GUT, HEPATOBILIARY SYSTEM, SPLEEN AND PANCREAS

STOMACH

- Stomach is the most dilatable part of alimentary tract intervening between oesophagus and duodenum. It occupies epigastric, umbilical and left hypochondriac regions. When empty, it is J-shaped, and when partially distended, it becomes pyriform in shape. The mean capacity of stomach is 30 ml (one ounce) at birth, 100 ml at puberty and 1.5 - 2 liters in adults.
- Stomach has two orifices (proximal cardiac orifice and distal pyloric orifice), two curvatures (lesser curvature and greater curvature) and two surfaces (anterior/anterosuperior and posterior/posteriorinferior). The most dependent part of lesser curvature is marked by angular notch (incisura angularis).
- The stomach is divided into two parts by line drawn downwards and to the left from incisura angularis:
  1. **Cardiac part**: It is divided into upper convex dome shaped ‘fundus’ and body of the stomach.
  2. **Pyloric part**: Is divided into pyloric antrum and pyloric canal.

![Stomach Diagram](image)

- The posterior surface of stomach is related to structures forming the stomach bed, **all of which are separated from stomach by the cavity of the lesser sac**. These structures forming stomach bed are (i) Diaphragm, (ii) left kidney (Kreula 01), (iii) left suprarenal (adrenal gland) (Kreula 01), (iv) pancreas (body) (Kreula 01), (v) transverse colon, (vi) splenic flexure of colon and (vii) splenic artery. Sometimes spleen is also included in stomach bed, but it is separated from stomach by greater sac (not lesser sac).

**Arterial supply**
- Arterial supply of stomach is as follows:
  - Along lesser curvature: Left gastric artery (P[GI 00], 01) (branch of coeliac trunk (Comed 07)) and right gastric artery (P[GI 01], 04) (branch of proper hepatic artery (Comed 07)).
  - Along greater curvature: Right gastroepiploic artery (branch of gastroduodenal artery) and left gastroepiploic artery (branch of splenic artery (P[GI 00], 01; Comed 07)).
  - Fundus: 5-7 short gastric arteries (branches of splenic artery (P[GI 00], 01; Comed 07)).

**Venous drainage**
- The veins of stomach drain into the portal (P[GI 00], 01), superior mesenteric (P[GI 02]) and splenic (P[GI 03]) veins:
  - Right gastric vein and left gastric vein drain into portal vein (P[GI 02]).
  - Short gastric vein and left gastroepiploic vein drain into splenic vein (P[GI 02]).
  - Right gastroepiploic vein drains into superior mesentric vein (P[GI 02]).

**Lymphatic drainage**
- Lymphatic drainage of stomach is divided into 4 sectors:
  1. **Sector a**: Upper part of left 1/3 of body along greater curvature and fundus drain into pancreaticosplenic nodes (NL 00).
  2. **Sector b**: Body of stomach along lesser curvature drains into left gastric nodes (superior gastric nodes).
  3. **Sector c**: Lower part of body close to greater curvature and pyloric antrum drain into right gastroepiploic (inferior gastric) nodes (NL 00) which in turn drains into subpyloric (pyloric) nodes (NL 00).
  4. **Sector d**: Pyloric canal drains into pyloric (subpyloric) nodes (NL 00), hepatic nodes and left gastric nodes.
- Finally all lymphatics from these nodes drain into coeliac group of lymph nodes (NL 00).
**Nerve supply**

- The stomach is supplied by sympathetic and parasympathetic system. The sympathetic nerves are derived from T₅-T₁₂, spinal nerve segments via greater splanchnic nerves, and coeliac and hepatic plexus. Pain sensations from stomach are carried along sympathetic fibers. The parasympathetic nerves are derived from right vagus and left vagus which enter the abdomen as anterior vagal trunk (anterior gastric nerve) from left vagus and posterior vagal trunk (posterior gastric nerve) from right vagus.

- **Anterior vagal trunk gives:** (i) Main gastric nerve of laterjet (PG197), (ii) Pyloric branch and (iii) Hepatic branch.

