

GI Physiology Conference

Chapters 5 & 6

Motility of the Small and Large
Intestine

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Chapter 5

Motility of the Small Intestine

Small Intestine

- Motility of small intestine organized to optimize digestion, absorption, and propulsion of undigested material
- Functions of contractions
 - Mixing of foodstuffs with digestive secretions and enzymes
 - Circulation of intestinal contents to facilitate contact with intestinal mucosa
 - Net propulsion of intestinal contents

Anatomic Considerations

- Two layers of smooth muscle cells
 - Outer layer
 - Long axis of cells arranged longitudinally
 - More abundant in proximal intestine
 - Inner layer
 - Long axis of cells arranged circularly
 - Thicker
 - More abundant in proximal intestine

Anatomic Considerations

- Myenteric or Auerbach plexus
 - Lies between circular and longitudinal layers
 - Plexal neurons provide integrated output to both muscle layers, epithelial cells, and perhaps endocrine and immune cells
- Interstitial cells of Cajal (ICCs)
 - Two classes
 - Generate slow waves
 - Mediate neural input to smooth muscle cells

Anatomic Considerations

- Extrinsic innervation supplied by the vagus nerve (preganglionic and cholinergic) and nerve fibers from the celiac and superior mesenteric ganglia (postganglionic and adrenergic)

Types of Contractions

- Between contractions, pressures within the lumen of the small intestine approximately equal intraabdominal pressure
- Involve only 1-4cm of bowel at a time
- Produce intraluminal pressure waves as nearly symmetric peaks of uniform shape
- Occur at multiple intervals of 5 seconds

Types of Contractions

- If contraction not coordinated, intestinal contents displaced proximally and distally during contraction and may flow back during period of relaxation – these contractions appear to divide bowel into segments called segmentation
- If contractions occur in proximal-to-distal sequence, aboral propulsion results
- Peristaltic response of propelling bolus in aboral direction first described by Bayliss and Starling and known as the law of the intestines

Patterns of Contractions

- In fasting humans, contractions do not occur evenly over time
- Migrating motor complex (MMC)
 - Sweep undigested contents from the stomach, through the small intestine, and into the colon
 - Maintain low bacterial counts in the upper intestine
 - Cycles at intervals of about every 1.5 hours in the fasting human

Patterns of Contractions

- In nonfasting humans, contractions are spread more uniformly over time
- Most common pattern of contractions is 1 to 3 sequential contractions separated by periods of 5, 10, 15, or 20 seconds
- Variable intensity
- Not as forceful as those that occur in the MMC

Patterns of Contractions

- Contractions controlled by activities of the ICCs and smooth muscle cells, nerves, and humoral substances
- Slow wave activity
 - Membrane potential that fluctuates rhythmically with cyclic depolarizations and repolarizations of 5-15mV
 - Always present and constant
 - Frequency not same at all levels of bowel
 - 12 cycles/min in duodenum and constant
 - 8 cycles/min in terminal ileum and declines linearly

Patterns of Contractions

- Spike potentials
 - Rapid depolarizations of smooth muscle cell membranes occurring only during depolarization phase of slow wave
 - Phasic in nature
 - If localized, segmenting occurs

Patterns of Contractions

- Peristaltic reflex (law of intestines)
 - Depends on intact enteric nervous system
 - Application of neural blocking agents abolishes or greatly reduces reflex
- Intestino-intestinal reflex
 - Depends on extrinsic neural connections
 - Sectioning of the extrinsic nerves abolishes reflex
 - Changes in emotional state induce alterations in small bowel motility

Patterns of Contractions

- Epinephrine
 - Inhibits contractions
 - Released from adrenal glands
- Serotonin
 - Stimulates contractions
- Gastrin, CCK, Motilin, and Insulin
 - Stimulate contractions
- Secretin and Glucagon
 - Inhibit contractions

Patterns of Contractions

- Motilin may regulate MMC cycle length
- Feeding abolishes MMC

Clinical Tests

- Auscultation to detect “bowel sounds” is the most common means to assess bowel activity

Chapter 6

Motility of the Large Intestine

Large Intestine

- Contractions organized
 - Optimal absorption of water and electrolytes
 - Net aboral movement of contents
 - Storage and orderly evacuation of feces

