GI system

Physiology

Number: - 4

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Doctor:
Gastrointestinal motilities

• Last time we discussed the functional structures of gastrointestinal tract and had an overview about the motor activity which is initiated by spontaneously generated smooth muscle action potentials, coordinated by central and enteric nervous motor programs, and modulated by local mechanical, chemical, or hormonal influences.

• As a result of the motor activity, ingested food is mixed with digestive secretions, digestible products are transported to absorptive sites, and indigestible products are transported to the rectum and evacuated.

• SO, now its noteworthy to know there are Two types of functional movements occurring in the gastrointestinal tract:

(1) propulsive movements⇒ cause food to move forward along the tract at an appropriate rate to accommodate digestion and absorption, and

(2) mixing movements⇒ keep the intestinal contents thoroughly mixed at all times.

The current discussion is confined to those movements along GI tract and the mechanics of food ingestion, especially mastication, swallowing, gastric motilities and intestinal motilities. let's start!

• Mixing movements differ in different parts of the alimentary tract.
  ▪ the requirements for mixing are quite different at each stage of processing, so multiple automatic nervous and hormonal mechanisms control the timing of each of these activities so they will occur optimally—not too rapidly and not too slowly.
Chewing:

- Chewing is the first mixing movement resulting in grinding action on food to get smaller particles in the oral phase.
- This occurs by activation of chewing reflex (centers in hypothalamus and cerebral cortex are stimulated by smell and taste is to cause chewing of food in the mouth).
- The initiation of chewing reflex appears by muscle stretching caused by drop of the lower jaw (due to the presence of food bolus in the mouth).
- Chewing accomplishes two outcomes:
  
  1) mixes food with saliva which lubricates the food to move more easily through more distal portions of the digestive tract and begins to be digested by salivary enzymes.
  2) forms the food into a bolus that is suitable for swallowing.

- Chewing is normally a voluntary act.
- In mouth, in addition to grinding by chewing, mixing is also promoted by the movements of the tongue

2) Swallowing:

- Swallowing is a complicated mechanism, principally because the pharynx serves respiration and swallowing.
In general, swallowing can be divided into:

  1) a voluntary stage, which initiates the swallowing process.
  2) a pharyngeal stage, which is involuntary and constitutes passage of food through the pharynx into the esophagus.
  3) an esophageal stage, another involuntary phase that transports food from the pharynx to the stomach.

So, its initiated voluntarily and continues involuntarily. And each phase is controlled by a different neurological mechanism.
**Voluntary stage**

It starts when the food is ready for swallowing, it is “voluntarily” squeezed or rolled posteriorly into the pharynx by pressure of the tongue upward and backward against the palate.

- The tongue pushes a bolus of food against the soft palate triggering the swallowing reflex.

- Quick note:

  In this phase, the soft palate is pulled upward, so it closes the passage (the first opening) between the nasopharynx and oropharynx. Larynx is pulled upward and anteriorly which results in closure of epiglottis.

**Involuntary stages (phase 2+3)**

- This phase of swallowing is unconscious and is controlled automatically, even though the muscles involved are skeletal!

- There are complex of events taking place by Reflexes which are initiated by introducing food into pharynx:

  i. **Pharyngeal phase:**

  ii. **Esophageal phase**

- In the pharyngeal phase of swallowing, the pharynx elevates to receive the bolus of food from the mouth and moves the bolus down the pharynx into the esophagus. After that the opening which connects the pharynx and the oral cavity is closed.

- The movement of bolus through the pharynx is influenced by contraction of pharyngeal constrictor muscles.
• At the same time, the upper esophageal sphincter which surrounds the upper part of esophagus relaxes, the elevated pharynx opens the esophagus, and food is pushed into the esophagus. (closure of the fourth opening) ...

• Opening of the upper esophageal sphincter is triggered by the swallowing reflex.

• The primary muscle of the upper esophageal sphincter is the cricopharyngeal part of the inferior pharyngeal constrictor.

• The pharynx can also contract by itself by extension. once its extended its contracted. this means that you can also have swallowing even in the absence of food by contraction of the pharynx. but at the same time, once the food is pushed into the pharynx the esophageal phase the esophageal sphincter closes.

• In the Esophageal phase the passage of food along esophagus is also belonging to swallowing in which it conducts the bolus to the stomach.

• Muscular contractions in the wall of the esophagus occur in peristaltic waves.

• The peristaltic waves associated with swallowing cause relaxation of the lower esophageal sphincter in the esophagus as the peristaltic waves, and bolus of food, approach the stomach.

• The lower esophageal sphincter can be identified physiologically as it remains tonically constricted to prevent the reflux of stomach contents into the lower part of the esophagus.

• The presence of food in the esophagus stimulates the enteric plexus, which controls the peristaltic waves.

