The patient history is key to evaluating 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.

A complete physical examination should be performed, the severity and location of symptoms directing the focus of the examination.

The GI tract is composed of organs and tissues that have diverse forms and functions. It includes the esophagus, stomach, small intestine, large intestine, colon, rectum, biliary tract, gallbladder, liver, and pancreas. 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 direction 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.

**SYMPTOMS OF GASTROINTESTINAL DYSFUNCTION**

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 symptoms that include 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. The following sections describe methods that are commonly used to assess patients with GI complaints. For specific details concerning each GI disease state, please consult that particular chapter in this book.

**PATIENT HISTORY**

A comprehensive patient history is the cornerstone in the evaluation of a patient with digestive complaints. A clear, detailed, chronologic account of the patient’s problems should be gathered. This account should include the onset of the problem, the setting in which it developed, factors that alleviate and aggravate the problem, and its manifestations. The symptom onset often provides important information that helps to 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, when do the symptoms occur? Are they alleviated or worsened by food and does the pain occur?
diminish when administered acid-suppressive therapy? Is the patient immunosuppressed (opportunistic infection vs. diseases such as diabetes mellitus)? In addition, aiding in the diagnosis is the identification of factors that alleviate or exacerbate the principal symptom. For instance, ingesting a meal often relieves the pain of duodenal ulcer, but worsens that of 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. Questions concerning past medical and family history detailing illnesses, surgical interventions, injuries, foreign travel, living conditions, and habits are valuable (eTable 16-1). A good cardiopulmonary history is also extremely relevant and should be performed during the overall history. A thorough medication use history including herbal and traditional Chinese medicines is vital as many agents cause GI injury (eTable 16-2).

**PHYSICAL EXAMINATION**

Many organ systems of the body interact and may provide important data needed for diagnosis, making it necessary to perform a thorough physical examination. A comprehensive evaluation of the patient should be performed with notable attention to physical appearances and vital signs as they may suggest clues. A careful examination of the abdomen 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, hemiases, 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 clinician to identify tenderness, rigidity, masses, and hernias. Moving from the abdominal exam, 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. Patients presenting with upper GI symptoms need more careful questioning to distinguish symptoms of reflux disease versus peptic ulcer disease. 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 (a) assess organ function, (b) screen for certain GI disorders, and (c) 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, 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. A serum chemistry panel provides clinicians with 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. Specifically, 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.

More specific laboratory blood tests are often useful in 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. 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 Chap. 25).

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 Clostridium 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. Patients presenting with watery diarrhea following antibiotic exposure within the previous 1 to 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 MALT lymphomas; identification of this organism is critical in patients experiencing upper GI symptoms and is often tested for during upper endoscopy (see Chap. 20).

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 test depends on the anatomic region involved, the suspected abnormality, reliability of the test (e.g., sensitivity vs. specificity), the patient’s overall condition, and 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.

Radiology

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.

Plain Radiography of the Gastrointestinal System

Radiographic evaluation of the GI tract often starts with plain films of the abdomen, which are noncontrast radiographs. Specific abdominal structures that may be identified include the kidneys, ureters, and bladder. In addition, the esophagus, stomach, small and large intestine, and stones may be seen. Stones located within the gallbladder body and within the kidney are also sometimes seen on plain abdominal films. Plain films are often used 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 are also sometimes seen using plain radiographic techniques; however, the widespread availability of computed tomography (CT) scanning is gradually replacing these techniques.

Contrast Agents

Barium sulfate and/or gastrograffin are the contrast agents of choice for studying the esophagus, stomach, and intestine. Barium sulfate is a metallic material detected by radiography after swallowing the liquid agent; it is termed the barium swallow. Barium sulfate is not generally absorbed, and constipation is the most frequent adverse effect reported with its use. Barium sulfate and/or gastrograffin can reveal mucosal defects and lumen size, and is helpful in diagnosing hiatal hernias, strictures along the GI tract, polyps, tumors, and in some cases ulcers. Upper endoscopy is largely replacing the contrast studies in the diagnosis of upper GI tract disorders, but in certain instances can be a tool in establishing a diagnosis prior to endoscopic evaluation. The barium esophagram should not serve as a primary diagnostic tool for patients with heartburn.

