Imaging Patients with Acute Abdominal Pain[1]

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Acute abdominal pain may be caused by a myriad of diagnoses, including acute appendicitis, diverticulitis, and cholecystitis. Imaging plays an important role in the treatment management of patients because clinical evaluation results can be inaccurate. Performing computed tomography (CT) is most important because it facilitates an accurate and reproducible diagnosis in urgent conditions. Also, CT findings have been demonstrated to have a marked effect on the management of acute abdominal pain. The cost-effectiveness of CT in the setting of acute appendicitis was studied, and CT proved to be cost-effective. CT can therefore be considered the primary technique for the diagnosis of acute abdominal pain, except in patients clinically suspected of having acute cholecystitis. In these patients, ultrasonography (US) is the primary imaging technique of choice. When costs and ionizing radiation exposure are primary concerns, a possible strategy is to perform US as the initial technique in all patients with acute abdominal pain, with CT performed in all cases of nondiagnostic US. The use of conventional radiography has been surpassed; this examination has only a possible role in the setting of bowel obstruction. However, CT is more accurate and more informative in this setting as well. In cases of bowel perforation, CT is the most sensitive technique for depicting free intraperitoneal air and is valuable for determining the cause of the perforation. Imaging is less useful in cases of bowel ischemia, although some CT signs are highly specific. Magnetic resonance (MR) imaging is a promising alternative to CT in the evaluation of acute abdominal pain and does not involve the use of ionizing radiation exposure. However, data on the use of MR imaging for this indication are still sparse.

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Acute abdominal pain is a common chief complaint in patients examined in the emergency department (ED) and can be related to a myriad of diagnoses. Of all patients who present to the ED, 4%–5% have acute abdominal pain (1). Obtaining a careful medical history and performing a physical examination are the initial diagnostic steps for these patients. On the basis of the results of this clinical evaluation and laboratory investigations, the clinician will consider imaging examinations to help establish the correct diagnosis.

Acute abdomen is a term frequently used to describe the acute abdominal pain in a subgroup of patients who are seriously ill and have abdominal tenderness and rigidity. Before the advent of widespread use of imaging, these individuals were candidates for surgery. However, with the present role of imaging, some patients with acute abdomen will not undergo surgery. Other patients with acute abdominal pain that does not meet the criteria to be defined as acute abdomen—for example, many patients suspected of having acute appendicitis—will need surgery. In this article, we use the term *acute abdominal pain* to refer to the complete spectrum of acute abdominal pain in patients who are treated in the ED and require imaging.

Essentials

- CT is the technique of choice for the diagnosis of acute abdominal pain, except in cases of acute cholecystitis.
- CT findings have a substantial effect on the treatment management of patients with acute abdominal pain.
- Despite its limitations, CT is the preferred imaging technique for the diagnosis of bowel ischemia.
- Conventional radiography may have a role in the assessment and/or diagnosis of bowel obstruction, especially if CT is not available.
- US is a well-established alternative—and MR imaging is a potential alternative—to CT in the setting of acute abdominal pain.

A considerable number of articles on the accuracy of imaging in determining specific diagnoses that may cause acute abdominal pain, such as acute appendicitis and diverticulitis, have been published. The accuracy of imaging techniques performed in carefully selected patients suspected of having a specific diagnosis in research studies cannot always be generalized to routine clinical practice in nonselected patients with acute abdominal pain because the pretest probabilities differ per disease in different settings. The spectrum of disease in this group of patients is broad and varies according to referral and demographic patterns (Table E1 [online]). The added value of imaging after clinical evaluation—particularly its effect on diagnostic accuracy and certainty and patient treatment—is important.

In this review, we discuss the role of imaging in adults who present with acute abdominal pain to the ED. Our focus is acute abdominal pain in general, but we also discuss a number of frequently encountered urgent diagnoses in patients with acute abdominal pain: appendicitis, diverticulitis, cholecystitis, and bowel obstruction. Although perforated viscus and mesenteric ischemia are less frequently encountered, these are also addressed because imaging is of paramount importance for the timely diagnosis of these abnormalities. Other conditions such as acute pancreatitis are not described. Imaging is important in the clinical management but is not pivotal for the diagnosis of conditions such as acute pancreatitis.

Conventional radiography, ultrasonography (US), and computed tomography (CT) are frequently used in the diagnostic work-up of patients with acute abdominal pain. Magnetic resonance (MR) imaging and diagnostic laparoscopy are also available, but they are used far less frequently for initial diagnostic work-up. In the literature, the accuracy of imaging in patients with acute abdominal pain usually is not expressed in terms of well-known parameters such as sensitivity, specificity, and predictive values because of the lack of adequate reference standards in many reports. Furthermore, acute abdominal pain may be due to a number of discreet diagnoses, so it is impossible to generate a straightforward 2 × 2 contingency table. Therefore, the diagnostic value of imaging modalities is often expressed in terms of the change in diagnoses, the change in clinical management, and/or the extent to which the treating physician in the ED found the given imaging examination helpful or diagnostic. If a given imaging examination is helpful (eg, leading to a higher level of diagnostic confidence) or diagnostic according to the treating physician, it is considered to have yielded positive findings or results at diagnostic work-up (2,3).

Acute Abdominal Pain

The causes of acute abdominal pain range from life-threatening to benign self-limiting disorders. Acute appendicitis, diverticulitis, cholecystitis, and bowel obstruction are common causes of acute abdominal pain. Other important but less frequent conditions that may cause acute abdominal pain include perforated viscus and bowel ischemia.

A confident and accurate diagnosis can be made solely on the basis of medical history, physical examination, and laboratory test findings in only a small proportion of patients. The clinical manifestations of the various causes of acute abdominal pain usually are not straightforward. For proper treatment, a diagnostic work-up that enables the clinician to differentiate between the various causes of acute abdominal pain is important, and imaging plays an important role in this process. Many patients are referred without a clear pretest diagnosis, and imaging is warranted to determine the diagnosis and guide treatment in these patients. According to American College of Radiology (ACR) appropriateness criteria (4), contrast mate-

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Abbreviations:
ACR = American College of Radiology
ED = emergency department
SBO = small-bowel obstruction

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rial–enhanced CT of the abdomen and pelvis is considered the most appropriate examination for patients with fever, nonlocalized abdominal pain, and no recent surgery. Nonenhanced CT, US, and conventional radiography are considered less appropriate initial imaging examinations for these patients.

Conventional Chest and Abdominal Radiography

Conventional radiography is commonly the initial imaging examination performed in the diagnostic work-up of patients who present with acute abdominal pain to the ED. This examination is widely available, can be easily performed in admitted patients, and is used to exclude major illness such as bowel obstruction and perforated viscus. Conventional radiography includes supine and upright conventional abdominal radiography and upright chest radiography.

The accuracy values for conventional radiography in the diagnostic work-up of patients with acute abdominal pain are not convincing. Some study investigators have reported an accuracy of 53% (5). In one study, treatment management changes after review of the radiographs were reported for only 4% of patients (6). In the majority of patients, further imaging is warranted after conventional radiography. US and CT (5,7), as compared with conventional radiography, yield markedly higher accuracy values. The overall sensitivity of CT is reportedly 96% compared with 30% for conventional radiography (5). Despite a lack of evidence to justify the extensive use of conventional radiography, it is often the initial diagnostic imaging examination performed in patients with acute abdominal pain at many institutions. Exact data on the number of individuals who present with acute abdominal pain to the ED and undergo conventional radiography are not available. Fifty to seventy-five percent of patients suspected of having acute appendicitis undergo conventional radiography (8,9), despite evidence in the literature that conventional radiography has no diagnostic value in these patients (7,9). In select cases, such as those of patients suspected of having bowel obstruction, perforated viscus, urinary tract calculi, or foreign bodies (7,10,11), conventional radiography has been reported to have good accuracy. Conventional radiography might be useful in these patients. In a recent study, however, only the sensitivity for the diagnosis of bowel obstruction was significantly higher after conventional radiograph evaluation (12). Thus, the use of conventional radiography might justifiably be limited to these patients only, especially if CT is not available. The radiation dose delivered at conventional radiography is relatively limited (approximately 0.1–1.0 mSv) compared with that delivered at CT (approximately 10 mSv) (13).

