Chapter e49: Evaluation of the Gastrointestinal Tract

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KEY CONCEPTS

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1. The patient history is key to evaluating gastrointestinal (GI) tract disorders and should include the problem onset, the setting in which it developed, and its presentation. Patient warning signs and alarm symptoms should be identified quickly and referral for further evaluation should be obtained in a prompt manner.
2. A complete physical examination should be performed, the severity and location of symptoms directing the focus of the examination.
3. Contrast agents, barium sulfate and Gastrografin® (diatrizoate meglumine and diatrizoate sodium solution), have gradually been replaced by endoscopy, but allow evaluation of the hollow organs of the digestive tract for mucosally based lesions as well as narrowing or strictures involving the GI tract.
4. The upper GI series involves radiographic visualization of the esophagus, stomach, and duodenum; whereas the lower GI series involves visualization of the colon and rectum.
5. Enteroclysis is used to evaluate the small bowel by introducing contrast agents by tube through the nose or mouth directly into the small intestine.
6. Transabdominal ultrasound, computed tomography, and magnetic resonance imaging provide images of the gallbladder, liver, pancreas, and abdominal wall and are increasingly utilized for assessing small bowel and colonic diseases.
7. Radionuclide imaging is sometimes useful to visualize and evaluate the liver, spleen, bile ducts, and gallbladder.
8. The endoscope, an illuminated optical instrument, remains the cornerstone of GI diagnosis and most importantly therapy. Common examples of endoscopic procedures include esophagogastroduodenoscopy, colonoscopy, enteroscopy, endoscopic retrograde cholangiopancreatography, and endoscopic ultrasound.
9. Capsule endoscopy, a newer less invasive endoscopic technique, takes pictures of the GI tract in the assessment of the small bowel in particular.
10. Ambulatory esophageal pH measurement is an important diagnostic test for gastroesophageal reflux disease and is often performed in conjunction with upper endoscopy. Most systems today are completely wireless and patient friendly.
11. Multichannel intraluminal impedance and pH monitoring combines acid exposure with impedance changes in resistant flow to aid the diagnosis of reflux in patients receiving a proton pump inhibitor and other antisecretory medications.

BEYOND THE BOOK

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This activity will encourage students to review the chapter to determine the most useful approach for diagnostic or therapeutic interventions for each gastrointestinal disease. With each of the following gastrointestinal diseases, determine which laboratory, radiologic, mechanical test, or patient history is required to confirm the diagnosis: unexplained diarrhea, bowel obstruction, Barrett esophagus, reflux disease treated with a proton pump inhibitor.

INTRODUCTION

The GI tract is an organ system responsible for nutrient absorption, waste excretion, and immunity. It is composed of the upper GI tract (oral cavity, esophagus, and duodenum), lower GI tract (small intestine, cecum, colon, rectum, and anus), and associated glandular organs (gallbladder, pancreas, and liver). A variety of symptoms can arise from GI tract dysfunction, including heartburn, dyspepsia, abdominal pain, nausea, vomiting, diarrhea, constipation, and GI bleeding. Signs and symptoms of malabsorption, hepatitis, and GI infection are also commonly seen. All clinicians must recognize warning or alarm symptoms including weight loss, intractable vomiting, anemia, dysphagia, odynophagia, and bleeding; and a patient presenting with any of these symptoms should be immediately referred for further diagnostic interventions.

Despite the rapid proliferation of technology for the diagnosis of digestive diseases, the patient history and physical examination remain important for initial assessment, triage, and guidance of further diagnostic interventions. When combined with a thorough patient history and physical examination, diagnostic procedures are essential in the evaluation of GI disorders. This chapter describes the most commonly used clinical tools to evaluate patients with GI tract-related diseases.

PATIENT HISTORY

1 A comprehensive patient history is the cornerstone in the evaluation of a patient with digestive complaints. The purpose of history taking is to obtain a clear and detailed account of the patient's complaints. It is considered the first step in the diagnostic workup and used to narrow the focus of the diagnostic and therapeutic plan for the patient. In addition to collecting information on current complaints, a thorough patient history should gather information concerning medical history, social and family history, and current medications. The healthcare professional should ask guided questions focused on determining the symptom's onset, location, severity, and duration, setting in which symptoms developed, aggravating and alleviating factors, and associated symptoms of the complaint. The symptom onset often provides important information that helps formulate a differential diagnosis. For example, biliary colic or pain, such as that encountered with symptomatic gallstone disease, typically evolves over minutes and is present for hours, but pain caused by pancreatitis evolves over hours and lasts for days. The setting is always relevant as it provides clues to the possible origin of the disorder. For example, in the patient with complaints of reflux or ulcer disease, obtaining information as to whether the pain is alleviated or worsened by food or diminished when administered acid-suppressive therapy can help guide diagnostic and therapeutic interventions. For instance, ingesting a meal often relieves the pain of duodenal ulcer, but worsens pain due to a gastric ulcer. The healthcare professional should ask questions that address potential etiologic possibilities, including motility disorders, structural diseases, malignancies, infections, psychosocial factors, dietary factors, and travel-associated diseases.[1,2] A good cardiopulmonary history is also extremely relevant and should be performed during the overall history. Questions concerning medical and family history detailing illnesses, surgical interventions, injuries, foreign travel, living conditions, and habits are valuable (Table e49-1). A complete medication use history including over-the-counter, herbal, and traditional Chinese medicines is vital as many agents cause GI injury (Table e49-2).

TABLE e49-1

General Questions in a GI History

1. Where is your pain located? Please point to the area where you feel pain. How rapidly did the pain come on? Is your pain constant or intermittent? What factors exacerbate or alleviate your pain? Does the pain awaken you at night?
2. Tell me about the problem that you are experiencing. When did it start? What were you doing when the symptoms began?
3. Have you recently had a change in bowel habits? Have you experienced any diarrhea or constipation lately? Do you experience painful bowel movements?
4. Have you experienced any nausea or vomiting lately? If so, please describe conditions centered on this event.
5. Have you experienced any recent change in weight? Was this intentional? How many pounds have you gained or lost and over what time period did this occur? How has your appetite been?
6. Have you passed any blood from your rectum or vomited blood? Have you noticed any dark, tarry stools?
7. Have you had any acid indigestion?
8. Do you have difficulty swallowing?
9. Have you had these symptoms in the past?
10. What medications are you taking to help alleviate the pain? How much do you take? Do these medications work?
11. Have you recently had a change in dietary intake? If so, please describe. Can you draw any correlation between the foods that you eat and your GI complaint?
12. Describe your medical history, including illnesses and surgeries.
13. Please describe any past injuries that you have experienced.
14. What other medications are you currently taking? Why are you taking them?
15. Has anyone in your family experienced similar GI complaints? If so, please describe. Does anyone in your family have a history of GI disorders, including cancer of the GI tract?
16. Have you recently traveled outside of the United States? If so, where? When? How long did you stay? What kind of living conditions did you experience? What foods and drinks did you ingest?

GI, gastrointestinal.