- **Posterior vagal trunk gives:** (i) Nerve of Grussi to fundus, (ii) Coeliac branches, and (iii) Main gastric nerve of laterjet (PG197).

**SMALL INTESTINE**

- The small intestine extends from the pyloric end of stomach to ileo-caecal junction. It consists of the proximal fixed part, the duodenum, and the lower mobile part which includes the jejunum and ileum. The total length of small intestine is about 6 meters long.

**DUODENUM**

- Duodenum is ‘C’ shaped, shortest, widest and most fixed part of small intestine. It is 25 cm long. It is devoid of mesentry. Most of the duodenum is retroperitoneal and fixed, except at its two ends where it is suspended by folds of peritoneum, and is therefore mobile. Duodenum lies opposite L1, L2 and L3 vertebrae.

- Duodenum is C-shaped curve which encloses the head of pancreas and is subdivided into four parts:
  1. **First part (Superior part):** It is 5 cm (2 inches) long. It begins at the pylorus and meet the second part at superior duodenal flexure. This part appears as duodenal cap on barium studies.
  2. **Second part (Descending part):** It is about 7.5 cm (3 inches) long. It is vertical part which begins at superior duodenal flexure and meet the third part at inferior duodenal flexure. The interior of second part of duodenum shows following features:
     i) **Major duodenal papilla:** It is present 8-10 cm distal to the pylorus. The hepatopancreatic ampulla (joint part of bile duct and pancreatic duct) opens here.
     ii) **Minor duodenal papilla:** It is present 6-8 cm distal to the pylorus. Accessory pancreatic duct opens here.
  3. **Third part (Horizontal part):** It is 10 cm (4 inches) long. It begins at inferior duodenal flexure and passes towards the left in front of IVC behind superior mesenteric vessels and root of mesentery to meet 4th part of duodenum.
  4. **Fourth part:** It is 2.5 cm (1 inches) long and runs upward immediately to the left of aorta. It ends at duodenojejunal flexure by joining the jejunum.
Arterial supply

- The part of duodenum before the opening of bile duct (major duodenal papilla) develops from foregut and therefore is supplied by coeliac trunk through superior pancreaticoduodenal artery (APMS 02), a branch of gastroduodenal artery, which in turn is a branch of common hepatic artery (APMS 02). Part of duodenum distal to opening of bile duct is developed from midgut (DPG 91, 98) and therefore is supplied by superior mesenteric artery through inferior pancreaticoduodenal artery. First part of duodenum receives additional supply from right gastric artery, supraduodenal artery (APMS 02) (a branch of common hepatic artery (APMS 02)), retroduodenal branch of gastroduodenal artery and right gastropiploic artery.

Histological features

- Mucous membrane shows villi (evaginations) and crypts of lieberkühn (invaginations). Submucosa is full of mucus-secreting Brunner’s glands.

JEJUNUM AND ILEUM

- The lower mobile part of small intestine includes jejunum (upper 2/5) and ileum (lower 3/5). Jejunum and ileum are suspended from posterior abdominal wall by the mesentery. They are supplied by superior mesenteric vessels (APMS 91, PGI 88) as they are midgut derivatives.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Jejunum</th>
<th>Ileum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Location</td>
<td>Occupies upper and left parts of the intestinal area</td>
<td>Occupies lower and right parts of the intestinal area</td>
</tr>
<tr>
<td>2. Walls</td>
<td>Thicker and more vascular</td>
<td>Thinner and less vascular</td>
</tr>
<tr>
<td>3. Lumen</td>
<td>Wider and often empty</td>
<td></td>
</tr>
<tr>
<td>4. Mesentery</td>
<td>a) Windows present</td>
<td>a) No windows</td>
</tr>
<tr>
<td></td>
<td>b) Fat less abundant</td>
<td>b) Fat more abundant</td>
</tr>
<tr>
<td></td>
<td>c) Arterial arcades, 1 or 2</td>
<td>c) Arterial arcades, 3 or 6</td>
</tr>
<tr>
<td></td>
<td>d) Vasa recta longer and fewer</td>
<td>d) Vasa recta shorter and more numerous</td>
</tr>
<tr>
<td>5. Circular mucosal folds</td>
<td>Larger and more closely set</td>
<td></td>
</tr>
<tr>
<td>6. Villi</td>
<td>Large, thick (leaf-like) and more abundant</td>
<td>Shorter, thinner (finger-like) and less abundant</td>
</tr>
<tr>
<td>7. Peyer’s patches</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>8. Solitary lymphatic follicles</td>
<td>Fewer</td>
<td>More numerous</td>
</tr>
</tbody>
</table>