US Examination

US is another imaging modality commonly used in the diagnostic work-up of patients with acute abdominal pain. With US, the abdominal organs and the alimentary tract can be visualized. US is widely available and is easily accessible in the ED. It is important that US is a real-time dynamic examination that can reveal the presence or absence of peristalsis and depict blood flow. Furthermore, it is possible to correlate US findings with the point of maximal tenderness. Wide availability in the ED, lower costs, and absence of radiation exposure are advantages of US, as compared with CT. When radiologists perform US in patients, relevant additional information can be obtained during the examination. For example, US findings may suggest a previously unexpected diagnosis, in which case additional clinical history information becomes important.

The most common US technique used to examine patients with acute abdominal pain is the graded-compression procedure (14). With this technique, interposing fat and bowel can be displaced or compressed by means of gradual compression to show underlying structures. Furthermore, if the bowel cannot be compressed, the noncompressibility itself is an indication of inflammation. Curved (3.5–5.0-MHz) and linear (5.0–12.0-MHz) transducers are used most commonly, with frequencies depending on the application and the patient's stature (15,16).

Although values for the accuracy of US performed in patients with acute abdominal pain are not available, in one study (17), US reportedly provided useful information for 56% of patients with acute abdominal pain, and in another study (18), it either yielded unique diagnostic information or confirmed one of the differential diagnoses in 65% of patients. Among 496 patients who presented with acute abdominal pain to an ED, the proportion of patients with a correct diagnosis after clinical evaluation increased from 70% to 83% after evaluation with US (19). In two published studies (17,20), US findings led to an alteration in treatment management for 22% of patients; however, the patient cohorts in these two investigations were not the same: Walsh et al (17) excluded patients who were strongly clinically suspected of having perforated viscus, bowel obstruction, or appendicitis, whereas Dhillon et al (20) included all patients with acute abdominal pain for whom US was requested by the treating physician in the ED.

CT Examination

Use of CT in the evaluation of acute abdominal pain has increased to a large extent. For example, in the United States, the number of CT examinations performed for this indication increased 141% between 1996 and 2005 (21). This increase was related to the high accuracy of CT in the diagnosis of specific diseases (eg, appendicitis and diverticulitis [15,16]) and the rapid patient throughput that can be achieved with use of multidetector CT scanners.

The CT technique used to examine patients with acute abdominal pain generally involves scanning of the entire abdomen after intravenous administration of an iodinated contrast medium. Although abdominal CT can be performed without contrast medium (5), the intravenous administration of contrast material facilitates good accuracy—with a positive predictive value of 95% reported for the diagnosis of appendicitis (22)—and a high level of diagnostic confidence, especially in rendering diagnoses in thin patients, in whom fat interfaces may be almost absent (Fig 1). Although rectal or oral contrast material may be helpful in differentiating fluid-filled bowel loops from abscesses in some cases, the use of oral contrast material can markedly increase the time these patients spend in the ED (23). The lack of enteral contrast medium does not seem to hamper the accurate reading of CT images obtained in patients with acute abdominal pain as it does in postoperative patients. For example, in a series of 1021 consecutive patients with acute abdominal pain in whom only intravenous contrast medium was administered, there were no inconclusive CT scans due to the lack of enteral contrast medium (24). Multiplanar reformation is beneficial, especially in cases of equivocal CT scans, and it increases the radiologist's level of confidence in the diagnosis.

Figure 1

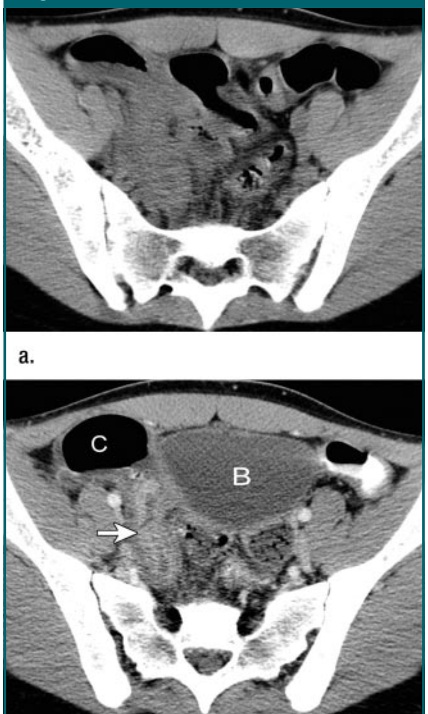


Figure 1: Axial CT images in 26-year-old slender woman clinically suspected of having acute appendicitis. Differentiation between pelvic inflammatory disease and appendicitis on US images was difficult; therefore, CT was performed. **(a)** Nonenhanced CT scan findings were also inconclusive because of absence of delineating fat. **(b)** CT scan obtained after intravenous and rectal contrast material administration shows appendicitis: a distended appendix with thickened wall (arrow) and surrounding infiltration. *B* = bladder, *C* = cecum. Appendicitis was confirmed at surgery and histopathologic analysis. (Images courtesy of Saffire S.K.S. Phoa, MD, Academisch Medisch Centrum, Universiteit van Amsterdam, Amsterdam, the Netherlands.)

Studies to evaluate the accuracy of abdominal CT performed in patients with acute abdominal pain generally are scarce. In the cohort study of 1021 consecutive patients with acute abdominal pain, US and CT were compared for the determination of urgent diagnoses (24). CT was significantly more sensitive than US (89% vs 70%, $P < .001$). The highest sensitivity (only 6% missed urgent cases) was obtained with a diagnostic strategy involving the use of initial US, followed by CT, only in negative or inconclusive US cases. Use of this approach also led to a reduction in radiation exposure because CT was needed for only 49% of the patients. Alternative strategies based on the body mass index or age of the patient or on the location of the pain resulted in a loss of sensitivity. In the literature, there are two randomized controlled trials in which standard practice was compared with early CT—in one study, early CT was performed within 1 hour of presentation, and in the other study, it was performed within 24 hours—in patients who presented with acute abdominal pain (25,26). In these two studies, standard practice involved conventional abdominal and chest radiography and, if necessary, additional CT. CT was requested in half the patients in the standard practice group. In the first trial (25), patients in the early CT group had shorter hospital stays, but this finding was not reproduced in the second randomized trial, which was powered to evaluate reductions in hospital stay (26). The percentages of correct diagnoses 24 hours after admission did not differ significantly between the two patient groups (76% for early CT, 75% for standard practice). However, a significantly greater percentage of serious diagnoses were missed in the standard practice group (21% vs 4%, $P < .001$).

Prospective studies involving the examination of patients for whom the clinician ordered CT scanning have shown that CT findings have a significant effect on diagnoses. In one study, the accuracy of the clinical diagnosis made before CT was performed improved from 71% to 93% after CT was performed (27). The accompanying change in treatment management was 46%. Another study revealed a significant increase in the level of confidence of the diagnosis made with CT: The treatment management for 60% of patients was changed (28). Abdominal CT reportedly yields good overall interobserver agreement and very good interobserver agreement for the determination of specific urgent diagnoses, with reported κ values of 0.84, 0.90, and 0.81 for agreement regarding the diagnoses of appendicitis, diverticulitis, and bowel obstruction, respectively (29).