TABLE e49-2

Drugs That May Cause GI Injury

GI mucosal injury	
Aspirin	Iron preparations
Bisphosphonates	Nonsteroidal anti-inflammatory agents
Chemotherapeutic agents	Pancreatic enzymes
Corticosteroids	Potassium chloride
Ethacrynic acid	Reserpine
Ethanol	Warfarin
Jaundice	
Acetohexamide	Ethanol
Androgens	Gold salts
Chlorpropamide	Nitrofurantoin
Corticosteroids	Phenothiazines
Erythromycin	Warfarin

Estrogens	
Liver damage	
Acetaminophen Allopurinol Amiodarone Aminosalicylic acid Dapsone Erythromycin Ethanol Glyburide Isoniazid Ketoconazole Lovastatin Methotrexate Methyldopa Monoamine oxidase inhibitors Nevirapine Niacin	Nifedipine Nitrofurantoin Phenazopyridine Phenytoin Propylthiouracil Quinolone antibiotics Rifampin Salicylates Sulfonamides Telithromycin Tetracycline Valproic acid Verapamil Warfarin Zidovudine
Herbal products	
Ayurvedic herbal products *Atractylis gummifera*	*Callilepsis laureola* Chaparral
Chinese herbal medicines	
Jin Bu Huan (*Lypocodium serratum*) Ma huang (*Ephedra sinica*) Dai-saiko-to (Sho-saiko-to, TJ-19) Geniposide Germander	Greater celandine Green tea Kava Pennyroyal pyrrolizidine alkaloids
Pancreatitis	
Azathioprine Corticosteroids Didanosine Estrogens Ethacrynic acid Ethanol Furosemide	Metronidazole Opiates Pentamidine Sulfonamides Tetracycline Tigecycline Thiazides

GI, gastrointestinal.

Data from References 3-7.

PHYSICAL EXAMINATION

2 A thorough physical examination, not limited to the GI tract, is necessary to provide important diagnostic data and determine the need for acute intervention.[8] A comprehensive evaluation of the patient should be performed with notable attention to physical appearances and vital signs as they may suggest signs of systemic conditions eliciting GI symptoms. An abdominal examination is an essential part of the GI workup and classically includes inspection, auscultation, percussion, and palpation in this order. Inspection of the abdomen may reveal scars, hernias, bulges, or peristalsis. Auscultation is mainly focused on analysis of bowel sounds and identification of bruits and should be performed prior to percussion and/or palpation. Percussion of the abdomen allows for detection of tympany, measurement of visceral organ size, and detection of ascites. Palpation may allow the examiner to identify tenderness, rigidity, masses, and hernias. Moving from the abdominal examination, the digital rectal examination is used to detect rectal masses and tenderness, and to assess muscle tone. Stool on the examiner's glove obtained during rectal examination is often subjected to testing for detection of occult blood.[2,8] Additionally, once cardiovascular disease is eliminated, patients with chest pain may have a GI source to their symptoms and further diagnostic workup may be needed.

LABORATORY AND MICROBIOLOGIC TESTS

Laboratory and microbiologic tests may be used to assess organ function, to screen for certain GI disorders, and to evaluate the effectiveness of therapy. Laboratory testing should be viewed largely as supportive to an accurate history and physical examination. To achieve an accurate diagnosis and provide the best care, it is important to assess the patient's fluid and electrolyte status, nutritional status, inflammatory markers, and abdominal organ function. A complete blood cell count should be completed early in the evaluation to provide information concerning infection, malignancy, bone marrow suppression, anemia, and blood loss.[9] A serum chemistry panel provides valuable information—involving several organ systems. For example, serum creatinine and blood urea nitrogen are often used as a measure of hydration status, as well as, serving as indicators for renal function. Elevations in serum creatinine and blood urea nitrogen may be indicative of renal dysfunction or dehydration, and bleeding from the upper GI tract may lead to elevations in blood urea nitrogen. Albumin and prealbumin levels can be used to assess the patient's nutritional and hydration status and provide information concerning hepatic and renal function. Low albumin may be indicative of malnutrition, hepatic dysfunction, nephrotic syndromes, or protein-losing enteropathies. Serum measurements of sodium, chloride, and potassium are useful to determine electrolyte abnormalities associated with diarrheal illnesses. The erythrocyte sedimentation rate and C-reactive protein are nonspecific inflammatory markers that are useful for the diagnosis and management of patients with inflammatory bowel disease.

More specific laboratory blood tests are often useful for classifying pancreaticobiliary disorders. Measurements of serum aspartate transaminase and alanine transaminase are elevated in most diseases of the liver, and serum alkaline phosphatase and bilirubin are often elevated in hepatobiliary disorders involving bile duct blockage and intrahepatic cholestasis. Prothrombin time and international normalized ratio are related to hepatocyte synthesis of vitamin K-dependent clotting factors and serve as indirect measurements of hepatic function. When evaluating patients with suspected pancreatitis, serum and urine measurements of amylase and lipase are important, because these will be elevated in many patients with acute pancreatitis (see Chapter 57, "Pancreatitis").

Microbiologic and related studies are useful in evaluating patients with unexplained diarrhea, abdominal pain, and suspected GI infections. Stool may be examined to detect the presence of bacteria, parasites, or toxins. Pathogens most often responsible for infectious diarrhea and enteritis include bacteria such as *Shigella*, *Salmonella, Escherichia coli, Yersinia*, and *Clostridioides difficile.* Viruses such as cytomegalovirus, especially in patients with acquired immune deficiency syndrome (AIDS), and parasites such as *Entamoeba histolytica* and *Giardia lamblia* are occasionally seen.[10] Patients presenting with watery diarrhea following antibiotic exposure within the previous 3 months should have their stool checked for *C. difficile* toxins A and B. An additional organism *Helicobacter pylori* is a significant factor associated with peptic ulcer disease and mucosa-associated lymphoid tissue (MALT) lymphomas; identification of this organism is critical in patients experiencing upper GI symptoms and is often tested for during upper endoscopy (see Chapter 51, "Peptic Ulcer Disease").[10]

DIAGNOSIS

The patient's history, physical examination, and routine laboratory tests are valuable in establishing a diagnosis, but frequently more specific studies

are required to confirm a clinical suspicion. The most appropriate diagnostic study depends on the anatomic region involved, the suspected abnormality, the reliability of the test (eg, sensitivity vs specificity), the patient's overall condition, and the clinical manifestations of the patient. The next sections outline the most frequently used diagnostic studies and procedures and their roles in evaluating the GI tract.

Noncomputer-Assisted Radiologic Studies

Radiologic procedures rely on the differential absorption of radiation of adjacent tissues to highlight anatomy and pathology. It is useful to divide radiologic testing into noncomputer- and computer-assisted procedures. Noncomputer-assisted radiologic procedures important in evaluating the GI tract include plain radiography, upper GI series with small bowel follow-through, lower GI series, and enteroclysis.[11,12]

Plain Radiography of the Gastrointestinal System

Radiographic evaluation of the GI tract often starts with plain films of the abdomen, which are noncontrast radiographs.[12] Specific abdominal structures that may be identified include the kidneys, ureters, and bladder. The esophagus, stomach, small and large intestine, and stones may also be seen. Stones located within the gallbladder body and within the kidney are sometimes seen on plain abdominal films. Plain films are often used initially to evaluate abdominal pain. Clinicians frequently employ plain radiographic fluoroscopy to guide and position other instruments that are used to evaluate and treat GI disorders; an example is the manipulation of dilation devices to treat esophageal strictures. Bowel obstruction and perforation can be seen using plain radiographic techniques; however, the widespread availability of computed tomography (CT) scanning is gradually replacing these techniques.

Contrast Radiography of the Gastrointestinal System

Oral, rectal, and intravenous contrast agents are used in a variety of ways for radiographic imaging of the GI system. Oral contrast agents, such as barium sulfate and other water-soluble contrasts, are commonly used for radiographic studies, such as pharyngographic studies, upper GI series, and small bowel follow-through examinations. Oral contrast agents are routinely used to opacity the GI tract in CT, magnetic resonance imaging (MRI), CT and MRI enterography, and CT- and MRI-positron emission tomography. Barium sulfate enema technique is an established method for evaluating the colon and to opacity the colonic lumen during abdominal and pelvis CT imaging. Contrast agents allow for visualization of biliary and pancreatic ducts during endoscopic retrograde cholangiopancreatography. Contrast agent nephrotoxicity in patients with preexisting renal impairment remains a clinically significant problem. Pretest treatment in high-risk patients with pharmacologic agents has mixed results.

