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Review Article

Role of CT in Acute Appendicitis

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Abstract: Acute appendicitis is the most common reason for abdominal surgery in children. Luminal obstruction of the appendix progresses to suppurative inflammation and perforation, which causes generalised peritonitis or an appendix mass/abscess. Classical features include periumbilical pain that migrates to the right iliac fossa, anorexia, fever, and tenderness and guarding in the right iliac fossa. Atypical presentations are particularly common in preschool children. A clinical diagnosis is possible in most cases, after a period of active observation if necessary; inflammatory markers and an ultrasound scan are useful investigations when the diagnosis is uncertain. Treatment is by appendicectomy after appropriate fluid resuscitation, analgesia and intravenous antibiotics. Laparoscopic appendicectomy is better than open appendicectomy in most cases because it is associated with less postoperative pain and a shorter hospital stay, but recovery after acute appendicitis is mostly dictated by whether the appendix was perforated or not. Management of the appendix mass remains controversial and not all affected children need an interval appendicectomy. This article discusses tips and pitfalls in diagnosis and addresses many of the controversies that surround the management of this condition.

Key words: Abdominal pain; appendix; laparoscopic appendicectomy; surgery.

INTRODUCTION

Acute appendicitis is one of the most common causes of acute abdominal pain, the most common condition that requires abdominal surgery in childhood, and the most common condition associated with lawsuits against emergency physicians.

Acute appendicitis occurs when the appendiceal lumen is obstructed, leading to fluid accumulation, luminal distention, inflammation, and, finally, perforation [1-4]. Classic symptoms of appendicitis are well described [5]. However, up to one third of patients with acute appendicitis have atypical presentations [6]. Moreover, patients with alternative abdominal conditions may present with clinical findings indistinguishable from acute appendicitis [7]. Thus, although appendicitis traditionally has been a clinical diagnosis, many patients are found to have normal appendixes at surgery. The misdiagnosis of this acute condition has led to the inappropriate removal of a normal appendix in 8–30% of patients [8]. A rate of unnecessary removal as high as 20% has been considered acceptable in the surgery literature [9, 10]. However, negative laparotomy can be avoided in many patients if modern diagnostic methods are used to confirm or exclude acute appendicitis.

In the mid 1980s, graded-compression sonography emerged as a promising imaging technique for the evaluation of suspected appendicitis, especially in children [11-18]. Sonography is a noninvasive, rapid, widely available, and relatively inexpensive technique. Most important, sonography does not involve the use of ionizing radiation, a key consideration when imaging otherwise healthy pediatric and young adult patients, who are up to 10 times more sensitive to the effects of radiation than are middle-aged and elderly adults [19, 20]. On the other hand, sonography is highly operator-dependent, requires a high level of skill and expertise, and may be difficult in some situations (severe pain, overlying gas). Sonography is particularly challenging in large and overweight adults, which is a major limitation to its use in North America and parts of Europe. Moreover, sonography frequently does not allow the detection of normal or perforated appendixes [12, 17]; thus, sonography may be of limited benefit in evaluating patients at the extremes of the disease spectrum. The reported diagnostic accuracy of graded compression sonography varies widely; reported

