Abdomen

The abdominal portion of the digestive system consists of a combination of solid and hollow organs. The term gastrointestinal (GI) tract refers to the stomach and intestines while accessory organs of the GI tract consist of the liver, gallbladder, and pancreas. The GI tract and accessory organs receive their blood supply from the celiac, superior mesenteric, and inferior mesenteric branches of the abdominal aorta; their venous return passes through the hepatic portal system.

Organs Supplied by the Celiac Artery (Trunk)

Celiac Artery

1) 1st single midline branch of the abdominal aorta; originates just below the diaphragm at T12
2) term “trunk” applied to vascular anatomy implies short and stubby
3) three branches
   a) common hepatic artery – supplies liver, gallbladder, stomach, duodenum, and pancreas
   b) splenic artery – supplies pancreas, stomach, and spleen
   c) left gastric artery – supplies esophagus and stomach

Esophagus (Abdominal Part)

1) about 1.5 cm of the esophagus lies within the abdomen
2) joins the cardiac portion of the stomach at the esophagogastric junction
3) lower esophageal sphincter (LES)
   a) a zone of smooth muscle at the esophagogastric junction whose tonic contraction is the major factor preventing a reflux of gastric contents into the esophagus
   b) LES relaxes upon swallowing – relaxation mediated by the vagus nerve
   c) LES contraction – initiated by the peristaltic wave of contraction created when swallowing; the peristalic wave pushes a bolus of food ahead of itself and then contraction of the LES occurs when the peristalic wave passes through the LES.
4) blood supply
   a) esophageal branch of the left gastric artery
   b) left gastric vein is a tributary of portal vein; participates with esophageal veins from the thorax in a portal-systemic anastomosis

Clinical Notes: 1) Gastroesophageal reflux disease (GERD) – the most common disorder of the esophagus; defined as the movement of gastric contents into the esophagus with resultant symptoms and/or tissue damage. A spectrum of disease from acute, mildly symptomatic with no esophageal tissue injury to chronic disease that can lead to pathology of the distal esophagus. The cardinal symptom of GERD is heartburn, an uncomfortable burning sensation behind the sternum. GERD reflects dysfunction in the anti-reflux mechanism of the LES. 2) Erosion - a small (< 5mm), superficial mucosal lesion; potential for only mild bleeding due to its limitation to the capillaries of the mucosa. 3) Ulcer - a lesion characterized by a loss of surface epithelium and extension deep enough to reach or penetrate through the muscularis mucosa; due to its depth bleeding may be vigorous reflecting involvement of arteries and arterioles. 4) Reflux esophagitis - GERD-induced esophageal injury that is characterized endoscopically (visual observation of the lining of the esophagus) by the presence of erosions and ulcers in the esophageal wall; may lead to esophageal strictures (regional narrowings of the esophageal lumen) that result from fibrous tissue production and deposition (scar formation) in the esophageal wall. Esophageal strictures in turn often lead to dysphagia. 4) Dysphagia – difficulty in swallowing.

