

Imaging in appendicitis: CT and sonography

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**Upon completion of this
activity, participants should
be able to:**

- Describe the usual clinical management of patients with appendicitis.
- Explain the strengths and weaknesses of CT and ultrasound in assessing patients with suspected acute appendicitis.
- Summarize the CT and ultrasound findings in acute appendicitis.
- Discuss the clinical settings in which CT or ultrasound is the preferred imaging modality in patients with right lower quadrant pain.

Who will benefit:

Radiologists, sonographers, physicians, physician assistants, nurses, and referring physicians interested in body imaging will benefit from the information in this educational activity and can receive Continuing Medical Education credit by completing the post-test and evaluation provided.

Only about 15% of patients presenting with abdominal pain in the emergency room require surgery or other significant intervention (Table 1).[1] In this 15%, acute appendicitis is the most common cause of right lower quadrant pain (Table 2).[2] Few comparative imaging studies evaluating right lower quadrant pain are available. Because of its frequency and importance, appendicitis is the subject of most imaging reports for these patients. Our focus will likewise be on appendicitis and the accuracy of imaging procedures in its diagnosis. Other diseases causing right lower quadrant pain will also be discussed.

While routine use of imaging in all patients with suspected appendicitis has been shown to be efficacious and cost-effective[3-6], current surgical opinion recommends laparotomy without imaging in about 66% of patients—those with typical clinical symptoms. Thus, only about 30% to 35% of patients (those with atypical clinical findings) undergo diagnostic imaging.[7] Older tests such as radiography and barium enema have largely been discarded in favor of sonography and, especially, CT. Both CT and ultrasound

are accurate in the diagnosis of acute appendicitis (Tables 3 and 4).

In a recent comparative trial from Belgium, multislice CT and ultrasound were equivalent statistically, although the frequency of inconclusive examinations was significantly higher with ultrasound than with CT.[8] While sonography is more technically demanding in the evaluation of right lower quadrant pain, it is clear that careful CT technique is also mandatory. CT is also user-dependent, albeit to a lesser degree than

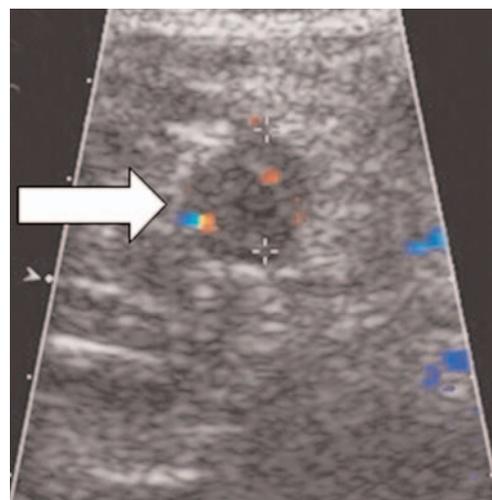


FIGURE 1. Acute appendicitis on ultrasound. Finding a greater than 7-mm outer diameter noncompressible appendix is virtually diagnostic for acute appendicitis. This appendix (white arrow) is 12 mm in outer diameter. There is some flow in the appendix, but color Doppler is generally not useful in ultrasound diagnosis of acute appendicitis.

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IMAGING IN APPENDICITIS: CT AND SONOGRAPHY

TABLE 1. COMMON CAUSES OF PAIN IN EMERGENCY ROOM PATIENTS ALL AGE GROUPS

NOTE: Prevalence varies in other series

CAUSE OF PAIN	%
Unknown	41.3%
Gastroenteritis	6.9%
Pelvic inflammatory disease	6.7%
GU infection	5.2%
Ureteral stone	4.3%
Appendicitis	4.3%
Cholecystitis	3.7%
Intestinal obstruction	2.5%
Constipation	2.3%
Duodenal ulcer	2.0%
Other A and B	22.0%

After Brewster RJ et al. *Am J Surg* 1976;131:219.[1]

A: 1% to 2%: Pregnancy, dysmenorrhea, pyelonephritis, gastritis, ovarian cyst, incomplete Ab

B: Less than 1%: Pancreatitis, aortic aneurysm, epididymitis

Used with permission from Dachman et al[16]

sonography. The most balanced and informative discussion comparing CT and sonography is probably that published by Birnbaum and Wilson.[9] One controversy is whether to use intravenous contrast in the CT evaluation of appendicitis. Malone et al reported that non-contrast-enhanced CT achieved results comparable to contrast-enhanced CT.[10]

Fortunately, the strengths of CT and sonography are complementary. Sonography is better in thin patients without much intra- and retroperitoneal fat, while CT is better in patients with significant amounts of fat, because periappendiceal inflammatory changes are thus easier to visualize. The thin patient with an inflamed appendix is often easily diagnosed sonographically, while this situation can be problematic on CT. Isolated mural changes, without inflamed fat, may be subtle on CT, but CT excels in obese patients and can evaluate patients with distended, noncompressible abdomens who are difficult to evaluate on graded compression sonography.