3 Barium sulfate is a water-soluble contrast agent that improves the visualization of the esophagus, stomach, and intestine in a radiographic image.[12] The area where barium localizes appears white on the radiographic film, creating distinctive definition and visual contrast between an organ and the surrounding tissues. Radiographic studies using barium sulfate are commonly referred to as barium esophogram (*barium swallow*) or barium enema studies as barium sulfate is only administered via the oral or rectal route. Barium sulfate is not generally absorbed, and constipation is the most frequent adverse effect reported with its use. Its use is contraindicated in the setting of known or suspected GI tract perforation due to increased risk of peritonitis. Diatrizoate meglumine and diatrizoate sodium solution (Gastrografin®) is an alternative oral contrast agent for use in patients that are unable to tolerate or are allergic to barium sulfate. Barium sulfate and/or Gastrografin® can reveal mucosal defects and lumen size, and are helpful in diagnosing hiatal hernias, strictures along the GI tract, polyps, tumors, and in some cases ulcers. Upper endoscopy is largely replacing contrast studies in the diagnosis of upper GI tract disorders, but in certain instances they can be a tool in establishing a diagnosis prior to endoscopic evaluation. The barium esophogram should not serve as a primary diagnostic tool for patients with heartburn.

Upper Gastrointestinal Series

4 The upper GI series refers to the radiographic visualization of the esophagus, stomach, and duodenum. Patient preparation for an upper GI series usually consists of instructing patients to refrain from eating or drinking 8 to 12 hours prior to testing, which allows the upper GI tract to empty. A contrast agent such as barium sulfate or Gastrografin® is administered to the patient at the beginning of the study. The observed swallowing of the contrast agent permits visualization and monitoring of esophageal structural and motor functions. A gastrointestinal radiologist sometimes uses double contrast techniques to enhance the visualization of the inside wall lining of the esophagus, stomach, and duodenum. The double contrast technique uses a gas, such as air or a carbonated substance, in addition to barium sulfate. The gas expands the organs and allows for the barium sulfate to coat the inner surface of the organ, providing sharpened visualization.[13]

The upper GI series can be continued as the contrast agent moves from the stomach and duodenum into the small intestine, referred to as the *small bowel follow-through*. The single contrast agent technique, with either barium sulfate or a water-soluble contrast, is utilized during a small bowel follow-through. An upper GI series with small bowel follow-through commonly uncovers gastric cancer, peptic ulcer disease, esophagitis, gastric outlet obstruction, and can be suggestive of Crohn's disease (Fig. e49-1). In general, the barium swallow is plagued by low sensitivity and specificity for many GI disorders and as mentioned is being replaced by upper endoscopic techniques.

FIGURE e49-1

Upper GI series with small bowel follow-through demonstrating narrowed distal terminal ileum and separation of small bowel loops (*arrow*). These findings are consistent with Crohn's disease.

Lower Gastrointestinal Series

The lower GI series is used to examine the colon and rectum and is particularly useful if a colonic obstruction is suspected. Patients complaining of lower abdominal pain, constipation, or diarrhea are often referred for a lower GI series, also called a barium enema. The colon is prepared for the procedure by instructing the patient to refrain from eating or drinking 8 to 12 hours before the procedure, and by administering bowel-cleansing agents such as sodium sulfate-based tablets, bisacodyl, magnesium citrate, magnesium hydroxide, or polyethylene glycol electrolyte (PEG) solution. A combination of laxatives and fluids are used for bowel cleansing prior to colonoscopy.[14] During a lower GI series, a barium sulfate enema is given to contrast the terminal large intestine and rectum. The lower GI series is sometimes useful to detect and evaluate enterocolitis, obstructions, volvulus, and mucosal and structural lesions.[12] Similar to the upper GI series, the double contrast technique with air may be used to enhance imaging of the

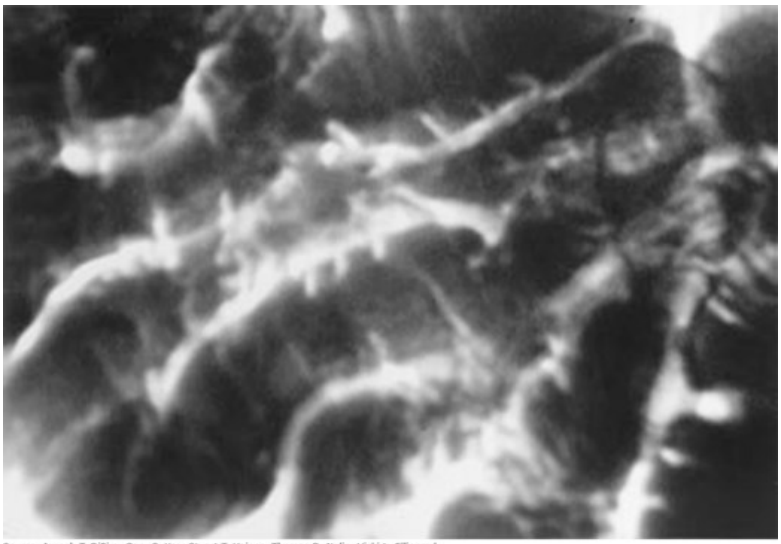
colon.

Small Bowel Enteroclysis

5 Enteroclysis, or small bowel enema, refers to the technique of direct small bowel introduction of a contrast agent through a tube inserted through the patient's mouth or nose directly into the small intestine. Sequential radiographic films are taken of the small bowel as the contrast agent flows distally (Fig. e49-2). The enteroclysis technique allows for optimal distention of the small bowel lumen and enables visualization of subtle mucosal abnormalities. Enteroclysis is not widely performed due to operator inexperience and is rapidly being replaced by improved radiologic techniques such as CT or MRI enterography or by small intestinal endoscopy known as single and double balloon enteroscopy and capsule endoscopy.

FIGURE e49-2

Normal small bowel enteroclysis. Contrast agents are instilled into the small bowel to highlight tumors, strictures, or other lesions. In this image, one can identify the normal circular folds.



Computer-Assisted Radiologic Studies

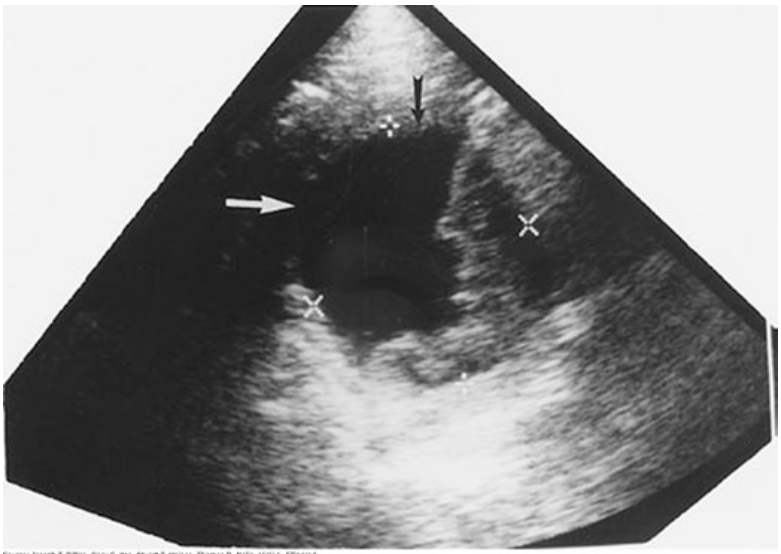
The second category of radiologic evaluation of the GI tract involves computer-assisted techniques, which allow a cross-sectional radiographic image of the body to be performed. Transabdominal ultrasonography, CT, radionuclide scanning, and MRI are frequently used imaging procedures for evaluating digestive disorders.[11,12]

Ultrasonography

6 Ultrasonography provides images of deeper structures such as the gallbladder, liver, and kidneys and can also be useful in helping define vascular abnormalities in the intra-abdominal cavity. Ultrasound involves the direction of a narrow beam of high-energy sound waves into the body and recording the reflections from the various organs and structures. In general, ultrasonography is a well-accepted, noninvasive, and relatively inexpensive method for evaluating GI pathology that requires no ionizing radiation and can be performed at bedside with a portable unit. It accurately depicts the presence of gallstones within the gallbladder, helps define liver morphology, and serves as a first test to evaluate the absence or presence of biliary ductal dilation in a jaundiced patient (Fig. e49-3). When combined with Doppler technologies, ultrasonography can image GI vascularity, in particular portal venous flow, and identify aneurysmal dilations of the abdominal aorta. The images produced by ultrasonography are not as sharp and clear as those produced by CT and the quality of the images produced relies heavily on the operator. Ultrasonography is limited by the presence of bowel gas and excessive amounts of body fat, particularly when evaluating deeper organs such as the pancreas.[11,12]

FIGURE e49-3

Abdominal ultrasonogram demonstrating a chronic pancreatic pseudocyst (*arrows*).