• The presence of food in the esophagus also stimulates tactile receptors, which send afferent impulses to the medulla oblongata through the vagus nerves.
• Motor impulses, in turn, pass along the vagal efferent fibers to the striated and smooth muscles within the esophagus, thereby stimulating their contractions and reinforcing the peristaltic contractions.
• Two types of contraction are taking place by esophageal muscle:

1) Primary peristaltic contractions:
Simply, those are continuation of the peristaltic wave that begins in the pharynx and spreads into the esophagus during the pharyngeal stage of swallowing. This wave passes all the way from the pharynx to the stomach in about 8 to 10 seconds.

2) Secondary peristalsis:
those peristaltic waves result from distention of the esophagus itself by the retained food. If the primary peristaltic wave fails to move all the food that has entered the esophagus into the stomach, (as if the esophagus is reinitiating its contraction). these waves continue until all the food has emptied into the stomach.
• The secondary peristaltic waves are initiated: 1) partly by myenteric nervous system, 2) and partly by reflexes that begin in the pharynx and are then transmitted upward through vagal afferent fibers to the medulla and back again to the esophagus through glossopharyngeal and vagal efferent nerve fibers.
• For example, if a large food particle does not reach the stomach during the primary peristaltic wave, the maintained distension of the esophagus by the particle activates receptors that initiate reflexes causing repeated waves of peristaltic activity (secondary peristalsis) that are not accompanied by the initial pharyngeal events of swallowing.
• Peristaltic wave of the esophagus ends with relaxation of gastroesophageal sphincter (lower esophageal sphincter) and receptive relaxation of the stomach. To push the bolus into the stomach.
• The relaxation is caused by the activation of the inhibitory neurons from the lower part of the esophagus.
• These neurons induce inhibition of the tonic contraction of the sphincter and the relaxation of the stomach. Failure of the sphincter to relax may result in a pathological condition known as "achalasia."

• In achalasia the ability of myenteric plexus to cause relaxation of the sphincter has failed. As a result, food swallowed into the esophagus fails to pass from the esophagus into the stomach. And the musculature of the lower esophagus remains spastically contracted and the myenteric plexus has lost its ability to transmit a signal to cause "receptive relaxation" of the gastroesophageal sphincter as food approaches this sphincter during swallowing.

Achalasia often isn’t clearly visible in Childs but it develops over time in which can cause infection. Aspiration and ulceration of esophageal mucosa and even death!

• Gastro-esophageal sphincter is also closed to prevent reflux of food from the stomach. The failure of this system may result in esophageal reflux (Return of gastric content toward esophagus).
Gastric motilities:

- Usually the stomach has a very small capacity which can be dilated from 50 to 1000 milliliters. Stomach secretes large amount of secretions (2000ml/day).
- This secretion when mixed with the ingested food in the stomach is forming chyme.
- The motor functions of the stomach are threefold:
  1) storage of large quantities of food until the food can be processed in the stomach, duodenum, and lower intestinal tract.
  2) mixing of this food with gastric secretions until it forms chyme.
  3) slow emptying of the chyme from the stomach into the small intestine at a rate suitable for proper digestion and absorption by the small intestine.

As in the esophagus, the stomach produces "peristaltic waves" in response to the arriving food. In which there are two movements:

1) "receptive relaxation movement" in which the contraction is at a lower tone.
   - Therefore those are weak peristaltic constriction waves, called mixing waves,
about once every 15 to 20 seconds, consisting of electrical “slow waves” that occur spontaneously in the mid to upper portions of the stomach wall and moves toward the antrum about once every 15-20 seconds.

- Receptive relaxation is a vasovagal reflex in that both its afferents and efferents are vagal fibers.

**A deeper illustration:**

*when food stretches the stomach, a “vasovagal reflex” from the stomach to the brain stem and then back to the stomach reduces the tone in the muscular wall of the body of the stomach so that the wall bulges progressively outward, accommodating greater and greater quantities of food up to a limit in the completely relaxed stomach of 0.8 to 1.5 liters*

2) "the gastric peristaltic movement "

Which occurs as the wave approaches the larger mass of wall muscle it's a more powerful contraction, which both mixes the luminal contents and closes the pyloric sphincter. *(a ring of smooth muscle and connective tissue between the antrum and the duodenum).*

The pyloric sphincter muscle contract upon arrival of a peristaltic wave. As a consequence of sphincter closing, only a small amount of chyme is expelled into the duodenum with each wave, and most of the antral contents are forced backward toward the body of the stomach (squeezing action)

the moving peristaltic constrictive ring, combined with this upstream squeezing action, is called “retropulsion,” which is an
important mixing mechanism in the stomach.

**hunger contraction**: is another type of contraction in which its mechanism isn’t well understood.

It appears when the stomach is empty and lasts for several hours. These contractions are rhythmical peristaltic contractions with duration of 2-3 minutes for each.

It seems that these contractions are in relation with glucose concentration in the blood (They are increased by decreasing glucose level in blood).