The use of CT and sonography is

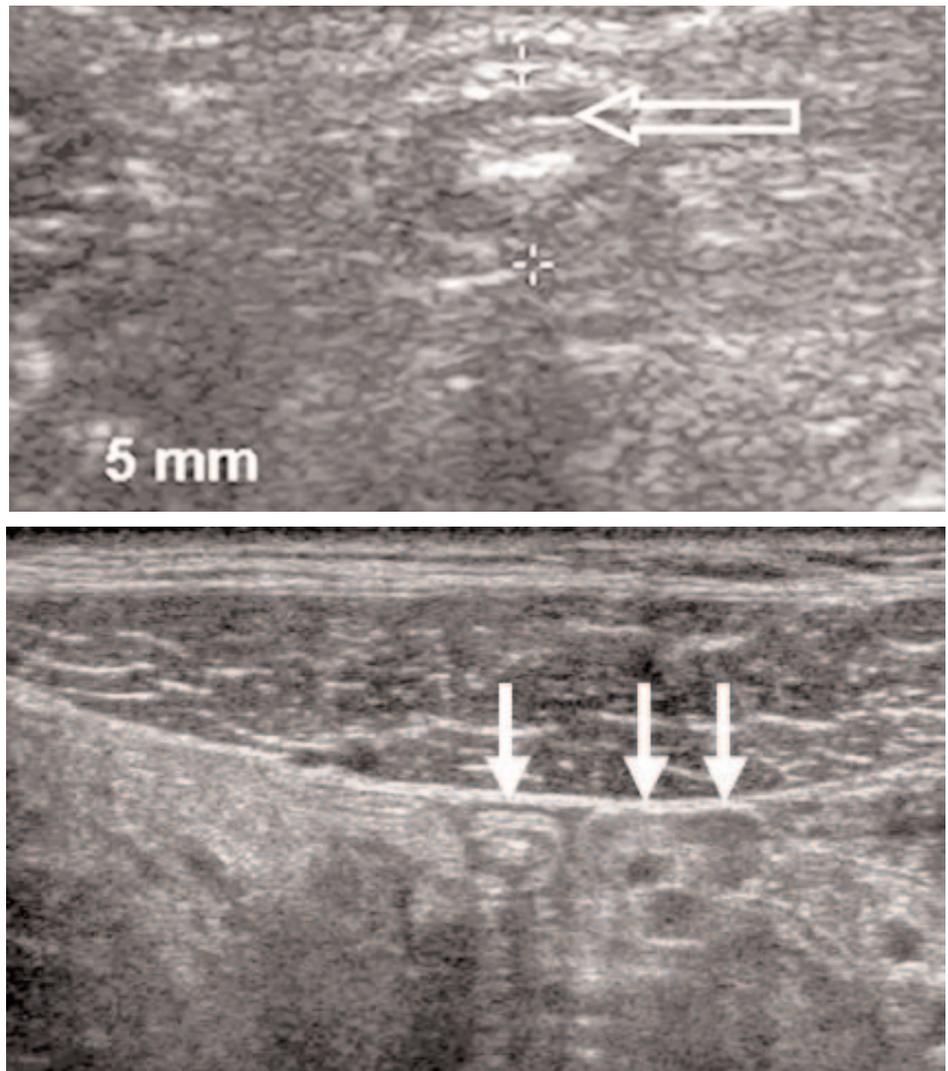


FIGURE 2. Top: Normal appendix on transverse oblique right lower quadrant graded compression ultrasound. This compressible appendix in a patient with fever, leukocytosis, and right lower quadrant pain was freely mobile, making it somewhat difficult to image. Note echogenic air within appendix (open arrow). Bottom: Normal appendix on longitudinal oblique right lower quadrant ultrasound. Several portions of this normal diameter, compressible, and freely mobile appendix are noted in this image (arrows). There is a small echogenic appendicolith within appendix, in loop indicated by leftmost arrow. Appendicoliths usually are noted in appendicitis but can on occasion be seen in normal appendices.

heavily influenced by institutional preference and expertise. Until more information is available, the following approaches might be appropriate:

- *Sonography preferred.* Graded compression sonography should be used as the screening test in most patients, especially children, young women, and pregnant women. MR is an alternative for pregnant women.

