Sonography as the First Line of Evaluation in Children With Suspected Acute Appendicitis

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Acute appendicitis is the most common cause of abdominal pain requiring urgent surgery in children and is a true gastrointestinal emergency. The diagnosis is suspected and made primarily on the basis of clinical findings. Classically, these clinical findings consist of periumbilical pain migrating to the right lower quadrant, accompanied by fever and leukocytosis. However, the classic signs are not always present, and symptoms can be nonspecific and overlap with other causes of abdominal pain. The clinical presentation is also complicated in young children by their limited communication skills.

Historically, computed tomography (CT) has been the first choice of imaging in acute abdominal pain, with sensitivity of up to 96% and specificity of up to 97%. However, because of the increasing awareness of the radiation dose imparted to patients by CT and the theoretical increased risk of cancer that it causes, there is a nationwide campaign to reduce the radiation from diagnostic imaging in children (Image Gently). Sonography uses sound waves instead of ionizing radiation to evaluate for disease and in some studies has demonstrated accuracy similar to that of CT. Therefore, sonography should be used as the primary diagnostic modality in the evaluation of suspected acute appendicitis in children.

Sonography is widely available, can be performed at the bedside, involves a short acquisition time, does not use ionizing radiation, is relatively inexpensive, and may show evidence of other causes of abdominal pain. It is particularly useful in evaluating young women, in whom the radiation dose to the reproductive organs should be minimized and for whom it is important to exclude ovarian and uterine conditions that might mimic appendicitis. There have been multiple studies evaluating the value of sonography in the evaluation of appendicitis, showing varying sensitivity, specificity, and accuracy. However, a recent study by Pacharn et al found that sonography for acute appendicitis had a negative predictive value of 95%, making it an excellent screening tool in the evaluation of acute appendicitis. Goldin et al suggested that standardizing the technique and criteria will decrease variability in the diagnostic accuracy of sonography across institutions.
Technique

The standard sonographic evaluation of the abdomen based on the American Institute of Ultrasound in Medicine practice guideline includes imaging of the appendix. A complete abdominal sonographic examination does not need to be performed in the evaluation of acute appendicitis. However, because the appendix is not always located in the right lower quadrant and an abscess could be present, imaging should include not only the right lower quadrant but also the pelvis and left lower quadrant. A survey of the abdomen for free fluid or bowel thickening elsewhere is also helpful, especially in cases of suspected perforation.

At the start of the examination, it is helpful to ask the patient to point to the site of maximal tenderness and begin scanning in this location. Using a high-resolution linear transducer, the abdomen should be compressed while scanning, which moves bowel gas out of the field of view. This compression sonography is performed with an empty bladder. The most reliable way to identify the appendix is to find the ascending colon, follow the colon proximally to the cecum, and then find the appendix extending off the cecum.

Figure 1. A, Longitudinal image of the right lower quadrant showing a normal appendix. The maximal outer wall diameters are 5.3 and 5.7 mm. Less than 6 mm is considered normal. B, Transverse images of the right lower quadrant. The image on the left shows a normal appendix (arrows). The image on the right is with compression; the appendix compresses (arrow).
If the appendix cannot be seen in the supine position, it may be helpful to place the patient in the left lateral decubitus position to cause a retrocecal appendix to be better seen. Scanning with a full bladder may also be helpful because it can better delineate a deep pelvic appendix that might be obscured by overlying bowel.

The complete appendix should be visualized, including the tip. The maximal outer wall diameter should be measured, and the wall thickness should be measured along the course of the appendix. The normal maximal outer wall diameter of the appendix is less than 6 mm, and the mural thickness is less than 2 mm (Figure 1A). Compression of the appendix should be performed, with documentation of the appearance of the appendix during compression. A normal appendix compresses (Figure 1B). Secondary signs such as free fluid, a fecolith, and hyperechoic surrounding fat should be documented. Doppler imaging is helpful to evaluate for hyperemia; however, a necrotic appendix will have decreased or no blood flow. Video clips should be obtained to show normal peristalsis unless the physician is present during the scan. If an abscess is suspected, a lower-frequency curved array transducer may be used for a larger field of view and deeper penetration.

It is not always necessary to identify a normal appendix to consider the findings negative.9 If there are no secondary signs as mentioned above, and clinical suspicion is moderately low for appendicitis, many institutions stop the evaluation and consider the sonographic findings negative for appendicitis.

In the setting of acute appendicitis, the appendix is noncompressible, and the maximal outer wall diameter is greater than 6 mm (Figure 2). An appendicolith may be present, helping the diagnosis (Figure 3); however, an appendicolith can be present without acute appendicitis, and the presence of an appendicolith does not confirm acute appendicitis. There may also be secondary signs of inflammation, such as hyperechoic surrounding fat, free fluid, or an abscess (Figure 4). The wall may be hyperemic (Figure 5). Enlarged nodes can also be seen in the right lower quadrant, but this finding is nonspecific and can also be seen in patients without appendicitis. The surrounding bowel may be dilated with loss of normal peristalsis due to ileus.

Conclusions

Right lower quadrant sonography, when performed using rigorous technique and criteria for diagnosis, is an excellent screening tool for acute appendicitis. This examination is quick and painless and does not involve the use of ionizing radiation. Although the sensitivity, specificity, and accuracy of sonography vary greatly in studies evaluating the imaging diagnosis of acute appendicitis, it should be the first imaging modality when there is clinical concern for acute appendicitis. Only if the examination is equivocal or if the appendix cannot be identified should other imaging modalities such as CT be considered.
Figure 3. Longitudinal image of the right lower quadrant showing an echogenic shadowing structure within a dilated appendix. It is an appendicolith associated with appendicitis.

Figure 4. Secondary signs of appendicitis. A, The fat surrounding this dilated tubular structure is echogenic (asterisks). This appearance is due to edema in the fat surrounding the appendix. B, Free fluid (arrow). C, Abscess appearing as a debris-filled fluid collection (asterisk) with surrounding echogenic fat.
References


Figure 5. Transverse color Doppler image of the right lower quadrant. This dilated appendix has increased flow to the wall.