Gastrointestinal

CHAPTER 31

Gastrointestinal Anatomy, Physiology, and Assessment

Joyce King

Learning Objectives

Upon completion of this chapter, the reader will be able to:

1. Describe the organs of the digestive tract and the basic digestive process.
2. Discuss the general mechanisms of regulating digestive function.
3. Identify the roles of enzymes and gastrointestinal hormones in the digestive process.
4. List the techniques that are used for assessing the gastrointestinal system.
5. Identify the difference between abnormal and normal gastrointestinal assessment findings.

Cells need nutrients, vitamins, and minerals to survive. The digestive system meets these cellular needs by removing the substances from the external environment (the digestive tract) and presenting them to the cells in a form that they can utilize. This process is another important step in maintaining homeostasis. This chapter briefly discusses the basic digestive processes: motility, secretion, digestion, and absorption. It also reviews the anatomy of the digestive tract and discusses techniques used in the assessment of the gastrointestinal system.

BASIC DIGESTIVE PROCESSES

Motility is the process whereby muscular contractions mix and move the contents of the digestive tract forward. The smooth muscle of the digestive tract maintains a constant low level of contraction known as tone. Tone maintains a steady pressure on the digestive tract contents and prevents permanent stretching. Propulsive movements (peristalsis) push the contents forward through the digestive tract at varying speeds. Mixing movements promote digestion by mixing food with the digestive juices and facilitate absorption by increasing contact of intestinal contents with the absorbing surfaces of the digestive tract (Clark, 2005).

Secretion involves the release of digestive juices (e.g., hydrochloric acid, enzymes) into the lumen of the digestive tract; these juices aid in digestion and absorption of food. This process is under neural and/or hormonal regulation.

Digestion refers to the breakdown of food structure by enzymes produced within the digestive system so that the nutrients locked in the complex foods become available for absorption and use. For instance, a carbohydrate molecule is too large to be able to be absorbed into the circulation. Enzymes will first break down this large molecule into smaller molecules called monosaccharides. The monosaccharides are then able to be absorbed across the epithelial cells and into circulation. Proteins are degraded into amino acids and small polypeptides, and fats are degraded into monoglycerides and free fatty acids. Unless an individual has a malabsorption problem, 100% of food digested is absorbed; therefore, caloric intake is regulated at the level of ingestion.

Absorption refers to the process whereby the products that result from digestion are transferred from the digestive tract lumen into the blood or lymph. Most absorption

takes place in the small intestines. Villi, microvilli, and mucosal folds increase the absorptive surface area of the small intestine. During the process of absorption, nutrient molecules must cross the mucus layer, the epithelium, the interstitial space, and the capillary wall (Martini & Bartholomew, 2000). The specific processes involved in crossing these layers will be discussed later in this chapter.

REGULATION OF THE DIGESTIVE TRACT

Four factors affect the regulation of digestive system function: (1) autonomous smooth muscle function, (2) intrinsic nerve plexi, (3) extrinsic nerves, and (4) gastrointestinal hormones.

The autonomous smooth muscle function consists of self-induced electrical activity in the smooth muscle, referred to as the basic electrical rhythm or pacesetter potential. Pacesetter cells do not have a constant resting potential, but rather display rhythmic variations in the membrane potential that cyclically bring the membrane closer to or farther from the threshold value. The membrane potential may eventually reach the threshold, triggering a volley of action potentials resulting in repeated, rhythmical muscle contractions. The rate of rhythmic digestive contractile activities, such as peristalsis, depends on the rate of action potentials triggered by these pacesetter cells (Clark, 2005).

The second factor involved in the regulation of digestive tract function is the intrinsic nerve plexi. This interconnecting network of nerve cells (i.e., myenteric plexus and submucous plexus) is located within the digestive tract wall and allows for a considerable degree of self-regulation. These cells are primarily responsible for coordinating local activity within the digestive tract, such as motility and secretion of enzymes and hormones (Clark, 2005).