Exposure to ionizing radiation is a disadvantage of CT. The effective radiation dose for abdominal CT is approximately 10 mSv. In comparison, the annual background radiation dose in the United States is approximately 3 mSv. A 10-mSv CT examination performed in a 25-year-old person is associated with an estimated risk of induced cancer of one in 900 individuals and a risk of induced fatal cancer of about one in 1800 individuals (30). For older individuals, these risks are considerably lower. These risks should be weighed against the direct diagnostic benefit and related to the lifetime cancer risk: One in three people will develop cancer within their lifetime. It is important to note that the effective radiation dose at abdominal CT may be reduced to some extent. In studies of appendicitis and diverticulitis, standard-radiation-dose (100- and 120-mAs) nonenhanced CT was compared with 30-mAs nonenhanced CT (31,32). There were no significant differences in accuracy between the low- and standard-dose CT examinations. In a series of 58 patients suspected of having appendicitis, low-dose CT with oral contrast medium had accuracy comparable to that of standard-dose CT with intravenous contrast medium (33). In general, the effective CT dose is influenced by the current dose modulation methods, which balance image quality and dose. The use of intravenous contrast medium is a drawback in patients with imminent renal insufficiency.

MR Imaging

MR imaging is not yet widely used in the diagnostic work-up of patients who present with acute abdominal pain to the

ED. The major advantage of MR imaging is the lack of ionizing radiation exposure. The high intrinsic contrast resolution rendered with MR imaging is another advantage, as intravenous contrast medium may not be required. The high intrinsic contrast resolution has the potential to be particularly valuable for assessment and diagnosis of pelvic disease in female patients, but this has not been substantiated. In the past, MR imaging required long examination times. Currently, with recently introduced high-speed techniques, MR imaging protocols for patients with acute abdominal pain involve examination times shorter than 15 minutes. However, the lack of around-the-clock availability of MR imaging is still a logistic problem at many hospitals.

MR imaging has demonstrated promising accuracy for the assessment and diagnosis of appendicitis, albeit in a relatively small series of patients, who often were pregnant (34) (Fig 2). MR imaging is also accurate in the diagnosis of diverticulitis (35). MR imaging is more accurate than CT for the diagnosis of acute cholecystitis and the detection of common bile duct stones (36). However, the body of scientific research on the use of MR imaging in patients with acute abdominal pain is relatively limited. Therefore, the availability of and expertise with this examination are limited, and the cost-effectiveness has not been studied. Further research should be directed toward better defining the role of MR imaging in the setting of acute abdominal pain, especially as compared with US and CT. At this time, MR imaging is used in only select cases at many institutions, primarily after US yields nondiagnostic findings in pregnant women. Current evidence indicates that MR imaging already could be used for a broader range of indications (37). MR imaging has contraindications, including claustrophobia, which may prevent MR imaging from being performed.

Figure 2

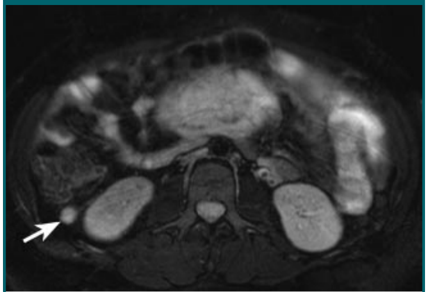


Figure 2: Axial fat-saturated half-Fourier acquisition with single-shot turbo spin-echo MR image (1900/72 [repetition time msec/echo time msec]) obtained in 28-year-old woman who was at 18 weeks gestation, was clinically suspected of having appendicitis, and had nondiagnostic US findings. Image shows thickened retrocecal appendix (arrow) with increased signal intensity and minimal infiltration of surrounding fat. Fundus uteri is seen directly anterior to the aorta. The diagnosis of appendicitis was confirmed at surgery.

Figure 3

Figure 3: Coronal contrast-enhanced reformatted CT image in 28-year-old man clinically suspected of having appendicitis shows inflamed appendix (straight arrow). Inflammation is more pronounced at the appendiceal tip, and discontinuity of the appendiceal wall is suggested. Small amounts of fluid (curved arrow) adjacent to the appendix are present. Adjacent fat inflammation (arrowheads) is more pronounced at the appendiceal tip. Surgery and histopathologic analysis results proved the presence of perforated retrocecal appendicitis.

Acute Appendicitis

The prevalence of appendicitis in patients who present with abdominal pain to the ED is approximately 14% (Table E1 [online]). The starting symptom is generally nondescriptive visceral pain in the periumbilical region, followed by nausea and vomiting. When the disease progresses, the pain typically migrates to the right lower quadrant because of more localized peritoneal inflammation. Owing to this frequent cause of acute abdominal pain, approximately 250 000 appendectomies are performed annually in the United States (38). After mortality and morbidity, the important quality indicators of care in patients suspected of having appendicitis are negative appendectomy rate and percentage of perforated appendicitis.

Making an accurate and timely diagnosis of appendicitis is challenging for clinicians. A false-positive diagnosis may lead to unnecessary surgical exploration, which is associated with increased mortality risk, prolonged hospital stay, and increased infection-related complication risk (39). A false-negative (missed) diagnosis can lead to prolonged time to treatment and increased risk of perforation. Several nonmedical factors (ie, prehospital time, availability of operating room for emergency surgery, time of presentation) have been shown to be significantly associated with perforated appendicitis (40). Compared with uncomplicated appendicitis, perforated appendicitis is associated with a two- to tenfold increase in mortality (Fig 3) (41).

Traditionally, acute appendicitis has been diagnosed on the basis of clinical findings. There has been a low threshold to perform appendectomy on the basis of the assumption that missed appendicitis—and thus the chance of perforation—has more hazardous consequences than does appendectomy that reveals negative findings. As a result, negative-finding appendectomy rates of 12%–40% have been reported (42). Despite having high sensitivity (up to 100%), clinical evaluation has relatively low specificity (73%) (43). This means that surgeons are likely to overestimate the presence of appendicitis in patients who present to the ED. Some clinicians hold the view that imaging should be performed only in patients who have equivocal clinical findings at presentation. Direct appendectomy can be performed in patients with classic signs and symptoms at presentation, particularly young men (44), whereas making a clinical diagnosis is more difficult in women. A combination of clinical features, including pain migration, abdominal rigidity, and elevated inflammatory parameters (45), has a high predictive value for appendicitis but is present in only a small proportion of patients suspected of having appendicitis. This makes clinically determining the diagnosis difficult in the majority of patients and emphasizes the added value of imaging in patients suspected of having appendicitis.

The exact role of imaging in the setting of suspected appendicitis is still a matter of debate. In general, radiography does not play a role in the work-up (9); US and CT have important roles, although CT has better accuracy (16) (Figs 4, 5). CT is the preferred imaging technique for the diagnosis and assessment of appendicitis in the United States (46) and has been shown to reduce the negative-finding appendectomy rate from 24% to 3%, with a simultaneous increase in CT use, from 20% to 85%, over a period of 10 years (47). Two randomized trials revealed negative-finding appendectomy rates of 5% and 2% in patients who underwent routine CT, compared with rates of 14% and 19% in patients in whom CT was performed selectively on the basis of clinical judgment (48,49). Furthermore, it has been shown that the routine use of CT is cost-effective because it facilitates a reduction in in-hospital costs of $447 per patient by preventing unnecessary hospitalizations and surgical explorations (50).