Stomach

1) a sac-like dilation of the gastrointestinal tract; shaped somewhat like the letter J
2) surface features
   a) anterior (anterior-superior) surface
      i) upper half – adjacent to the diaphragm and liver
      ii) lower half – adjacent to the liver and anterior abdominal wall
      iii) faces greater sac
   b) posterior (posterior-inferior) surface
      i) lies on “stomach bed” consisting of diaphragm, pancreas, splenic artery, spleen, transverse mesocolon, and left kidney and adrenal gland.
      ii) faces lesser sac
   c) greater and lesser curvatures
      i) angular notch – permanent indentation in lesser curvature
3) regions
   a) cardia
      i) poorly defined region around the esophagus
      ii) contains cardiac orifice – opening to the esophagus
   b) fundus
      i) superior region above the cardiac orifice and cardiac notch
      ii) immediately deep to the diaphragm, usually contains gas evident radiographically
   c) body – cardiac orifice to angular notch
   d) pyloric antrum - angular notch to pylorus
   e) pylorus (Gr. gatekeeper) = pyloric canal + pyloric sphincter (thick circular ring of smooth muscle in a tonic state of contraction)
      i) "emptying of the stomach" - passage of chyme from pyloric antrum to duodenum
      ii) regulation of pyloric sphincter - most important is feedback control from the duodenum, both neural and hormonal
4) surface anatomy
   a) the stomach is relatively fixed at two points, i.e. junction with esophagus and junction with duodenum; shape and position varies widely between these two points
   b) esophagogastric junction – typically positioned posterior to the 7th costal cartilage slightly to the left of midline
   c) left costal margin “divides” the stomach in half, i.e. proximal half of the stomach is deep to the left side of the rib cage (lateral to the costal margin) while the distal half is deep to the anterior abdominal wall (medial to the costal margin)
   d) gastroduodenal junction - located to the right of midline and medial to the right costal margin near the level of the 9th costal cartilage
5) peritoneal relations
   a) stomach is intraperitoneal
   b) lesser omentum – between lesser curvature and liver
   c) greater omentum – two continuous parts
      i) gastrocolic omentum – between 1st part of duodenum & greater curvature and the transverse colon
      ii) gastrosplenic omentum – between greater curvature and the spleen
6) rugae – interior longitudinal folds of the mucous membrane; disappear with distention
7) blood supply
   a) gastric arteries - run along lesser curvature
      i) left (br. of celiac artery) and right (br. of hepatic artery)
   b) gastroepiploic arteries – run along greater curvature
      i) left (br. of splenic artery) and right (br. of gastroduodenal br. of hepatic artery)
   c) short gastric arteries – project to greater curvature (brs. of splenic artery)

8) function
   a) digestion - cleavage of molecules into smaller components
   b) mixing of food with gastric secretions to form a semifluid mixture called chyme (Greek for juice)
   c) storage of large quantities of food until it can be accommodated by the duodenum
   d) regulation of the passage of chyme into the duodenum (emptying of the stomach) at a rate and volume suitable for proper intestinal digestion and absorption

Clinical Notes: 1) Peptic ulcer disease – the development of ulcers at sites exposed to peptic juice (HCl and pepsin); most common in the stomach (called gastric ulcers) and duodenum (called duodenal ulcers). Two major factors responsible for a person's susceptibility to peptic ulcers are a) Helicobacter pylori bacteria infection and b) use of aspirin or other non-steroidal anti-inflammatory drugs. Potential complications of peptic ulcer disease include a) bleeding, which may be fatal, b) perforation - extension of the ulcer through the entire wall of the organ, reaching the visceral layer of peritoneum; typically results in peritonitis (inflammation/infection of the peritoneum) from leaked stomach or duodenal contents, c) penetration - extension of the ulcer into an adjacent organ; most often involves the pancreas leading to acute pancreatitis, and d) gastric outlet obstruction (impaired emptying of the stomach) - in peptic ulcer disease the obstruction is due to either edema/inflammation or scarring (fibrosis) near the pyloric canal. 2) Incidence of peptic ulcer disease - about 500,000 new cases and 4,000,000 recurrences of peptic ulcer disease are diagnosed each year in the U.S..

Liver

1) largest organ in the body
2) location
   a) mainly in RUQ but left lobe extends across the midline to LUQ
   b) directly inferior to the diaphragm
   c) lies deep to the thoracic cage; right side of its sharp anterior border follows the right costal margin
3) smooth, dome-shaped diaphragmatic surface versus irregular visceral surface
4) porta hepatis (portal fissure, hepatic portal) – on visceral surface; the “doorway to the liver”, i.e. entrance of blood vessels and nerves, exit of bile ducts
5) peritoneal relations
   a) falciform ligament - connects liver to umbilicus and anterior abdominal wall
   b) coronary and triangular ligaments – a continuous peritoneal reflection that connects the liver to the underside of the diaphragm
   c) bare area of the liver – portion of the superior and posterior surfaces of the liver that is not covered wth visceral peritoneum; surrounded by b) above
   d) subphrenic recesses - regions of peritoneal cavity between liver and diaphragm
   e) hepatorenal recess (Morison's pouch) - region of peritoneal cavity where peritoneum on visceral surface of the right lobe of the liver reflects onto the anterior surface of the right kidney; most dependent (lowest) point of the peritoneal cavity when a patient is supine.
6) portal circulation – a blood flow pattern of arteries to capillaries to veins to capillaries to veins, i.e. an "additional" set of veins and capillaries interposed within the normal circulatory pattern of the systemic circulation.
   a) significance - allows additional physiologic processes to be conducted on the venous blood prior to its return to the heart
7) hepatic portal circulation
   a) portal vein
      i) receives deoxygenated blood from the GI tract between lower esophagus and upper rectum plus pancreas, gallbladder, and spleen.
      ii) formed behind the neck of the pancreas from a union of the superior mesenteric and splenic veins

