CLINICAL PRACTICE

Suspected Appendicitis

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This Journal feature begins with a case vignette highlighting a common clinical problem. Evidence supporting various strategies is then presented, followed by a review of formal guidelines, when they exist. The article ends with the authors' clinical recommendations.

An otherwise healthy 22-year-old woman comes to the emergency department with acute abdominal pain of 18 hours' duration in the right lower quadrant. On physical examination, she is afebrile, with tenderness on deep palpation in the right lower quadrant, and has no peritoneal signs. Pelvic examination reveals tenderness in the right adnexa without a mass. How should this patient be further evaluated?

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THE CLINICAL PROBLEM

Approximately 3.4 million patients with abdominal pain seek medical care at emergency departments in the United States annually.[1] The various underlying causes of the pain range from benign processes to acute life-threatening disorders. Timely diagnosis and treatment of conditions for which a delay in care may have grave consequences remain a challenge.

More than 250,000 appendectomies are performed in the United States each year, making it the most common abdominal operation performed on an emergency basis.[2] Although the diagnosis of appendicitis in young men who have abdominal pain is usually straightforward,[3] the diagnostic considerations are broader for premenopausal women with the same clinical presentation. In addition, abdominal pain in patients at the extremes of age often presents a diagnostic challenge because of delays in seeking medical care or difficulty obtaining a history and performing an accurate physical examination. Since delayed diagnosis and treatment of appendicitis are associated with an increased rate of perforation, with resulting increases in morbidity and mortality rates,[4-6] timely intervention is crucial.

To minimize the risk of appendiceal perforation while patients await treatment, surgeons have traditionally favored early laparotomy, even in the absence of a definitive diagnosis. In approximately 20 percent of patients who undergo exploratory laparotomy because of suspected appendicitis, the appendix is normal. When advanced age or female sex confounds the usual signs and symptoms of appendicitis, the error rate in managing pain in the right lower quadrant can approach 40 percent.[7] In an effort to improve diagnostic accuracy, observation of the patient, laparoscopy, and diagnostic imaging have been used when the clinical presentation is equivocal.

STRATEGIES AND EVIDENCE

HISTORY AND PHYSICAL EXAMINATION

The history taking and physical examination remain the diagnostic cornerstone in evaluating pain in the right lower quadrant. Although no single aspect of the clinical presentation accurately predicts the presence of the disease, a combination of various signs and symptoms may support the diagnosis. The specificity and sensitivity of

common signs and symptoms of appendicitis are presented in Table 1. The three signs and symptoms that are most predictive of acute appendicitis are pain in the right lower quadrant, abdominal rigidity, and migration of pain from the periumbilical region to the right lower quadrant.[8] The duration of pain, defined as the time from the onset of symptoms to presentation, has also been shown to be an important predictor, since patients with appendicitis have a significantly shorter duration of pain than do patients with other disorders.[10]

For women with appendicitis, the most common misdiagnoses include pelvic inflammatory disease, gastroenteritis, abdominal pain of unknown origin, urinary tract infection, ruptured ovarian follicle, and ectopic pregnancy.[11] In a retrospective study of signs and symptoms that differentiated appendicitis from pelvic inflammatory disease in women with abdominal pain who were seen in the emergency department,[12] the findings that were most predictive of pelvic inflammatory disease included a history of the disorder, a history of vaginal discharge, vaginal discharge on examination, urinary symptoms, abnormalities on urinalysis, tenderness outside the right lower quadrant, and cervical-motion tenderness. A history of anorexia was not helpful in differentiating appendicitis from pelvic inflammatory disease.[12]

Table 1. Sensitivity and Specificity of Clinical Findings for the Diagnosis of Acute Appendicitis.