Figure 4

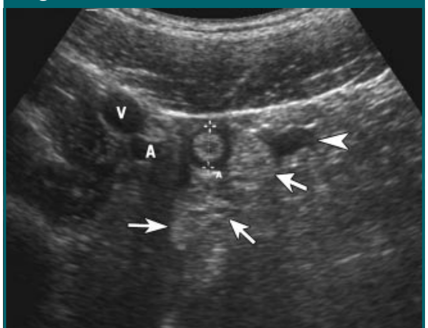


Figure 4: US image in 43-year-old man clinically suspected of having acute appendicitis shows noncompressible thickened (10-mm) appendix surrounded by inflamed mesenteric fat (arrows) and some fluid (arrowhead). Calipers mark the appendix. *A* = iliac artery, *V* = iliac vein.

Figure 5

Figure 5: Axial CT image obtained after intravenous contrast medium administration in 47-year-old man with 2-day history of right lower quadrant pain and clinically suspected of having acute appendicitis shows thickened appendix (arrow) with maximal diameter of 14 mm and adjacent fat infiltration (arrowheads). *C* = cecum.

Figure 6

Figure 6: Axial abdominal CT image in 62-year-old woman with known factor V Leiden trombophilia and a fever without an apparent cause for more than 2 weeks, obtained after the administration of oral and intravenous contrast media to exclude lymphoma shows an appendicolith (arrow) in a noninflamed appendix as an incidental finding.

Figure 7

Figure 7: Axial CT scan obtained after intravenous contrast medium administration in 24-year-old woman with right lower quadrant pain, a clinical differential diagnosis of gynecologic disorder (tubo-ovarian abscess, pelvic inflammatory disease, ovarian torsion) or appendicitis, and inconclusive US findings shows a normal appendix (straight arrow) and an enlarged right ovary (arrowheads), which most likely is due to tubo-ovarian abscess or ovarian torsion. Free fluid and some thickening of the peritoneum (curved arrows) are also visible. Laparoscopy revealed ovarian torsion. *U* = uterus.

There are several individual CT findings that suggest a diagnosis of appendicitis; an enlarged (>6 mm) appendix has a high positive predictive value (51,52). Likewise, the sensitivity of adjacent fat infiltration is high for the diagnosis of appendicitis (52,53). However, the visualization of appendicoliths has been shown to have a low positive predictive value for the diagnosis of appendicitis because these may also be present in individuals who do not have appendicitis (Fig 6) (51). CT has limitations in the detection of appendiceal perforation. For the detection of perforated appendicitis, extraluminal gas, abscess, focal appendiceal wall defect, and small-bowel obstruction (SBO) have high specificity at CT; however, these findings are not very sensitive (54,55). If appendicitis can be ruled out, the most common alternative imaging-based diagnoses are gynecologic diseases (Fig 7), diverticulitis, and colitis (31,56). Other alternative conditions, which require conservative treatment, include right-sided diverticulitis and epiploic appendagitis (Fig 8).

Despite the high diagnostic performance of CT, this modality has the aforementioned drawbacks. Therefore, alternative strategies for the diagnosis of acute appendicitis that involve less use of CT have been proposed—for example, US performed as the initial diagnostic test, with CT performed only secondarily, after US has yielded nondiagnostic findings. However, US can be limited by gas-filled bowel, which may obscure the underlying abnormality and thus necessitate secondary CT in many individuals (Fig 9). MR imaging might be an alternative to CT in the future.

Acute Diverticulitis

Acute colonic diverticulitis is the second most common cause of acute abdominal pain and leads to 130 000 hospitalizations in the United States annually (57). The prevalence—and thus the incidence—of diverticulosis increases with age. Ten percent of the general population younger than 40 years and more than 60% of people older than 80 years are affected by diverticulosis (58). Ten percent to 20% of the affected people will develop diverticulitis, which is localized on the left side of the colon in 90% of cases (59). Seventy-two percent of patients admitted to the hospital for diverticulitis have uncomplicated diverticulitis. A sensitivity of 64% for the clinical diagnosis of acute diverticulitis in the ED has been reported—that is, one-third of the cases are missed clinically (60). These patients are most often suspected of having acute appendicitis. Because the treatments for acute appendicitis (appendectomy) and acute diverticulitis (mainly conservative treatment) are different, the differentiation of these two diagnoses is important. The reported positive predictive value of 53% for the presence of diverticulitis after clinical evaluation indicates that approximately 40% of primary clinical diagnoses are false-positive (60).

The disease stage in patients with diverticulitis is often determined by using the modified Hinchey classification system (61), in which imaging and/or surgical findings are incorporated (Table). Most patients with uncomplicated diverticulitis can follow a conservative treatment regimen of antibiotics and diet modification. In mildly ill patients with a presentation clearly suggestive of uncomplicated diverticulitis (Hinchey stage 0 or 1a), the treatment decision is not based on the imaging results but rather on the patient's clinical status. In patients who have Hinchey stage 1b diverticulitis with a small (<2 cm) abscess, treatment can be conservative as well. Patients with larger abscesses are treated with percutaneous drainage. Diverticulitis-associated abscesses are found at CT in approximately 15% of patients (62) (Fig 10). The majority of these collections, approximately 36%–59%, are mesocolic abscesses, which can be treated with percutaneous drainage. The diverticulitis recurrence rate is the highest (40%) in this group (63,64).

If patients do not respond to or deteriorate while undergoing conservative treatment, they will undergo surgery (61,65). Approximately 13% of patients who are treated conservatively will have a recurrence of diverticulitis, and only 4% of patients will have a third episode (66). On the basis of the low recurrence rates, Broderick-Villa et al (66) proposed that elective surgery is not indicated in these patients. In another study, 10% of the patients underwent surgery after initial conservative treatment for diverticulitis (62). CT plays a role in confirming the diagnosis and staging suspected complicated disease. CT assists in therapeutic decisions and in the detection of alternative diseases, according to guidelines of the American Society of Colorectal Surgeons (59,65). In a recent meta-analysis, the accuracies of US and CT in the assessment and diagnosis of diverticulitis were not significantly different (15). Overall sensitivities were 92% for US and 94% for CT (P = .65), and overall specificities were 90% for US and 99% for CT (P = .07). The sensitivity of CT for the diagnosis of alternative diseases was higher and ranged between 50% and 100%.

Two frequently present CT findings that have high sensitivity for the diagnosis

Figure 8

b.

Figure 8: Axial CT images in 25-year-old woman suspected of having appendicitis. At US, the appendix was not well visualized; therefore, CT was performed after intravenous contrast medium administration. **(a)** Image shows right-sided diverticulitis, indicated by right-sided colon diverticula (arrow) and fecalith with thickened wall, wall enhancement, and adjacent fat infiltration (arrowheads). **(b)** Image shows some secondary wall thickening of the adjacent appendix (arrow), with air in the lumen. Only some secondary changes—and no appendicitis—are seen. *C* = cecum.

Figure 9

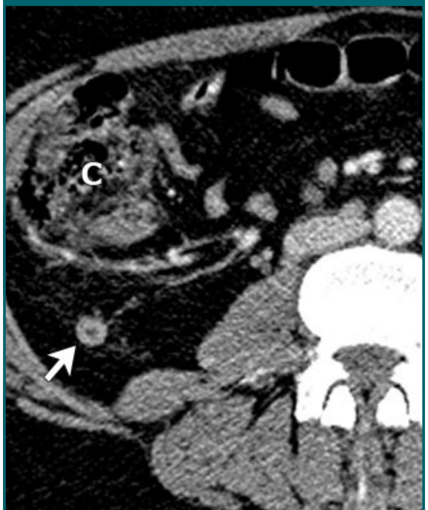


Figure 9: Axial CT image obtained after intravenous administration of contrast medium in 39-year-old woman with classic clinical manifestations of appendicitis shows retrocecal inflamed appendix (arrow) with thickened wall and some surrounding infiltration. The appendix could not be visualized at US because of overlying (bowel) gas. Appendicitis was confirmed at surgery and histopathologic analysis. *C* = cecum.

of diverticulitis are wall thickening (95% sensitivity) and fat stranding (91% sensitivity). Although fascial thickening and inflamed diverticulum are less frequent findings, they have reported specificities of 97% and 91%, respectively (67). CT is used not only to make diagnoses but also to stage disease in patients with diverticulitis. CT can also be used to differentiate colorectal cancer from diverticulitis. Features associated with the diagnosis of colon carcinoma are pericolonic lymph nodes and luminal mass, whereas pericolonic inflammation and segment involvement larger than 10 cm are more commonly associated with diverticulitis (Figs 10, 11). However, these signs are not very accurate, and cancer can be missed (Fig 10). Therefore, endoscopy and biopsy are often required to make this differentiation after the clinical symptoms have resolved—often after 6 weeks.