Upper Gastrointestinal Series

The upper GI series refers to the radiographic visualization of the esophagus, stomach, and small intestine. Patient preparation for an upper GI series usually consists of instructing patients to refrain from eating or drinking for 8 to 12 hours prior to testing, which allows the upper GI tract to empty. A contrast agent such as barium sulfate or gastrograffin 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. As the contrast medium flows into the stomach and small intestine, several regional radiographic films are taken to inspect these areas. This tracking of contrast agents through the small intestine is referred to as the small bowel follow-through. The 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 (efig. 16-1). 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.

**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 bisacodyl, magnesium citrate, magnesium hydroxide, or polyethylene glycol electrolyte (PEG) solution. 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.

**Small Bowel Enteroclysis**
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 (eFig. 16-2). Because the enteroclysis technique is a useful study for evaluation of the upper GI tract, but is not widely performed due to operator inexperience and is rapidly being replaced by improved radiologic techniques such as CT or magnetic resonance imaging (MRI) enterography or more recently by small intestinal endoscopy known as single and double balloon enteroscopy and capsule endoscopy.

**Imaging 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.

**Ultrasonography**
Ultrasonography provides images of deeper structures such as the gallbladder, liver, and kidneys and can also be very useful in helping to define vascular abnormalities in the intraabdominal 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. Ultrasonography is noninvasive, relatively inexpensive, requires no ionizing radiation, and can be performed at bedside with a portable unit, and as such it is a well-accepted and useful technology. It accurately depicts the presence of gallstones within the gallbladder, helps define liver morphology, and is an excellent first test in the evaluation of the jaundiced patient to evaluate the absence or presence of biliary ductal dilation (eFig. 16-3). When combined with Doppler technologies, ultrasonography can image GI vascularity, in particular portal venous flow and in the early identification of aneurismal dilations of the abdominal aorta. Ultrasonography is limited by the presence of bowel gas and excessive amounts of body fat, particularly when evaluating deeper organs such as the pancreas.

**Computed Tomography**
Computed tomography or computed axial tomography (CT) scans provide 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. Contrast agents may be added in a CT procedure to illuminate specific hollow structures and 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 organs and tissues adds to its popularity for evaluation of the GI system. CT scanning is rapidly replacing plane radiography of the abdomen due to its widespread availability, diminishing cost, and wealth.
of information gained. CT is useful in the identification of suspected intraabdominal malignancy, pancreatitis, intraabdominal abscesses, and cysts (eFig. 16-4).³⁷ Unlike ultrasonography, patient body size or the presence of gas does not limit the quality of imaging with CT. Contrast used during CT scanning is nephrotoxic and close attention to a patient’s renal function is mandatory in these patients.

**Radionuclide Imaging**

Radionuclide imaging 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 (⁹⁹ᵐTc) tagged to a carrier molecule. Radionuclide imaging is sometimes useful to visualize the liver and spleen (liver–spleen scan), bile ducts, gallbladder (HIDA [hepatoimnodiacetic acid] scan), and gut (tagged red blood cell).³⁶ Cysts, abscesses, tumors, and obstructions are detected and displayed as areas of differential uptake of radioactivity.³⁶ Radionuclide bleeding scans may detect hemorrhages and may assist in localization to help with therapeutic intervention. Contrast media nephrotoxicity in
Organ-Specific Function Tests and Drug-Induced Diseases

SECTION

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) and magnetic resonance cholangiopancreatography (MRCP) 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.\(^6,7\) MRI has greater sensitivity for identifying liver tumors than do ultrasonography, CT, and radionuclide imaging. Significant advances in MRI technology and imaging capabilities often make this a preferred diagnostic test, particularly in the evaluation of pancreaticobiliary disorders particularly with the addition of secretin to enhance bile and pancreatic duct visualization.\(^6,7\)