- Peyer’s patches are aggregated lymphoid follicles which are more numerous in ileum and are present along antimesenteric border (APMS 91).
- The nervous and villous coat of jejunum are extensive and are thrown into folds, called Valvulae conniventes (PGI 89) (plica circulare).

Meckel’s diverticulum

- Meckel’s diverticulum is the persistent proximal part of the vitellointestinal duct (PGI 87) which normally disappears during intrauterine life. It follows ‘rule of 2’: present in 2% subjects (51, 98, PGI 88), 2 inches (5 cm) long and is situated
Interior of anal canal
- The interior of anal canal is divided by pectinate line and Hilton’s white line into three parts.
  1) Upper part (mucous part)
     - It is upper 15 mm part of anal canal and extends up to pectinate line. It is lined by mucous membrane which is simple columnar. Mucosa shows 6-10 longitudinal folds called anal columns of Morgagni. Lower ends of these folds are united by short transverse folds, anal valves. Line of attachment of anal valve is known as pectinate line or dentate line. Slight depression above each anal valve is known as anal sinus.
  2) Middle part (transitional zone or pecten)
     - This area is 15 mm in extent and intervenes between pectinate (dentate) line and Hilton’s white line. It is lined by non-keratinized stratified squamous epithelium without sebaceous and sweat glands.
  3) Lower part (cutaneous part)
     - It is about 8 mm in extent and is lined by true skin, i.e. stratified squamous keratinizing epithelium with sebaceous and sweat glands.

Development of anal canal
- Part of anal canal above pectinate line develops from dorsal part of endodermal cloaca (primitive rectum) and part of anal canal below pectinate line develops from ectodermal proctodeum.

Nerve supply
- Mucous membrane above pectinate line is supplied by autonomic nerves (sympathetic L1 L2 and parasympathetic: S1 S2 S3) and therefore is insensitive to pain. Part below the pectinate line is supplied by somatic nerves (inferior rectal nerve a branch of pudendal nerve) and therefore is sensitive to pain. Thus pain sensations are carried by pudendal nerve.

Lymphatic drainage
- Pectinate line forms the water-shed line of anal canal. Area above pectinate line drains into internal iliac nodes and area below it drains into superficial inguinal nodes.

Blood supply
- Arterial supply of the area is above pectinate line is through superior rectal artery (continuation of inferior mesenteric artery) and area below pectinate line is supplied by inferior rectal artery.
- Venous drainage above the pectinate line is through superior rectal vein which drains into inferior mesenteric vein, a branch of splenic vein (portal system) and below the pectinate line is through inferior rectal vein which drains into internal pudendal vein (systemic circulation). Thus pectinate line is the level of porto-systemic anastomosis and internal hemorrhoids develop just above pectinate line. Venous drainage occurs through :-
  i) Internal rectal venous plexus (Hemorrhoidal plexus) - It lies in the submucosa of anal canal and drains mainly into superior rectal vein, but communicates freely with external plexus. The internal plexus is in the form of a series of dilated pouches and veins present in the 3, 7 and 11 o’clock positions (as seen in lithotomy position) are large and constitute potential sites for primary internal piles (hemorrhoids).
  ii) External rectal venous plexus - It lies outside the muscular coat of rectum and anal canal. Lower part is drained by inferior rectal vein into internal iliac vein; the middle part by middle rectal vein into internal iliac vein; and upper part by superior rectal vein.
  iii) Anal veins - These are arranged radially around anal margin and communicate with internal plexus and inferior rectal veins. Rupture of these veins may cause perianal hematoma called external piles.