Acute Cholecystitis

Cholecystolithiasis is the main cause of acute cholecystitis, for which an estimated 120 000 cholecystectomies are performed annually in the United States (68). The prevalence of acute cholecystitis is approximately 5% in patients who present with acute abdominal pain to the ED. Traditionally, the diagnosis has been based on the clinical triad of right upper quadrant tenderness, elevated body temperature, and elevated white blood cell count. In a prospective series of patients with acute cholecystitis (69), however, this triad was present in only 8% of patients. Relatively recently published Tokyo guidelines introduced diagnostic and severity assessment criteria (70). The diagnostic criteria for acute cholecystitis are one local sign of inflammation (Murphy sign; mass, pain, and/or tenderness in right upper quadrant), one systemic sign of inflammation (fever, elevated C-reactive protein level, elevated white blood cell count), and confirmatory imaging findings. Cholecystitis severity is classified as mild, moderate, or severe (stages I, II, and III, respectively). Mild cholecystitis is defined as cholecystitis in a patient who has mild inflammatory changes adjacent to the gallbladder without organ dysfunction. Findings of moderate cholecystitis are elevated white blood cell count, palpable tender mass in the right upper quadrant, duration of complaints longer than 72 hours, and marked local inflammation. Severe cholecystitis is defined as cholecystitis combined with multiple organ dysfunction syndrome.

Radiologic findings have an important influence on treatment management in patients with cholecystitis and organ failure due to sepsis. Percutaneous drainage of the inflamed gallbladder with delayed cholecystectomy can be a safe option. In all other cases that do not involve severe inflammation or surrounding infiltration at imaging, laparoscopic cholecystectomy should be performed within 96 hours after the start of the complaints. Imaging findings are therefore essential in making decisions regarding treatment for cholecystitis.

Several imaging techniques are available for the evaluation of suspected acute cholecystitis. US is the most frequently performed modality for right upper quadrant pain and yields a sensitivity of 88% and a specificity of 80% in the diagnosis of acute cholecystitis (71). Features of cholecystitis include gallbladder wall thickening; enlarged tender, noncompressible gallbladder; and adjacent infiltration or fluid collections (Figs 12, 13). According to ACR appropriateness criteria, US is considered the most appropriate imaging modality for patients suspected of having acute calculous cholecystitis (72). In a highly select study sample, CT also showed good accuracy, with a sensitivity of 92% and a specificity of 99% (73). In patients with acute abdominal pain, CT has demonstrated accuracy comparable to that of US in the diagnosis of acute cholecystitis (69). US should be considered the primary imaging technique for patients clinically suspected of having acute cholecystitis (72).

Modified Hinchey Classification of Disease Stage in Patients with Diverticulitis

Stage	Characteristic
0	Mild clinical diverticulitis
1a	Confined pericolic inflammation, no abscess
1b	Confined pericolic inflammation with local abscess
2	Pelvic, retroperitoneal, or distant intraperitoneal abscess
3	Generalized purulent peritonitis, no communication with bowel lumen
4	Feculent peritonitis, open communication with bowel lumen

Source.—reference 61.

Bowel Obstruction

Bowel obstruction is a relatively frequent cause of acute abdominal pain (Table E1 [online]). The majority of patients found to have bowel obstruction after they present to the ED have an SBO.

SBO Disease

SBO is primarily caused by postoperative adhesions. The combination of vomiting, distended abdomen, and increased bowel sounds is suggestive of SBO and has a positive predictive value of 64% (74). Other patient characteristics and risk factors associated with bowel obstruction are previous abdominal surgery, age older than 50 years, and history of constipation (74). In patients with SBO complicated by ischemia (strangulated hernia), immediate surgery is warranted, whereas many other patients with low-grade obstruction can be treated conservatively with a nasogastric tube and bowel rest. Seventy-three percent of all patients who are treated conservatively will not be readmitted. In one series, however, 19% of the patients were readmitted for recurrent obstruction—one-third of these subjects underwent surgery—and 8% of the patients died (75). Approximately one quarter of patients who are initially found to have SBO in the ED will undergo surgery (75). For adequate treatment, it is important to identify the cause (eg, adhesion, neoplasm, or hernia) and severity of

Figure 10

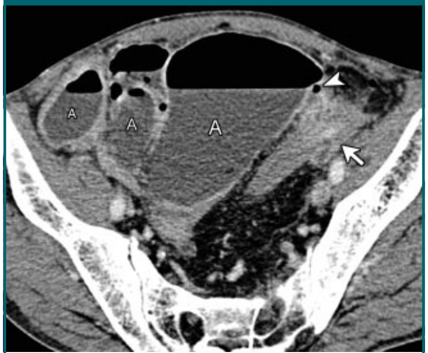


Figure 10: Axial CT image obtained after intravenous contrast medium administration in 54-year-old man with a history of colitis that was diagnosed at age 15 and a several-month-long history of abdominal pain and weight loss, who presented to the ED with progressive abdominal pain of 1 week duration. Image shows a thickened sigmoid colon with some surrounding infiltration (arrow), a contained perforation (arrowhead), and multiple abscesses *(A)*. Histopathologic analysis revealed extensive perforated diverticulitis and adenocarcinoma. (Image courtesy of C. Yung Nio, MD, Academisch Medisch Centrum, Universiteit van Amsterdam, Amsterdam, the Netherlands.)

Figure 11

a.

b.

Figure 11: **(a, b)** Axial CT images obtained after intravenous, oral, and rectal contrast material administration in 46-year-old man with 2-year history of abdominal pain and recent progressive acute abdominal pain. He had not defecated for the past 2 days and had experienced weight loss of 12 kg during the past year. Acute diverticulitis was clinically suspected, with colorectal cancer as a differential diagnosis. Images show **(a)** apple-core stenosis (arrow) of the sigmoid colon caused by colorectal cancer and **(b)** proximal prestenotic dilatation of descending colon and cecum (arrow).

Figure 12

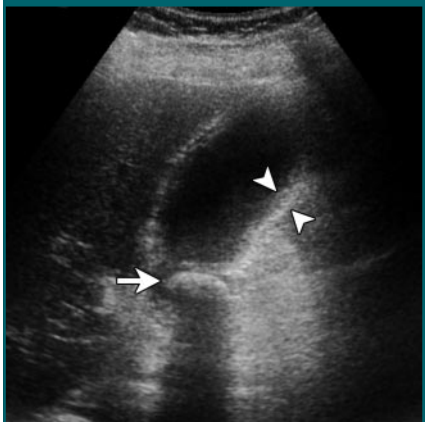


Figure 12: US image obtained in 79-year-old man with 4-day history of right upper quadrant pain, nausea, and vomiting shows a thickened gallbladder wall (arrowheads) and an obstructing gallstone (arrow), which was position independent. The patient was initially treated with percutaneous gallbladder drainage.