Finding	Sensitivity	Specificity	Study
	percent		
Signs			
Fever	67	69	Wagner et al.[8]
Guarding	39–74	57–84	Wagner et al.,[8] Jahn et al.[9]
Rebound tenderness	63	69	Wagner et al.[8]
Indirect tenderness (Rovsing's sign)	68	58	Jahn et al.[9]
Psoas sign	16	95	Wagner et al.[8]
Symptoms			
Right-lower-quadrant pain	81	53	Wagner et al.[8]
Nausea	58–68	37–40	Wagner et al.,[8] Jahn et al.[9]
Vomiting	49–51	45–69	Wagner et al.,[8] Jahn et al.[9]
Onset of pain before vomiting	100	64	Wagner et al.[8]
Anorexia	84	66	Wagner et al.[8]

LABORATORY TESTING

Laboratory tests are performed as part of the initial evaluation of right-lower-quadrant pain in order to rule out or confirm specific disorders. In all women of reproductive age who present with acute abdominal pain, the serum β-human chorionic gonadotropin level should be measured to rule out uterine or ectopic pregnancy. Although approximately 70 to 90 percent of patients with acute appendicitis have an elevated leukocyte count, leukocytosis is also characteristic of several other acute abdominal and pelvic diseases and thus has poor specificity for the diagnosis of acute appendicitis.[13-17] Use of the leukocyte count alone to make management decisions in cases of suspected appendicitis may result in missed diagnoses or unnecessary surgery.

Approximately 10 percent of patients with abdominal pain who are seen in the emergency department have urinary tract disease.[18] A urinalysis may confirm or rule out urologic causes of abdominal pain. Although the inflammatory process of acute appendicitis may cause pyuria, hematuria, or bacteriuria in as many as 40 percent of patients,[19] urinary erythrocyte counts exceeding 30 cells per high-power field or leukocyte counts exceeding 20 cells per high-power field suggest a urinary tract disorder.

OBSERVATION AND LAPAROSCOPY

When the history and findings on physical examination are consistent with the diagnosis of appendicitis, appendectomy is often performed without further evaluation. If the initial clinical presentation does not suggest the need for immediate surgery, the patient may be observed for 6 to 10 hours in order to clarify the diagnosis.[20,21] This practice may reduce the rate of unnecessary laparotomy without increasing the rate of appendiceal perforation.[22-24] However, with the improved diagnostic accuracy of computed tomography (CT), early use of CT may result in lower overall costs and use of hospital resources[25] than the observation strategy.

Diagnostic laparoscopy has been advocated to clarify the diagnosis in equivocal cases and has been shown to reduce the rate of unnecessary appendectomy.[26] It is most effective for female patients, since a gynecologic cause of pain is identified in approximately 10 to 20 percent of such patients.[27,28] However, diagnostic laparoscopy is an invasive procedure with approximately a 5 percent rate of complications, which in most cases are associated with the use of a general anesthetic.[27]

CONVENTIONAL RADIOGRAPHY

Abdominal radiography has low sensitivity and specificity for the diagnosis of acute appendicitis.[29,30] Similarly, contrast-enema examination has a low accuracy. In the era of cross-sectional imaging, neither test has a role in the diagnosis of acute appendicitis.[29-31]

ULTRASONOGRAPHY

A carefully performed ultrasonographic study has a sensitivity of 75 to 90 percent, a specificity of 86 to 100 percent, and a positive predictive value of 89 to 93 percent for the diagnosis of acute appendicitis,[32-37] with an overall accuracy of 90 to 94 percent.[9] In addition, ultrasonography may identify alternative diagnoses, such as pyosalpinx or ovarian torsion, in as many as 33 percent of female patients with suspected appendicitis[38,39] (Fig. 1). Although appendicitis may be ruled out if the appearance of the appendix is normal on ultrasonography, a normal appendix is seen in less than 5 percent of patients.[33,35,40] Most physicians hesitate to make clinical decisions about appendicitis when the appendix itself is not seen on imaging studies. Therefore, the failure to see the appendix, whether it is diseased or normal, fundamentally limits the usefulness of ultrasonography for the diagnosis of appendicitis.

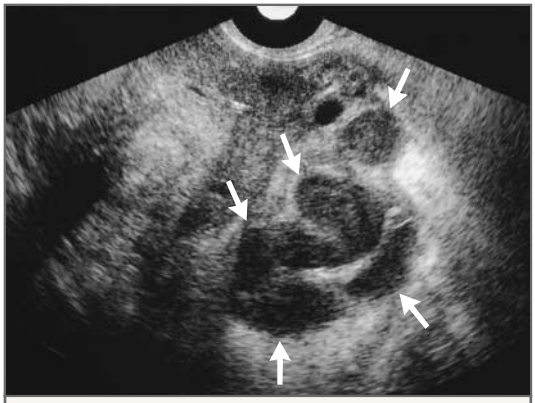

Figure 1. Endovaginal Ultrasonogram in a 46-Year-Old Premenopausal Woman with Right-Lower-Quadrant Pain, Adnexal Tenderness, and an Elevated White-Cell Count.

