THE DIGESTIVE SYSTEM
Motility

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Page 1: Title Page
• The muscles of the digestive tract wall are responsible for propelling and mixing its contents.

Page 2: Goals
• To discuss the types of motility found in each section of the digestive tract
• To describe the function of each type of motility
• To describe the control of motility throughout the digestive tract.

Page 3: Chewing occurs in the mouth
• Chewing is a mechanical digestive process that tears and grinds food into pieces small enough to be swallowed as a bolus
• Chewing mixes food with saliva, thereby lubricating the bolus so that it can be swallowed easily
• Chewing has both voluntary and involuntary reflex components
• The small intestine reflexively slows gastric (stomach) emptying to allow for neutralizing, enzymatic digestion, and absorption of its contents
Swallowing initiates primary peristalsis in the esophagus

- The only function of the esophagus is to move the bolus from the pharynx (throat) to the stomach

- The esophagus moves its contents via peristalsis (now is a good time to play the animation on page 4 of the Motility topic)

- Swallowing begins voluntarily but is completed by reflexive (involuntary) primary peristalsis controlled by the swallowing center in the brain stem

- The sequence of events in swallowing is as follows:
  1. The soft palate rises to close off nasopharynx and prevent bolus from rising into the nasal cavity
  2. The tongue retracts to force the bolus into the oropharynx
  3. The larynx elevates and the glottis closes
  4. The epiglottis covers the glottis
  5. The pharyngeal muscles contract and the UES relaxes to allow the bolus to move from the oropharynx into the upper esophagus
  6. Primary peristalsis begins and both the LES and stomach relax
  7. The bolus moves into stomach and LES closes

- The larger the size of the bolus, the more force generated by peristalsis in the esophagus

- It takes approximately 9 seconds for a typical bolus to move from the esophagus to the stomach; liquids, like water, take about 1 second to travel down the esophagus

Stretch of the esophageal wall initiates secondary peristalsis

- Secondary peristalsis (a second wave of peristalsis) begins if a food bolus does not make it to the stomach via primary peristalsis

- Distension of the esophagus causes its stretch receptors to send signals to the CNS, which then responds by triggering secondary peristalsis
Page 6: Relaxation and peristalsis occur in the stomach
- The stomach stores food, mixes it with gastric juice for chemical digestion, and empties the partially digested food (chyme) into the small intestine (duodenum).

- Receptive relaxation of the fundus and body allow for approximately 1 liter of food to enter the stomach.
- Peristaltic contractions of the stomach (~3-5/min) mix the stomach contents with gastric juice and empty the chyme into the duodenum.
- The frequency of peristaltic contractions is regulated by the interaction between pacemaker cells and smooth muscle cells.
- Larger volumes of food in the stomach produce stronger gastric contractions than smaller volumes of food.

- Chemical composition of food influences the rate of digestion: lipid rich meals take longer to digest than carbohydrate rich meals.
- Contractions of the antrum propel chyme into the duodenum in small squirts (gastric emptying) via the pyloric sphincter (play the animation on page 6 of the Motility topic).
• Closure of the pyloric sphincter forces chyme back into the stomach (retropulsion) for further mixing
• The rate of gastric emptying is slowed by the presence of fats, acids, and hypertonic solutions in the duodenum; distention of the duodenum also slows the rate of gastric emptying

Page 7: Nerves and hormones control gastric motility
• Nerves control the response of the stomach during the cephalic phase of digestion
• The cephalic phase is regulated by long reflexes
• The vagus nerve carries signals from the brain to the stomach
• Gastric motility increases in preparation for the receipt of food during the cephalic phase
• Both nerves and hormones control the response of the stomach during the gastric phase of digestion.
• Gastrin is the hormone that regulates gastric secretion.
• Stretching the intestinal wall stimulates its stretch receptors and causes a response by the duodenum
• Gastric motility/emptying decrease as the duodenum begins to receive chyme from the stomach; this allows the duodenum sufficient time to process the chyme
• Fats in the duodenum cause the release of the hormone CCK, which causes gastric motility to decrease
• CCK also stimulates the gall bladder to release bile into the duodenum, which causes fat emulsification
• Both the hormone secretin and nerves elicit a response from the duodenum when it contains acid
• Hypertonic solutions in the duodenum elicit a response, but the precise mechanism of the response is unknown
• The automatic communication between the intestine and the stomach is called the enterogastric reflex
• Sympathetic nervous system activity decreases digestive processes while parasympathetic activity increases them
Page 8: Segmentation occurs in the small intestine during digestion
- Segmentation and limited peristalsis are the two types of motility in the small intestine
- Segmentation involves oscillatory, alternating contractions and relaxations of the small intestine’s smooth muscle. These contractions move the chyme in a bidirectional fashion
- Segmentation in the intestine mixes chyme with intestinal secretions and brings it into repeated contact with the intestinal absorptive epithelium (check out the animation on page 8 of the Motility topic).
- The frequency of segmentation contractions is greatest in the duodenum (~12/min) and least in the ileum (~9/min), and this frequency is regulated by pacemaker cells
- The slow passage of chyme in the small intestine insures that nutrients will be absorbed

Page 9: Nerves and hormones control small intestine motility
- Long reflexes act on the ileum to increase its activity when food is in the stomach
- Increased peristalsis in the ileum moves undigested contents into the large intestine for ultimate elimination as feces
- Gastrin, produced by the stomach during the gastric phase, stimulates peristalsis of the ileum and relaxation of the ileocecal sphincter; this is the gastroileal reflex
- Distention of the small intestine stimulates stretch receptors, which results in an increase in segmenting contraction strength (a neural reflex)
- Sympathetic nervous system activity decreases intestinal motility; parasympathetic activity increases it