- *CT preferred.* CT can be used as a primary modality in patients who are obese or have a rigid, noncompressible

abdomen, or patients in whom there is a strong suspicion of advanced complicated appendicitis with periappendiceal abscess. It is used as a secondary study in selected patients who have pain that suggests a condition requiring surgery and an equivocal graded compression sonogram.

SONOGRAPHIC TECHNIQUE

Graded compression sonography of the right lower quadrant should usually be performed with a high-resolution (5 to 12 MHz) linear-array transducer. Newer

IMAGING IN APPENDICITIS: CT AND SONOGRAPHY



FIGURE 3. Acute appendicitis seen on endovaginal ultrasound. At times, acute appendicitis is detected during pelvic ultrasound examination. Sometimes an endovaginal scan is the only image that shows abnormal appendix. (Image used with permission of Stephanie Wilson, M.D.)

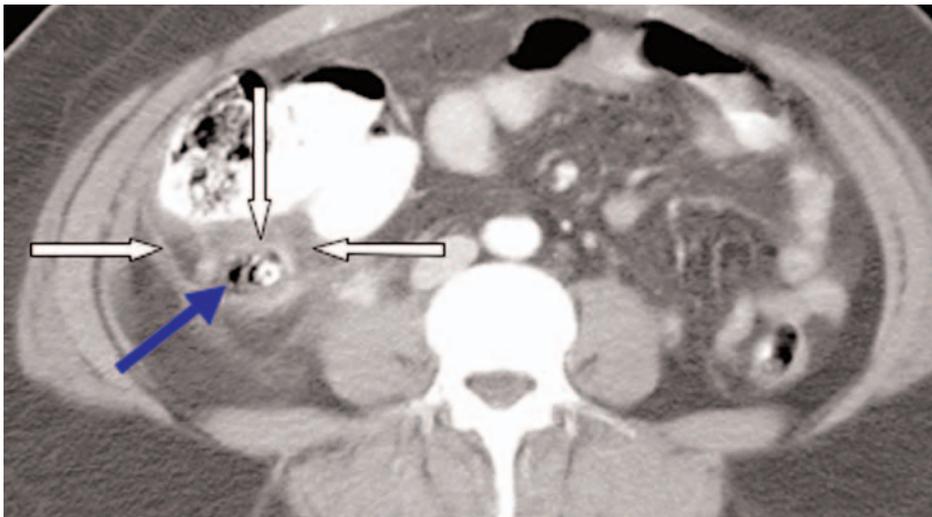


FIGURE 4. Perforated acute appendicitis on CT. Image exhibits a number of CT findings in acute appendicitis. Periappendiceal inflammation (white arrows) is present in almost all patients with acute appendicitis and is most common finding noted on CT. In this patient, dense appendicolith is noted within appendix. There is gas (blue arrow) adjacent and to right of appendix, indicative of perforation.

high-frequency curved linear transducers can also be used successfully. A wide footprint (larger transducer face) is very helpful to compress gas and other bowel contents out of the gastrointestinal tract so that an abnormal appendix can be visualized.

The exam is most successful when sufficient compression can be used, so that the skin surface is within 4 to 5 cm of the

muscles posteriorly. CT should be considered in patients in whom this degree of compression cannot be achieved. The examiner must remember to both apply and release compression gradually, to avoid eliciting peritoneal tenderness. Transverse scans in the right lower quadrant are performed to identify the proximal right colon. Scanning should then proceed caudally to the cecal tip.

**TABLE 2. CONDITIONS
REQUIRING SURGERY
EMERGENCY ROOM PATIENTS**

CAUSE OF PAIN	%
Acute appendicitis	36.9%
Intestinal obstruction	35.2%
Perforated ulcer	8.0%
Acute cholecystitis	6.2%
Abscess	4.4%
Pancreatitis	2.1%
Diverticulitis	1.5%
Colon perforation	1.1%
Other	4.4%

After Jordan G. *Adv Surg* 1980;14:259.[2]

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All gas and fluid should be expressed from the normal bowel. At this point, an abnormal noncompressible appendix (7 mm or more in outer diameter) is usually seen in patients with acute appendicitis (Figure 1). If an abnormal appendix is not identified, an abnormal retrocecal appendix should be sought by scanning laterally through the flank. The normal appendix can be seen but usually in only a minority of patients. When imaged, the normal appendix measures 6 mm or smaller in outer diameter (Figure 2). Often it is quite mobile. Inflammation apparently fastens the inflamed appendix to the surrounding structures. Retrocecal appendicitis is often best diagnosed by scanning with the transducer next to the cecum, using oblique scan angulation. Occasionally, an inflamed pelvic appendix is seen in women only on endovaginal scanning.[9]

Subsequent to a negative graded compression appendiceal exam, pelvic sonography should be performed. Female patients with right lower quadrant pain frequently have acute gynecologic disorders such as pelvic inflammatory disease or pelvic masses that can be diagnosed with pelvic sonography. While transabdominal imaging may be useful, endovaginal sonography is usually better for delineating pelvic pathology (Figure 3).