Figure 13

Figure 13: Axial CT image obtained after administration of oral and intravenous contrast media in 73-year-old obese woman with abdominal pain, fever, elevated C-reactive protein level (400 mg/L), and a normal white blood cell count shows cholecystitis with wall thickening, radio-opaque gallstones (arrow), and some adjacent fat infiltration. The broad clinical differential diagnosis in this patient included cholecystitis, diverticulitis, and appendicitis. The acute cholecystitis was treated with percutaneous drainage because of this patient's critical condition.

the obstruction. An obstruction can be partial or complete and complicated by ischemia, especially in the case of closed-loop obstruction (strangulation). Unlike adhesions, internal hernia is an uncommon cause of bowel obstruction in the Western world. Accurate diagnosis is mandatory because of the risk of strangulation. Because clinical evaluation has limitations in the diagnosis of bowel obstruction (74), imaging is routinely performed to identify the site, cause, and severity (high- vs low-grade) of the obstruction. All of these are important parameters to help guide patient treatment.

Radiography has long been the primary imaging modality of choice for patients suspected of having bowel obstruction. Radiography has been reported to have 69% sensitivity and 57% specificity in the diagnosis of bowel obstruction (76) (Fig 14).

CT has the best reported accuracy for the diagnosis of SBO, with a sensitivity of 94% and a specificity of 96% (77). In one study, the cause of the obstruction was correctly identified at CT in 85% of patients with a clinically equivocal diagnosis of bowel obstruction (77). The clinical management was correctly altered for 23% of patients—mainly from conservative to surgical treatment. Evaluating the location and differentiating the common causes of bowel obstruction are more difficult on abdominal radiographs (76). CT can also enable the differentiation between high- and low-grade obstruction (79). However, the sensitivity of CT is markedly lower for the diagnosis of low-grade (64%) SBO than for the diagnosis of high-grade SBO (80).

An important CT finding that may suggest SBO is a clear change in bowel diameter. With SBO, loops proximal to the transition point are distended, whereas loops distal to the transition

Figure 14

Figure 14: Upright conventional abdominal radiograph obtained in 59-year-old man who had abdominal pain and a distended abdomen at clinical evaluation, as well as a history of SBO 3 years ago, for which he was treated conservatively, shows distended small-bowel loops and air-fluid levels (arrowheads), consistent with SBO. The previous obstruction was most likely caused by adhesions because the patient had previously undergone appendectomy. This patient was again treated conservatively.

Figure 15

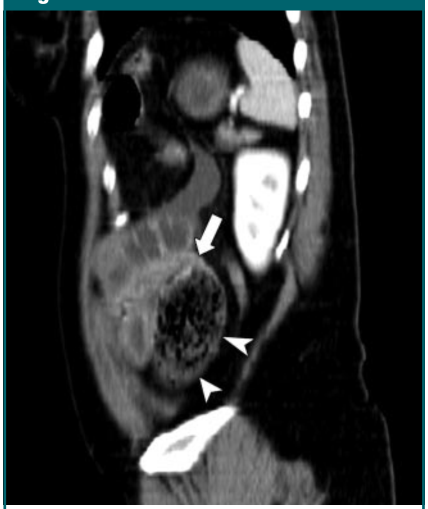


Figure 15: Sagittal reconstructed CT image in 47-year-old woman who had a history of lysis of adhesions and presented with cramping pain of 2 days duration, nausea, and vomiting shows the transition point (arrow) and the small-bowel feces sign (arrowheads) proximal to the transition point. No mass is visible, and the diagnosis is obstruction by adhesions. The patient was treated conservatively with a successful outcome.

point are collapsed. A helpful sign for identifying the point of obstruction is the small-bowel feces sign—that is, feces-like material in the distended small bowel (81) (Fig 15). The transition point should be scrutinized for the cause of the obstruction (adhesion, neoplasm, hernia, or inflammatory disorder).

Because SBO is most often due to adhesions, which are usually not visible at CT, in most patients, no cause will be identified at CT. In this setting, the diagnosis of SBO due to adhesions is made by means of exclusion. In some patients with adhesions, an adhesive band may be suggested if extraluminal compression and kinking (acute angle) of the bowel are present (82).

Internal hernias can be difficult to identify. The sensitivity and specificity of CT in the diagnosis of internal hernias are moderate, 63% and 73%, respectively (83). A cluster of small-bowel loops is a CT finding strongly associated with the diagnosis of internal hernia (odds ratio, 7.9) (84).

The ACR proposes that abdominopelvic CT with intravenous contrast medium is the most appropriate imaging examination when complete or high-grade SBO is suspected (85). If low-grade or intermittent SBO is suspected, several CT techniques (barium or water as the contrast agent, enteroclysis) or small-bowel examinations (follow-through, enteroclysis) are more or less equally appropriate, according to the ACR.

Other imaging modalities such as US and MR imaging are not widely used, although US reportedly has good accuracy (81%) in the diagnosis of bowel obstruction (84). Fluid-filled loops are easily visualized at US, and one can easily differentiate between mechanical obstruction and paralytic ileus by visualizing peristaltic movement (84). US has important limitations: Gas-filled loops may obscure the underlying abnormality, which has important treatment management–related implications, and the obstruction is difficult to stage accurately. The ACR states that US is the least appropriate imaging modality when high- or low-grade SBO is suspected (85). Evidence supporting the accuracy of MR imaging in the diagnosis of bowel obstruction is limited, but results are promising. A sensitivity of 95% and a specificity of 100% were reported in a small study by Beall et al (86). Overall, CT can be considered the primary imaging technique for patients suspected of having SBO.

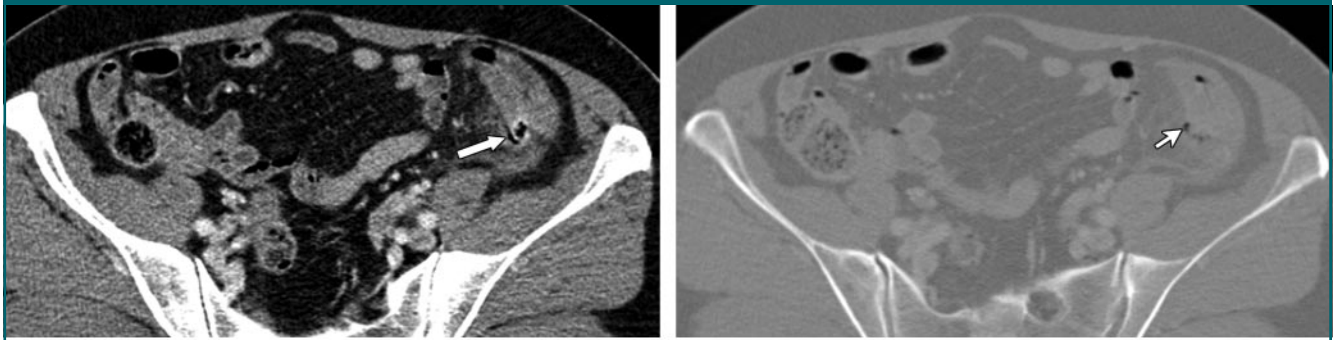
Large-Bowel Obstruction

Large-bowel obstruction (LBO) is most commonly caused by colorectal cancer (60% of cases) (Fig 11), sigmoid volvulus (10%–15% of cases), and diverticulitis (10% of cases). The clinical features of LBO—abdominal pain, constipation, and abdominal distention—are not very specific. Therefore, the clinical diagnosis is often incorrect. Traditionally, conventional radiography has been the initial imaging examination performed. At present, CT is more often used to identify the cause of the obstruction, the level of obstruction, and the presence of a complicated obstruction (eg, strangulation). LBO is diagnosed at CT if the colon is dilated (colon diameter > 5.5 cm, cecum diameter > 10 cm) and filled with feces, gas, and fluid proximal to an abrupt transition point, after which the colon is collapsed distally. The accuracy of CT in the diagnosis of LBO has been reported in only one study—that by Frager et al (87). In that study, CT had a sensitivity of 96% and a specificity of 93%. LBO can be diagnosed with barium enema examination. Although obstruction can often be adequately detected with barium enema examination, unlike CT, barium enema examination generally does not enable the visualization of mural changes and extracolonic abnormalities. CT is the imaging modality of choice in the diagnosis of LBO in patients. For short luminal segmental obstruction caused by colorectal cancer, a colonic stent can be placed as either a palliative treatment or a “bridge” to elective surgery (88). Volvulus of the large bowel can be reduced endoscopically.

