DIGESTION IN THE DUODENUM.
THE ROLE OF THE PANCREAS AND LIVER IN DIGESTION

Glands of the duodenal mucosa:

Brunner glands (similar to pyloric),
Liberkune glands (typical intestinal glands).

pH 7.2-8.0 (without digestion)

pH 4.0-8.5 (upon receipt of food)

Methods for Research of Digestion in Duodenum

- **Experimental**

- fistula of the pancreatic duct
- gallbladder fistula
- fistula of the common bile duct

- **Clinical**

- sounding

Pancreatic Juice Composition

Colorless, clear alkaline reaction liquid (pH = 7.8-8.4)

- bicarbonates (neutralize hydrochloric acid coming from the stomach)
- proteolytic enzymes (break down proteins to amino acids)

- exopeptidases (carboxypeptidase A and B, aminopeptidase)

- endopeptidases (trypsin, chymotrypsin, elastase)

- lipolytic enzymes (phospholipase, lipase)
- glycolytic enzymes

(α-amylase, maltase, lactase and others)

- trypsin inhibitor

The mechanism of Activation of Proteolytic Enzymes

- Proteolytic enzymes are secreted in an inactive state (trypsinogen, chymotrypsinogen, proelastase, procarboxypeptidases A and B).
- Enzyme activation occurs in the lumen of the duodenum.
- Trypsinogen is the first to enter the active state under the action of enterokinase.
- Enterokinase is an enzyme (enzyme enzyme) that is secreted by the Brunner glands under the influence of hydrochloric acid.
- Trypsinogen is converted to trypsin.
- Trypsin activates all other proteolytic enzymes.
- Trypsinogen activation is possible only in the duodenum because the trypsin inhibitor surrounds the trypsinogen granules while they move along the excretory duct of the pancreas.

Phases of the Pancreatic Secretion

1. Complex reflex (brain) phase
2. Gastric (neurohumoral) phase
3. Intestinal (neurohumoral) phase

In general, pancreatic secretion lasts 6-14 hours and depends on the composition of the food.

Complex Reflex (Brain) Phase

- The latent period of this phase is 2-3 minutes, the duration is 20 minutes.

  Pancreatic juice enzymes are used to hydrolyze food along the entire length of the intestinal tract. It takes time for the distribution of enzymes in the digestive tract and their activation.
- The mechanism includes:

- **conditioned reflexes** (for example, the appearance of juice in appearance, the smell of food, talking about food);
- **unconditioned reflexes** (receptors of the oral mucosa, pharynx, afferent nerves, vagus nerve nucleus, vagus nerve, pancreas).

Gastric (Neurohumoral) Phase
(chyme is in the stomach)

- **Reflex mechanism**

Mechano- and chemoreceptors of the stomach, afferent fibers of the vagus nerve, medulla oblongata, efferent fibers of the vagus nerve, pancreas.

- **Humoral mechanism**

Gastrin stimulates the secretion of the pancreas. It is released under the influence of extractive substances, products of protein hydrolysis, and mechanical irritations.

Secretion is controlled by the vagus nerve. Vegetable juices, fat hydrolysis products stimulate secretion.

Intestinal (Neurohumoral) Phase (chyme is in duodenum)

The intestinal phase is the most important.

- **Humoral mechanism**

- Secretin

It is secreted in the duodenum under the influence of hydrochloric acid, promotes the release of bicarbonates.

- Cholecystokinin-Pancreosimine

It is secreted by the action of hydrolysis products of proteins, fats, carbohydrates. Cholecystokinin-pancreosimine stimulates the secretion of enzymes.

- **Reflex mechanism**

- The reflex regulation of pancreatic secretion is primarily triggering and partially corrects the humoral mechanism.

- The parasympathetic nervous system stimulates secretion and controls the action of hormones (secretin and pancreosimine).

- The sympathetic nervous system inhibits the secretion of the pancreas.

Liver Function

1) Bile formation
2) Metabolic
3) Detoxification (barrier)

Bile

- It is a golden liquid.
- 0.5-1.5 l of bile is formed per day.
- Bile is secreted by hepatocytes continuously. Blood is filtered, substances pass into the bile capillaries, bile is formed, which enters the gallbladder through the ducts.
- Outside a meal, bile is deposited in the gallbladder, concentrated 7-10 times, enriched with mucin.

  Bile is concentrated in the gall bladder, acquires a dark olive color.