A carefully performed ultrasonographic examination of the right lower quadrant failed to show the appendix or the cause of pain. Endovaginal ultrasonographic examination of the right adnexa shows a fluid-filled, dilated, tubular structure (arrows), which is consistent with the presence of a hydrosalpinx or pyosalpinx. The patient underwent exploratory laparotomy, and a pyosalpinx was identified. Salpingo-oophorectomy was performed, and the patient had an uneventful recovery.

COMPUTED TOMOGRAPHY

With improvements in CT, including multislice spiral CT, the entire abdomen can be scanned at high resolution in thin slices during a single period of breath-holding. Such scanning virtually eliminates motion and misregistration artifacts and routinely results in high-quality, high-resolution images of the appendix and periappendiceal tissue. For patients with suspected appendicitis, spiral CT has a sensitivity of 90 to 100 percent, a specificity of 91 to 99 percent, a positive predictive value of 95 to 97 percent, and an accuracy of 94 to 100 percent.[33,41-49] In a retrospective review of 650 consecutive adults with clinical findings suggestive of acute appendicitis, CT had a sensitivity of 97 percent, a specificity of 98 percent, and an accuracy of 98 percent; alternative disorders were diagnosed in 66 percent of patients.[50]

CT has also proved to be accurate in patients in whom the diagnosis is uncertain. In one study, 107 consecutive patients in the emergency department who had pain in the right lower quadrant but equivocal clinical or physical findings were evaluated by means of contrast-enhanced CT.[45] All the patients underwent appendectomy, and the histologic diagnosis was compared with the CT diagnosis. CT had a sensitivity of 92 percent, a specificity of 85 percent, a positive predictive value of 75 percent, a negative predictive value of 95 percent, and an overall accuracy of 90 percent.

CT findings that are diagnostic of appendicitis, such as a distended appendix, a thickened appendiceal wall, and periappendiceal inflammation, are shown in Figure 2. Since CT provides a view of the entire abdomen and pelvis, alternative diagnoses may be readily identified.[38,39] Alternative diagnoses include, but are not limited to, colitis, diverticulitis, small-bowel obstruction, inflammatory bowel disease, adnexal cysts, acute cholecystitis, acute pancreatitis, and ureteral obstruction.[50]

COMPUTED TOMOGRAPHY VERSUS ULTRASONOGRAPHY

Two prospective studies directly comparing the efficacy of CT with that of ultrasonography in adults have shown the superiority of CT in diagnosing appendicitis.[38,39] In one study, 100 consecutive patients with suspected appendicitis underwent imaging, regardless of the degree of diagnostic certainty

Figure 2. CT Scan in an 18-Year-Old Man with Abdominal Pain and Nausea.

CT examination of the right lower quadrant after the administration of intravenous and enteric contrast material shows a dilated, fluid-filled appendix with a thickened wall (arrows). There are inflammatory changes in the adjacent fat tissue (arrowheads). Laparotomy confirmed the diagnosis of acute appendicitis, and an appendectomy was performed. The patient had an uneventful recovery.

on the basis of the history and physical examination.[38] As compared with ultrasonography, CT had greater sensitivity (96 percent vs. 76 percent), greater accuracy (94 percent vs. 83 percent), and a higher negative predictive value (95 percent vs. 76 percent). There were smaller differences in specificity (89 percent for CT and 91 percent for ultrasonography) and the positive predictive value (96 percent and 95 percent, respectively). Among patients who did not have appendicitis, an alternative diagnosis was detected more frequently with CT than with ultrasonography. In cases in which there were conflicting interpretations of the CT and ultrasonographic findings, the CT findings were more frequently correct. Abscesses and phlegmons were also more likely to be detected by CT.[38]

Similar findings were reported in a prospective trial of 120 patients with an equivocal clinical presentation of appendicitis.[39] CT and ultrasonography had a sensitivity of 95 percent and 87 percent, specificity of 89 percent and 74 percent, positive predictive value of 97 percent and 92 percent, and negative predictive value of 83 percent and 63 percent, respectively. Among patients who did not have acute appendicitis, the correct alternative diagnosis was based on CT studies more frequently than on ultrasonographic studies. CT detected an abscess in 15 percent of patients, whereas ultrasonography detected an abscess in 9 percent of patients. There was no difference in diagnostic accuracy between men and women with the use of either CT or ultrasonography.[39]

