (Fig. 10). Check to see if there is a cystic vein draining into the portal vein below the liver. XXX
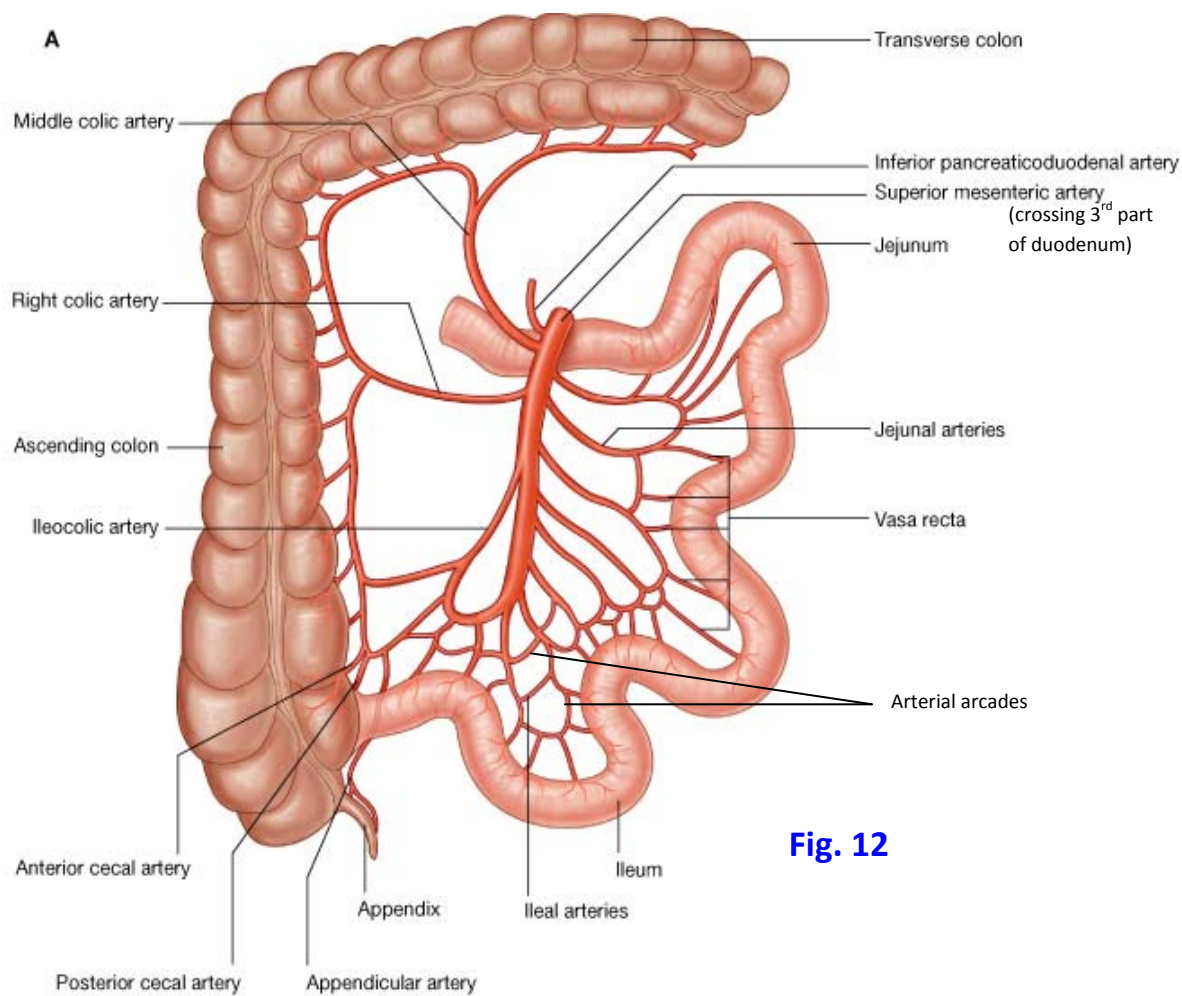
A