**Stomach emptying**: (most of this part is quoted from handout1)

- The whole activity that results in gastric emptying is known as pyloric pump.
- Reflexes in duodenum slow stomach activity and increase intestinal activity by interference of sympathetic nerves.
- The initiation of these reflexes depends upon the contents of both the stomach and small intestines.
- All the factors that regulate acid secretion can also alter gastric motility.
- For example, gastrin secreted by the antral mucosa. This hormone has mild stimulatory effect on the peristaltic activities of the stomach pylori pump
- Distension of the stomach also increases the force of antral contractions through long and short reflexes triggered by mechanoreceptors in the stomach wall
- Therefore, the larger a meal, the faster the stomach’s initial emptying rate
- As the volume of the stomach decreases, emptying also decreases
Hormones also affect this process in which secretin hormone decreases stomach secretions, and cholystokinin decreases stomach emptying.

Enterogastric reflex inhibits gastric emptying: The passage of chyme to the duodenum causes decrease pH (in duodenum). This initiate intrinsic and extrinsic reflex to decrease gastric emptying.

3 levels of inhibition induced by enterogastric reflexes:
- Through ENS.
- Through prevertebral ganglia.
- Through signals via the vagus nerve to inhibit the excitatory signals of vagus nerve to the stomach.

The effects of these reflexes decrease the antral propulsive contractions and increase the tone of the pyloric sphincter.

- Hormonal feedback from the duodenum:
  - GIP: Gastric Inhibitory Peptide: also inhibits gastric emptying in which its released from upper small intestinal specialized cells and stimulated by fat and carbohydrates in chyme.

Movement of small intestines:

Motility patterns in the small intestine differ within different regions and with time since the last meal.

Mixing and propulsion of chyme are the primary mechanical events that occur in the small intestine:

- propulsive movements ensure the movement of chyme anal ward at an appropriate rate.
- all movements of the small intestine cause at least some degree of both mixing and propulsion.
- After a meal, four types of contraction occur. They are:

  1) segmentation contractions (related to the mixing movement)
  2) peristaltic contractions
3) migrating contractions. 
Also, we can have some movement of mucosa

Mixing movement in the small intestines:

- is provided by the activity of circular smooth muscle cells. 
  - The type of contraction that appears during this movement is the segmentation contraction
- Which are brief, localized events in circular muscles.
- They appear, disappear, and reappear regularly (contraction after relaxation...), forming contraction rings that involve only 1 to 4 cm of bowel at a time.
- They last less than 5 seconds and occur in sets that are spaced 5 to 10 seconds apart.
- Such contractions divide bowel contents into segments, and their primary purpose is local mixing.
- They are also propulsive and cause a slow but steady movement of bowel contents toward the colon. This means that although segmentation contractions have mainly mixing effect on chyme, they also have some propulsive effects which cause movement in anal ward direction.
- To summarize, those contractions appear along the intestine as interspaced by the relaxation of adjacent smooth muscle cells up and down to the contracted segment causing spaced segmentations of the intestine.

- The rate of contractile activity is determined by the rate of slow waves in that segment of the intestine.
- The maximum frequency of contractions is about 12/minute in the upper part of intestine (duodenum and jejunum) and 8/minute in the terminal
ileum (the same as the rate of slow waves or Basic Electrical Rhythm (BER)).

Propulsive movements: (peristalsis in the small intestines)

Chyme is propelled through the small intestine by peristaltic waves.

By peristaltic movement we mean contraction up, relaxation down. This is the first component, the second component is the lengthening and shortening of the longitudinal layer. This component is taking place all the time, those contractions can take place even if the organ is empty. This is because they have an electrical control which is not related to the presence of bolus. The purpose of those contractions is to propel the content to colon in a velocity of 1cm/minute which is the "propulsive effect over chyme".

An effective peristaltic activity to cause a propulsive movement of chyme requires an intact and active ENS

Note that segmentation contraction characterizes the fed state while the peristaltic contraction is a basic contraction existed continuously! This indicates that when having a section of the intestines and hanging it only the longitudinal shortening and lengthening will be seen!

If you like to see the circular contraction....

**Control of intestinal movements:**

1. Neural control by ENS and
2. Parasympathetic nervous system: this system can modulate the peristaltic activities by changing the activity of neural network or by changing the activity of smooth muscle cells.
4. Electrical activity of muscle
• Importantly, before having a surgical operation patient must be fast at least 6 hours before the operation to avoid some of the complications caused by anesthesia. Like ileus which is disruption caused by the failure of peristalsis, so if you have food or fluid in your stomach during your surgery, you could vomit while under anesthesia. and intubation makes it possible for you to inhale the vomit into your lungs.

• Other Pathological conditions cause increasing or decreasing movement along intestines, or even the pumping of content occurs toward the stomach instead of anal ward!! .

another type of contraction called the,

• Migrating Motor Complex (MMC) begins in the stomach in the inter-digestive periods. The activity begins in the distal part of the stomach and continues along the entire small intestine. The function of these contractions is to sweep the intestinal content in the time between meals. These movements are controlled by hormonal (Motulin is believed to be involved.

The end

Don’t forget to refer to hand out 1.

"the more you learn ,the more you earn"