The Composition of Bile

pH = 7.8-8.6

1) bile acids (cholic, chenodeoxycholic)
2) pigments (bilirubin, biliverdin)
3) cholesterol
4) fatty acids
5) mucus (mucin)
6) ions (potassium, sodium, calcium, chlorine)

The Role of Bile in Digestion

1) It inactivates pepsin of gastric juice
2) It neutralizes intestinal contents
3) It increases the activity of pancreatic and intestinal enzymes
4) It emulsifies fats
5) It dissolves fat hydrolysis products, promotes their absorption
6) It provides absorption of fat-soluble vitamins, calcium salts, cholesterol
7) It stimulates bile formation
8) It stimulates motor activity of the small intestine
9) It has a bactericidal and bacteriostatic effect

Choleresis is bile formation.

Cholekinesis is biliary excretion.

Regulation of Bile Formation (Choleresis)

- **Reflex mechanisms**:

- parasympathetic autonomic nervous system contributes to the formation of bile
- The sympathetic autonomic nervous system inhibits the secretion of bile

- **Humoral factors:**

Stimulate bile formation:

- gastrin
- secretin
- bile acids

Cholekinesis

- Bile enters the duodenum 5-10 minutes after the start of a meal.
- Cholekinesis continues until the last portion of the gastric contents reaches the duodenum.
- Darker, gallbladder bile is secreted first, then hepatic, lighter.
- Cholekinesis is provided by the coordinated activity of the gallbladder and biliary tract sphincters.

- Sphincter Mirizzi
- Sphincter of Lutkens
- Sphincter of Oddi (sphincter of the common bile duct) regulates the secretion of bile into the duodenum. The sphincter is closed outside the meal, the smooth muscles of the gallbladder are relaxed. When smooth muscles contract, the sphincter opens.

Regulation of Cholekinesis

- Reflex mechanisms:

- Conditioned reflexes by sight, food smell, meal time.
- Unconditioned reflexes from mechano-, chemo-, thermoreceptors of the oral mucosa, from the receptors of the stomach and duodenum.

- Humoral stimulants:

- cholecystokinin-pancreosimine
- fats
- proteins

DIGESTION IN THE INTESTINE. PHYSIOLOGY OF SUCTION

Digestion in the Small Intestine

Small intestine enzymes (Over 20)

- proteolytic
- lipolytic
- Amylolytic

Small intestinal juice has a slightly alkaline reaction. pH increases with intense secretion. About 2.5 liters of intestinal juice are released per day.

The Tiri-Vella Method

- The Tiri-Vella method allows you to get intestinal juice in the experiment.
- A loop of the small intestine is isolated. An isolated section of the small intestine produces pure juice.

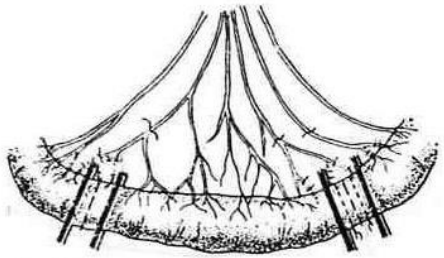
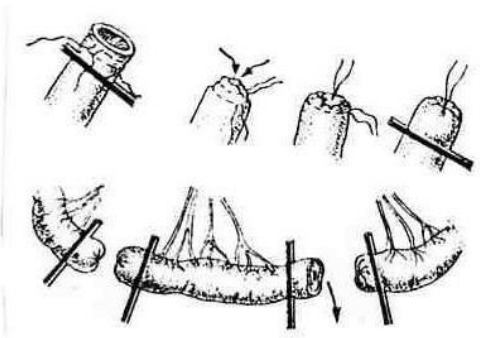
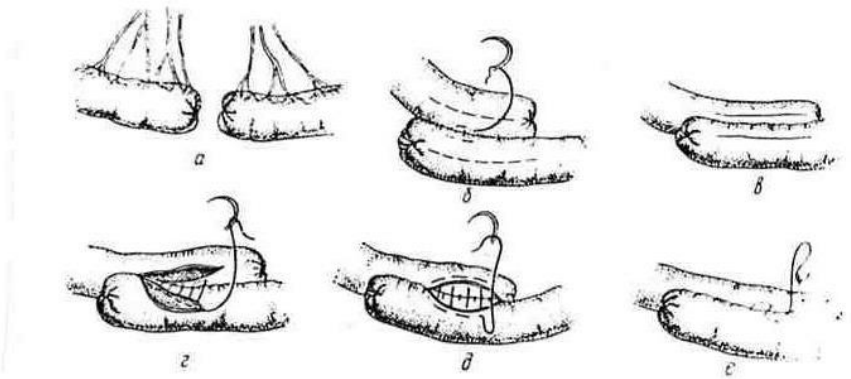


Рис. 173. Перевязка кровеносных сосудов и наложение жомов на кишку в местах будущего ее рассечения





Regulation of Secretory Function of the Small Intestine

- **Reflex mechanism**

- Parasympathetic system stimulates secretion

- The sympathetic system inhibits secretion

- **Humoral mechanisms**
- Serotonin, a vasoactive intestinal polypeptide (VIP), stimulates secretion.
- Somatostatin inhibits secretion.
- **Local mechanisms**

Intestinal secretion does not occur along the entire length of the intestine, but only where there is content.