Transverse colon

Middle colic artery

Inferior pancreaticoduodenal artery

Superior mesenteric artery
(crossing 3rd part
of duodenum)

Jejunum

Right colic artery

Jejunal arteries

Ascending colon

Vasa recta

Ileocolic artery

Arterial arcades

Fig. 12

Anterior cecal artery

Ileum

Appendix   Ileal arteries

Posterior cecal artery   Appendicular artery

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SUPERIOR MESENTERIC ARTERY AND THE DIGESTIVE ORGANS IT SUPPLIES

The large **superior mesenteric artery and vein** emerge from behind the **neck of the pancreas** to cross anterior to the **uncinate process of the pancreas** and the **inferior (third) part of the duodenum** to enter the mesentery **(Fig. 13**; **G11** 2.25, 2.33, 2.34, 2.43, 2.44; **G12** 2.26, 2.33, 2.34, 2.39, 2.40; **N** 284, 288, 323). In rare patients the superior mesenteric vessels may compress the duodenum, obstructing the passage of intestinal contents (**superior mesenteric syndrome**). The superior mesenteric artery is also a common site for **acute mesenteric ischemia** produced by an **thromboembolus** dislodged from the heart, by sudden occlusion at a focus of long-standing **atherosclerosis**, or by **intestinal vasospasm** (e.g., see http://emedicine.medscape.com/article/758674-overview). Mortality rates are ≥ 60%.

The **superior mesenteric artery** gives off the **inferior pancreaticoduodenal artery** and **jejunal and ileal branches** to the small intestine **(Figs. 12, 13)**. It supplies the large intestine via

middle colic, **right colic**, and **ileocolic branches**. The ileocolic artery also contributes to the blood supply of the terminal ileum.

The **middle colic artery** arises from the right side of the superior mesenteric artery just distal to the pancreas and enters the **transverse mesocolon**. Near the wall of the transverse colon it divides into **right** and **left branches (G11** 2.43, 2.44A, 2.45; **G12** 2.39, 2.40A, 2.41; **N** 287, 288).

The next branch of the superior mesenteric artery is the **right colic artery**, which has a variable origin and occasionally is absent. It may arise from the superior mesenteric artery, from the middle colic artery, or from the ileocolic artery. The right colic artery passes to the right side in a retroperitoneal position and divides into **ascending** and **descending branches** to supply the ascending colon.
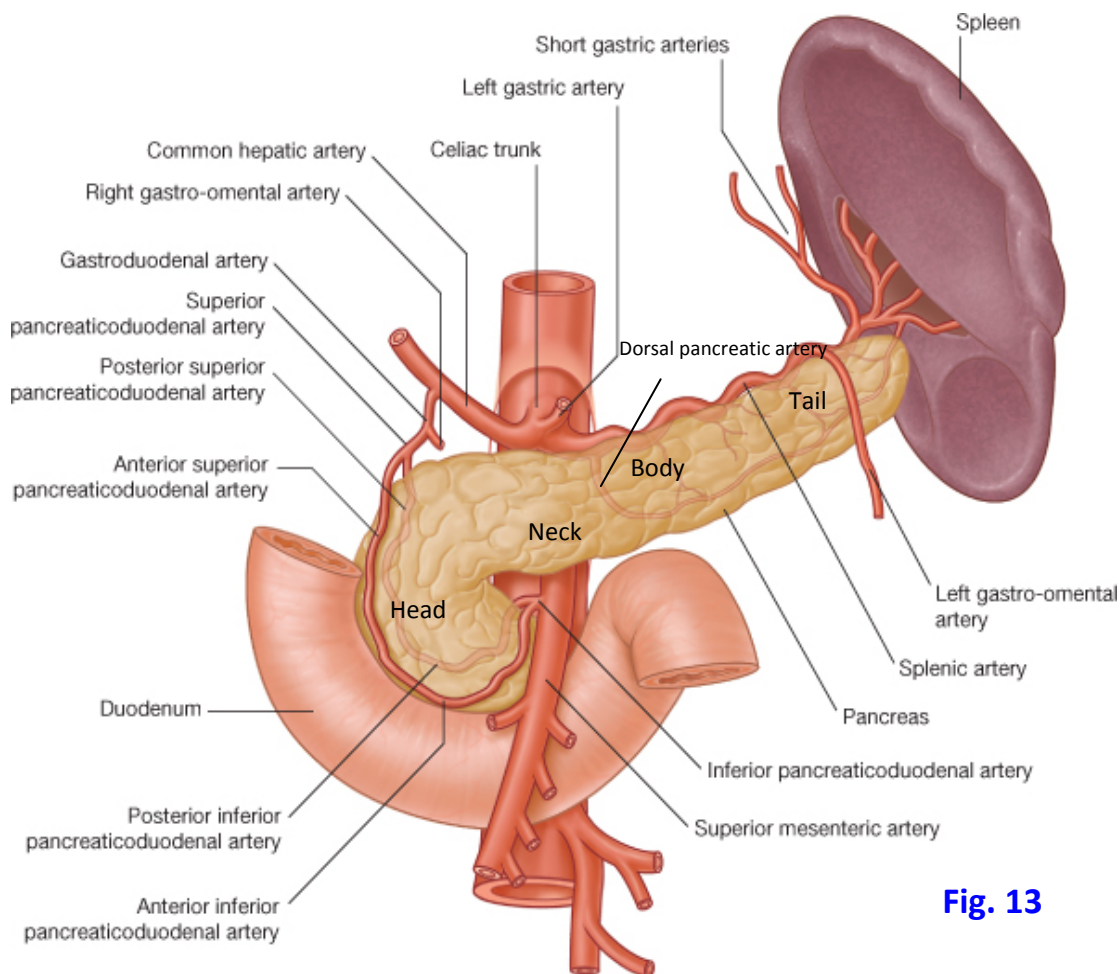