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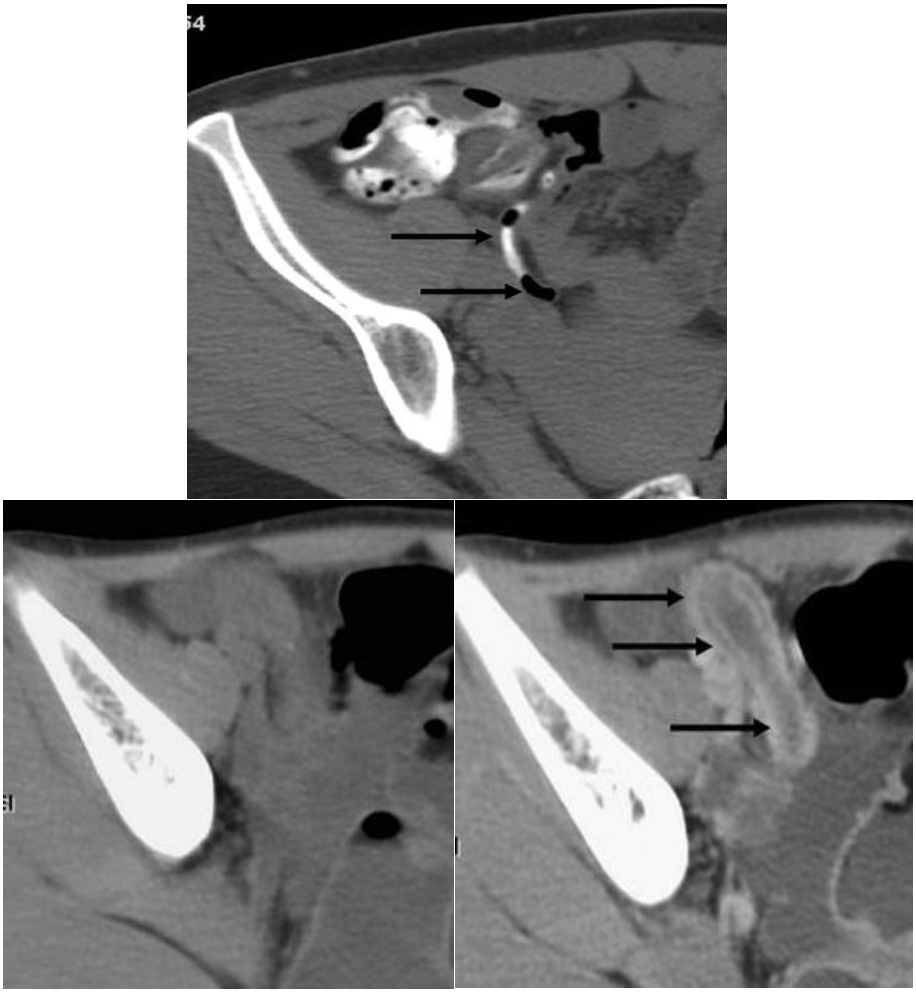
sensitivity of sonography in children ranges from 44% to 94%, and specificity, from 47% to 95% [11-13, 16-18]. In 1995, Orr *et al*., performed a meta-analysis of pediatric and adult studies published between 1986 and 1994, showing an overall sonography sensitivity of 85% and specificity of 92%. Anecdotally, our personal experience with sonography in the diagnosis of appendicitis has been disappointing. We reserve sonography as the initial examination in children, adolescents, thin adults, and women of reproductive age with possible gynecologic presentations, but if the sonographic results are negative or inconclusive, we generally proceed with CT

CT has high accuracy for the noninvasive assessment of patients with suspected appendicitis, with reported sensitivities of 88–100%, specificities of 91–99%, positive predictive values of 92–98%, negative predictive values of 95–100%, and accuracies of 94–98% [8, 32–34], and has emerged as the technique of choice in many centers for imaging evaluation of these patients. More recently, several authors have also reported the accuracy of helical CT for the diagnosis of acute appendicitis in children [11]. Important advantages of CT are that it depicts the appendix, the periappendiceal tissues, and other intraabdominal structures. Thus, CT allows the radiologist to confidently exclude appendicitis if a normal appendix is visualized and to diagnose appendicitis if the appendix is abnormal. Importantly, by depicting the severity and extension of the inflammatory process, CT can also help guide appropriate management. CT has several important disadvantages, however. The most serious is that it uses ionizing radiation. Radiation dose depends on CT technique. This article reviews CT technique, key CT findings, complications, unusual manifestations, and differential diagnosis.



CT TECHNIQUE

Because visualization of both the normal (Fig. 1) and the inflamed appendix can be challenging, especially in asthenic patients with a paucity of visceral fat, meticulous technique is important. Nevertheless, the optimal CT technique for appendicitis remains controversial, and a variety of methods have been advocated. It is generally accepted that appendiceal CT should incorporate thin-section scanning (5 mm) through the right lower quadrant (RLQ) to improve identification of the appendix, but debate exists regarding the need for IV contrast material, the use and route of enteric contrast agents, and the necessity for scanning the entire abdomen and pelvis versus

performing a focused data acquisition through the RLQ. The most commonly used CT technique for studying the appendix is a scan of the entire abdomen and pelvis after both oral and IV administration of contrast material, but several other approaches are possible. We describe the most commonly used CT techniques in the evaluation of appendicitis.