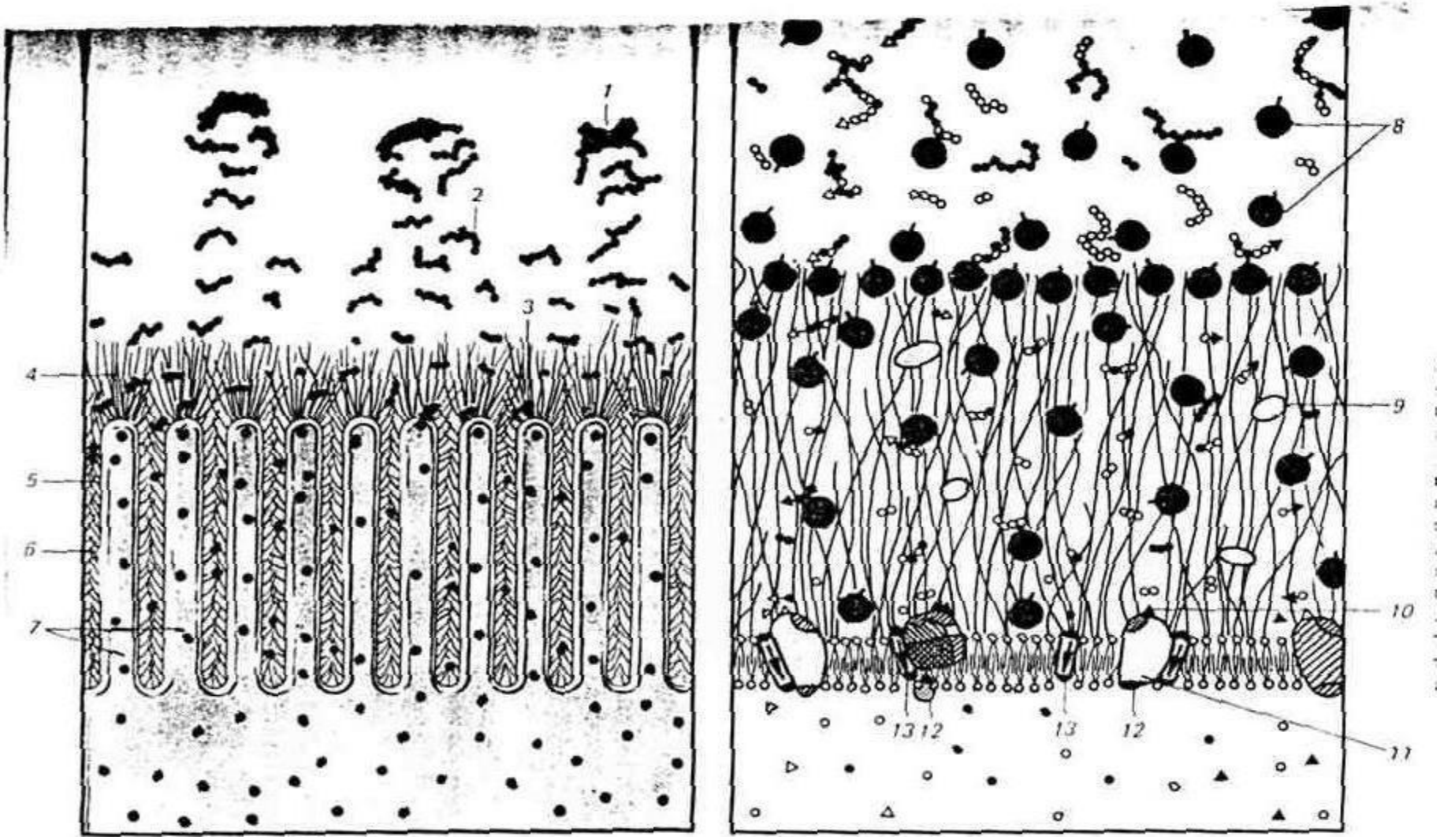
1) Irritation of the mechano- and chemoreceptors (hydrochloric acid) of the mucous membrane of the small intestine increases the secretion of the liquid part of the juice using peripheral reflexes.

2) Chemical irritation of secretory cells of the mucosa (protein digestion products, fatty acids, lactate, pancreatic juice, hydrochloric acid).

Membrane Digestion

- A. M. Ugolev discovered membrane digestion in 1958.
- Enzymes of the intermediate stage of hydrolysis are adsorbed on the glycocalyx of microvilli.
- Most of the enzymes are integrated into the membrane. They provide the final stage of digestion.