Fig. 13

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The **ileocolic artery** descends toward the ileocecal junction (**G11** 2.43, 2.44A; **G12** 2.39, 2.40A; **N** 287, 288). It has **ascending colic**, **cecal**, and **ileal branches**. The **appendicular artery** also commonly branches directly from the ileocolic artery. The appendicular artery is an **end artery**

(i.e., it doesn't have anastomoses). Consequently, if acute infection and inflammation of the appendix (**acute appendicitis**) results in edema compressing the artery or in the artery's **thrombosis**, then **necrosis** and **perforation** of the appendix may result. A potentially fatal generalized **peritonitis** may be prevented if the greater omentum walls off the site of infection, producing a localized **abscess**.

Clean the superior mesenteric artery and its branches. They are enclosed within a dense superior mesenteric plexus of autonomic nerve fibers (i.e., sympathetic, parasympathetic, and visceral afferent fibers). Find the small inferior pancreaticoduodenal artery, a proximal branch from its right side as the superior mesenteric artery emerges from behind the pancreas (N 286, 287). The inferior pancreaticoduodenal artery divides into anterior and posterior branches that anastomose, forming arcades, with the corresponding branches of the superior pancreaticoduodenal artery. Continuing into the mesentery, dissect examples of the 12-16 jejunal and ileal arteries that branch from the left side of the superior mesenteric. Their arterial arcades and vasa recta were studied earlier.

Clean the middle colic, right colic, and ileocolic arteries and identify their branches. Pay attention to the appendicular artery.

Now study the bile passages, the duodenum, and the pancreas. The origin of the (common) bile duct by the union of the cystic duct and common hepatic duct has already been seen. Follow the bile duct inferiorly behind the head of the pancreas, which was mobilized earlier. Usually the bile duct occupies a groove on the posterior surface of the pancreas, but it may be completely embedded within pancreatic tissue. What is the potential clinical significance of this relationship in pancreatic cancer?