The third factor is the extrinsic nerves that originate outside the digestive tract and innervate the various digestive organs (i.e., sympathetic and parasympathetic nervous systems). These nerves help to coordinate activity between different regions of the gastrointestinal tract (Clark, 2005). For example, the act of chewing not only results in an increase in salivary secretions in the mouth but, via input from the vagus nerve, also increases secretions from the stomach, pancreas, and liver in anticipation of the arrival of food.

The fourth factor involved in regulation of digestive function is the gastrointestinal hormones, which are released primarily in response to specific local changes in the luminal contents. These hormones can exert either excitatory or inhibitory influences on smooth muscle and exocrine gland cells (i.e., enzyme-producing cells). The wall of the digestive tract contains three types of sensory receptors that respond to these local changes: (1) chemoreceptors, (2) mechanoreceptors, and (3) osmoreceptors. Chemoreceptors are sensitive to the chemical components of the chyme (i.e., the amount of fat present). Mechanoreceptors (pressure receptors) are sensitive to the stretch or tension within the wall of the digestive tract. The osmoreceptors are sensitive to the osmolarity of the luminal contents (Clark, 2005).

Clearly, regulation of gastrointestinal function is highly complex. As noted here, several synergistic and overlapping pathways influence the processes of digestion and absorption.

COMPONENTS OF THE DIGESTIVE SYSTEM

This section examines the four basic digestive processes—motility, secretion, digestion, and absorption—at each organ along the digestive tract. The digestive tract, also called the alimentary canal, is a series of hollow organs joined in a long tube running from the mouth to the anus (**Figure 31-1**).

Mouth

In the *mouth*, the first step in the digestive process is chewing. Chewing breaks food into smaller pieces to facilitate swallowing, mixes food with saliva, and stimulates the taste buds. Saliva—the secretion associated with the mouth—is produced by three pairs of salivary glands and is composed primarily of water, mucus, and enzymes. Saliva initiates digestion of carbohydrate through the action of salivary amylase (Martini & Bartholomew, 2000). Note that no absorption of nutrients occurs in the mouth, although some medications can be absorbed by the oral mucosa [e.g., nitroglycerin (Nitrostat®)].

Esophagus

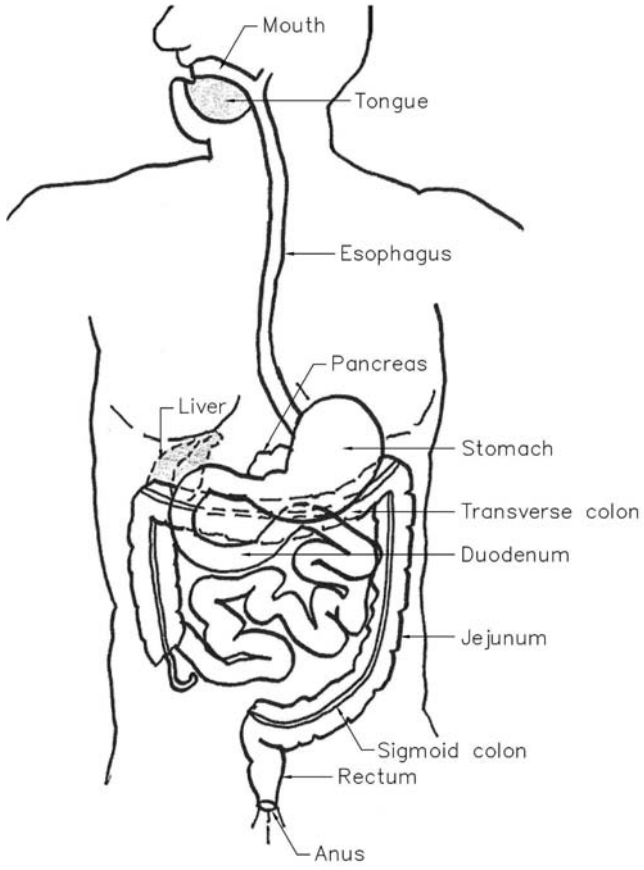
The esophagus is primarily involved with swallowing, the process of moving food from the mouth to the stomach. The esophagus secretes mucus to protect the mucosal membranes from any sharp edges of the food products as well as from any acid or enzymes in the gastric juice if gastric reflux should occur. No digestion or absorption occurs in the esophagus.