b) portal vein feeds the capillaries (sinusoids) of the liver
c) liver sinusoids coalesce into hepatic veins that unite with the inferior vena cava (IVC)
d) portal-systemic anastomoses – sites of continuity between veins draining into the portal vein and veins of the systemic circulation that bypass the hepatic portal circulation
   i) esophagus - lower 1/3 (portal) and middle 1/3 (systemic) esophageal veins
   ii) rectum - superior (portal) and middle (systemic) rectal veins
   iii) paraumbilical veins (portal) – travel in falciform ligament; connect with superficial veins (systemic) of the anterior abdominal wall
   iv) veins of the ascending & descending colon (portal) with small retroperitoneal veins (systemic) on the posterior abdominal wall

8) blood supply
   a) 70% from the portal vein - deoxygenated
   b) 30% from the hepatic artery - oxygenated
   c) hepatic veins - venous outflow of the liver; blood combined from a and b above
9) division of the liver
   a) anatomical division - left and right lobes defined by falciform ligament; small caudate and quadrate lobes on visceral surface
   b) functional (surgical) division - based on blood flow of the hepatic artery and portal vein and outflow of the biliary duct system; there is no mixing of blood or bile between the two functional sides of the liver
      i) demarcated by a line drawn through the depressions on the visceral surface for the gallbladder and IVC and extending over the diaphragmatic surface between the two depressions
      ii) provides a "left liver" and a "right liver"; places caudate and most of quadrate lobe in the “left liver”
10) functions – major categories include
   a) vascular - storage & filtration (e.g. remove drugs, bilirubin) of blood
   b) metabolic - carbohydrate, fat, and protein metabolism
   c) secretory - produces bile
   d) storage - e.g. vitamins and iron

Clinical Notes: 1) Cirrhosis – a diffuse pathologic process in which the hepatocytes of the liver are replaced with fibrous connective tissue; a response to a variety of hepatic insults including viral infections and chronic alcoholism. Cirrhosis is the most common cause of ascites and portal hypertension. 2) Portal hypertension - elevated blood pressure in the portal vein that reflects a resistance to blood flow through the hepatic portal circulation; etiologies may be prehepatic (e.g. portal vein compression by a pancreatic tumor), intrahepatic (e.g. alcoholic cirrhosis), or extrahepatic (e.g. hepatic vein or inferior vena cava occlusion due to invasion by renal carcinoma). Portal hypertension can lead to a broad spectrum of symptoms, including but not limited to ascites, splenomegaly (enlargement of the spleen), and dilation of portal-systemic anastomoses (e.g. esophageal varices).

Gallbladder & Biliary Ducts

1) gallbladder
   a) an elongated, pear-shaped organ located on the visceral surface of the liver
   b) regions
      i) fundus – projects past the anterior border of the liver
      ii) body - attached to visceral surface of the liver
      iii) neck - continuous with the cystic duct
         (1) spiral valve - fold of mucous membrane that extends into the cystic duct - keeps the lumen to the gallbladder open
   c) function

   i) stores bile - liver produces 600-1200 ml/day
   ii) concentrates bile
   iii) secretes bile
d) blood supply – cystic artery; usually a branch of right hepatic artery