Carefully clean the bile duct down to where it joins the fragile main pancreatic duct to form a dilatation, the hepatopancreatic ampulla, which opens near the middle of the second part of the duodenum at the major duodenal papilla (G11 2.37; G12 2.54). Note that the major duodenal papilla is the only one of these structures visible from the lumen if the duodenum is cut open. Unless it is sectioned, the hepatopancreatic ampulla can only be seen as it is formed by the union of the bile and main pancreatic ducts *before* it begins to penetrate the wall of the duodenum (G11 2.37; G12 2.54). XXX

A circular smooth muscle sphincter at the hepatopancreatic ampulla (**hepatopancreatic sphincter** [of Oddi]) controls the entrance of secretions into the lumen of the duodenum. In

addition, the bile duct and main pancreatic duct may have their own smooth muscle sphincters. A gallstone that has traversed the cystic and bile ducts may become **impacted** within the hepatopancreatic ampulla, causing the reflux of bile into the pancreas with the development of **pancreatitis**. A tumor within the hepatopancreatic ampulla may have the same result. A second smaller **accessory pancreatic duct** opens at the **minor duodenal papilla** above the major papilla (**G11** 2.37; **G12** 2.54).

The **pancreas** is a combination **exocrine** and **endocrine gland**. Its exocrine secretions enter the duodenum through the main and accessory pancreatic ducts. Its endocrine secretions (hormones) enter the blood. The pancreas is divided for descriptive purposes into a head, neck, body, and tail (**Figs. 10, 13**; **G11** 2.32, 2.33; **G12** 2.33A, 2.33B-C; **N** 281). The **head of the pancreas** occupies the C-shaped curvature of the duodenum. The **uncinate process** is a projection from the inferior part of the head that passes to the left posterior to the superior mesenteric vessels. The **neck** of the pancreas lies anterior to the superior mesenteric artery. The **superior mesenteric vein** joins the **splenic vein** behind the neck to form the **portal vein**. The **body** of the pancreas continues to the left from the neck and ends in the tail. The **tail of the pancreas** occupies the **splenorenal ligament** with the splenic vessels (**Fig. 14**) and is in danger during removal of the spleen (**splenectomy**).
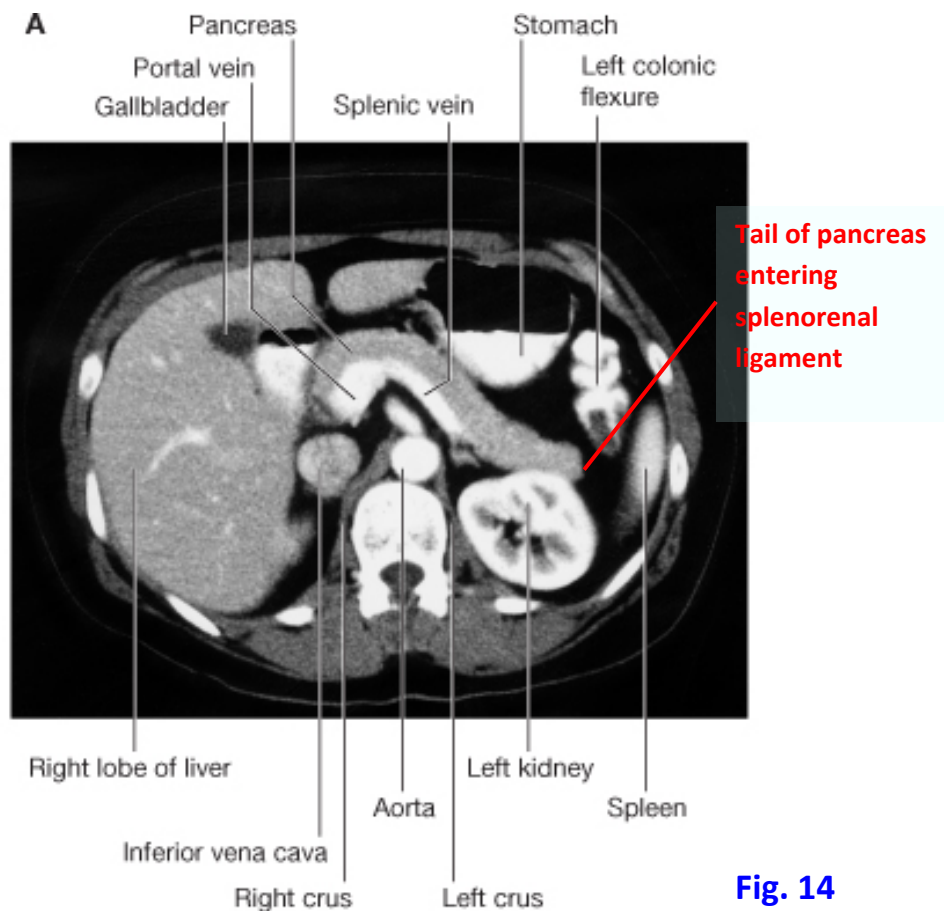