Arteriography

Arteriography of the gut depicts the configuration of visceral blood vessels after IV administration of a contrast medium. Arteriography may be employed for vascular anomalies such as an aneurismal dilatation and in the evaluation of obscure bleeding lesions. Therapeutic applications, including embolization of bleeding vessels, fistulas, and inoperable tumors.\(^6,7\)

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 and washings for cytology studies. Standard upper GI tract endoscopy (i.e., 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. Standard upper and lower endoscopy can also be used to perform many therapeutic procedures and in addition many newer diagnostic and therapeutic endoscopic devices are now available.\(^6\)

Preparation for endoscopic examinations includes instructing patients 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. IV sedating agents, such as the benzodiazepines, lorazepam, midazolam, and, more recently, propofol, are among the most common agents used to induce differing levels of sedation, most commonly “conscious sedation” prior to the endoscopy. 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. Serious adverse events have occurred with these agents when used for conscious sedation. In addition, antimuscarinic agents such as atropine sulfate are occasionally used for their cardiovascular effects, such as increasing a patient’s heart rate, or for their antispasmodic effects, such as reducing duodenal and colonic motility. Because of its effectiveness at reducing bowel motility, glucagon may be used. Endoscopy should be pursued with caution in patients with severe respiratory or cardiac failure, and endoscopy is contraindicated for patients with suspected perforated visceras. The most commonly used endoscopic studies are upper endoscopy (EGD), colonoscopy, flexible sigmoidoscopy, and endoscopic retrograde cholangiopancreatography (ERCP).\(^8\) Newer endoscopic techniques include capsule endoscopy, endoscopic ultrasound (EUS), and single or double balloon enteroscopy. These techniques are outlined in detail below.

EGD is used to examine the esophagus, stomach, and duodenum. Patient preparation for EGD includes fasting prior to the procedure and the administration of sedatives and topical anesthetics. Common indications include evaluation of suspected upper GI bleeding, obstructions, upper abdominal pain, and persistent vomiting. Evaluation of radiographic abnormalities is also a frequent procedural indication.\(^12\) EGD can 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’s esophagus, a premalignant condition of the esophagus and other esophageal ulcer erosive disorders (eFig. 16-5). Once viewed as the method of choice to diagnose gastrointestinal reflux disease, upper endoscopy, although commonly used, is often times not performed before a trial of a proton pump inhibitor has been undertaken. The favorable side-effect profile of proton pump inhibitors in addition to their superior healing ability make these agents extremely powerful and widely prescribed by primary care physicians for heartburn and other symptoms attributed to gastrointestinal reflux disease.

Primary care physicians usually refer patients for EGD only when they fail to respond to a course of proton pump inhibitor therapy, and by the time an endoscopy is performed the examination is likely to reveal normal-appearing mucosa. Even in patients undergoing upper endoscopy in the evaluation of reflux type symptomatology in the absence of proton pump inhibitor therapy, endoscopy will be normal in up to 50% of patients.\(^6\)

Colonoscopy

Colonoscopy permits direct examination of the large intestine and rectum and in addition allows 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 fast 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, because of 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 and a short-acting narcotic agent are given to produce conscious sedation and in patients refractory or intolerant to conscious sedation agents, propofol is often administered to provide a deeper level of sedation. As with upper GI endoscopy, 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. Additionally colonoscopy remains an invaluable procedure in the diagnosis, staging, and therapy of patients with inflammatory bowel disease (e.g., ulcerative colitis and Crohn’s disease).

**Sigmoidoscopy**

Flexible sigmoidoscopy is used to evaluate the sigmoid colon via the anorectum (eFig. 16-6). Flexible sigmoidoscopy 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 hema-tochezia, 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 abstain 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 ano-rectal lesions, pain with defecation in particular, and severe itching. Patients undergoing sigmoidoscopy or anoscopy generally do not require sedation.