UNENHANCED CT

Some centers advocate examination without oral or IV contrast material [8]. Unenhanced scanning eliminates patient preparation time to receive enteric contrast material—thus expediting the examination and diminishing the risk of appendiceal perforation before scanning—and also eliminates the risks associated with IV contrast injection. Ege *et al.,* reported a sensitivity of 96%, specificity of 98%, positive predictive value of 97%, and negative predictive value of 98%. On the basis of these results, the authors recommended that if no definite inflammatory changes are detected with unenhanced CT, patient clinical monitoring could be done. However, other authors found less promising results for unenhanced CT. Heaston *et al*., [3] showed a sensitivity of 84% and a specificity of 92%. Our anecdotal experience is that unenhanced CT accuracy probably depends on the patient's body habitus (particularly visceral fat content), although to our knowledge this hypothesis has not yet been tested.

FOCUSED CT

Some authors advocate a focused CT examination from the right renal lower pole through the entire pelvis with various combinations of oral, rectal, and IV contrast media. Focused CT has the advantage of decreasing patient radiation dose, which is especially desirable in pediatric patients. In one study, Fefferman *et al*., reported high sensitivity (97%), specificity (93%), positive predictive value (90%), and negative predictive value (98%). However, the focused CT technique has some limitations. In one study of 100 patients presenting to the emergency department with RLQ pain, Kamel *et al*., showed that if only focused CT had been performed, 7% of patients with abnormalities outside the pelvis (4% of whom required surgery) would be undiagnosed. They concluded that both abdominal and pelvic CT examinations are necessary because there are many possible upper abdominal causes of RLQ pain in patients with clinically suspected appendicitis.

Use of Enteric Contrast Material

Most investigators recommend the use of enteric contrast material, either oral or rectal, claiming that positive enteric contrast material decreases the number of false-negative cases and improves characterization of appendicitis and detection of its complications.

Rectal administration—Cecal opacification and distention may be achieved by rectal administration of 800–1,500 mL of contrast material. The contrast agent is given with the patient on the CT gurney as a bolus under gravity control without fluoroscopic visualization. Several studies have shown high accuracy of appendicitis CT in both adults and children after rectal contrast material administration. In one study, helical CT with rectal contrast material was as accurate (98%) as helical CT with both oral and rectal contrast material. Rectal contrast material distends the cecum, delineates the thickness of its wall, and opacifies an unobstructed appendix. By distending the cecal lumen, this technique depicts several cecal signs of appendicitis, including the arrowhead sign, the "cecal bar" sign, and focal cecal apical thickening. These signs are discussed further in the subsection Cecal Changes under Key CT Findings. An important advantage of rectal contrast administration is that it is relatively fast to perform and the patient does not need to wait the 1–2 hr usually required with the oral route for terminal ileal and cecal visualization. Disadvantages of routine rectal contrast administration include patient discomfort, inconsistent opacification of the terminal ileum, and logistical or procedural difficulties. Rectal contrast material is contraindicated in neutropenic patients and those with peritoneal signs or other evidence of gross perforation.

Oral administration—Distal small-bowel and cecal opacification may be achieved by oral administration of 800–1,000 mL of contrast material in small increments over 1.5–2 hr. Opacification of these structures is often helpful because otherwise they may mimic or obscure an abnormal appendix. Unfortunately, oral contrast administration delays the examination. Moreover, optimal opacification of the ileocecal region is often not achieved because of variability in gastrointestinal transit time and patient compliance; patients with abdominal pain are often nauseated and may not tolerate oral contrast material. In our experience, oral contrast material is not usually beneficial except in cases of perforation, when oral contrast material can help identify extraluminal fluid collections.