Fig. 14

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Pancreatic cancer is the fourth leading cause of cancer deaths with a five-year survival rate of 5% (see http://emedicine.medscape.com/article/280605-overview). **Adenocarcinoma of the head of the pancreas** may cause extrahepatic **obstruction of the bile duct**. Excess bile is absorbed into the blood, producing yellowing of mucous membranes, conjunctiva, and skin (**obstructive jaundice**). Painless jaundice is often the first indication of cancer involving the head of the pancreas. Pancreatic cancer involving the body and tail commonly causes severe epigastric pain that radiates to the back. New-onset diabetes mellitus or hyperglycemia in individuals over the age of 50 without a family history may be the first indication of pancreatic cancer.

The **duodenum** is the first part of the small intestine (**Fig. 10, 13**; **G11** 2.32, 2.33, 2.37; **G12** 2.33A. 2.33B-C, 2.54; **N** 270, 271, 281). It begins at the **pylorus** and ends at the **dudodenojejunal junction**, where the duodenum is continuous with the jejunum. The duodenum is divided into **four parts**. The **superior (first) part**, which is approximately 5 cm long, has an initial short segment (2 cm) that is **intraperitoneal**. This intraperitoneal part has the greater omentum attached to its lower margin and has its upper margin connected to the liver by the **hepatoduodenal ligament**. This intraperitoneal part of the duodoenum has a distinct
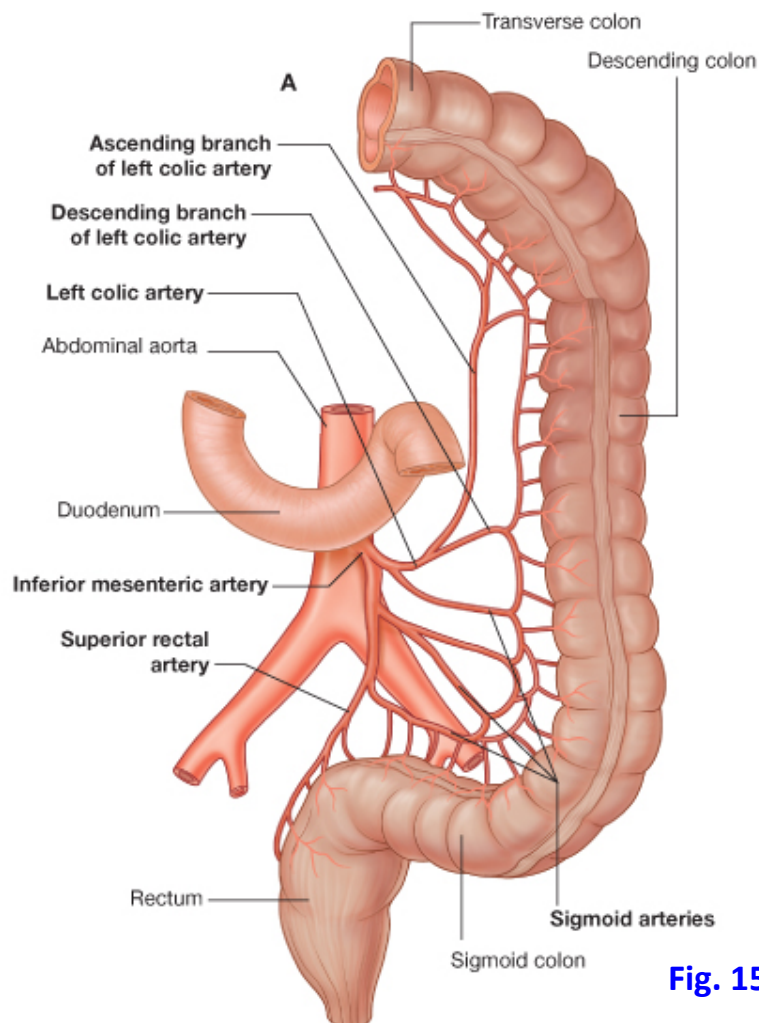