2) biliary ducts
   a) common hepatic duct – formed by union of right and left hepatic ducts; conducts bile from liver to bile duct
   b) cystic duct – conducts bile between gallbladder and bile duct
   c) bile duct (common bile duct)
      i) forms in the free edge of the lesser omentum (anterior to epiploic foramen) by union of a & b above
      ii) conducts bile to the 2nd part of the duodenum
      iii) passes posterior to the 1st part of the duodenum and then in a groove or is embedded within the posterior side of the head of the pancreas
      iv) joins main pancreatic duct to form ampulla of Vater (hepatopancreatic ampulla) that pierces the duodenal wall to open into the duodenal lumen; creates elevation on inner wall called major duodenal papilla
      v) distal end of bile duct has a circular layer of smooth muscle called sphincter of the bile duct; tonically contracted
      vi) ampulla of Vater surrounded by a circular layer of smooth muscle called the sphincter of Oddi (sphincter of the hepatopancreatic ampulla); tonically contracted
3) regulation of bile flow
   a) bile is continuously produced by the liver and with a closed sphincter of the bile duct it accumulates in the gallbladder
   b) emptying of the gallbladder - hormonal and neural stimulation of the smooth muscle in the wall of the gallbladder; initiated by
      i) a fatty meal, whose entrance into the duodenum triggers the duodenal mucosa to secrete the hormone cholecystokinin, which causes the smooth muscle to contract
      ii) innervation of the smooth muscle by the vagus and enteric portions of the ANS
   c) relaxation of the sphincter of the bile duct and the sphincter of Oddi
      i) cholecystokinin is a weak relaxant
      ii) peristalsis in the duodenum – the sphincters relax with the relaxation phase of a peristaltic wave; hence bile enters the duodenum in rhythmic squirts synchronized with duodenal peristalsis
4) bile – a combination of products
   a) bile salts - facilitate digestion and absorption of fat by
      i) emulsification (breaks fat into smaller particles) that renders it more susceptible to pancreatic enzymes
      ii) forming complexes called micelles with lipids, rendering them soluble in chyme and thus easier to absorb
   b) waste products from the blood, in particular bilirubin (end product of hemoglobin breakdown from senescent erythrocytes)
   c) bicarbonate - neutralizes the acid coming into the duodenum from the stomach

Clinical Note: Gallstones - classified as cholesterol or pigment stones which have similar chemical constituents albeit in different ratios; cholesterol stones are the most common type in the U.S.. Cholesterol is a normal constituent of bile and an essential feature for gallstone formation (called cholelithiasis) is hepatic synthesis of a bile with a supersaturated concentration of cholesterol. Cholesterol precipitates out of the supersaturated bile as a cholesterol crystal that then serves as a nucleus for the formation of a larger gallstone. The calcium of bile often precipitates out with the cholesterol and its inclusion renders gallstones radio-opaque. Although less common, gallstones may also form in the bile duct system itself; called primary bile duct stones versus secondary bile duct stones that formed in the gallbladder and subsequently passed into the duct system. Clinical

presentation of gallstones ranges from mild episodic pain in RUQ or right back, reflecting transient obstruction of the cystic or bile duct, to intense persistent pain, reflecting sustained obstruction of the cystic or bile duct resulting in distension and inflammation of the gallbladder (cholecystitis) and/or bile duct (cholangitis).

Spleen

1) location
   a) intraperitoneal
   b) in LUQ entirely under cover of the thoracic cage and thus not palpable
   c) immediately deep to the left dome of the diaphragm
   d) extends between the 9th and 11th ribs immediately posterior to the midaxillary line
2) surfaces
   a) smooth, curved diaphragmatic surface
   b) irregular visceral surface
      i) abuts stomach (fundus and/or body), left colic flexure, and left kidney
      ii) hilum – a fissure through which neurovascular structures enter and exit
3) peritoneal relations
   a) gastrosplenic omentum – runs between greater curvature of stomach and hilum of the spleen
   b) splenorenal ligament – extends from hilum of spleen to anterior surface of the left kidney; contains tail of the pancreas and splenic artery
4) accessory spleens
   a) small (usually 1-2 cm) functioning spleens located near the hilum or in the adjacent splenorenal ligament or gastrosplenic omentum
   b) reflect incomplete embryonic fusion of the developing splenic mass
   c) present in about 15% of individuals
5) blood supply
   a) splenic artery
      i) branch of celiac trunk; runs along upper border of the pancreas to the hilum
      ii) usually divides into multiple branches near the hilum
      iii) sends short gastric and left gastroepiploic branches to the stomach
      iv) pancreatic branches - a major source of blood to the pancreas
   b) splenic vein – joins superior mesenteric vein to form portal vein
6) function - a lymphatic organ that
   a) filters blood - removes senescent cells and particulate matter
   b) removes iron from hemoglobin
   c) contributes to an immune response – produces lymphocytes and antibodies
   d) stores and releases blood