EFFECT OF IMAGING ON OUTCOME

Although CT has been shown to be sensitive and specific for the diagnosis of acute appendicitis, retrospective studies of its effects on management decisions and rates of unnecessary appendectomy have had conflicting results.[51,52] However, prospective studies have directly addressed these questions.[24,53] One study prospectively evaluated CT in 100 consecutive patients with suspected appendicitis for whom the initial management plan was either immediate surgery or admission for observation.[25] The initial plan was compared with the actual care received after CT studies had been performed. The accuracy of CT in diagnosing appendicitis was 98 percent, and it led to a change in management in 59 patients, including avoidance of an unnecessary appendectomy, avoidance of admission for observation (on the basis of normal CT findings), prompt surgery (on the basis of CT evidence of appendicitis), and identification of an alternative disease process. Taking into account the costs of an unnecessary appendectomy, one day of inpatient observation, and the CT scan, the use of CT resulted in an average cost savings of $447 per patient.[25]

Another study included 99 patients for whom a surgical consultation was obtained because of suspected appendicitis.[53] After the initial management plan had been established, all patients underwent CT and ultrasonographic studies of the right lower quadrant. Approximately two hours later, each patient was reevaluated clinically, and the treating physicians were informed of the imaging results. The surgical team then developed a final plan, using all the available information. Forty-four patients were initially scheduled for appendectomy, 49 were to be admitted for observation, and 6 were to be discharged. Among the 44 patients originally scheduled for surgery, CT combined with repeated clinical examination led to cancellation of the planned surgery for 6 patients, none of whom were found to have appendicitis; all 6 were women. Overall, of the 18 women initially assigned to surgery, 9 (50 percent) had appendicitis. Six of the 9 women who did

not have appendicitis were spared unnecessary surgery by the use of CT, with the rate of unnecessary appendectomy reduced from 50 percent (9 of 18) to 17 percent (3 of 18), a difference that was statistically significant. The fact that only 50 percent of the women initially designated to have surgery actually had appendicitis emphasizes the difficulty of establishing the correct diagnosis in women.

In contrast, of the 26 men initially assigned to surgery, 24 (92 percent) had appendicitis and 2 (8 percent) did not. The addition of CT did not influence the decision to operate in any of these men. There were no men or women in whom the use of ultrasonography alone led to the cancellation of a planned surgery.

Among the 49 patients for whom observation was planned, the CT findings, combined with repeated clinical examination, led to the discharge of 13 patients from the hospital and immediate appendectomy in 10 patients. Given the costs of observation in the hospital, CT, and appendectomy (both in patients who had appendicitis and in those who did not), the authors calculated that this approach resulted in an average cost savings of $206 per patient.

AREAS OF UNCERTAINTY

Whether CT should be performed with the use of intravenous iodinated contrast material or enteric contrast material is a controversial matter.[33,41,42,47] Recent work indicates that intravenous contrast material improves the delineation of a thickened appendiceal wall, as well as the detection of inflammation within and surrounding the appendix, leading to improved diagnostic accuracy.[49] The primary purpose of using enteric contrast material is to permit definitive identification of the terminal ileum and cecum, since terminal ileitis can mimic appendicitis both clinically and radiographically.[33] The enteric contrast material can be delivered orally or rectally. Some suggest scanning solely in the region of the appendix[48]; others suggest scanning the entire abdomen and pelvis.[44,49,50] The spiral CT technique with slice thicknesses of no more than 5 mm is critical for accurate imaging of acute appendici-