Page 10: Migrating motility complexes occur during fasting
- After a meal is digested (i.e. during the inter-digestive period), segmentation is replaced by migrating motility complexes.
- Migrating motility complexes are peristaltic waves from stomach to ileum that sweep undigested material toward the terminal ileum
- The frequency of migrating motility complexes is approximately one every 90 minutes or 6-8 overnight.
- Migrating motility complexes are controlled by the enteric nervous system
Page 11: Segmentation and mass movements occur in the colon
- There are two major functions of the large intestine:
  1. Storing and concentrating fecal matter
  2. Absorption of water, salts, and vitamin K
- The ileocecal sphincter opens to allow chyme to enter the cecum and then closes to prevent backflow
- About 500 ml of chyme enters the cecum daily
- Slow, segmenting contractions (~ 1-5/min) allow for vitamin K, water and salts to be absorbed through the large intestine’s epithelium

- Pouches called haustra are formed by contractions in the transverse and descending colon
- Mass movements are sustained, intense peristaltic contractions of the large intestine (the animation on page 11 of the Motility topic nicely demonstrates these).
- Haustral contractions and mass movements propel feces toward the sigmoid colon and finally into the rectum
- Distention of the rectum causes the internal anal sphincter (involuntary, smooth muscle) to relax, which produces the urge to defecate
- The external anal sphincter (skeletal muscle) is under voluntary control; relaxation of this sphincter, coupled with contraction of the rectum and sigmoid colon, results in defecation
- Only about 150 ml of the 500 ml of chyme that enter the cecum is eliminated as feces; most of the remaining 350 ml is absorbed water
- Feces contain mostly undigested foodstuffs and bacteria (mostly E. coli ~ 1/3 dry weight of feces)

Page 12: Reflexes govern the activity of the colon
- The gastroileal reflex promotes mass movements of the colon
- Distention (stretching) of the rectum stimulates the defecation reflex
- Both long and short reflexes are involved in defecation
- The internal anal sphincter is under involuntary control while the external anal sphincter is under voluntary control
- Emotions influence colonic motility
  - Pain, fear, depression – may produce constipation
Anger, anxiety, and hostility – may cause diarrhea

Page 13: Vomiting moves stomach contents orally

- The vomiting reflex is coordinated in the brainstem
- The vomiting reflex may be stimulated by:
  - Excessive stretching of the stomach
  - Abnormal vestibular stimulation (e.g. seasickness)
  - Urogenital pain (esp. testicular)
  - Other painful injuries
  - Increased intracranial pressure
  - Tickling to the back of the throat
  - Noxious and/or toxic chemicals
- Vomiting is preceded by copious saliva production
- The sequential events of vomiting are as follows:
  - Reverse peristalsis moves bile-laden contents from the small intestine into the stomach
  - The stomach antrum contracts, forcing stomach/intestinal contents through the relaxed LES, up the esophagus, through the UES, and out the mouth
- Vomiting may serve a protective function, i.e. to remove harmful substances from the GI tract.
Study Questions on Motility: Digestive System:

1. (Page 3.) In addition to grinding food into smaller pieces to be swallowed, what other function or functions does the mouth serve?
2. (Page 4.) Briefly list the sequence of events that occur during swallowing.
3. (Page 4, 5.) Discuss the difference between primary and secondary peristalsis.
4. (Page 6.) What is the function of peristaltic contractions in the stomach?
5. (Page 6.) What is the rate of peristaltic contractions in the stomach?
6. (Page 6.) What nervous system component(s) controls the frequency of peristaltic contractions in the stomach?
7. (Page 6.) Describe the difference between gastric emptying and retropulsion.
8. (Page 6.) What would cause the rate of gastric emptying to slow?
9. (Page 7.) Do short or long reflexes control the cephalic phase of digestion?
10. (Page 7.) Gastric motility decreases during the cephalic phase of digestion. True or false?
11. (Page 7.) Which hormone regulates gastric secretion during the gastric phase?
12. (Page 7.) Describe the dual role of CCK during digestion.
13. (Page 7.) Discuss the enterogastric reflex.
14. (Page 8.) Compare and contrast segmentation and peristalsis.
15. (Page 8.) Compare the rate of segmentation in different regions of the small intestine.
16. (Page 8.) Why is chyme moved so slowly through the small intestine?
17. (Page 9.) Describe the activity of the ileum when food is in the stomach.
18. (Page 9.) What effect does gastrin have on the ileum during the gastric phase of digestion?
19. (Page 10.) Compare and contrast migrating motility complexes and segmentation.
20. (Page 10.) How often do migrating motility complexes occur and what neural mechanism controls this process?
21. (Page 11.) Compare and contrast mass movements and segmentation in the colon.
22. (Page 11.) What are the major functions of the large intestine?
23. (Page 11.) Discuss the neuromuscular mechanisms that produce defecation.
24. (Page 11.) What are feces primarily composed of?
25. (Page 12.) Which reflex regulates mass movements?
26. (Page 13.) Where is the control center for the vomiting reflex located?
27. (Page 13.) Describe the sequence of events that occur during vomiting.
28. (Page 13.) What might be an adaptive function of vomiting?