Is There a Role for Abdominal Computed Tomographic Scans in Appendicitis?

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**Objective:** To better define the effectiveness of abdominal computed tomographic scanning (ACTS) in adult patients with suspected appendicitis.

**Design:** Retrospective analysis.

**Setting:** A community teaching hospital.

**Patients:** Ninety-seven patients with appendicitis in the differential diagnosis, whose clinical findings were insufficient to perform surgery or to discharge from the hospital, during a 14-month period.

**Interventions:** None.

**Main Outcome Measures:** Accuracy of ACTS, rate of appendectomies that show no appendicitis (negative appendectomy rate), and frequency of ACTS as a definitive diagnostic test.

**Results:** Forty-nine of the 50 patients with appendicitis were correctly diagnosed by ACTS. Forty-three of the 47 patients without appendicitis were correctly diagnosed by ACTS. Positive predictive value was 92%, negative predictive value was 98%, and accuracy was 96%. The ACTS group had a negative appendectomy rate of 5.8% (3/52), lower than the hospital rate of 14% for the preceding 3 years. The ACTS established an alternative diagnosis in 16 patients, allowed 10 other patients to be discharged early or not admitted, and was the critical diagnostic test in 30 of the patients with appendicitis. Therefore, the ACTS played a definitive role in the treatment of 56 (57.7%) of the 97 patients.

**Conclusions:** The ACTS was an accurate test in the diagnosis of appendicitis and was of significant benefit in 57.7% of the patients studied. However, it was difficult to predict which patients were most likely to benefit. Expanded selective use of ACTS for patients with clinically indeterminate appendicitis may result in a lower negative appendectomy rate and fewer patient admissions for observation.

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ALTHOUGH ACUTE appendicitis in adults can usually be reliably diagnosed on the basis of clinical criteria, diagnostic errors are frequent. Rates of appendectomies that show no appendicitis (negative appendectomy rates) as high as 30% have been reported, with rates of up to 40% in women.1,2 Recently, the accuracy of abdominal computed tomographic scanning (ACTS) in the diagnosis of appendicitis has been demonstrated in the radiology literature,3,4 but the appropriate use of this test in the management of adult acute appendicitis has not been well defined in clinical practice.

To better assess the use of ACTS in the management of suspected appendicitis, we selectively used this test to examine patients with indeterminate clinical evidence of appendicitis. The data were retrospectively analyzed to determine the accuracy of ACTS in the diagnosis of acute appendicitis and to determine whether the use of ACTS affected the negative appendectomy rate in our hospital. In addition, we reviewed the patients’ medical charts to identify the frequency with which ACTS provided the definitive clinical information for patient treatment. Finally, we reviewed the financial impact associated with performing ACTS and compared that cost with the expense of negative appendectomy.

See Invited Commentary at end of article
PATIENTS AND METHODS

From November 1, 1995, through December 31, 1996, 149 adults with suspected appendicitis were studied. After evaluation by a staff surgeon, surgical resident, or emergency medicine physician, patients who were judged by history, physical examination findings, and laboratory test results likely to have appendicitis underwent surgery (group 1: 52 patients). The remaining 97 patients, with a clinically equivocal diagnosis of appendicitis, underwent ACTS as part of their evaluation (group 2). Information provided by the ACTS was used to treat these patients. Surgical residents participated in the examination of most patients. An ACTS was ordered after discussion by the resident with an attending surgeon or emergency physician, one of whom also examined the patient. Occasionally, ACTS was ordered by an emergency physician or surgeon without resident involvement. The final decision to operate was always made by an attending surgeon.

The patients undergoing ACTS were examined in 1 type of scanner (GE 9800, General Electric Co, Milwaukee, Wis). The patients drank 950 mL of water or juice containing 50 mL of iothalamate meglumine (Conray 60) during a 2-hour period before the scan. The scan protocol included a test cut through the cecum to check for contrast in the cecum. When contrast was identified in the cecum, the abdomen was examined with a helical technique: 5-mm-thick slices with a 1:1 pitch through the region of the cecum, with 10-mm-thick slices with a 1:1 pitch through the rest of the abdomen. Patients received 150 mL of iothalamate meglumine or 150 mL of iopamidol (Isovue 300) at an injection rate of 2 mL per second intravenously. A scan delay of 75 seconds after the initiation of the contrast injection was used to allow optimal enhancement of the appendiceal wall.

The ACTSs were interpreted either by staff radiologists or by radiology residents. Several consultations were requested for a second radiologist’s opinion, but there was no substantial disagreement. The formal interpretation was made by the radiologist assigned to the CT scan on that day. However, 9 patients were given immediate readings of acute appendicitis on the CT scan by the radiology resident in the middle of the night. All of these readings were confirmed by the staff radiologist the following morning. The CT diagnosis of acute appendicitis was based on the observation of a distended thickened appendix (>6 mm), an enhancing appendiceal wall, periappendiceal inflammatory changes, and/or the presence of an appendicolith. An additional CT observation of acute appendicitis was the presence of thickening of the wall of the cecum that extended into the base of the appendix.