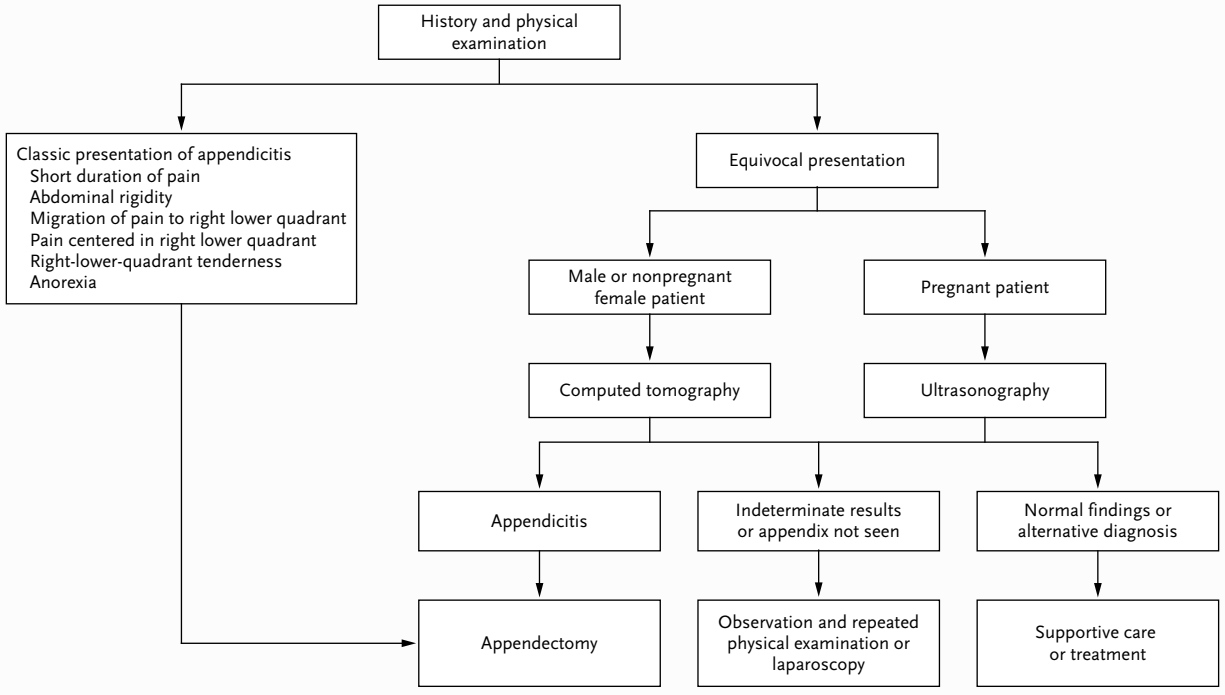

Figure 3. Clinical Algorithm for the Evaluation of Pain in the Right Lower Quadrant.

The algorithm is for suspected cases of acute appendicitis. If gynecologic disease is suspected, a pelvic and endovaginal ultrasonographic examination should be considered.

tis.[32,33,46] In addition to the scanning technique, the skill and experience of the radiologist influence the usefulness of the examination.

GUIDELINES

To our knowledge, no major medical organization has proposed specific guidelines for the evaluation of patients with acute pain in the right lower quadrant.

CONCLUSIONS AND RECOMMENDATIONS

The evaluation of acute pain in the right lower quadrant is a common clinical problem. The diagnosis relies heavily on an accurate history and physical examination. Figure 3 shows our proposed approach. A patient, male or female, who presents with acute abdominal pain that has migrated from the umbilicus to the right lower quadrant and that is associated with tenderness in the right lower quadrant should be taken directly to the operating room for an appendectomy. The expected diagnostic accuracy in these circumstances approaches 95 percent and is probably not improved by imaging. If the clinical presentation is equivocal or if there is the suspicion of a mass or perforation with abscess formation, we advocate CT imaging to help establish the diagnosis, as in the patient described in the clinical vignette. CT has demonstrated superiority over transabdominal ultrasonography for identifying appendicitis, associated abscess, and alternative diagnoses. We reserve the use of ultrasonography for the evaluation of women who are pregnant and women in whom there is a high degree of suspicion of gynecologic disease.

The results of imaging can be broadly classified as positive for appendicitis, indeterminate, or negative for appendicitis. If imaging suggests the presence of appendicitis, we recommend that an appendectomy be performed without further delay. If the appendix is not seen or if the results of imaging are otherwise indeterminate, we suggest further clinical observation and repeated physical examination or laparoscopy, with appropriate intervention. Finally, if CT studies show the presence of another disorder or an absence of abnormalities, there is no need for appendectomy, and supportive care or appropriate alternative treatment can be provided. This strategy can reduce the cost of observation, since a normal CT scan rules out appendicitis with a high degree of accuracy. We believe that adherence to these guidelines will increase diagnostic accuracy, leading to timely intervention, while reducing the rate of unnecessary appendectomy, and largely eliminating the costs of unnecessary imaging or observation.

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