University of Mosul
Lecture No.:
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Lecture title: **Digestive system**

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Summary:

Motility of Small Intestine

The peristaltic waves at the proximal part of intestine are rapid and far spreading which gradually become shorter and slower towards the distal gut to achieve different transit rates along the intestine.

Under physiological conditions, small intestine exhibits different contractile patterns: -

1. **Peristaltic waves:**

This type of intestinal movement moves the ingesta along the intestine (propulsive movement)

Mechanism of peristaltic reflex

Bolus food

↓

Stretch of smooth muscle

↓

Stimulate of myenteric plexus to release Ach + substance P (contract of circular smooth muscle)

↓

But, nitric oxide + vasoactive intestinal polypeptide (relax longitudinal smooth muscle)

↓

So, Peristaltic to facilitate an aboral transport of chyme (forward)

2. Segmenting contractions (Stationary contractions):

This type of intestinal movement **does not move the ingesta** along the intestine but the segmental contractions at single sites, just **mixes** to facilitates absorption by bringing the ingesta into the intestinal walls.

mechanism of segmented contraction

the bolus of food initiate reflex

⇓

Contractions of circular smooth muscles divide the ingesta into segments.

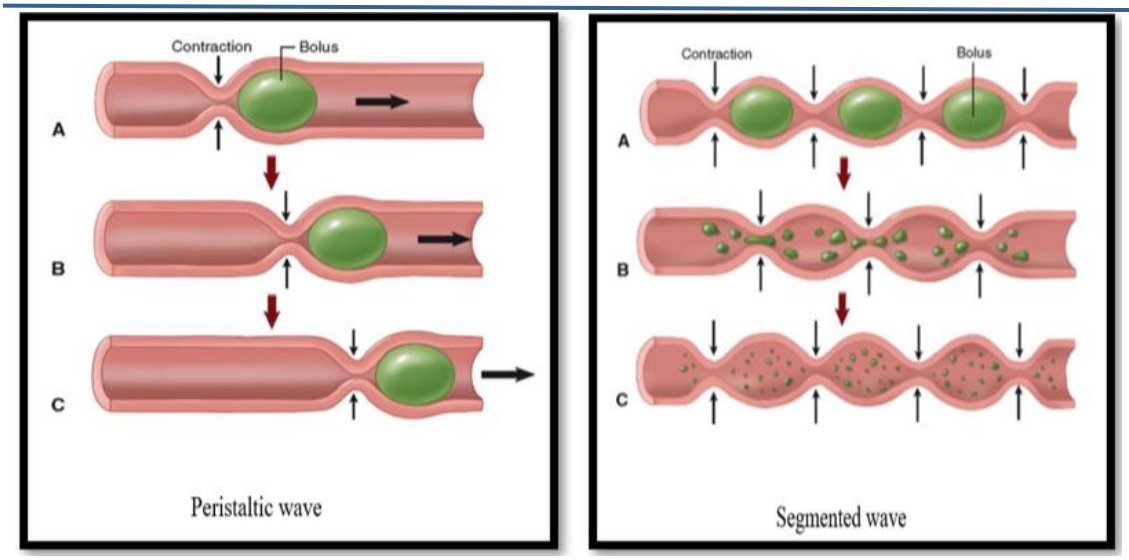
⇓

The segment to force the chyme both backward (retrograde) and forward (anterograde), unlike peristalsis **within single region**

⇓

It occurs to pushed **orally** and **aborally** at a localized area for the mixing of the luminal contents.

- After few seconds the next series of contractions are occurs Segmentation contractions occurring at rate of 12-16 per minute



3. Migrating Motility Complex (MMC):

- Occur between meals (fasting state)
- Type of peristaltic start from stomach to ilium
- All cycle occurs during 2 hours
- The main function of MMC is sweep the dead cell, bacteria, undigested food driven by hormone called **"motilin** "

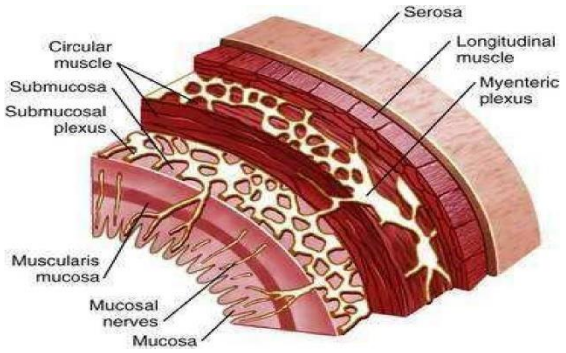
Enteric nervous system

- A third division of the nervous system is enteric nervous system – is considered by some physiologists to be a part of the autonomic nervous system and by others to be independent of that system.
- The enteric nervous system consists of two large nerve networks located in the walls of the digestive tract, identified as: -

1- submucosal (Meissner) plexus: is located between the circular muscle and the submucosa; it senses the environment of the lumen and regulates gastrointestinal blood flow and epithelial cell function.