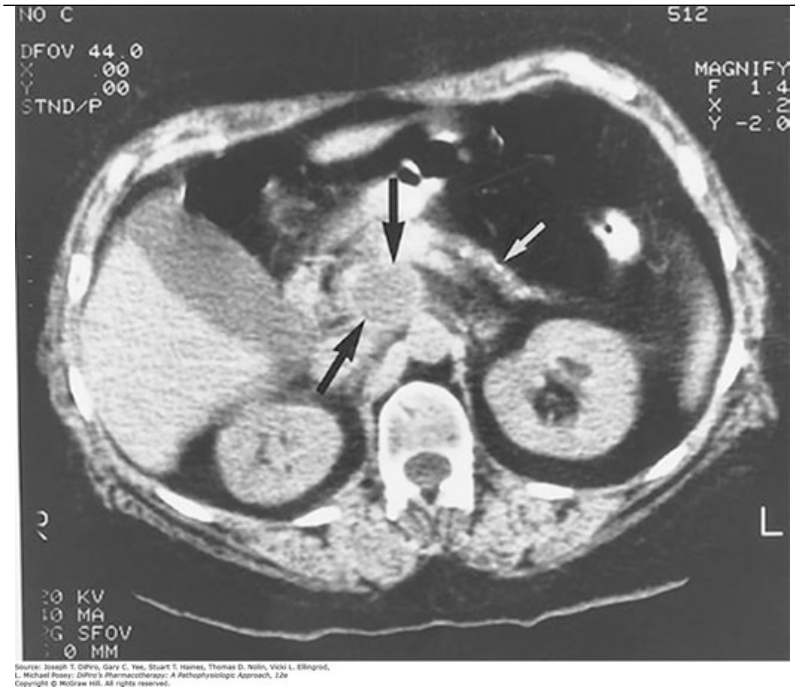
Computed Tomography

Advances in CT or computed axial tomography (CAT) scanning have resulted in a paradigm shift for chest and abdominal-pelvic imaging, providing improved resolution and faster acquisition of radiographic information. A CT examination provides detailed images of the GI system in which transverse planes of tissue are swept by a radiographic beam and a computer analysis of the variance in absorption produces a precise reconstructed image of that area.[11] Contrast agents may be added during a CT procedure to enhance the difference in density of various structures. Oral and rectal administration of a contrast agent, such as barium sulfate or a water-soluble contrast agent, will help delineate the GI tract, while intravenous administration of a water-soluble contrast agent will illuminate the vascularity of the GI tract.

The abdominal CT displays organs from the diaphragm down to the pelvic brim, and is especially valuable for detecting GI diseases of the liver, pancreas, spleen, and colon. Patient preparation for CT includes refraining from eating or drinking for a minimum of 4 hours before the test. The remarkable detail that CT offers in imaging of organs and tissues adds to its popularity for evaluation of the GI tract. CT scanning is rapidly replacing plane radiography of the abdomen due to its widespread availability, diminishing cost, and wealth of information provided. CT is also useful in the identification of suspected intra-abdominal malignancy, pancreatitis, intra-abdominal abscesses, and cysts (Fig. e49-4).[11,12] Unlike ultrasonography, patient body size or the presence of gas does not limit the quality of imaging with CT. Contrast agents used during CT scanning are nephrotoxic and close attention to a patient's renal function is mandatory in these patients.

FIGURE e49-4

CT scan of the abdomen showing pancreatitis with calcification (*white arrow*) and pancreatic pseudocyst (*black arrows*).



CT enteroclysis combines the methods of barium enteroclysis and abdominal CT into one technique. It is highly accurate in depicting mucosal abnormalities in Crohn's disease and diagnosing of low-grade small bowel obstructions. During CT enteroclysis, the small bowel is expanded by introduction of a contrast agent through a nasoduodenal tube directly into the small intestine with or without intravenous contrast. CT enterography uses the same method as CT enteroclysis; however, the patient orally ingests the contrast agent without the use of a nasoduodenal tube. For the investigation of small-bowel disease, CT enteroclysis is considered a complementary addition to capsule endoscopy technique discussed later in this chapter.[15]

Radionuclide Imaging

Radionuclide imaging, commonly referred to as nuclear medicine, is a well-suited diagnostic tool that allows for structural and functional visualization of the GI tract. It involves IV injections of a radiopharmaceutical imaging agent and the use of a computerized detection camera to gather images. A secretory agent is sometimes given in addition to the radiopharmaceutical agent to improve sensitivity. Although the choice of a radiopharmaceutical agent depends on the specific organ or function being studied, the most commonly used agent is technetium (^{99m}Tc) tagged to a carrier molecule. Radionuclide imaging is sometimes useful to visualize the liver and spleen (liver–spleen scan), bile ducts, gallbladder (hepatoiminodiacetic acid [HIDA] scan), and gut (tagged red blood cell).[11,12] Cysts, abscesses, tumors, and obstructions are detected and displayed as areas of differential uptake of radioactivity.[11] Radionuclide bleeding scans may detect hemorrhages and may assist with localization of therapeutic interventions. Patient preparation for radionuclide imaging includes refraining from eating or drinking for a minimum of 8 hours before the test.

Magnetic Resonance Imaging

MRI allows for a comprehensive evaluation of intra-abdominal solid organs including, the liver, pancreas, and spleen, without the use of ionizing radiation. An MRI places the patient in close proximity to a high-strength magnetic field through which pulses of radiofrequency radiation are projected, thereby exciting the nuclei of hydrogen, phosphorus, oxygen, and other elements. The radiofrequency signals are manipulated and recorded by a computer, and a two-dimensional image representing a section of the patient is produced.[11,12] MRI has greater sensitivity for identifying liver tumors than do ultrasonography, CT, and radionuclide imaging. Patient preparation for an MRI includes refraining from eating or drinking for a minimum of 4 hours before the test. Significant advances in MRI technology and imaging capabilities often make it a preferred diagnostic test, particularly in the evaluation of pancreaticobiliary disorders when secretin is added to enhance bile and pancreatic duct visualization.[11,12] Magnetic resonance cholangiopancreatography (MRCP) is used for evaluating the biliary tract and pancreatic duct in a noninvasive manner without the need for exogenous contrast agents. In MRCP, static fluid in the ducts appears bright against the darker tissue.