At either end of the esophagus are *sphincters*. The upper sphincter is the pharyngoesophageal sphincter. This sphincter remains closed except during swallowing and prevents large volumes of air from entering the digestive tract. The lower sphincter, the gastroesophageal sphincter, prevents reflux of gastric contents (Martini & Bartholomew, 2000).

Stomach

The stomach is a J-shaped saclike chamber that is divided into three sections: the fundus, body, and antrum. At the distal end of the stomach is the pyloric sphincter, which acts as a barrier between the stomach and the small intestine. Major functions of the stomach are to store food and then to empty the partially

FIGURE 31-1 The Digestive Tract



Source: Illustrated by James R. Perron.

digested food into the duodenum at a rate that does not exceed the small intestine's capacity to handle it. Another important function is to secrete hydrochloric acid (HCl) and enzymes that initiate protein digestion. In the stomach, strong peristaltic contractions mix the food with HCl and the digestive enzymes, producing chyme. In the antrum (lower stomach), peristaltic contractions are responsible for gastric emptying. The main factor that influences the strength of the contractions is the amount of chyme in the stomach. Factors in the duodenum are also of primary importance in controlling the rate of gastric emptying. These factors include the amount of fat and/or acid in the chyme, the osmolarity of the chyme, and duodenal distention.

The cells responsible for gastric secretion are located in the gastric mucosa in what are called gastric pits (Martini & Bartholomew, 2000). Three types of secretory cells are found in the walls of the pits. The *mucous neck cells* secrete thin, watery mucus that provides a mucosal barrier, protecting the stomach lining from gastric secretions. The *chief cells* secrete the enzyme precursor pepsinogen. The *parietal cells* secrete HCl and intrinsic factor; intrinsic factor is essential for intestinal absorption of vitamin B_{12}. These secretions are all released into the lumen of the stomach (Martini & Bartholomew, 2000).

Endocrine cells, called *G cells*, which are located in the pyloric region of the stomach, secrete the hormone gastrin into the blood. Gastrin, in turn, stimulates both the parietal cells and chief cells to increase secretion of HCl and pepsinogen. HCl is not actively involved in the digestion of food but rather is responsible for activating the enzyme precursor pepsinogen so that it becomes the active enzyme pepsin. Pepsin then initiates the digestion of protein. No food or water is absorbed into the blood from the stomach, although alcohol and aspirin are absorbed from this site (Martini & Bartholomew, 2000).

Control of gastric secretion involves three phases: the cephalic phase, the gastric phase, and the intestinal phase. The cephalic phase refers to the increase in secretion of HCl and pepsinogen that occurs when a person thinks about, smells, or tastes food. The gastric phase occurs when food actually reaches the stomach. Distention of the stomach and the chemical content of food are responsible for increasing gastric secretions during this phase. The intestinal phase of gastric secretion encompasses factors originating in the small intestine that influence gastric secretion. While the other phases are excitatory, this phase is inhibitory, helping to shut off gastric secretions as the chyme begins to be emptied into the small intestine (Martini & Bartholomew, 2000).

Pancreas

The pancreas has both exocrine and endocrine functions. The exocrine portion consists of acinar cells, which secrete three types of enzymes, and duct cells, which secrete an alkaline secretion that is rich in sodium bicarbonate. The three types of pancreatic enzymes are proteolytic enzymes (e.g., trypsin), which are involved in protein digestion; pancreatic amylase, which continues the carbohydrate digestion that was initiated in the mouth; and pancreatic lipase, the major enzyme involved in fat digestion. The proteolytic enzymes are secreted in an inactive state and become activated only when they reach the lumen of the small intestine, although both amylase and lipase are secreted in the active state. Pancreatic enzymes are most effective at breaking down their specific nutrients in a neutral or slightly alkaline environment; therefore the alkaline fluid secreted from the duct cells serves the important function of neutralizing the acidic chyme.