Fig. 15

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appearance on radiographs using contrast medium and is called the **duodenal cap (ampulla)** (Gr 2.31B-D). The remainder of the duodenum is **secondarily retroperitoneal**.

The **descending (second) part** of the duodenum near its midpoint receives the openings of the bile duct and main pancreatic duct at the **main duodenal papilla** (**G11** 2.37; **G12** 2.54; **N** 271). Usually these ducts unite to form the **hepatopancreatic ampulla**. The accessory pancreatic duct enters the duodenum a little higher, at the **accessory duodenal papilla**. However, there is occasional variation in these ducts (**G11** 2.38D-G; **G12** 2.55D-G).

The **inferior (third or horizontal) part** of the duodenum runs transversely toward the left over the **inferior vena cava** and **aorta** at the level of the **3rd lumbar vertebra**. The **superior mesenteric artery and vein** pass anterior to the third part of the duodenum (**Fig. 13**; **G11** 2.83G, 2.85B-C; **G12** 2.85G, 2.87B-C).

The **ascending (fourth) part** of the duodenum passes superiorly and to the left to join the jejunum at the **duodenojejunal junction (duodenojejunal flexure)** (**G11** 2.32, 2.47; **G12** 2.33, 2.43; **N** 262). The duodenojejunal flexure is supported by a fibromuscular slip of tissue, the **suspensory muscle of the duodenum (ligament of Treitz)**, which is a surgical landmark. The duodenojejunal junction is where the small intestine again becomes intraperitoneal. It is also the demarcation between **upper and lower GI bleeding**, which have different clinical characteristics.

Study the pancreas and duodenum. Identify the parts of each. Verify that the head of the pancreas occupies the C-shaped curvature of the duodenum. Identify the uncinate process of the pancreas projecting to the left posterior to the superior mesenteric artery and vein. Note the relationship of the neck of the pancreas to the superior mesenteric artery and the origin of the portal vein in the union of the superior mesenteric and splenic veins. Identify the body and tail of the pancreas and note that the latter enters the splenorenal ligament with the splenic blood vessels. Try to dissect the delicate main pancreatic duct via a posterior approach.