All appendices removed were evaluated pathologically, and normal ones in groups 1 and 2 were tabulated. Negative appendectomy rates in these groups were calculated. The accuracy of ACTS in predicting appendicitis or a normal appendix was computed. Alternative diagnoses identified by ACTS were also recorded. One of us, a surgeon (J.G.S.), retrospectively evaluated patient records to identify patients in whom the ACTS played a definitive role in patient treatment and those who might have been treated without ACTS. The reviewer also noted charts in which information from the ACTS was not optimally used and those in which other diagnostic tests were used to confirm ACTS findings.

Patients who had ACTS negative for appendicitis and who did not undergo surgery were contacted after discharge, and none returned to our hospital or elsewhere with appendicitis.

The data were analyzed by means of nonpaired Student t test and χ² test (Stat View, Berkeley, Calif). Statistical significance was defined as P=.05.

RESULTS

There were 25 female and 27 male patients in group 1, with ages ranging from 17 to 68 years. In group 2, the 97 patients ranged in age from 15 to 88 years. There were 59 female and 38 male patients (P=.13 between groups 1 and 2).

All 52 patients in group 1 underwent appendectomy and 41 had appendicitis, resulting in a negative appendectomy rate of 21%. Two patients had diverticulitis: 1 required sigmoid resection and the other, with cecal diverticulitis, was treated with antibiotics. Therefore, 10 patients could have been treated without surgery if the correct diagnosis had been made.

Forty-nine of the 97 patients in group 2 had appendicitis and 1 had endometriosis of the appendix that caused her symptoms. Forty-seven did not have appendicitis. Three normal appendixes were removed in 52 procedures, resulting in a negative appendectomy rate of 5.8%. The ACTS was positive for appendicitis in 49 of these patients. There was 1 false-positive ACTS in which cecal diverticulitis was diagnosed as appendicitis. There was one false-negative case in which a subtle appendicitis was not diagnosed on the ACTS. Therefore, the ACTS correctly identified 49 of the 50 patients with pathologic appendixes, a sensitivity of 98% and positive predictive value of 92%. Seven (13%) of the patients who underwent surgery in group 2 had perforated appendicitis (Table 1).

Of the 47 patients in group 2 without appendicitis, the ACTS correctly predicted the absence of appendicitis in 43 patients (91.5%). There were 3 equivocal scans on which the ACTS could not distinguish adnexal abnormality from appendicitis: 2 patients had ruptured ovarian cysts and 1 patient thought to have an adnexal mass on ACTS had normal results of laparoscopy. The negative predictive value was 98%. The overall accuracy of the ACTS was 96%.

Records of patients in group 2 were reviewed to assess those in whom the ACTS made a critical difference in management. The ACTS provided the decisive clinical information that prompted surgery in 30 of the 50 patients in group 2 who had abnormal appendixes. In several of these cases, plans had been made to discharge the patients because of improving results of clinical examination until the ACTS disclosed appendicitis. In the 47 patients in group 2 without appendicitis, 10 patients either were not admitted to the hospital or were discharged early because of a normal ACTS. In addition, an alternative diagnosis was established in 16 patients (di-
verticulitis in 8, colon carcinoma in 1, Crohn disease in 2, pelvic inflammatory disease in 2, and ovarian cysts in 3). Therefore, the ACTS provided critical diagnostic information in 56 (57.7%) of the patients in group 2.

Among the 41 patients in whom the ACTS was judged not critical to patient treatment were the 5 with either indeterminate, false-negative, or false-positive studies. Fifteen patients were thought to have had a high probability of appendicitis and 7 a low probability of appendicitis by usual clinical criteria. We believed these patients could have been satisfactorily treated without ACTS. Five patients required a water-soluble contrast enema examination to confirm ACTS findings, although in each case the ACTS was correct. The results of 9 ACTSs that were negative for appendicitis were ignored by clinicians, as the patients were observed in the hospital for an additional 1 to 3 days. Although not relying on the ACTS result was more a failure of management than of the tests, the ACTS were considered not to have altered these patients’ courses in this review.

The records were reviewed also to learn whether patients' sex, age, presence or absence of temperature greater than 37.2°C, or leukocytosis (white blood cell count, >10.0 ×10⁹/L) could predict those in whom ACTS was likely to make a difference in management. None of these factors that are commonly available when a patient is initially examined was predictive of which patients would benefit substantially from ACTS (Table 2).

**COMMENT**

Although the clinical diagnosis of appendicitis in adults is correct in approximately 80% of patients, the errors bring morbidity and expense. Morbidity involves perioperative complications, adhesions (which may cause intestinal obstruction years later), lost time from work, and infertility secondary to perforated appendicitis. Ideally, appendicitis should be recognized before perforation occurs while minimizing the number of patients who undergo unnecessary surgery.