The exocrine secretions are regulated primarily by two hormones, secretin and cholecystokinin (CCK). Both of these hormones are released from the duodenal mucosa. Secretin is

released in response to the presence of acid in the duodenum, which in turn stimulates the pancreatic duct cells to secrete sodium bicarbonate. CCK is released in response to the presence of fat in the chyme, which results in the stimulation of pancreatic enzyme secretion (Clark, 2005).

Liver

The liver performs a wide variety of functions and, in fact, is the most important metabolic organ in the body. The only function that will be discussed in this chapter is the role that the liver plays in the digestive process—specifically, in biosynthesis and secretion of bile. Bile is secreted by the liver and is concentrated and stored in the gallbladder between meals. CCK stimulates contraction of the gallbladder, which in turn results in the release of bile, via the common bile duct, into the duodenum. Bile then facilitates both fat digestion, by the emulsification of large fat droplets, and fat absorption, through micellar formation. *Micelles* transport the water-insoluble products of fat digestion to the intestinal wall where they can be absorbed (Sherwood, 2004).

Small Intestine

The small intestine is the site where most digestion and absorption take place. This 6-meter tube extends between the stomach and the large intestine and has three subdivisions: the duodenum, the jejunum, and the ileum. Special anatomical features greatly increase the surface area for absorption—namely, the circular folds of the inner surface of the intestine, villi, and microvilli or brush border. Altogether, the folds, villi, and microvilli increase the surface of the small intestine 600 times more than if the tube were lined by a flat surface (Clark, 2005).

The cells of the brush border contain three types of enzymes:

- Enterokinase activates trypsinogen.
- Disaccharidases complete carbohydrate digestion with the end-product being monosaccharides (e.g., glucose, lactose).
- Aminopeptidases complete protein digestion with the end-product being amino acids.

Very little peristalsis occurs in the small intestine. Instead, motility consists primarily of segmentation that both mixes the nutrients with digestive juices secreted into the small intestine lumen and slowly propels the chyme forward (Clark, 2005).

Large Intestine

The horseshoe-shaped large intestine begins at the end of the ileum and ends at the anus. It consists of the colon, cecum, appendix, and rectum. The large intestine is primarily a drying and storage organ whose major function is the reabsorption of water. Approximately 500 mL of chyme enter the large intestine from the ileum; of this amount, about 350 mL are absorbed, leaving only about 150 mL to be expelled as feces. No digestion and minimal absorption occur in the large intestine. In addition to water and sodium being absorbed, vitamin K, which is synthesized by bacteria in the lumen of the colon, is absorbed as well (Martini & Bartholomew, 2000).

Organs that help with digestion, but are not part of the digestive tract, include the tongue and the salivary glands.

Tongue

The tongue is composed of voluntary skeletal muscle and is important in guiding food within the mouth during chewing and swallowing. Another important function of the tongue is taste; taste buds are embedded in the surface of the tongue.

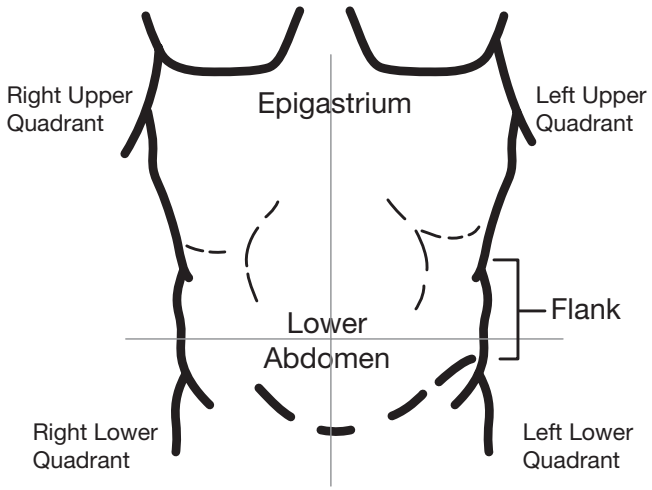
Salivary Glands

The salivary glands produce saliva. The most important salivary proteins are the enzyme amylase, which initiates carbohydrate digestion; mucus, which facilitates swallowing by providing lubrication; and lysozyme, an enzyme that destroys bacteria within the mouth (Clark, 2005).