Identify the four parts of the duodenum. Locate the duodenal cap (**G11** 2.31B-D; **G12** 2.32B-D; **N** 271). It is the first 2 cm of the superior part of the duodenum and is the only intraperitoneal part of the duodenum. The hepatopancreatic ampulla was identified earlier entering the middle of the descending part of the duodenum. Verify that the superior mesenteric artery and vein pass anterior to the inferior (horizontal, third) part of the duodenum. Look for the suspensory muscle of the duodenum at the duodenojejunal flexure, where the ascending part of the duodenum joins the jejunum. This is where the small intestine again becomes intraperitoneal. **XXX**
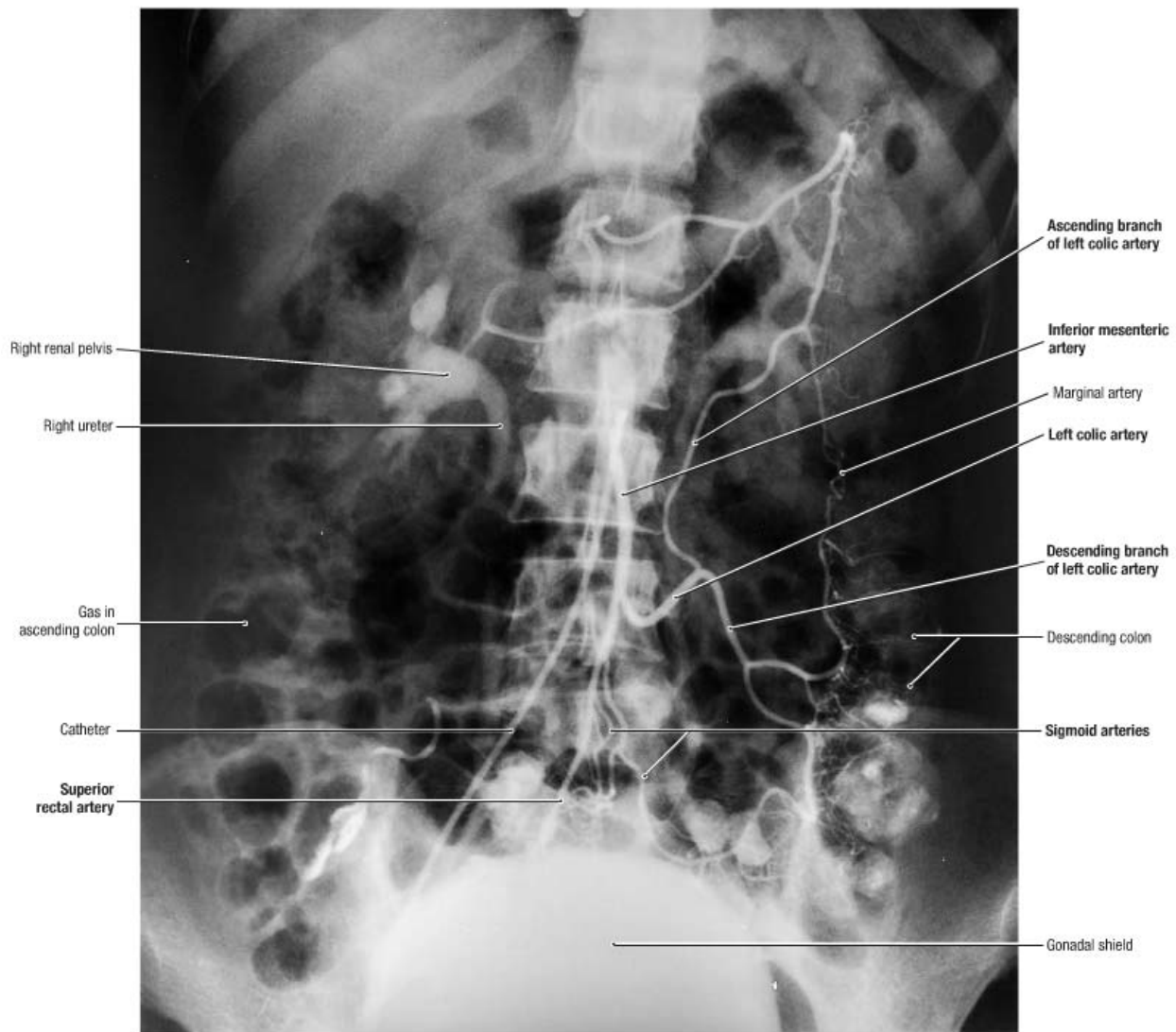
Inferior mesenteric arteriogram   **Fig. 16**

INFERIOR MESENTERIC ARTERY AND THE ABDOMINAL ORGANS IT SUPPLIES

The **inferior mesenteric artery** sends a **left colic branch** to the descending colon and **sigmoid branches** to the sigmoid colon. The **superior rectal artery** is the continuation of the inferior mesenteric artery to the rectum and upper half of the anal canal (**Figs. 15, 16**; **G11** 2.45, 2.46; **G12** 2.41, 2.42; **N** 288).

The **left colic artery** passes to the left behind the peritoneum and divides into **ascending** and **descending branches**. The ascending branch anastomoses with the left branch of the middle colic artery from the superior mesenteric, helping to form a **marginal artery** that extends from the **ileocecal junction** to the **sigmoid colon**. This is important during the **atherosclerotic occlusion** or **surgical ligation** of the inferior mesenteric artery.