**Endoscopic Retrograde Cholangiopancreatography**

ERCP is an important therapeutic procedure that is used to evaluate and treat diseases of the pancreaticobiliary tree. Common indications include common bile duct stone management, bile and pancreatic duct stricture management, and in the diagnosis and therapy of patients with biliary tract and/or pancreatic malignancies. Contrast injection following wire-guided bile or pancreatic duct cannulation reveals abnormalities such as obstruction due to malignancy, the presence of biliary or pancreatic duct calculi, and the improved characterization of biliary strictures. ERCP also allows for the use of therapeutic techniques such as biliary or pancreatic sphincterotomy, removal of ductal stones from the common bile duct or main pancreatic duct, and in the 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. Recent 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 conscious sedation and glucagon to relax gut motility and often requires the use of an anesthesiologist due to the complex and long procedural times associated with ERCP (eFig. 16-7).

**Endoscopic Ultrasound**

EUS is a newer, exciting endoscopic technology, which represents a marriage between upper endoscopy and standard ultrasound.

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*eFIGURE 16-7* 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).
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 including pancreatic cystic neoplasms (nonpseudocystic), celiac plexus block versus neurolysis in pancreatic malignant and chronic pancreatitis patients, and in some centers in the direct instillation of antitumor agents into pancreatic malignancies. EUS-guided bile duct access is also an additional indication gaining popularity in those patients in whom access at ERCP fails or is not technically feasible. Lower GI tract EUS is also commonly performed most often 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 does remain 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/jejenum 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 in 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

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 (eFig. 16-8). 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. 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 often times 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.

Miscellaneous 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 placed approximately 5 cm above the distal esophagus. Because intragastric pH is normally higher (pH 6) than that of the stomach (pH approximately 1 to 3), the pH probe will record a decrease 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 (eFig. 16-9). 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 radio-telemetry 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 proton pump inhibitor therapy or in the detection of nonacidic or weakly acidic refluxate.11

![eFigure 16-8 Capsule endoscopy images of a mildly scalloped jejuna fold (left) and an ileal tumor (right) in a patient with celiac sprue. (From Kasper DL, Braunwald E, Hauser S, et al., eds. Harrison’s Principles of Internal Medicine, 17th ed. New York: McGraw-Hill. http://www.acessmedicine.com. Images courtesy of Dr. Elizabeth Rajan; with permission.)](image1)

![eFigure 16-9 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).](image2)

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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 proton pump inhibitor therapy in GERD, the 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.12,13 The Bernstein test, an older procedure that is used to measure gastric fluid pH, has largely been replaced by ambulatory pH monitoring. The procedure requires inserting a nasogastric tube and administering alternating dripped solutions of normal saline and 0.1 N hydrochloric acid (HCl) into the esophagus via the nasogastric tube. If patient symptoms are reproduced by the acid perfusion and not the saline, the study is considered abnormal and indicative of acid hypersensitivity.14

**Esophageal Manometry**

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. 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 pseudoobstruction, achalasia, and aiding in the positioning instruments such as pH probes. Esophageal manometry almost always is 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, it is important to remember, is extremely invasive. Reasons for doing laparoscopy include evaluating patients with abdominal masses, chronic abdominal pain of unclear etiology, abnormalities indicated on liver-spleen scan, such as acute or chronic cholecystitis, and to aid in the diagnosis and management of intraabdominal malignancy.

**ABBREVIATIONS**

<table>
<thead>
<tr>
<th>CT</th>
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<tr>
<td>EGD</td>
<td>esophagogastroduodenoscopy</td>
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<td>ERCP</td>
<td>endoscopic retrograde cholangiopancreatography</td>
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<tr>
<td>EUS</td>
<td>endoscopic ultrasound</td>
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<tr>
<td>MRCP</td>
<td>magnetic resonance cholangiopancreatography</td>
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<td>MRI</td>
<td>magnetic resonance imaging</td>
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<td>PEG</td>
<td>polyethylene glycol electrolyte solution</td>
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**REFERENCES**