ASSESSMENT OF THE GASTROINTESTINAL SYSTEM

Gastrointestinal complaints are common problems in clinical practice. The first step in the assessment process is a careful and detailed interview. Frequently, the interview will lead you to the underlying disorder. Gastrointestinal symptoms that are commonly reported include indigestion, anorexia, nausea, vomiting, hematemesis, abdominal pain, dysphagia (difficulty swallowing), jaundice, and change in bowel function, including constipation, diarrhea, and bleeding. It is important to focus on descriptive characteristics for each of the patient's symptoms, such as their timing (onset, frequency, duration), their location (**Figure 31-2**), their severity, aggravating or alleviating factors, associated symptoms, and the patient's thoughts on what precipitated or caused the problem (Bickley & Hoekelman, 2003). "How has your appetite been?" may be a good initial question that may lead to identification of problems such as indigestion, nausea and vomiting, anorexia, excessive belching, and changes in the patient's weight. A thorough medical history should include questions regarding previous procedures (both diagnostic and surgical), illnesses, hospitalizations, immunizations (e.g., hepatitis A or B), medications (including prescription, over-the-counter, and herbal remedies), and allergies. A family history of gastrointestinal problems, such as Crohn's disease, may be helpful in the assessment of your patient.

FIGURE 31-2 Four Quadrants of the Abdomen



Source: Illustrated by James R. Perron.

Many exogenous factors can contribute to gastrointestinal symptoms and diseases, including infectious diseases (e.g., hepatitis and travel-acquired intestinal organisms), toxic chemicals, and stress (Bickley & Hoekelman, 2003). It is important to remember that the bowel is often a sounding board for our emotions.

PHYSICAL ASSESSMENT

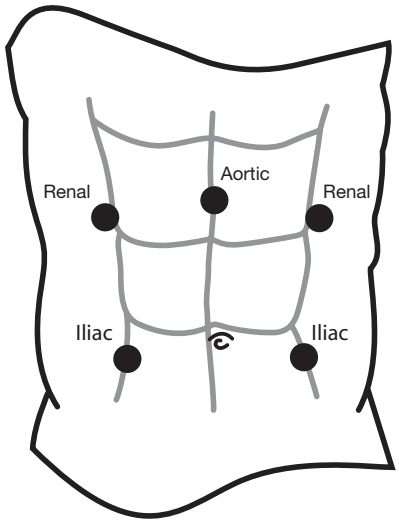
The physical examination of the abdomen includes inspection, auscultation, percussion, and palpation. The patient's bladder should be emptied prior to the exam. Place the patient in the supine position with a pillow under the head and with the knees slightly bent. Having the patient place arms folded across the chest helps to relax the abdominal muscles. As you examine the abdomen, imagine lines drawn vertically and horizontally through the umbilicus that divide it into four quadrants (see Figure 31-2): right upper quadrant, left upper quadrant, right lower quadrant, and left lower quadrant. Visualize the organs in each quadrant as you proceed with the examination. When referring to any findings, describe them using the appropriate quadrant (Bickley & Hoekelman, 2003).

Begin the examination with a thorough inspection, noting the abdominal contour and symmetry. Abdominal asymmetry may be caused by obesity, organomegaly, or fluid and/or gas distention. Carefully observe the skin for color, texture, turgor, hair distribution, presence of veins, striae, or scars. Silvery-white striae are common findings and are caused by rapid stretching of the skin as occurs with pregnancy; purple-blue striae may be indicative of Cushing's syndrome (Bickley & Hoekelman, 2003). Ecchymosis around the umbilicus (Cullen's sign) occurs in intraperitoneal hemorrhage. Normal aortic pulsation is frequently visible in the epigastric area (see Figure 31-2).