IMAGING IN APPENDICITIS: CT AND SONOGRAPHY

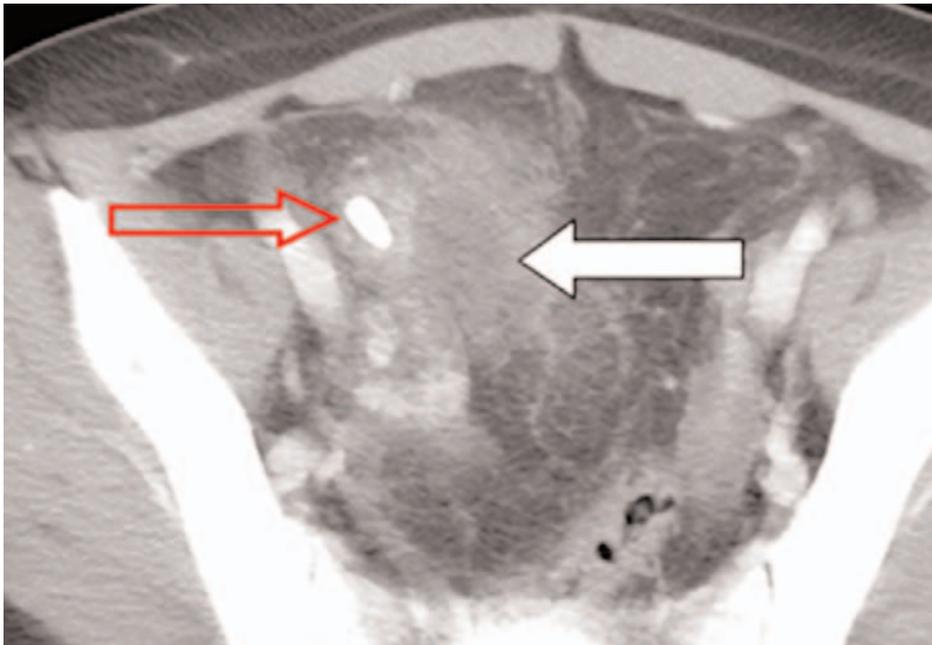


FIGURE 5. Acute appendicitis with appendicolith and abscess on CT. There is a large appendicolith in inflamed appendix (open arrow). Note small abscess medial to appendix (arrow). CT excels in demonstrating complications of appendicitis.

Mesenteric adenitis can be diagnosed when there is no evidence of appendicitis and sonography demonstrates multiple enlarged lymph nodes. Finding both mural thickening of the terminal ileum and mesenteric adenopathy suggests the diagnosis of infectious terminal ileitis. A thickened terminal ileum should not be confused with an enlarged inflamed appendix. There are three helpful distinguishing features: The appendix originates from the cecal tip more caudally,

has no visible peristalsis, and ends in a blind pouch.

SONOGRAPHIC CRITERIA FOR DIAGNOSIS OF ACUTE APPENDICITIS

A noncompressible appendix with an outer diameter of 7 mm or larger is diagnostic of appendicitis in the appropriate clinical situation. In acute appendicitis, the appendix is usually immobile, probably because of the inflammation, and inflamed periappendiceal fat is often

increased in echogenicity.

If an appendicolith is visualized, appendicitis should be diagnosed even if the appendix is smaller than 7 mm in diameter, unless the appendix is freely mobile. A normal appendix may be imaged in a minority of these patients.

Signs of gangrenous appendicitis and perforation include loss of the echogenic submucosal layer and fluid or other hypoechoic masses adjacent to the appendix. CT is superior to sonography in demonstrating extra-appendiceal inflammatory masses and is, therefore, often necessary if percutaneous drainage of periappendiceal abscess is considered.

CT TECHNIQUE

Many different CT techniques have been used to assess patients with right lower quadrant pain. Generally, thin-section (5-mm section collimation) scans are used to improve detection of the appendix, compared with 10-mm protocols. Appendiceal CT protocols vary according to the anatomic area being scanned and the use of intravenous and gastrointestinal contrast (oral and/or rectal).