2- myenteric (Auerbach) plexus. is located between longitudinal and circular layers of muscle; it is involved in control of digestive tract motility. It is referred to as a "**Mini brain**" or "**Gut brain**".

- The parasympathetic efferent system is the primary controller of functions by increasing peristalsis (motility), secretion, and digestion by vagus nerve (medulla) with pelvic nerves (sacral region).
- The sympathetic efferent system opposite actions of the parasympathetic efferent system, but their action is minor, just effect on blood flow during (fight or flight reflex) and strong stimulation causing constipation.



Pancreas

- Pancreas is a lobulated gland comprises two distinct components exocrine and endocrine.
- The exocrine pancreas is an acinus gland that stored pancreatic enzymes in the form Proenzymes (inactive) and convert to active enzyme only when in the duodenum to avoids self- digestion of the pancreatic cells
- ducts drain separately into the duodenum along with common bile duct by sphincter of Oddi.

- The exocrine secretion and their function include: -
  1) Pancreas secrets HCO3 ions that neutralizes acid chyme entering into the duodenum.
  2) Pancreas released enzymes from of an acinus gland upon activation for digestion of carbohydrates, proteins, and lipids.

- Types of pancreatic enzymes: -

1) **Pancreatic α-amylase** causes hydrolysis of α-1,4-glucosidic bonds present in starch and glycogen.

2) **Proteolytic enzymes** for protein hydrolysis includes:

1. Endopeptidases cleave interior peptide bonds such as (Trypsin, Chymotrypsin and Elastase)
2. Exopeptidases act at the amino terminal (carboxypeptidases A and Carboxypeptidase B).

3) Pancreatic enzymes for lipid hydrolysis includes:
   1. **lipase** hydrolyses dietary triglycerides into glycerol, monoglycerides, and fatty acids with aid of **Bile salts** to emulsified fat
   2. **phospholipase** A that converts lecithin to lysolecithin.

4) Nucleic acids are split into nucleotides by the **pancreatic nucleases**.

- The endocrine secretion of pancreas by of "**Islets of Langerhans**"
  1. (α) cells –secrete glucagon (Increase blood glucose levels)
  2. (β) cells-secrete insulin (Decrease blood glucose levels)
  3. (δ) cells - secrete somatostatin (Inhibit the secretion of insulin and glucagon).
  4. (F/γ) cells - secrete pancreatic polypeptide (Inhibits exocrine pancreatic secretions)

Control of Pancreatic Secretion

1. Cephalic phase:

It is induced by sight, taste, and smell of food. Acetylcholine is released from vagal nerve endings and acts through muscarinic receptors to increase enzymes exocytosis with little amount of water and electrolytes.

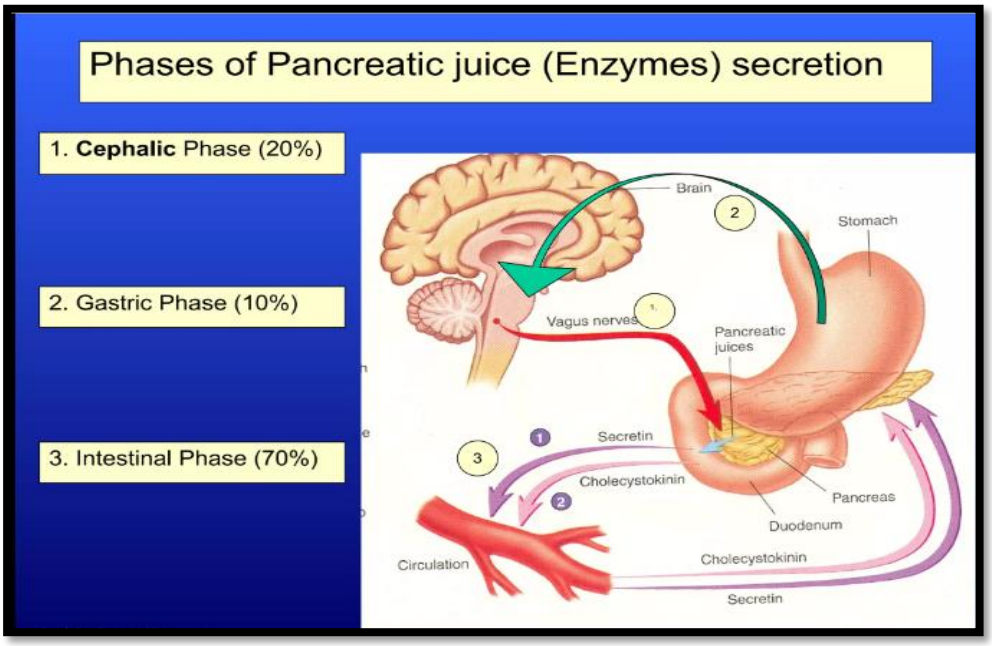
2. Gastric phase:

It is initiated after the presence of food in stomach. Gastric distension stimulates stretch receptors and to initiate gastro-pancreatic reflex.

3. Intestinal phase:

The copious secretion of pancreatic enzymes along with water and electrolytes occurs during the intestinal phase. The enzyme secretion is mediated by

- CCK under the influence of proteoses
- Secretin cause secretion of water and bicarbonate



Liver

- hepatobiliary system comprises liver, gall bladder, and bile ducts.
- Liver is the largest gland in the body that performs wide ranges of physiological functions including: (**liver functions**)
  - Metabolic functions: Carbohydrates, fats, proteins, synthesis of lipoproteins-HDL, LDL, VLDL (cholesterol homeostasis)
  - Synthetic functions: plasma proteins, clotting factors, enzymes (GOT, GPT), urea
  - Immunity by phagocytic cell in the liver called (**Kupffer cells**).
  - Endocrine function of the liver: is responsible for secreting hormone precursors such as insulin-like growth factor (somatomedin), angiotensinogen, thrombopoietin.

- Detoxification of xenobiotic compounds, drugs, and hormones.
- Finally, bile secretion

Gall bladder

- Gall Bladder, it is a pear-shaped organ that helps to store bile until the body needs it for digestion.
- The cell of the liver (hepatocytes) produces **bile** (complex lipid-rich hepatic secretion) that transports through bile ducts into the **gall bladder**
- The cell in the bile called **cholangiocytes**

- Composition of Bile:

Is made up of:

1. water
2. bile salt (sodium and potassium salts)
3. bile pigment (Bilirubin and biliverdin)
4. bile acids are two types:

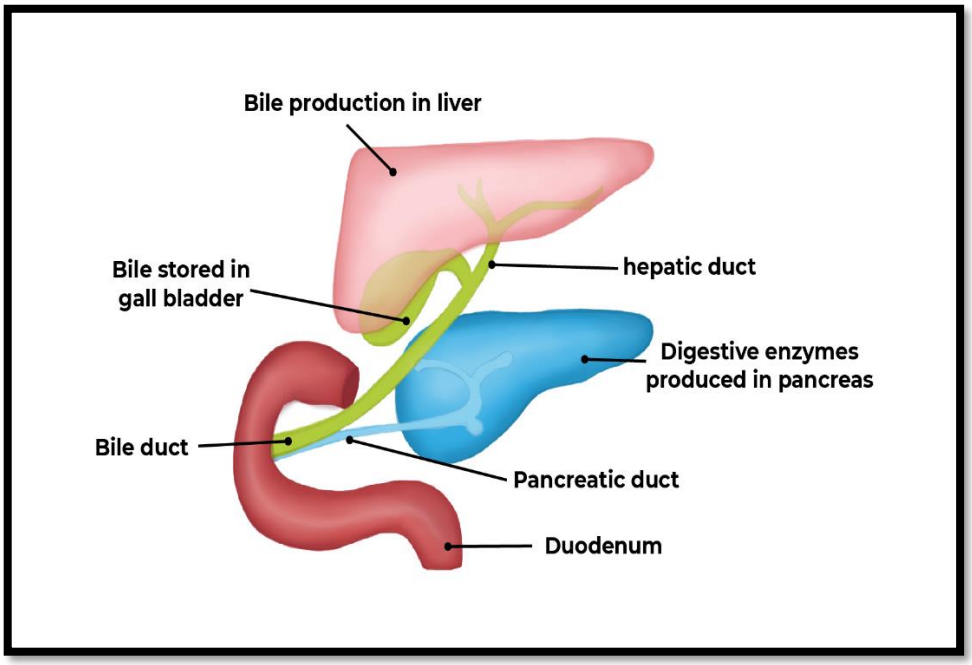
- Primary bile acids are produced by hepatocytes from cholesterol. (cholic acid & chenodeoxycholic acid).
- When they reach duodenum and colon, they are converted into Secondary bile acids (deoxycholic acid and lithocholic acid) by bacterial action.