Perforated Viscus

Acute abdominal pain as a result of gastrointestinal tract perforation is most commonly caused by a perforated gastroduodenal peptic ulcer or diverticulitis. Less frequent causes include carcinoma

Figure 16



a. b.

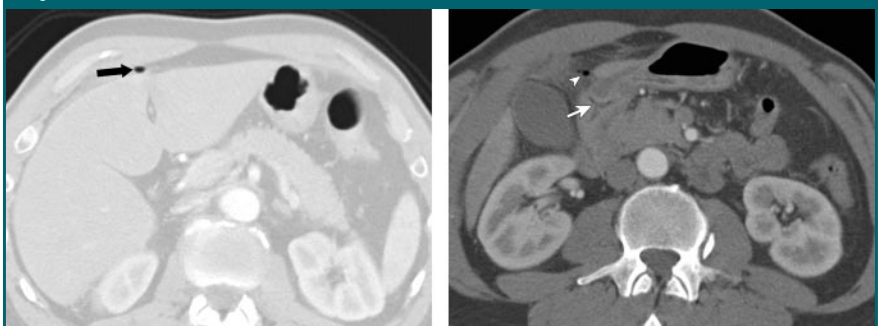
Figure 16: Axial CT images obtained in **(a)** abdominal and **(b)** lung window settings after intravenous contrast medium administration in 71-year-old woman who had a 2-day history of left lower quadrant pain and was suspected of having diverticulitis show diverticulitis of the sigmoid colon with a contained perforation (arrow) and infiltration of pericolic fat. The patient was treated conservatively with antibiotics.

and bowel ischemia. Perforated viscus is a generally recognized diagnosis, although the incidence of this abnormality with free perforation is low (1%) in the ED (Table E1 [online]). Perforation of a peptic ulcer is now less frequent because of the availability of adequate medical therapy for peptic ulcer disease. Among patients who are evaluated for possible acute diverticulitis, only 1%–2% have free perforation (57). Most perforated diverticula are contained perforations (Fig 16).

Because the clinical symptoms of free perforation are associated with the underlying cause of the perforation, the clinical presentations of patients with perforated viscus are quite variable. Besides the variable symptoms of the underlying mechanism, a rigid abdomen usually is present. Recognizing a perforation and establishing the cause and site of the perforation can yield crucial information for the surgeon. Formerly, suspected free intraperitoneal air was always an indication to perform surgery. Currently, with the increased use of CT, contained perforations are more commonly diagnosed, and the initial treatment for these may be conservative. For example, contained perforated peptic ulcers and Hinchey type 2 diverticulitis with peridiverticular air bubbles (Fig 16) are often treated with conservative management.

Upright posteroanterior chest radiography traditionally has been used for the initial examination of patients suspected of having pneumoperitoneum. Pneumoperitoneum is visualized as a translucent crescent or area below the diaphragm. Left lateral decubitus radiography is an alternative in patients who are not able to stand upright. CT is currently replacing conventional radiography for this indication. This reflects the fact that multisection CT is more sensitive for the detection of smaller amounts of free intraperitoneal air. Conventional radiography is insensitive for the detection of air pockets smaller than 1 mm and only 33% sensitive for the detection of 1–13-mm pockets (89). The major advantage of CT, as compared with radiography and US, is that it can correctly depict the actual site of perforation in 86% of cases (90). A concentration of extraluminal air bubbles, a focal defect of the bowel wall, and segmental bowel wall thickening are CT findings substantially associated with correct identification of the location of a perforation (Fig 17). The location of the free air is a useful indicator of the site of the perforation. If free air is located around the liver and stomach, this most likely indicates a gastroduodenal perforation. Free air detected predominantly in the pelvis and supramesocolic and inframesocolic re-

Figure 17



a. b.

Figure 17: Axial CT images obtained after intravenous administration of contrast medium in 54-year-old woman who presented to the ED with acute periumbilical abdominal pain that radiated to the back. The abdominal pain started after the woman ingested a nonsteroidal antiinflammatory drug. **(a)** Image obtained in lung window setting shows free intraperitoneal air (arrow). **(b)** Image shows wall thickening at the duodenal bulb and evidence of perforation (arrow), with adjacent soft-tissue infiltration and air bubbles (arrowhead). A diagnosis of perforated duodenal ulcer was made and confirmed at surgery.

gions makes perforation of the colon or appendix more likely (90). Multiplanar reformations at CT are helpful for identifying perforations (91). A perforation can be diagnosed at US when echogenic lines or spots with comet-tail reverberation artifacts representing free intraperitoneal air are seen adjacent to the abdominal wall in a supine patient. A sensitivity of 92% and a specificity of 53% have been reported for the detection of perforation with US and constitute an overall accuracy of 88% (92). It is important to note that establishing the cause and location of the perforation is difficult with US.

Bowel Ischemia

Although bowel ischemia is a potentially life-threatening cause of acute abdominal pain, it is present in only about 1% of patients who present with acute abdominal pain (Table E1 [online]) (92,93). Gastrointestinal blood flow normally comprises 20% of cardiac output. This can increase to 35% postprandially and decrease to 10% in critical situations such as hypovolemia (93). If the blood supply to the bowel decreases any further, mesenteric ischemia will develop. Acute bowel ischemia can be caused by occlusion of the arteries (60%–70% of cases) or veins (5%–10% of cases) or by nonocclusive diminished vascular perfusion (20%–30% of cases) (94,95).

Patients with bowel ischemia often have a short clinical history of prominent abdominal pain, while other possible symptoms such as nausea, vomiting, diarrhea, and distended abdomen are substantially less prominent. All of these symptoms are nonspecific. A diagnosis of bowel ischemia is often made after the more frequently occurring diagnoses with similar associated symptoms are excluded. Bowel ischemia should be considered especially in elderly patients with known cardiovascular disease (eg, atrial fibrillation) and in younger patients known to have diseases that may cause inadequate mesenteric blood flow, such as vasculitis, hereditary or familial coagulation disorders such as antiphospholipid syndrome, and protein C or S deficiency. Laboratory findings such as elevated lactate level, elevated amylase level, and leukocytosis are nonspecific nonearly signs of ischemia (93).

In many patients with mesenteric ischemia, the differential diagnosis is broad and includes peptic ulcer disease, bowel obstruction, pancreatitis, inflammatory bowel disease, appendicitis, and diverticulitis. Diagnostic imaging is always warranted to establish the diagnosis in a timely manner and differentiate between arterial and venous occlusive bowel ischemia. Acute arterial mesenteric ischemia is treated surgically, with percutaneous thrombolytic treatment as an alternative

Figure 18

Figure 18: Portal venous phase CT image obtained after intravenous administration of contrast medium in 58-year-old woman who presented to the ED with abdominal pain, anal blood loss of several hours duration, and an abdomen that had been distended for the past 2 days. She had a history of breast cancer and hypertension. Bowel ischemia was clinically suspected. Image shows superior mesenteric vein occlusion (straight arrow); the superior mesenteric artery is open. A transition point (arrowheads) is also clearly visible, with a normal small bowel proximally and a thickened bowel wall with decreased enhancement distally. Free peritoneal fluid (curved arrow) is also seen. This patient underwent surgery, during which a large part of the small bowel was resected, and recovered uneventfully.