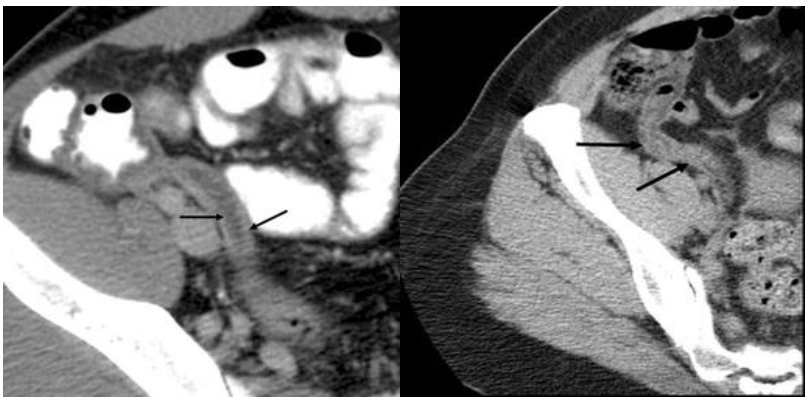
Use of IV Contrast Material

Although some authors believe that the use of enteric contrast material alone is adequate to diagnose appendicitis, other authors believe that IV contrast material is necessary. IV contrast material can be especially helpful in subtle cases and in patients with minimal intraabdominal fat by showing enhancement of the appendiceal wall (Fig. 2A, 2B). Complications such as appendiceal perforation, extraappendiceal fluid collections, abscess formation, and septic seeding of the mesenteric–portal venous system are also better characterized after IV contrast administration. Furthermore, IV contrast material is useful to diagnose and assess other causes of abdominal pain, including pancreatitis, inflammatory bowel disease, and

pyelonephritis. Disadvantages include possible adverse reactions and costs.

Unenhanced CT with Selective Use of Contrast Material

An alternative, theoretically more elegant approach, is unenhanced CT with the selective use of contrast material. In this approach, patients with suspected appendicitis are initially evaluated with unenhanced CT. If unenhanced images are conclusive (i.e., positive or negative for appendicitis), no further imaging is necessary. However, if findings are inconclusive, a repeat scan is performed with contrast material. The type of contrast material (IV, oral, rectal) and the imaging volume (e.g., focused RLQ scan or scan of the entire abdomen and pelvis) are chosen by the interpreting radiologist. This approach permits immediate imaging assessment of patients with suspected appendicitis and rational choice of contrast material tailored to a particular patient if the preliminary unenhanced scan is inconclusive. Disadvantages of this approach are that it requires monitoring by the radiologist to determine whether contrast administration is needed and that it results in additional scanning in patients in whom unenhanced images are inconclusive, thereby increasing radiation exposure and potentially delaying diagnosis. Tamburrini *et al*., found that in 25% of patients, the preliminary images were inconclusive and additional scanning with contrast material was necessary. The frequency with which additional scanning is necessary may be influenced by patient demographic factors (age, sex) and visceral fat content; this is under active investigation.



Our Approach

The large number of proposed CT techniques presents a challenge to radiologists who wish to start using CT for diagnosis of appendicitis at their institution. The simplest and most widely used technique is CT with both oral and IV contrast material. However, as discussed previously, we find that positive oral and IV contrast material are not helpful in most patients.

On the basis of our personal experience and to satisfy the needs of our emergency department colleagues, we tailor our protocol according to the patient's clinical presentation and other factors. If the patient is a child, adolescent, thin young adult, or reproductive-age woman with a possible gynecologic source of pain, try sonography first; if that is inconclusive, perform CT with IV contrast material. If the patient is a large adult, try unenhanced CT with selective use of contrast material. This method expedites the CT examination, which is critical for our emergency department physicians. If the symptoms have persisted for more than 72 hr, try CT with oral and IV contrast material because of the high probability of perforation. If the patient has a history of cancer, inflammatory bowel disease, immune deficiency, or lower abdominal or pelvic surgery, try CT with oral and IV contrast material because there is a high pretest probability of disorders other than appendicitis and possibly distorted anatomy.

The individualized approach advocated here may be impractical in nonacademic institutions or in institutions that rely on remote coverage of after-hours cases. A uniform protocol may be preferred. The chosen protocol must satisfy the needs of referring clinicians and be appropriate for the patient population. Our emergency department colleagues, for example, place a premium on expediting the examination, and most of our patients are overweight adults. For this reason, we perform unenhanced CT with the selective use of contrast material in most patients.

CONCLUSION

Helical CT is an accurate, effective technique for diagnosing acute appendicitis. Although the optimal CT technique for evaluation of patients with suspected acute appendicitis is controversial, results from many studies show appendicitis CT to be highly accurate independently of the chosen protocol. Familiarity with CT findings is important for the correct diagnosis of acute appendicitis, differentiation of appendicitis from other entities, and identification of complications. CT does have important disadvantages, however. These include the use of ionizing radiation, possible adverse reactions to IV contrast material, discomfort caused by

enteric agents, limited assessment of acute gynecologic disorders, and potentially inadequate RLQ visualization in thin individuals. For these reasons, sonography will continue to play an important role. In our opinion, sonography probably should be performed first in children, adolescents, thin young adults, and women of reproductive age with possible gynecologic causes of pain.

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