- **Function of bile**:

1. Bile increases the solubility of lipids (cholesterol and long-chain fatty acids) and reduce surface tension for better enzymatic actions to promotes the digestion and absorption by forming the **"micelle"** in a process known as "emulsification"

2. Bile also helps in the absorption of fat-soluble vitamins (A, D, E, K).

3. The bile act as bacteriostatic actions in the GI tract by damaging the membrane of microbes.



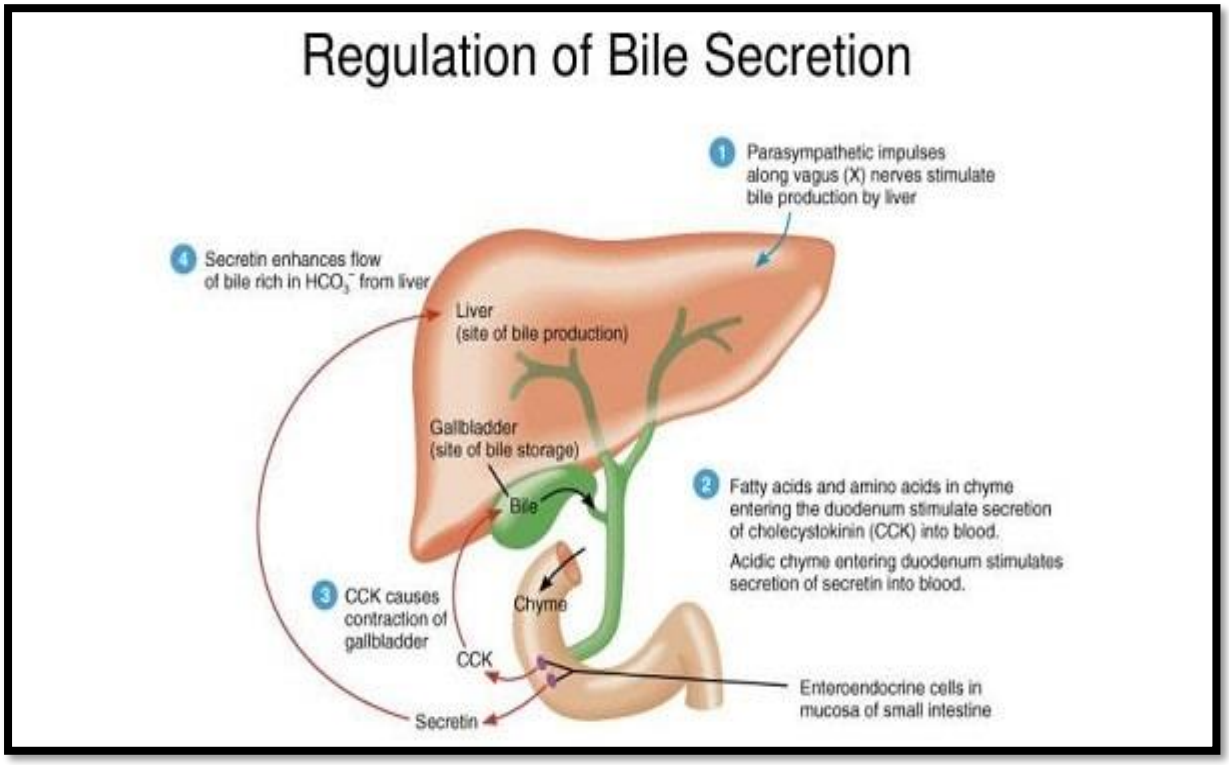
Control of Bile Secretion

1. Agents that increase the secretion of bile are called **choleretics** (bile salts and Secretin).

2. The hepatic duct system, sphincter of Oddi, and gall bladder are innervated by ANS. **Parasympathetic** nervous system increase bile flow, but **sympathetic** system decreases bile flow.