Similar to CT, magnetic resonance enteroclysis and enterography are used to evaluate and monitor patients with Crohn's disease. Due to the lack of radiation exposure, magnetic resonance enteroclysis offers an advantage over CT enteroclysis particularly in younger patients that will likely require numerous examinations over their lifetime. However, it appears to be less accurate than CT enteroclysis which has higher sensitivity.[15]

Arteriography

Arteriography of the gut depicts the configuration of visceral blood vessels after intravascular administration of an iodinated contrast agent. Arteriography may be employed for vascular anomalies such as an aneurysmal dilation and in the evaluation of obscure bleeding lesions. The therapeutic applications for arteriography include embolization of bleeding vessels, fistulas, and inoperable tumors.[11,12]

Endoscopy

Refinement in optical engineering and fiber optics led to the development of the endoscope, which has revolutionized the management of GI disorders. Most endoscopic equipment today uses a computer chip device to provide high definition, detailed images of the particular lumen being examined. An endoscope is an illuminated white light and non-white light optical instrument designed to inspect the interior of the GI tract. Endoscopes enable the practitioner to inspect intraluminal mucosal lesions and to obtain biopsies, washings and brushings for cytology studies. Standard upper GI tract endoscopy (ie, esophagogastroduodenoscopy [EGD]) is capable of inspecting the esophagus, stomach, and proximal small bowel. Lower GI tract endoscopic evaluation of the rectum and colon may be accomplished by colonoscopy or flexible-sigmoidoscopy. In addition to standard upper and lower endoscopy many newer diagnostic and therapeutic endoscopic devices are now available.[16]

Patients should be instructed to refrain from eating or drinking for at least 8 to 12 hours prior to the endoscopic procedure. Bowel cleansing is necessary for colonoscopy and sigmoidoscopy using a variety of PEG-based solutions. Topical pharyngeal anesthetics, such as viscous lidocaine or benzocaine, usually improve patient acceptance of the upper endoscopic tube. Intravenous sedating agents, such as lorazepam and midazolam, are commonly used to induce a state of altered consciousness, referred to as conscious sedation that minimizes discomfort during the endoscopic procedure. These sedating agents tend to improve patient acceptance and ease of the procedure. The agents should not be used without appropriate monitoring and the availability of flumazenil, a benzodiazepine antagonist. Propofol has been used to induce a deeper sedation than traditional sedation agents and improves patient comfort and shortens recovery and discharge time.[17] Propofol has a negative cardiac inotropic effect which can cause a decrease in cardiac output, vascular resistance, and arterial pressure, and can induce respiratory depression in a dose-dependent fashion. The potential for serious adverse events with these agents used for sedation during endoscopic procedure should be considered and patients should be monitored appropriately. Antimuscarinic agents, such as atropine sulfate, are occasionally used to increase a patient's heart rate and reduce duodenal and colonic motility. Glucagon may be used to reduce bowel motility. Endoscopy should be pursued with caution in patients with severe respiratory or cardiac failure, and endoscopy is contraindicated for patients with suspected perforated viscera. The most commonly used endoscopic studies are upper endoscopy (EGD), colonoscopy, flexible sigmoidoscopy, and endoscopic retrograde cholangiopancreatography (ERCP).[16] Newer endoscopic techniques include single or double balloon enteroscopy, capsule endoscopy, and endoscopic ultrasound (EUS). These techniques are outlined in detail below.

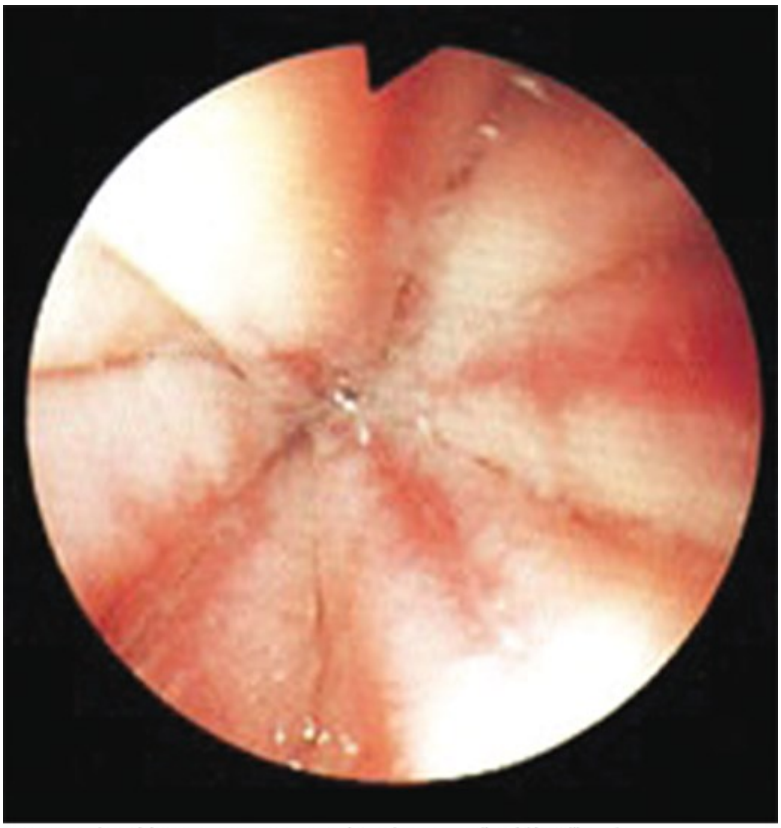
Upper Endoscopy

EGD, upper endoscopy, is used to examine the esophagus, stomach, and duodenum. Common indications for EGD include evaluation of suspected upper GI bleeding, obstructions, upper abdominal pain, and persistent vomiting, as well as, evaluation of radiographic abnormalities.[18] Patient preparation for EGD includes refraining from eating or drinking prior to the procedure and the administration of sedatives and topical anesthetics. EGD can also be used therapeutically in upper GI bleeding for ligation procedures involving esophageal varices, sclerosing, or vasoconstrictive agent administration at the site of the bleed in peptic ulcer-induced bleeding, or via the use of a thermal device such as a gold probe or heater probe on a bleeding vessel. In addition to its therapeutic potential, EGD commonly uncovers peptic ulcer disease and is the method of choice to diagnose Barrett esophagus, a premalignant condition of the esophagus and other esophageal ulcer erosive disorders (Fig. e49-5).

Endoscopy may also be used for the diagnosis of eosinophilic esophagitis. A patient with an esophageal biopsy demonstrating at least 15 eosinophils per high power field (HPF) suggests eosinophilic esophagitis in the absence of gastroesophageal reflux disease and other disease processes.[19]

FIGURE e49-5

Esophagogastroduodenoscopy (EGD) demonstrating linear red streaks with a central white streak extended up the esophagus in peptic regurgitant esophagitis. *(Reproduced, with permission, from Topazian, M. Gastrointestinal endoscopy. In: Kasper DL, Braunwald E, Hauser S, et al., eds. Harrison's Principles of Internal Medicine, 16th ed. New York: McGraw Hill, 2005.)*



Colonoscopy

Colonoscopy, lower GI endoscopy, permits direct examination of the large intestine and rectum and in addition allows for therapeutic removal of polyps and biopsy diagnosis of suspicious colonic lesions. Colonoscopy represents the main screening modality for the early detection and management of colonic polyps, which, in some cases, represent the precursor lesions for colorectal cancer development. To prepare for colonoscopy, the patient should refrain from eating or drinking for at least 8 to 12 hours prior to the examination, and bowel cleansing should be completed. Bowel preparations have traditionally involved a PEG-based or phosphate-based solution. However, due to concerns regarding phosphate-induced nephropathy, there has been a return to standard PEG-based solutions. Newer trends in bowel preparation mainly include the advent of split dose bowel preparation involving the ingestion of approximately two-thirds of the bowel preparation the night before and the additional one-third 6 hours prior to the schedule procedure. This improves bowel visualization, particularly visualization of the right colon. A benzodiazepine is often given to produce conscious sedation and improve patient comfort. Propofol is often administered to provide a deeper level of sedation in patients who are refractory or intolerant to conscious sedation agents. Indications for lower GI endoscopy can be either diagnostic or therapeutic in nature. Common indications include evaluation and detection of abnormalities visualized by radiography, as well as diagnosis and therapy of GI hemorrhage, and importantly, screening patients for colorectal carcinoma. Colonoscopy remains an invaluable procedure in the diagnosis, staging, and therapy of patients with inflammatory bowel disease (eg, ulcerative colitis and Crohn's disease).[20]