Auscultation of the abdomen provides information regarding bowel motility. Both percussion and palpation can have an effect on bowel motility; therefore, it is important to auscultate before percussing or palpating the abdomen. Using the stethoscope's diaphragm placed lightly against the patient's skin, listen for bowel sounds in each of the four quadrants. Normal bowel sounds vary, but they generally sound gurgly and occur anywhere from 5 to 30 times per minute. Bowel sounds may be altered in diarrhea, intestinal obstruction, peritonitis, or with laxative use. Using the bell of the stethoscope, listen in the epigastrium and in each of the upper quadrants for bruits. Bruits are vascular sounds that resemble heart murmurs and may be heard when there is turbulent blood flow caused by either constriction or dilation of the blood vessels (Bickley & Hoekelman, 2003). This part of the examination is especially important with hypertensive patients. You may also auscultate over the iliac arteries if you suspect arterial insufficiency in the legs (**Figure 31-3**). Auscultate over the liver and spleen to detect any peritoneal friction rubs that may be present with infection, tumors, or infarcts.

Percussion, or tapping against the patient's skin, helps to assess the amount of fluid or gas in the abdomen, locate and estimate the size of a mass, and estimate both liver and spleen size. To perform percussion, place the distal joint of your middle finger of your nondominant hand on the patient's ab-

FIGURE 31-3 Listening Points for Abdominal Bruits



Source: Illustrated by James R. Perron.

domen. Make sure that no other part of your hand is touching the abdomen. With a quick, sharp, bent, relaxed wrist motion, strike your finger with the tip of the middle finger of your dominant hand. With practice, you will discern subtle sound differences: Dullness is a muffled, thud-like sound that is heard over the liver, spleen, or tumors; tympany is a drum-like sound that is heard over gas-filled organs such as the stomach and intestines. Percuss in each quadrant as well as over the liver and spleen. The normal liver is 6 to 12 cm at the right midclavicular line; the normal spleen is less than 7 cm at the left midaxillary line. It is important to note that a full stomach or intestine can cause a dull sound (Bickley & Hoekelman, 2003).

Percussion can also be useful for assessing possible ascites. Because fluid characteristically moves to dependent areas of the abdomen, a patient with ascites most likely will have a tympanic sound with percussion in the mid-abdominal area and a dull sound in the flank areas (Bickley & Hoekelman, 2003). Remember that percussion gives only a gross estimate of the size, location, and presence of fluid. The definitive test for abnormal findings is an abdominal ultrasound.

Palpation, or feeling the abdomen, helps to determine the presence of muscle spasms, fluid, and masses, and assesses any tenderness. Each quadrant is palpated using both light and deep palpation techniques. Note any tenderness, pain, or rigidity. Involuntary rigidity or muscle spasm may indicate peritoneal inflammation. Light palpation is helpful in identifying abdominal tenderness; deeper palpation is useful for assessing organs such as the liver, spleen, and kidneys and detecting masses. Rebound tenderness is associated with peritoneal inflammation. To assess for rebound tenderness, press your fingers slowly and deeply, and then quickly withdraw your fingers (Bickley & Hoekelman, 2003). Pain that is induced or worsens with quick release is a reliable test for peritoneal inflammation.

Assessment findings can indicate many pathological conditions. Clustering symptoms together can lead the nurse to hypothesize about possible causes of assessment data. **Table 31-1** lists some abnormal findings and possible causes for them.