Nonenhanced spiral CT of the entire abdomen and pelvis[11] takes less than 10 minutes and requires no patient preparation. Nonenhanced CT is complementary with sonography, as it works best in obese patients, where sonography is limited. Many advocate the use of intravenous and oral contrast material to diagnose not only appendicitis, but also other conditions that may simulate appendicitis. Unfortunately, this means scanning must be delayed at least 30 minutes to obtain adequate gastrointestinal opacification of the cecal region. Rao et al[12] have used a limited spiral CT study of the right lower quadrant, performed after the rapid administration of colonic contrast material, to avoid this delay and obtain excellent ileocecal opacification. Accurate results can be obtained within 15 minutes with this approach, but it has the drawback of missing conditions not encompassed in the region scanned.

TABLE 3. CT VERSUS ULTRASOUND IN SUSPECTED ACUTE APPENDICITIS: RESULTS IN PROSPECTIVE COMPARATIVE TRIALS (%)

	CT (range)	Ultrasound (range)
Sensitivity	95*, 96**, 86†/80†, 97†† (80-97)	87*, 76**, 97†, 76†† (76-97)
Specificity	89*, 89**, 95†/94†, 100†† (89-100)	74*, 91**, 93†, 76†† (74-93)
Accuracy	94**, 92†† (92-94)	83** (83)
PPV	97*, 96**, 91†/91† (91-97)	92*, 95**, 92† (92-95)
NPV	83*, 95**, 92†/88† (83-95)	63*, 76**, 98† (63-98)

*Pickuth et al[17]: 120 consecutive "atypical" adult patients; performed by radiologists

**Balthazar et al[18]: 100 consecutive adult patients; performed by radiologists

†Kaiser et al[19]: 600 Children [US only vs. combined US/CT]; performed by radiologists

††Horton et al[20]: 106 "atypical" adult patients; performed by surgeons

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IMAGING IN APPENDICITIS: CT AND SONOGRAPHY

TABLE 4. CT AND ULTRASOUND IN SUSPECTED ACUTE APPENDICITIS (%)

Results in noncomparative trials

	CT range	Ultrasound range
Sensitivity	90-100	75-98
Specificity	91-99	86-100
Accuracy	94-98	87-96
PPV	92-98	91-99
NPV	89-99	89-98

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CT CRITERIA FOR DIAGNOSIS OF ACUTE APPENDICITIS

A definitive CT diagnosis of acute appendicitis can be made if an abnormal appendix is identified or a calcified appendicolith is seen in association with pericecal inflammation. The inflamed appendix usually measures 7 to 15 mm in diameter. Periappendiceal inflammation (Figure 4) is present in almost all patients with acute appendicitis.[9] Of course, thin patients may lack sufficient fat to allow visualization of the inflammation.

Other conditions may cause inflammation in the fat of the right lower quadrant. Circumferential wall thickening is often present. Other findings include focal cecal apical thickening and the arrowhead sign.[13] The arrowhead sign is said to be present when cecal contrast material funnels symmetrically at the cecal apex to the point of appendiceal occlusion. The arrowhead sign is usually, but not always, seen only on thin-section CT scans.

Abscesses and inflammation are present when perforation of the appendix has occurred. Sometimes an appendicolith may be seen within the abscess or inflammatory mass (Figure 5). Extraluminal air, enlarged lymph nodes, and small-bowel obstruction may be present. Contrast-enhanced CT may demonstrate the remains of a fragmented appendix.

FUTURE OF IMAGING IN SUSPECTED ACUTE APPENDICITIS

Despite the complementary, synergistic value of CT and ultrasound in evaluation

of acute appendicitis, it seems likely that CT will be favored over sonography in most radiology practices. There are several reasons for this. Because graded compression sonography requires experience and expertise to obtain optimal results, many radiologists are reluctant to use it. Radiologists are generally more confident about interpreting CT than sonography.[14] CT generally requires less radiologist time and less interpretive expertise than sonography. That CT is compensated at a higher level than sonography is likely a factor in the choice of study.

There is little doubt that use of routine imaging in patients with suspected acute appendicitis would result in fewer unneeded laparotomies.[3,4,6,15] Routine imaging is more cost-effective and would also result in less delay before proper treatment.[6] Current surgical habit and economic incentive favor performing surgery rather than not doing it. These are the main impediments to imaging all or nearly all patients with suspected appendicitis. In the future, I predict that imaging will almost always be done before surgery for suspected appendicitis. ■

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For further reading

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