Anatomic Considerations

- Large intestine
 - Cecum
 - Ascending colon
 - Transverse colon
 - Descending colon
 - Sigmoid colon
 - Rectum
 - Anal canal

Anatomic Considerations

- Muscular layers
 - Longitudinal fibers
 - Three flat bands called taeniae coli
 - From cecum to rectum
 - Circular fibers
 - Continuous from cecum to anal canal where it increases in thickness to form the internal anal sphincter
 - Striated muscle distal to internal anal sphincter forms the external anal sphincter

Anatomic Considerations

- Haustra or haustrations
 - Segments of colon
 - Probably the result of structural and functional properties of the colon
 - More prominent in areas that possess taeniae coli
 - Not fixed

Anatomic Considerations

- Innervated by the autonomic nervous system (ANS)
- Extrinsic innervation from both parasympathetic and sympathetic branches of ANS
- Shunt fascicles innervate myenteric nerves

Anatomic Considerations

- Parasympathetic innervation
 - Vagus nerve
 - Cecum
 - Ascending colon
 - Transverse colon
 - Pelvic nerves from the sacral region of the spinal cord
 - Descending colon
 - Sigmoid colon
 - Rectum

Anatomic Considerations

- Sympathetic innervation
 - Superior mesenteric ganglion
 - Proximal regions of large intestine
 - Inferior mesenteric ganglion
 - Distal regions of the large intestine
 - Hypogastric plexus fibers
 - Distal rectum
 - Anal canal

Anatomic Considerations

- Most parasympathetic fibers are preganglionic
- Most sympathetic fibers are postganglionic
- External anal sphincter (striated muscle) innervated by the somatic pudendal nerves

Anatomic Considerations

- Excitatory mediators
 - Acetylcholine
 - Tachykinins such as substance P
- Inhibitory mediators
 - Nitric oxide
 - Vasoactive intestinal peptide
- Pudendal nerves and external anal sphincter
 - Acetylcholine

Types of Contractions

- Cecum and ascending colon
 - Wide variety of contractions
 - Absorption of water and electrolytes
 - Mostly segmental in nature with durations of 12 to 60 seconds and varying pressures
 - Propulsion occurs with mass movement when segmental activity ceases and the colon undergoes a contraction that sweeps intraluminal contents in an aboral direction
 - Estimated to occur 1 to 3 times daily in healthy people

Types of Contractions

- Descending and sigmoid colon
 - Segmenting types of contractions not resulting in propulsion
 - Reduce liquid content

Types of Contractions

- Rectum and anal canal
 - When the rectum is distended by fecal material, internal sphincter relaxes due to rectosphincteric reflex
 - Rectal distension elicits sensation to signal urge to defecate
 - Rectum can accommodate large quantities of material and acts as a storage organ
 - Defecation involves voluntary and involuntary acts

Control of Motility

- Influences of motility in the large intestine
 - Interstitial cells of Cajal (smooth muscle properties)
 - Enteric nerves
 - Extrinsic nerves
 - Circulating or locally released chemicals
- Relaxation of the ileocecal sphincter and an increase in contractile activity of the ileum occur with or shortly after eating and is termed the gastroileal reflex
- Factors that control motility of the large intestine are complex and poorly understood

Clinical Significance

- Constipation
 - Delayed transit
 - Mostly, dietary in origin
 - Direct correlation between dietary fiber, increased colonic intraluminal bulk, and enhanced transit

Clinical Significance

- Congenital megacolon (Hirschsprung's disease)
 - Absence of enteric nervous system in the distal colon
 - Internal anal sphincter always involved
 - Involved segment exhibits increased tone, very narrow lumen, and is devoid of propulsive activity
 - Treated with surgical resection of diseased segment

Clinical Significance

- Irritable bowel syndrome
 - Abdominal pain and altered bowel habits
 - During stress, patients with IBS and constipation exhibit increased segmentation while those with IBS and diarrhea exhibit decreased segmentation
 - Cause of disorder remains unknown
- Diverticula
 - Outpouchings of mucosa that extend through the muscular wall

Clinical Tests

- Techniques for monitoring contractions are not in general clinical use

References

- Gastrointestinal Physiology by Leonard R. Johnson