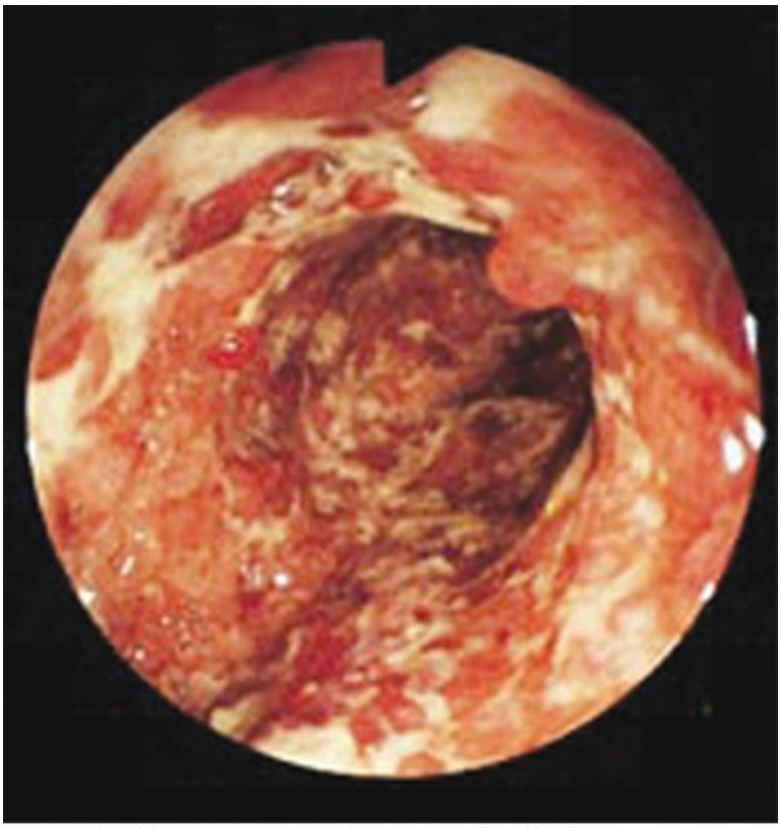
Sigmoidoscopy

Flexible sigmoidoscopy is used to evaluate the sigmoid colon via the anorectum (Fig. e49-6). It has virtually replaced rigid sigmoidoscopy because of increased patient comfort and superior performance. The major indication for this examination is to evaluate symptoms related to the distal colon or

rectum, such as hematochezia, painful defecation, and unexplained diarrhea. Flexible sigmoidoscopy is gradually being replaced by full colonoscopy in the evaluation and screening of patients for colorectal carcinoma. Patient preparation involves instructing patients to refrain from eating or drinking for at least 8 hours prior to the procedure and the administering of bowel-cleansing agents. Anoscopy is especially useful in evaluating the anus. The major indications for anoscopic examination include symptoms related to the anus and rectum, such as bleeding, protruding anorectal lesions, pain with defecation, and severe itching. Patients undergoing sigmoidoscopy or anoscopy generally do not require sedation.

FIGURE e49-6

Sigmoidoscopic photograph demonstrating severe ulcerative colitis with diffuse ulceration, bleeding, and exudation. *(Reproduced, with permission, from Topazian, M. Gastrointestinal endoscopy. In: Kasper DL, Braunwald E, Hauser S, et al., eds. Harrison's Principles of Internal Medicine, 16th ed. New York: McGraw Hill, 2005.)*

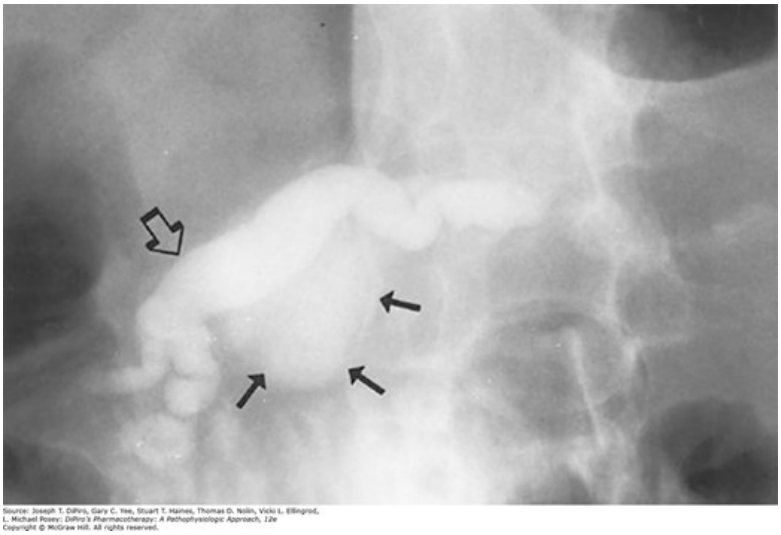


Endoscopic Retrograde Cholangiopancreatography

ERCP is an important therapeutic procedure that combines endoscopy and fluoroscopic imaging techniques to evaluate and treat diseases of the pancreaticobiliary tree. Common indications for ERCP include common bile duct stone management and bile and pancreatic duct stricture management, as well as, diagnosis and therapy of biliary tract and/or pancreatic malignancies. Cannulation of the bile or pancreatic duct is achieved through the wire-guided approach. Once the location of the guide wire has been confirmed, contrast agent is injected into the bile duct which can reveal abnormalities such as obstruction due to malignancy, confirm presence of biliary or pancreatic duct calculi, and improved characterization of biliary strictures. ERCP also provides therapeutic modalities such as biliary or pancreatic sphincterotomy, removal of ductal stones from the common bile duct or main pancreatic duct, and stenting of biliary or pancreatic strictures. ERCP is also a useful method for tissue acquisition in the pancreaticobiliary tract using a variety of brush and biopsy devices. Advances in ERCP include the addition of direct bile duct or pancreatic duct visualization (cholangioscopy and/or pancreatoscopy), a procedure which has greatly aided in the diagnosis and therapy of pancreaticobiliary disorders. Preparation for ERCP consists of glucagon to relax gut motility and conscious sedation which often requires the use of an anesthesiologist due to the complex and long procedural times associated with ERCP (Fig. e49-7).[12,20]

FIGURE e49-7

Endoscopic retrograde cholangiopancreatography (ERCP) demonstrating a dilated, irregular pancreatic duct with areas of stricturing (*large arrow*). A pancreatic pseudocyst is visible immediately adjacent to the spine (*small arrows*).



Endoscopic Ultrasound

EUS is a newer endoscopic technology, which represents a marriage between endoscopy and standard ultrasound techniques. A high frequency ultrasound probe is attached to the working end of a diagnostic (radial array) or therapeutic (linear array) oblique viewing echoendoscope. EUS is commonly used to stage and diagnose upper GI tract malignancies such as those involving the esophagus, stomach, and pancreas. Upper GI tract locoregional tumor staging and tissue acquisition is highly sensitive and specific and provides a less invasive manner of tissue acquisition in many cases. Expanded uses of EUS include diagnosis and management of pancreatic fluid collections such as pancreatic cystic neoplasms (nonpseudocystic), celiac plexus block versus neurolysis in pancreatic malignant and chronic pancreatitis patients, and in some centers, direct instillation of antitumor agents into pancreatic malignancies. The development of ultrasound contrast agents, referred to as contrast-enhanced EUS, allows for better visualization of the vasculature and more accurate characterization of detected lesions. Ultrasound contrast agents consist of gas-filled microbubbles encapsulated by a phospholipid shell which oscillate to sound pressure and cause back-scattering of the ultrasound signal.[21] EUS-guided bile duct access is an additional indication gaining popularity in those patients in whom access at ERCP fails or is not technically feasible. Lower GI tract EUS is commonly performed in the diagnosis and locoregional staging of anorectal carcinoma and in evaluation of the anal sphincters. EUS is an invaluable tool in the management of GI tract disorders but its use remains centered largely in academic, tertiary care referral institutions.