The following common diagnostic procedures may be useful in assessing gastrointestinal conditions:

- *Barium studies.* This test involves the patient swallowing barium or having a barium enema prior to diagnostic imaging studies. A barium swallow allows diagnosis of inflammatory, neoplastic, and motility disorders and of lesions that cause stenosis or obstruction. Typical indications for barium enemas include symptoms of colon carcinoma, diverticular disease, and inflammatory bowel disease. Use of barium is discouraged because it interferes with other tests being performed later (e.g., colonoscopy or angiogram) (Holzman, Schirmer, & Nasraway, 2005).
- *Flexible sigmoidoscopy.* This direct visualization of the distal colon is used to evaluate rectal bleeding, new-onset or persistent diarrhea or constipation, mass on digital examination, and left lower quadrant abdominal pain and cramping (National Digestive Diseases Information Clearinghouse, 2006).
- *Colonoscopy.* This test is similar to sigmoidoscopy, except that a colonoscopy allows the practitioner to visualize

TABLE 31-1 Abnormal Assessment Data

Data	Possible Cause
Asymmetry in the upper quadrant	Tumor, pancreatic cyst, gastric dilatation
Asymmetry in the lower quadrant	Ovarian tumors, fibroid tumors, pregnancy, bladder distention
Ecchymosis around umbilicus (Cullen's sign)	Intraperitoneal hemorrhage
Jaundice	Altered liver function
Diminished or absent bowel sounds	Postoperative, peritonitis, paralytic ileus, late bowel obstruction
Increased bowel sounds	Diarrhea, gastroenteritis, complete intestinal obstruction, bleeding ulcers
Bruit over vessels	Aneurysm
Friction rub over spleen or liver	Splenic infarct, hepatic tumor
Continuous venous hum over periumbilical	Hepatitic cirrhosis
Dullness percussed over midaxillary line	Enlarged spleen
Pain on palpation	Peritoneal inflammation
Abdominal distention	Trapped air or fluid in the abdomen

Sources: Bickley & Hoekelman, 2003; Bickley & Szilagyi, 2003.

the entire large bowel and not just the sigmoid or lower portion of the colon (Tham & Collins, 2000).

- *Ultrasound.* This test is used to detect gallbladder stones and to evaluate the liver and spleen. A disadvantage of ultrasound is its inability to penetrate gas-filled structures, such as the colon and stomach (Valley & Fly, 2006).
- *Urea breath test.* This test is used to diagnose *Helicobacter pylori* infection of the stomach, the major etiologic factor for patients with active peptic ulcer disease (National Guideline Clearinghouse, 2006).
- *Abdominal paracentesis.* This test is used for diagnosing the cause of ascites. It is also used to remove large amounts of fluid in patients where the increased intra-abdominal pressure (IAP) is causing respiratory distress (Nissl, 2006).
- *Intra-abdominal pressure monitoring.* This test identifies intra-abdominal hypertension through a urinary catheter. Measuring the pressure in the bladder indicates the IAP. Increased IAP leads to respiratory compromise, organ hypoperfusion, and a high mortality rate. Intra-abdominal hypertension has been defined as a pressure reading greater than 20 mm Hg (Brooks, Simpson, Delbridge, Beckingham, & Girling, 2005). At high pressures (> 25 mm Hg) surgical decompression is mandatory (Malbrain, 2005).

SUMMARY

Assessment of the gastrointestinal system can be challenging. It is important to remember that a timely and accurate assessment can help in making the correct diagnosis of the patient's problem and may alter the patient's outcome.

CRITICAL THINKING QUESTIONS

1. Why does a partial gastrectomy frequently lead to pernicious anemia?
2. How is the stomach lining protected from damage from the strong hydrochloric acid secretions? What effect do nonsteroidal anti-inflammatory drugs have on the lining of the stomach?
3. List signs and symptoms that arise when the gastrointestinal system is hypoperfused.
4. Which diagnostic test should be ordered to measure intra-abdominal hypertension?
5. What are the implications for alkalizing the gut with either H_2 blockers or antacids?

Online Resources

Abdominal Compartment Syndrome: www.trauma.org/resus/DCSacs.html

Society of Gastrointestinal Nurses and Associates: www.sgna.org

GI system tutorial: www.le.ac.uk/pathology/teach/va/anatomy/case6/frmst6.html

Digestive System Learning Resources and Animations: www.innerbody.com/image

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