Anal sphincters
- Two sphincters, internal and external, surround the anal canal.
  Internal sphincter (sphincter ani internus)
    - It is an involuntary sphincter formed by thickening of circular muscle of lower part of rectum. It surrounds upper 3/4 of anal canal and lower end of internal sphincter corresponds with Hilton’s line. Internal sphincter is supplied by sympathetic fibers through superior hypogastric plexus and by parasympathetic fibers from pelvic splanchnic nerves (S2 S3 S4) . Internal sphincter remains in the state of tonic contraction most of time to maintain resting tone or pressure.
  External sphincter (sphincter ani externus)
    - It is a voluntary sphincter and surrounds the entire length of anal canal. It is made up to striated muscle and consists of three parts - Subcutaneous, superficial and deep. It is supplied by inferior rectal nerve and perineal branch of S.
    - External sphincter is contributed by fibers from puborectalis part of levator ani muscle in upper most part; superficial transverse perineal muscles anteriorly and anococcygeal raphe posteriorly (in upper third) and anococcygeal ligament (in middle third).
HEPATOBLIARY SYSTEM

LIVER

- Liver is the largest gland of body situated in right upper quadrant of abdominal cavity and occupies whole of the right hypochondrium, greater part of epigastrum with extension into left hypochondrium. It weighs about 1500-1600 gm in males and 1200-1300 gm in females.
- Liver has five surfaces: anterior, posterior, superior, inferior and right. It has only one prominent border, inferior border.
- Liver is covered by Glisson's capsule. Interior of liver is divided into hexagonal lobules. Lobule contains sinusoids which have fenestrated endothelium covering the subendothelial space of Disse. Two important cells in liver are hepatocytes (Parenchymal cells) and kupffer cells (monocytic-macrophages).

Lobes of liver
- The liver can be divided into right and left lobe anatomically and physiologically.

Anatomical lobes
- Anatomically liver is divided into a large right lobe and a small left lobe by line of attachment of falciform ligament (anterosuperiorly), fissure for ligamentum teres (inferiorly), and fissure for ligamentum venosum (posteriorly). Right lobe is much larger and forms five-sixth of liver and left lobe forms only one-sixth. Caudate lobe and quadrate lobe are parts of anatomical right lobe.
  - Caudate lobe: It is situated on posterior surface of right lobe, bounded by groove for IV 
    tractus (PFU), on left by fissure for ligamentum venosum, and inferiorly by porta hepatitis containing hepatic artery, portal vein, bile duct, nerve plexus and lymphatics. Just behind the porta hepatitis caudate lobe is connected to rest of right lobe by caudate process. There is a small rounded elevation to the left called papillary process. Caudate lobe lies in superior recess of lesser sac and is related to crura of diaphragm, right inferior phrenic artery and coeliac trunk.
  - Quadrate lobe: It is situated on the inferior surface and rectangular in shape. It is bounded anteriorly by inferior border of liver, posteriorly by porta hepatitis, on right by fossa for gall bladder and on left fissure for ligamentum teres.

Physiological lobes
- Physiologically right and left lobes are equally divided by an imaginary line (cholecysto-vena caval line) running from fossa for gall bladder to the groove for IVC. The physiological right and left lobes have separate biliary drainage and vascular supply, i.e. they are supplied respectively by right and left branches of portal vein and hepatic artery and bile is conveyed by the corresponding hepatic ducts (bile ducts).
  - Quadrate lobe (anatomical part of right lobe) belongs to physiological left lobe because it is supplied by a branch of left hepatic artery and left branch of portal vein and is drained into left hepatic duct.
  - Caudate lobe (anatomical part of right lobe) belongs physiologically to both right and left lobes because it receives blood from right and left hepatic arteries; right and left branches of portal vein; and drains bile into both right and left hepatic ducts.