3. **Cholecystokinin (CCK)** is the only known hormone that contracts the gallbladder along with relaxation of the sphincter of Oddi.

4. **Secretin** has stimulatory role in bicarbonate secretion HCO_3.



Large intestine

- Unlike small intestinal mucosa, the villi are absent in large intestine but contains **deep tubular pits** for

Function of large intestine:

1. The large intestine serves as fermentation chambers wherein microbial digestion takes place
2. Absorption of water and electrolytes from the chyme to form solid feces.

3. Absorption of vitamins, and some of them are synthesized by bacteria that grow in the colon.
4. Storage of fecal matter until it can be expelled

- The colonic mucosal cells include:
  1) **Goblet cells** They secret mucins that provide physical protective barrier against intestinal pathogens.
  2) **Microfold (M) cells** specialized epithelial cells found in the intestinal lymphoid tissue (Peyer's patches).
  3) **Paneth cells** are situated at the base of the intestinal crypt responsible for the secretion of antimicrobial.

Motility of Large Intestine

1. Peristaltic and antiperistaltic waves:

These are characteristic motor patterns of the caecum and proximal colon. Waves with slow contractions (**Peristaltic**), followed by low retropulsion is causes by an intensive mixing of chyme (**Antiperistaltic**).

2. Segmenting contractions:

These are **unique** contractile patterns of the large intestine frequently seen in dogs and horses, in contrast to the segmenting contractions of the small intestine, the segmenting contractions of large intestine represent long-lasting circular contractions that occur simultaneously at adjacent sites with slow distal movement.

3. Haustral movements:

Haustral movements are types of segmenting contractions. haustra are characterized either by an oral or aboral rolling movement causing absorption of liquids rather than for mixing movement.

Defecation

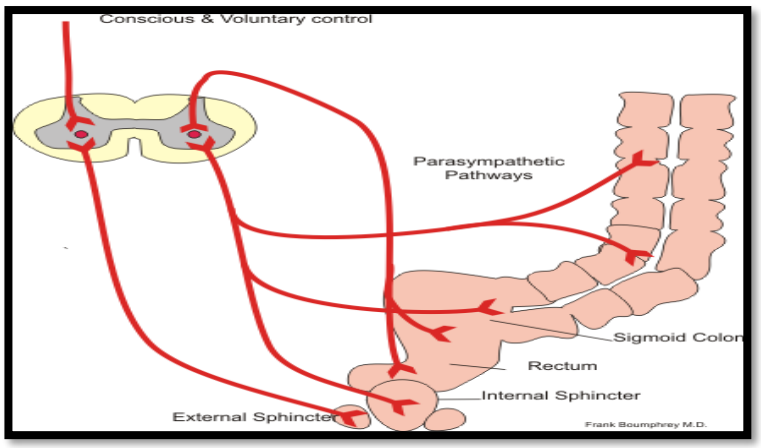
- It is the act of expelling feces from the digestive tract through the anus.

- Defecation requires a complex and synchronized interactions between gastrointestinal system, nervous system, and musculoskeletal system.
- The anal opening is surrounding by **internal** (involuntary circular smooth muscle) and **external anal sphincter** (voluntary striated muscle).
- The fecal contents are channelized into the rectum by peristalsis of colon. The filling of rectum stimulates mechanoreceptors of the wall of the rectum to initiate defecation reflexes.

- The reflexes are of two types:

1. Intrinsic reflex: It is mediated by enteric nervous system (myenteric plexus) after the distension of rectal wall. It causes relaxation of internal anal sphincter to allow a small amount of feces to pass through to the anal canal. It is called the **recto-anal inhibitory reflex.**

2. Defecation reflex (Parasympathetic):
   - In the reflex, the signals for rectal filling first transmitted into the spinal cord and then back to the descending colon, sigmoid, rectum, and anus through parasympathetic nerve fibers in the pelvic nerves.
   - These parasympathetic signals result strong peristaltic waves followed by relaxation of the internal anal sphincter (smooth m.) to clear the bowl.
   - Voluntary defecation can be limited by relaxing the external sphincter (striated muscle) that stimulated by somatic nervous system.
   - Contracting the abdominal muscles, thus aiding the reflex emptying of the distend rectum.
   - Distention of the stomach by food initiates contractions of the rectum and a desire to defecate **(gastro colic reflex).**


Conscious & Voluntary control
Parasympathetic Pathways
Sigmoid Colon
Rectum
Internal Sphincter
External Sphincter
Frank Boumphrey M.D.