Membrane Digestion



Benefits of Membrane Digestion

1) Large surface interaction with enzymes
2) Enzymes are embedded in the membrane and are not lost with substrates
3) Enzymes are turned by active centers to the substrate
4) It is carried out in sterile conditions
5) The absorption process and the hydrolysis process are mutually

activate each other

6) Inhibition of enzymes does not occur.

Types of Small Intestine Motility

1) Rhythmic segmentation
2) Pendulum contractions
3) Peristaltic contractions
4) Tonic contractions

Rhythmic Segmentation

The inner (circular) layer is reduced 8-10 times per minute with the formation of constrictions (1-2 cm wide). Relaxed muscle fibers (15-20 cm) are between 2 adjacent constrictions. Then the segments change. As a result, the chyme is mixed, better contact with the parietal layer is achieved, and translational motion is slowed down.

Pendulum Contractions

They perform the same functions as rhythmic segmentation. Involved the longitudinal layer of muscles.

Peristaltic Contractions

They spread in waves along the intestine and move its contents to the distal section. The wave begins above the chyme, below the relaxation of the fibers, a pressure difference is created. Peristaltic waves can be weak (the surface layer of the chyme is mixed) and strong (propagate along the entire length of the small intestine to the ileocecal flap).

Tonic Contractions

This moderate contraction of all muscle layers, which maintains hydrostatic pressure in the gut, is the basis for all other types of contraction.

Regulation of Small Intestine Motility

- Reflex mechanism (conditioned and unconditioned reflexes)
- Humoral mechanism
- Myogenic (local) mechanism

Reflex Mechanism

- The **parasympathetic system** stimulates motor function.
- **Sympathetic** inhibits motor function.
- Motor function increases with strong excitement of the sympathetic department.
- **Peripheral reflexes** (closed in the intramural ganglia). They coordinate abbreviations of all types.

Myogenic Mechanisms of Regulation of Motility of the Small Intestine

- There are rhythm drivers for the automation of the muscles of the small intestine (pacemaker zones). The foci of automation are in the area of the sphincter of Oddi and in the ileum.
- The higher the metabolic processes, the greater the automation. Also affected by temperature, bioactive substances, fats, mechanical effects of roughage.

Humoral regulation of motor function of the small intestine

Motility stimulating substances:

- gastrin
- serotonin
- cholecystokinin-pancreosimine
- hydrochloric acid
- alkali
- concentrated salt solutions
- fat digestion products

Digestion in the Large Intestine

Features of the Secretory Function of the Colon

- Intestinal juice with a low content of enzymes is released. It mainly contains mucus and rejected epithelial cells.
- Regulation occurs due to local mechanisms (mechanical irritation).
- The large intestine can increase secretion if the function of the small intestine is impaired.

Functions of Normal Microflora of the Large Intestine

- It inhibits the growth of pathogenic microorganisms
- stimulates natural immunity,
- inhibits the activity of microorganisms that cause rotting of proteins,
- destroys enzymes, bile acids, more than 50% of fiber,
- provides carbohydrate fermentation,
- affects protein metabolism,
- synthesizes vitamins K, E, B6, B12.

Features of motor activity of the colon

- Provides the accumulation of intestinal contents, the absorption of water, the formation of feces, the removal of feces from the intestines.
- Additionally, there are 2 types of abbreviations:

- antiperistaltic contractions (provide the formation of feces, water absorption).

- propulsive contractions (move the contents in the caudal direction, occur 3-4 times a day).

Regulation of Colon Motility

- **Nervous regulation**

- The sympathetic nervous system slows down,

- parasympathetic - stimulates.

- **Local mechanisms** (peripheral reflexes) due to irritation of the colon wall with fiber.

- **Humoral factors:**

- cortisone enhances motility,

- serotonin, glucagon, adrenaline inhibit motility.

SUCTION (Absorption) is a physiological process that ensures the transfer of substances from the digestive tract to the internal environment of the body.

Substances Absorbed in the Oral Cavity

- sodium
- potassium
- some amino acids
- alcohol
- nitroglycerine
- glucose

Substances Absorbed in the Stomach

- water
- alcohol
- some salts
- monosaccharides

Substances Absorbed in the Small Intestine

- water
- mineral salts
- vitamins
- hydrolysis products of proteins, fats, carbohydrates

Water that is not absorbed in the small intestine is absorbed **in the colon.**

Suction Mechanisms

- **Passive transport** (by gradient).
- **Active transport** (using carrier proteins involving ATP).
- **Light diffusion** (using carrier proteins, but without ATP).

Passive Transport Mechanisms

- **Diffusion** (by concentration, electrochemical gradient).
- **Osmosis** (according to the osmotic gradient).
- **Filtration** (according to the gradient of hydrostatic pressure).

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