Enteroscopy

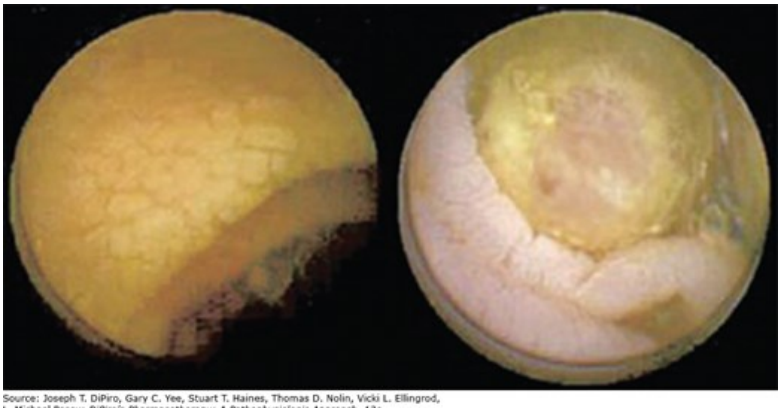
Enteroscopy, or direct visualization of the small intestine, has traditionally been limited to examination of the proximal most portions of the duodenum/jejunum because of excessive endoscope looping and discomfort to the patient during the examination. To overcome these difficulties, two newer techniques, single and double balloon enteroscopy, have been developed. Sometimes referred to as “deep enteroscopy,” these particular endoscopic procedures involve sequential inflation and deflation of balloon attachment devices in order to sequentially “walk” the enteroscope down the small or large intestine. A combination of inflation, deflation, and endoscope reduction via torque and withdrawal allow for a pleating of the mucosal surface being examined. Complete traversal of the small intestine is routinely achieved via the oral route and significant traversal of the colon and distal small intestine is now possible from the rectal route. Common indications for these procedures include the evaluation of obscure GI bleeding, the diagnosis and evaluation of possible inflammatory bowel disease, and the evaluation of radiologically discovered lesions such as mass or bowel wall thickening. Numerous studies, including some head-to-head trials, have yielded a high sensitivity and specificity for these technologies. The added advantage of deep enteroscopy is the ability to directly observe lesions of interest, to biopsy readily during the procedure, and in cases of obscure GI bleeding to add therapeutic maneuvers such as the application of thermal therapy or argon plasma coagulation to lesions felt to be responsible for ongoing blood loss.

Capsule Endoscopy

9 Capsule endoscopy allows the visualization of the esophagus, stomach, and small intestine. This device consists of a vitamin pill-sized video camera that is swallowed and acts as an endoscope (Fig. e49-8). As the video capsule travels naturally through the digestive tract, images are transmitted to a recording device placed on the patient's hip. Patients return the recording device to the practitioner so that the images can be downloaded to a computer and evaluated. Eventually, the camera is naturally excreted and not retrieved.[22] Capsule endoscopy represents a noninvasive means to evaluate the upper and lower GI tracts but unfortunately lacks therapeutic capability. Capsule endoscopy is often used in the evaluation of obscure GI bleeding and in the evaluation of suspected inflammatory bowel disease and is oftentimes used in conjunction with single or double balloon enteroscopy. Capsule endoscopy continues to represent a powerful diagnostic tool in the management of many GI tract disorders.

FIGURE e49-8

Capsule endoscopy images of a mildly scalloped jejuna fold (left) and an ileal tumor (right) in a patient with celiac sprue. *(From Wong-Kee-Song LM, Topazian M. Gastrointestinal endoscopy. In: Kasper DL, Braunwald E, Hauser S, et al., eds. Harrison's Principles of Internal Medicine, 17th ed. New York: McGraw Hill. Image courtesy of Dr. Elizabeth Rajan; with permission.)*



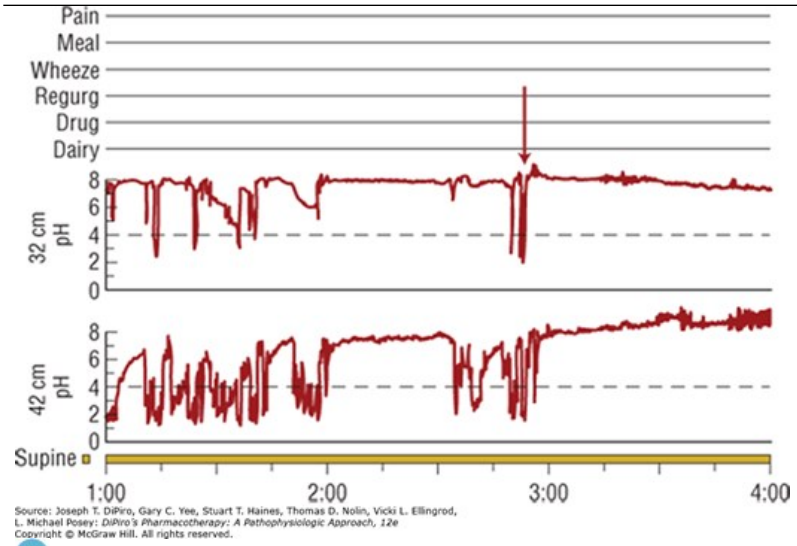
MISCELLANEOUS GASTROINTESTIONAL TESTS

Ambulatory Esophageal pH Monitoring

10 Esophageal pH monitoring is considered by many clinicians as the gold standard in the evaluation of patients who complain of gastroesophageal reflux. The evaluation of dyspepsia, whether it be organic or functional, is an extremely prevalent GI tract complaint and the use of ambulatory 24-hour pH monitoring is an elegant way to link esophageal acid exposure, as detected by a probe in the esophagus, with patient symptoms. The pH probe is transnasally placed approximately 5 cm above the distal esophagus. Intraesophageal pH is normally higher (pH 6) than that of the stomach (pH approximately 1-3), the pH probe will continuously record any decreases in pH if gastroesophageal reflux occurs. The most accepted method to identify gastroesophageal reflux during monitoring is the sudden decrease in pH below 4.0. The ambulatory 24-hour pH study links the patient's symptom to an acid event (Fig. e49-9). Wireless pH monitoring systems have gradually replaced the older methods that required a wire probe placement. A capsule is attached to the distal esophagus by a delivery system. The capsule then transmits measured pH data to a receiver by a radiotelemetry technique. Wireless systems offer the advantage of better patient acceptance and extended monitoring of up to 96 hours versus 24 hours of the wire method. There are limitations to ambulatory pH monitoring in patients receiving PPI therapy or in the detection of nonacidic or weakly acidic refluxate.[23]

FIGURE e49-9

Ambulatory pH monitoring. The pH recordings from two esophageal probes are plotted over a 3-hour interval. Notice that the patient's symptom of regurgitation correlates with a low pH (<4) event (*arrow*).