Clinical Notes: 1) Splenomegaly – abnormal enlargement of the spleen. The spleen is a highly distensible organ that under disease conditions may enlarge up to 10 times its normal size; typically when the spleen more than doubles in size it extends across the left costal margin where it can now be palpated. Splenomegaly is usually associated with a broad, pathologic disorder and less rarely a disease confined to the spleen itself (e.g. a space-occupying lesion such as an abscess). The most common cause of moderate and transient splenomegaly is a systemic infectious disease (e.g. viral mononucleosis). Etiologies of chronic splenomegaly include primary hematologic disorders (e.g. sickle cell anemia), infiltrative diseases (e.g. leukemia), and portal hypertension (enlargement called congestive splenomegaly). An enlarged spleen is more susceptible to rupture. 2) Ruptured spleen – while the spleen is a somewhat fragile organ due to its highly vascular nature and thin connective tissue capsule, it rarely spontaneously ruptures. Splenic rupture, leading to varying degrees of hemorrhage depending on the severity of the injury, is most often caused by penetrating (e.g. knife wound) or non-penetrating (e.g. a contact sport injury) trauma or operative trauma. The spleen is the most frequently injured abdominal

organ in non-penetrating trauma and 20% of patients with left lower rib fractures have an associated splenic injury. 3) Splenectomy – surgical removal of the spleen; performed either as a response to a splenic injury or as part of a therapeutic plan (e.g. autoimmune hemolytic anemia is a disease in which erythrocytes are prematurely destroyed as a result of the patient's own immune system, much of the destruction occurring within the spleen).

Pancreas

1) an elongated, lobulated gland resembling the shape of a tadpole
2) secondarily retroperitoneal, lying transversely across the posterior abdominal wall behind the stomach and between the duodenum and spleen
3) anatomical parts (regional definitions, not functional)
   a) head – fits into the C-shape curve of the duodenum
   b) uncinate process – small projection off the head; superior mesenteric artery and vein directly anterior to it
   c) neck – directly anterior to the formation of the portal vein
   d) body
   e) tail – in peritoneal splenorenal ligament; extends to hilum of the spleen
4) pancreatic duct system
   a) main (chief) pancreatic duct - runs entire length of the organ; smooth muscle "sphincter of the pancreatic duct" at its terminal end
   b) main pancreatic duct joins the bile duct on posterior surface of the head of the pancreas
   c) combined main pancreatic and bile ducts called ampulla of Vater (syn. hepatopancreatic ampulla) - pierces left side of 2nd part of duodenum
   d) sphincter of Oddi (sphincter of the hepatopancreatic ampulla)
      i) controls secretion into the duodenum
      ii) in a state of tonic contraction that undergoes relaxation with each peristaltic wave passing down the duodenal wall
   e) accessory pancreatic duct – drains head and may join main pancreatic duct or open into duodenum separately (minor duodenal papilla) above the main duct
5) blood supply
   a) superior and inferior pancreaticoduodenal arteries that each provide anterior and posterior branches
   b) pancreatic branches of the splenic artery
6) function - both exocrine and endocrine secretions
   a) exocrine - pancreatic juice; digestive enzymes for all three types of food (fat, proteins, and carbohydrates) and bicarbonate ions to neutralize acid from stomach
   b) endocrine - secrete glucagon and insulin that regulate carbohydrate metabolism

Clinical Note: 1) Pancreatic cancer - usually arises from the epithelial cells of the pancreatic ducts. Cancer in the head region often compresses the bile duct and/or hepatopancreatic ampulla (ampulla of Vater) and accounts for most cases of extrahepatic obstruction of the biliary system leading to obstructive jaundice (Fr. Jaune, yellow; the yellow staining of tissues, skin, mucous membranes, and conjunctiva due to impaired clearance and secretion of bilirubin). The close proximity of the portal vein, superior mesenteric vein, splenic vein, and inferior vena cava to various regions of the pancreas renders them susceptible to external compression from pancreatic tumors.

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ISBN 0-9655384-9-4