Segmental anatomy of the liver
- Based on the distribution of portal vein and hepatic vein, Couinaud divided each physiological (functional) lobe of liver into 4 segments each and hence liver is divided into 8 segments. The physiological left lobe is composed of 4 segments designated I to IV and is supplied by left branch of hepatic artery, left branch of portal vein and drained by left hepatic duct. The physiological right lobe consists of segment V, VI, VII, and VIII and is supplied by right branch of portal vein and drained by right hepatic duct.
- Segment I corresponds to caudate lobe and segment IV to quadrate lobe.
- Right lobe is subdivided into anterior and posterior segment and left lobe into medial and lateral segments. Thus, the segments of liver are:
  1. Right anterior → V(AIMS 3) (inferior), VIII(AIMS 3) (superior)
  2. Right posterior → VI (inferior), VII (superior)
Blood supply

- Liver has dual blood supply and receives 20% of its blood supply through hepatic artery and 80% through portal vein.
- Venous drainage is through hepatic veins into IVC.

**EXTRAHEPATIC BILIARY SYSTEM**

- Extrahepatic biliary system, as the name suggests, is the part of biliary system which is outside the liver. It includes right and left hepatic duct, common hepatic duct, Gall bladder, Cystic duct, Bile duct:

![Diagram of biliary system](image)

- Right and left hepatic ducts unite at the right end of porta hepatis to form common hepatic duct. Common hepatic duct is 3 cm long and is joined by cystic duct (from its right side) to form Bile duct. Bile duct is about 8 cm long and passes downwards and backwards in the free margins of lesser omentum, crosses posterior to 1st part of duodenum to open in 2nd part of duodenum after joining the pancreatic duct. Bile duct is divided into following parts:
  
  1. **Supraduodenal part (above first part of duodenum):** This part lies in the free margins of lesser omentum. Its relations are:
     - Anterior → Liver
     - Posterior → Portal vein and epiploic foramen
     - Left side → Hepatic artery
  
  2. **Retro-duodenal part (behind first part of duodenum):** Its relations are:
     - Anterior → 1st part of duodenum
     - Posterior → IVC
     - Left side → Gastro-duodenal artery
  
  3. **Infraduodenal part (below first part of duodenum):** Its relations are:
     - Anterior → Head of pancreas
     - Posterior → IVC
  
  4. **Infraduodenal part (within second part of duodenum):** In the wall of duodenum, bile duct unites with pancreatic duct to form hepatopancreatic ampulla (ampulla of Vater) which opens in 2nd part of duodenum at major duodenal papilla, 8-10 cm distal to pylorus.

- Preampullary part of bile duct (terminal part of bile duct just before its junction with pancreatic duct) is surrounded by sphincter choledochus (sphincter of Boyden). This sphincter is always present. Terminal part of pancreatic duct (preampullary part of pancreatic duct) is surrounded by sphincter pancreaticus. Other sphincter surrounds
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hepatopancreatic ampulla, called **sphincter of Oddi proper (sphincter ampulla)**. Actually all the three sphincter are considered as **sphincter of Oddi** (AMS 16.99).

![Blood supply of the gall bladder and bile ducts](image)

**Gall bladder and cystic duct**
- Gall bladder is a pear-shaped hollow viscus situated in a non-peritoneal fossa on the undersurface of right lobe of liver. It is 7-10 cm long, 3 cm broad and has a capacity of 30-50 ml. Gall bladder is divided into (from below upwards): fundus, body and neck. Fundus projects beyond the inferior border of liver (AMS 99). Body lies in the fossa for gallbladder on the undersurface of right lobe of liver. Neck is 'S' shaped and extends from the body to cystic duct, i.e. neck becomes continuous with cystic duct. From the neck, a small diverticulum known as **Hartman's pouch** projects downwards and backwards towards the duodenum. The wall of gall bladder is made up of mucous membrane, a fibromuscular coat (AMS 99) and a serous layer that covers part of organ. The mucosa is noted for outpouchings extending into and through muscular fibers, called as **Rokitansky-Aschoff sinuses**.
- Cystic duct is 3-4 cm in length and begins from the neck of gall bladder. It passes downwards, backwards and to left and ends by joining the right side of common hepatic duct at an acute angle to form bile duct. The interior of cystic duct presents about 5 to 12 crescentic valves known as spiral valves of Heister (AMS 99). Angle between the cystic duct and common hepatic duct contains cystic node (AMS 99).