11 Multichannel intraluminal impedance monitoring is an emerging technique to study acid and nonacid reflux. The method combines pH measurements with manometry that enables the measurement of and distinction between swallowing and reflux. In patients whose symptoms have not responded to empiric PPI therapy in GERD, impedance test can separate those in whom symptoms are associated with acid reflux from those in whom symptoms are associated with nonacid reflux. Outcomes studies are required to further evaluate the usefulness of this diagnostic method; however, accumulating data are extremely promising.[18,24]

Esophageal Manometry

High-resolution esophageal manometry is used to evaluate diseases of the esophagus by assessing esophageal motor functions. Common indications for this procedure include dysphagia and obscure chest pain or patients unresponsive to acid-suppressive therapy not explained by other diagnostic tests. A special catheter equipped with pressure transducers is placed into the esophagus to measure esophageal pressures and peristalsis. Provocative testing with pharmacologic agents such as edrophonium chloride, a cholinergic muscle stimulant, may be used to precipitate esophageal pain during this procedure. Typical indications for esophageal manometry include evaluating suspected esophageal dysmotility, nonobstructive dysphagia, obscure chest pain, intestinal pseudo-obstruction, achalasia, and aiding in the positioning instruments such as pH probes. Esophageal manometry is almost always performed following endoscopic evaluation of the upper GI tract and can be a valuable tool in diagnosing many nonspecific disorders of the upper GI tract.

Laparoscopy

Laparoscopy uses a tube-like device with an elaborate optical system that permits distinct visualization of the peritoneal cavity. General anesthesia is often required and a surgical incision is made in the abdomen to allow the passage of the laparoscope. The exterior of the liver, gallbladder, spleen, peritoneum, diaphragm, and pelvic organs may be examined during the laparoscopic examination. Similar to the other endoscopic techniques mentioned, biopsies and therapeutic interventions may be performed during the laparoscopy. Laparoscopy is extremely invasive. Indications for laparoscopy include evaluation of patients with abdominal masses, chronic abdominal pain of unclear etiology, abnormalities indicated on liver-spleen scan, such as acute or chronic cholecystitis, and the diagnosis and management of intra-abdominal malignancy.

ABBREVIATIONS

CT	computed tomography
EGD	esophagogastroduodenoscopy
ERCP	endoscopic retrograde cholangiopancreatography
EUS	endoscopic ultrasound
GERD	gastroesophageal reflux disease
HPF	high-power field
MRCP	magnetic resonance cholangiopancreatography
MRI	magnetic resonance imaging
PEG	polyethylene glycol electrolyte solution
PPI	proton pump inhibitor

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SELF-ASSESSMENT QUESTIONS

1. A patient presenting with watery diarrhea and a history of antibiotic use 2 months ago should have their stool checked for:

   A. *Helicobacter pylori*

   B. *Clostridioides difficile* toxin

   C. *Enterobacter cloacae*

   D. *Escherichia coli* toxin

2. The preferred imaging method to detect an intra-abdominal malignancy is:

A. Small bowel enteroclysis

B. Computed tomography

C. Plain radiography films

D. Barium swallow with radiography

3. In a patient presenting with signs and symptoms of acute liver failure, which of the following agents has been associated with liver damage?

A. Phenytoin

B. Amoxicillin

C. Morphine

D. St. John's wort

4. Bacteria associated with infectious diarrhea include:

A. *Streptococcus pyogenes*

B. *E. coli*

C. *Klebsiella oxytoca*

D. *H. pylori*

5. Serum sodium or potassium abnormalities may be indicative of which of the following GI tract disorders?

A. Diarrheal illnesses

B. Mild hepatic dysfunction

C. Gastroesophageal reflux disease (GERD)

D. Diverticulitis

6. In a patient undergoing a computed tomography study with contrast, which of following adverse events is most commonly associated with the use of a contrast agent?

A. *Clostridioides difficile* infection

B. Leukopenia

C. Hyperkalemia

D. Nephrotoxicity

7. Which test should be used in a patient with suspected reflux disease but not responding to a PPI?

A. Ambulatory pH monitoring

B. Capsule endoscopy

C. Multichannel intraluminal impedance

D. Endoscopic ultrasound

8. Pain associated with pancreatitis usually:

   A. Rapidly develops and resolves within a few minutes.

   B. Typically evolves over hours and last for days.

   C. Is episodical, with complaints occurring only in the morning.

   D. Often presents with gastritis and dyspepsia.

9. An often overlooked assessment of gastrointestinal disease is:

   A. Cardiopulmonary examination

   B. Medication history

   C. Surgical history

   D. Duration and severity of pain

10. A 69-year-old gentleman presents with bleeding from the upper gastrointestinal tract. Which of the following laboratory tests is often elevated in a patient with an upper gastrointestinal tract bleed?

    A. Troponin

    B. C-reactive protein

    C. White blood cell count

    D. Blood urea nitrogen

11. In a patient presenting with signs and symptoms consistent with hepatitis C, which of the following laboratory test is an indirect measurement of hepatic function?

    A. Erythrocyte sedimentation rate

    B. Prothrombin time and international normalized ratio (INR)

    C. Serum creatinine

    D. Atrial natriuretic peptide

12. Prior to colonoscopy, the colon should be prepared by administration of:

    A. Sodium sulfate–based tablets.

    B. Polyethylene glycol electrolyte solution

    C. Magnesium citrate.

    D. A combination of laxatives and fluids.

13. Ultrasonography is a useful diagnostic method to define:

    A. Bleeding gastric ulcer.

    B. Malt lymphoma in the small bowel and colon.

C. Gallstones within the gallbladder.

D. The GI tract in a patient presenting with water diarrhea.

SELF-ASSESSMENT QUESTION-ANSWERS

1. **B.** A patient with a recent history of antimicrobial use and diarrhea should always be suspected of having *Clostridioides* infection. *H. pylori* is generally associated with peptic ulcer disease and does not induce diarrhea. *E. coli* can cause diarrhea, but usually not associated with recent antimicrobial use.

2. **B.** Computer tomography (CT) scan provides improved resolution and faster acquisition of radiographic information. All of the other procedures in this question do not provide the same detail as a CT scan.

3. **A.** Phenytoin is known to cause GI injury. The other medications listed are not.

4. **B.** Only *E. coli* is associated with infectious diarrhea of the pathogens listed. *S. pyogenes* is associated with strep throat and necrotizing fasciitis. *H. pylori* is associated with peptic ulcer disease, and *Klebsiella* is primarily associated with nosocomial systemic infections.

5. **A.** Depending upon severity, diarrhea can result in fluid and electrolyte loss, such as potassium and sodium. Mild to even moderate hepatic dysfunction has modest effects on electrolytes. Electrolyte abnormalities are usually absent in gastroesophageal reflux disease.

6. **D.** Nephrotoxicity is commonly associated with contrast agents. A predisposing factor is underlying renal disease. Although other adverse events have been reported with contrast agents, they have a very low frequency.

7. **C.** If a patient is receiving a PPI, ambulatory pH monitoring, capsule endoscopy, or endoscopic ultrasound may not be able to detect any changes in the esophagus. Multichannel intraluminal impedance is a technique to study acid and nonacid reflux and can be performed on a patient using a PPI.

8. **B.** Because of the underlying pathology in pancreatitis and the resulting tissue damage, pain evolves over hours and may last for days.

9. **A.** The cardiopulmonary exam is often overlooked when evaluating the gastrointestinal tract and liver. Electrolyte shifts and fluid loss are typically found in GI disease and may result in heart abnormalities.

10. **D.** When upper GI bleeding occurs, blood protein is metabolized and converted to urea and then to BUN in the urea cycle. Other labs listed in this question are not directly impacted by GI bleeding.

11. **B.** Prothrombin may be impacted by clotting factors synthesized by the liver. During hepatic disease, a decrease in the clotting factor production may lead to a prolonged prothrombin time and INR. Erythrocyte sedimentation rate may also be elevated in hepatic disease, but is a not specific and more indicative of a chronic disease. Atrial natriuretic factor and serum creatinine are more indicative of cardiac or renal disease, respectively.

12. **D.** Only a combination of fluids and laxatives provides adequate evacuation of the bowel prior to colonoscopy.

13. **C.** Ultrasonography is a noninvasive procedure providing images of deep structures in the gastrointestinal tract, including the gallbladder. The other listed disease states are more diffused and not easily visualized by a high-energy sound wave.