The **descending branch of the left colic artery** anastomoses with **sigmoid branches**, which enter the sigmoid mesocolon to supply the sigmoid colon (**Fig. 15**; **G11** 2.45, 2.46; **G12** 2.41, 2.42; **N** 288, 378). The direct continuation of the inferior mesenteric artery is the **superior rectal artery (Fig. 16)**. It descends into the pelvis and anastomoses with the **middle rectal arteries** from the right and left **internal iliac arteries**. These arteries will be studied during dissection of the pelvis.
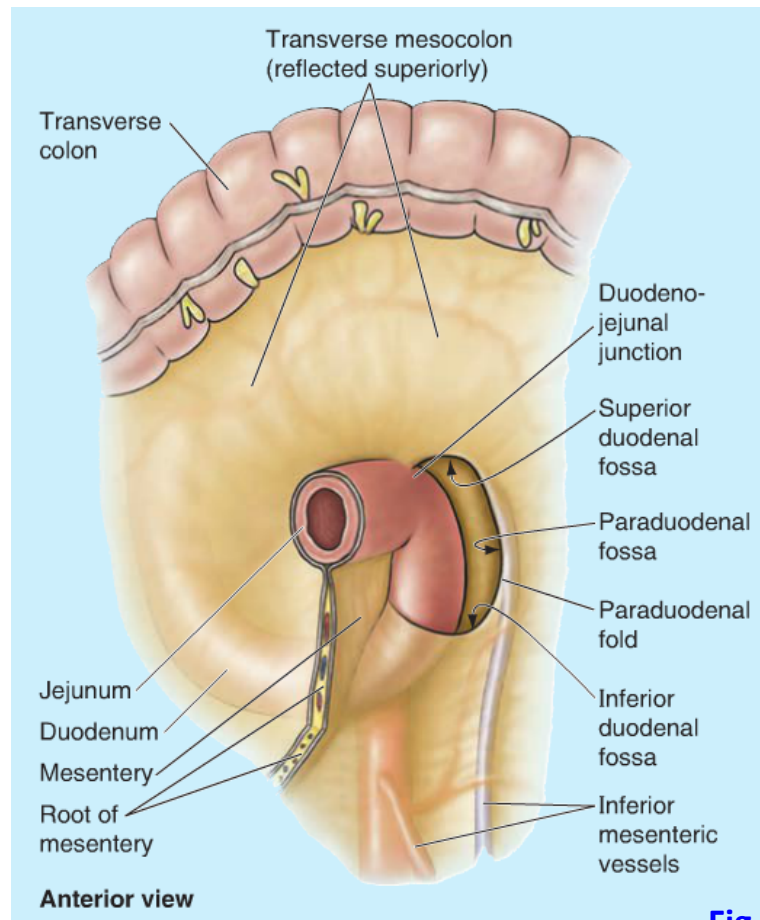
Transverse mesocolon
(reflected superiorly)

Transverse colon

Duodeno-jejunal junction

Superior duodenal fossa

Paraduodenal fossa

Paraduodenal fold

Jejunum

Duodenum

Mesentery

Root of mesentery

Inferior duodenal fossa

Inferior mesenteric vessels

Anterior view

Fig. 17

Moore et al. 2010 *Clinically Oriented Anatomy*,
6E, Lippincott Williams & Wilkins, p. 258

Displace loops of jejunum and ileum to the right to identify and clean the inferior mesenteric artery and its left colic, sigmoid, and superior rectal branches. The inferior mesenteric nerve plexus within which the arteries are enclosed will have to be carefully dissected away. Clean the inferior mesenteric vein as it ascends retroperitoneally to join the splenic vein (G11 2.60; G12 2.60; N 291). Note the close relationship of the inferior mesenteric vein to the duodenojejunal flexure. This relationship is

important during the surgical repair of a type of internal abdominal hernia (paraduodenal hernia) in which a loop of small intestine becomes entrapped within a nearby peritoneal recess, the paraduodenal fossa (Fig. 17). In some bodies the inferior mesenteric vein may empty into the superior mesenteric vein instead of the splenic vein. XXX