**SPLAEN AND PANCREAS**

**SPLAEN**
- The spleen is a lymphoid organ situated in the upper and left part of abdomen between fundus of stomach and diaphragm. It lies mainly in left hypochondrium (lateral 2/3) and partly in epigastrium (medial 1/3). On an average, spleen is 1 inch (2.5 cm) thick, 3 inches (7.5 cm) broad, 5 inches (12.5 cm) long and 7 ounces in weight. It is related to 9th to 11th ribs on left side (AMS 99). The spleen lies obliquely along the long axis of th 10th rib (AMS 99). Thus it is directed downwards, forwards and laterally, making an angle of about 45 degrees with horizontal plane (AMS 12).

**Gross morphology**
- Spleen has two ends (anterior or lateral and posterior or medial), three borders (superior, inferior and intermediate), two surfaces (visceral and diaphragmatic), two angles (anterobasal angle or posterobasal angle) and hilum.
- Anterior end is supported by phrenicolicigament (AMS 99).
- Superior border is characteristically notched near its anterior end (AMS 99).
- Visceral surface is related to fundus of stomach (AMS 99) (at gastric impression), left kidney (AMS 99) (at renal impression), splenic flexure of colon (AMS 99) (at colic impression) and tail of pancreas (at pancreatic impression). Its lower end is related to phrenicolicigament. Diaphragmatic surface is related to the diaphragm.
- Spleen is surrounded by peritoneum and is suspended by following ligaments:
  - **Gastroplenic ligament**: It connects the hilum of spleen to stomach (greater curvature). It contains short gastric vessels, associated lymphatics and sympathetic trunk.
Liver:
- Superior layer of coronary ligament
- Falciform ligament
- Ligamentum teres
- Glissonean

Liga. Teres:
- Caudate lobe
- Hepatic duct
- Hepatic a. Portal vein
- Quadrate lobe

Sup. layers of coronary lig. Base area
Inf. layers of coronary lig. IVC

Note: The diagram includes various anatomical structures labeled with text.
6. Anterior gastric nerve contains mainly the left vagal fibres, and the posterior gastric nerve mainly the right vagal fibres. Each gastric nerve is represented by one or two trunks and combines a few sympathetic fibres from the greater splanchnic nerve (Fig. 19.12a).

HISTOLOGY

Mucous membrane—Epithelial lining is stratified squamous nonkeratinised in nature. Lamina propria consists of loose connective tissue with papillae.

Muscularis mucosae is distinct in lower part and formed by longitudinal muscle fibres.

Submucosa contains mucus secreting oesophageal glands.

Muscularis externa is composed of striated muscle in upper third, mixed type in middle third and smooth muscles in lower third. Its outer layer comprises of longitudinal coat and inner layer comprises of circular coat of muscle fibres.

Adventitia is the connective tissue with capillaries.

CLINICAL ANATOMY

- The lower end of the oesophagus is one of the important sites for portosystemic anastomoses. In portal hypertension, the anastomoses opens and forms venous dilatations called oesophageal varices. Their rupture causes severe and dangerous haematemesis (Fig. 19.4).

- Normally the lower end of the oesophagus remains closed and dilates only during the passage of food. However, due to neuromuscular incoordination it may fail to dilate leading to difficulty in passage of food or dysphagia. The condition is known as achalasia cardia. Marked dilatation of the oesophagus may occur due to collection of food in it (Fig. 19.5).

- The lower end of the oesophagus is also prone to inflammation or ulceration by regurgitation of acid from the stomach. It is the commonest site of oesophageal carcinoma. Next site is the middle third of oesophagus.

- Hiatal hernia occurring through the oesophageal opening and can be rolling or paraesophageal and sliding (Figs 19.6a and b).

- Barrett's oesophagus: Squamous epithelium of lower oesophagus may be replaced by columnar epithelium in certain clinical conditions. The abnormal type of epithelium present in oesophagus is referred as Barrett's epithelium.

- Tracheo-oesophageal fistula: At times the separation of trachea and oesophagus may not be complete. Proximal segment ends in a blind pouch and distal segment communicates with trachea (Fig. 19.7).

- The lumen of the oesophagus may be abnormally narrowed due to improper canalisation.

- The lumen of oesophagus may not be canalised at all leading to oesophageal stenosis.