Figure 19

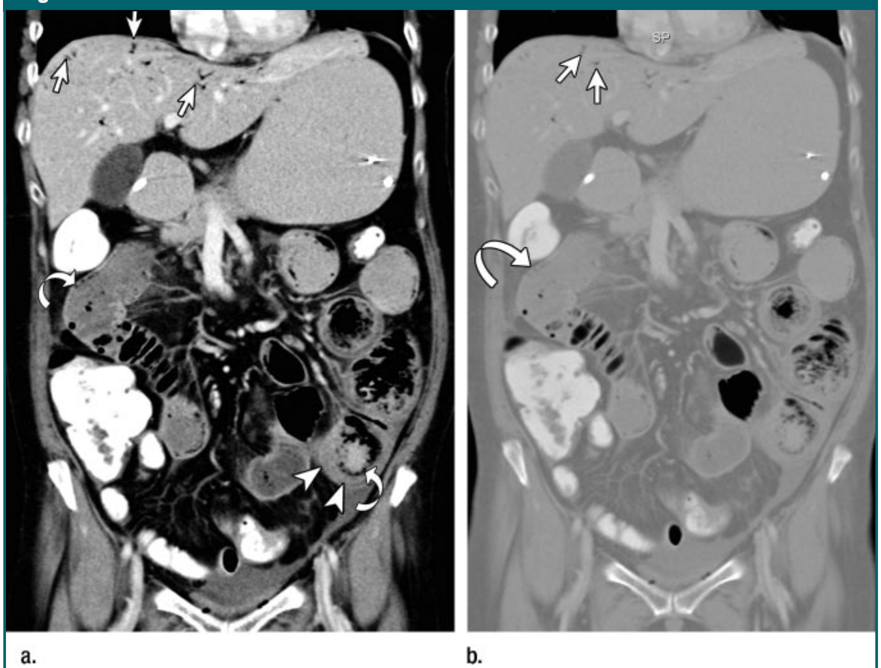


Figure 19: Multiplanar reformatted abdominal CT images obtained in **(a)** soft-tissue and **(b)** lung windows after intravenous administration of contrast material in 59-year-old woman with nausea and vomiting who had undergone sigmoid colon resection for a gastrointestinal stromal tumor 5 days earlier. A distended abdomen identified at physical examination and an increasing C-reactive protein level were noted. Images show portovenous gas (straight arrows) in the periphery of the liver and pneumatosis (curved arrows). The bowel wall (arrowheads) is thickened and enhanced. On the basis of these CT findings, bowel ischemia was considered. However, the clinical findings were more suggestive of bacterial translocation. The patient responded well to treatment with antibiotics. (Images courtesy of Ludo F.M. Beenen, MD, Academisch Medisch Centrum, Universiteit van Amsterdam, Amsterdam, the Netherlands.)

(96). In some patients with low-grade ischemia, vascular reconstructive surgery can be performed to preserve the mesenteric blood supply. In these patients, CT information can be of vital importance. Venous mesenteric ischemia is usually not transmural and can often be treated conservatively with anticoagulative therapy (97). Venous mesenteric ischemia in closed-loop obstruction requires treatment of the mechanical obstruction.

Formerly, the diagnosis of bowel ischemia was made with angiography. CT is currently used to identify the primary cause, severity, location, and extent of the bowel ischemia. Angiography can be used to confirm the diagnosis of bowel ischemia and treat occlusive bowel ischemia. Angiography is less accurate in cases of nonocclusive mesenteric ischemia than in cases of occlusive mesenteric ischemia.

In patients suspected of having mesenteric ischemia, biphasic CT performed during the arterial and venous phases is particularly useful. Volume rendering or multiplanar reformation facilitates evaluation of the vessels. Arterial phase CT is very helpful for evaluating the celiac trunk and the mesenteric arteries. A venous phase CT scan also can show occlusions of mesenteric arteries, but it predominantly enables evaluation of the mesenteric veins, bowel wall, and other causes of acute abdominal pain (Fig 18).

Although several CT signs are associated with bowel ischemia, these signs are not very frequent or specific (Fig 19). Visualized occluded mesenteric arteries or venous thrombus is a clear sign of mesenteric ischemia (Fig 18). The bowel wall may be thickened (>3 mm) because of mural edema, hemorrhage, congestion, or superinfection. Thickening owing to edema, congestion, or hemorrhage is a frequent finding of venous obstruction. Bowel wall hypoattenuation (edema), bowel wall hyperattenuation (hemorrhage), abnormal bowel wall enhancement (target sign), and absence of bowel wall enhancement are features of bowel ischemia. The absence of bowel wall enhancement is highly specific but is often missed. The bowel wall may become paper thin, and this may indicate impending perforation. Luminal dilatation and fluid levels (fluid exudation of the ischemic bowel segments) are common in irreversible bowel ischemia, and mesenteric stranding and ascites are nonspecific CT findings of bowel ischemia.

Pneumatosis cystoides intestinalis can be present and manifest as a single gas bubble or a broad rim of air dividing the bowel wall into two layers. Pneumatosis was formerly thought to be highly associated with a diagnosis of bowel ischemia. However, pneumatosis can also be caused by infectious, inflammatory, or neoplastic disorders and is therefore a nonspecific sign for the diagnosis of bowel ischemia. When pneumatosis cystoides intestinalis is seen in combination with portal venous gas, especially in the liver periphery, it is definitely associated with bowel ischemia but is not a pathognomonic finding. Portal venous gas is an ominous sign that is generally seen in patients with a poor prognosis.

The reported accuracy of CT in the diagnosis of bowel ischemia is comparable to the accuracy of angiography. Sensitivities of 93% for CT and 96% for angiography (98) and specificities of 79% for CT and 99% for angiography (94) have been reported. In contrast, a more recent study showed CT to have sensitivity as low as 14% and a specificity of 94% (99). The disappointing results of that study suggest that radiologists may be unaware of the signs and symptoms of bowel ischemia. This diagnosis should be more commonly considered in patients with acute abdominal pain, especially older patients with known cardiovascular disease. The use of contrast-enhanced US for the diagnosis of bowel ischemia has been evaluated. Contrast-enhanced Doppler US reportedly has a sensitivity of 63% when the color signals are diminished and 80% when the color signals are absent (100). CT is currently the preferred imaging modality for the assessment and diagnosis of bowel ischemia, despite a number of indeterminate signs.

Conclusions

The clinical findings–based diagnosis rendered in patients with acute abdominal pain is often inaccurate. Therefore, imaging plays an important role in the treatment of patients with acute abdominal pain. Because US and CT are widely available, radiography is rarely indicated for the examination of patients with acute abdominal pain, with the exception of select patients groups—for example, patients with bowel obstruction. CT is an effective examination with results that have a positive effect on the treatment of many patients with acute abdominal pain. At present, CT can be considered the primary imaging technique for patients with acute abdominal pain, with the exception of patients suspected of having acute cholecystitis. US is preferable in these patients, but CT is an acceptable alternative.

The widespread use of CT raises imaging costs. To our knowledge, the cost-effectiveness of increased CT use has been studied—with increased CT use proved to be cost-effective—only in patients suspected of having acute appendicitis. This issue should be further evaluated for patients with acute abdominal pain who present to the ED. Radiation exposure is a drawback of CT; therefore, US may serve as an initial diagnostic test. CT may then be reserved for patients with nondiagnostic US results (24). MR imaging has the potential to advance as a valuable alternative to CT, but supportive data are still scarce.

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