In efforts to reduce the number of negative appendectomies and to decrease the use of observation time in the hospital, multiple diagnostic tests including barium enema examination, ultrasound, and laparoscopy have been used. Each of these methods has proved successful and has its proponents. Yet each method has limitations, requiring surgeons to search for a more accurate and less invasive diagnostic test for appendicitis. Recently, ACTS has been shown to be highly sensitive and accurate in the diagnosis of acute appendicitis (Table 3). Our experience in this diagnostically difficult patient population confirms the high sensitivity (98%), positive predictive value (92%), and negative predictive value (98%) for ACTS in the diagnosis of acute appendicitis.

In acute appendicitis, the ACTS usually demonstrated a thickened distended appendix (>6 mm in diameter) with periappendiceal inflammation. A normal appendix was seen on ACTS in 68% of our patients who did not have appendicitis and the absence of periappendiceal inflammation was seen in 100% of our patients. Malone et al commented that thin patients with little mesenteric or retroperitoneal fat were at higher risk for a false-negative ACTS. Other authors have reported identification of a normal appendix on ACTS in 44% to 51% of asymptomatic adults. Rao et al were able to identify a normal appendix in all patients in their series who were examined for acute appendicitis, and Birnbaum and Balthazar did so in 43% of their patients. In our study, when a normal appendix was not seen nor was other intra-abdominal abnormality identified on the ACTS, patients were discharged from the hospital. These negative studies proved just as reliable in ruling out appendicitis as when a normal appendix was clearly seen.

### Table 2. Characteristics of Patients Who Underwent Critical and Noncritical ACTS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Critical ACTS</th>
<th>Noncritical ACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24 (43)</td>
<td>15 (37)</td>
</tr>
<tr>
<td>Female</td>
<td>32 (57)</td>
<td>26 (63)</td>
</tr>
<tr>
<td>Age (mean ± SD), y</td>
<td>38 ± 3</td>
<td>40 ± 3</td>
</tr>
<tr>
<td>Fever</td>
<td>34 (61)</td>
<td>22 (54)</td>
</tr>
<tr>
<td>Elevated WBC count</td>
<td>37 (66)</td>
<td>26 (63)</td>
</tr>
</tbody>
</table>

*Values are number (percentage) unless otherwise indicated. ACTS indicates abdominal computed tomographic scan; WBC, white blood cell.

### Table 3. Diagnosis of Appendicitis by Computed Tomography

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Patients</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>Positive Predictive Value, %</th>
<th>Negative Predictive Value, %</th>
<th>Normal Appendix Identified, %</th>
<th>Accuracy, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birnbaum and Balthazar</td>
<td>100</td>
<td>96</td>
<td>90</td>
<td>95</td>
<td>95</td>
<td>43</td>
<td>93</td>
</tr>
<tr>
<td>Malone et al</td>
<td>211</td>
<td>87</td>
<td>97</td>
<td>94</td>
<td>93</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Rao et al</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>Present study</td>
<td>97</td>
<td>98</td>
<td>91</td>
<td>92</td>
<td>98</td>
<td>68</td>
<td>96</td>
</tr>
</tbody>
</table>

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We used actual Medicare payments for 1997 to calculating ACTS in patients with possible appendicitis and cutaneous drainage. The patient who had an appendiceal abscess underwent percutaneous drainage. The elderly patient with colon carcinoma. Both patients with Crohn disease were treated without surgery. The 1 patient who required surgery for appendicitis provides greater confidence in diagnosis and treatment of clinically suspected appendicitis. Patients now are more likely to undergo an early ACTS rather than be admitted for observation. The ACTS that is negative will become the definitive diagnostic test in 60% (30/50) of patients with acute appendicitis and in 55% (26/47) of patients without acute appendicitis. This experience with ACTS has affected our management of clinically suspected appendicitis. Patients now are more likely to undergo an early ACTS rather than be admitted for observation. The ACTS that is negative for appendicitis provides greater confidence in discharging these patients rather than observing them in the hospital.

More frequent use of the ACTS has also enabled us to better treat patients with other intra-abdominal sources of their symptoms. Eight of the 9 patients found to have diverticulitis on ACTS were successfully treated without surgery. The 1 patient who required surgery had a planned semiurgent resection, as did the patient with colon carcinoma. Both patients with Crohn disease were treated without surgery. The elderly patient who had an appendiceal abscess underwent percutaneous drainage.

Finally, we evaluated the added expense of performing ACTS in patients with possible appendicitis and compared it with the expense of a negative appendectomy. We used actual Medicare payments for 1997 to calculate the expense, although we recognized that these figures did not accurately represent the cost of the services. The total Medicare payment for an uncomplicated appendectomy (including physician payments) was $5786. The total Medicare payment for ACTS (including physician payment) was $396. A brief look at Table 4 illustrates the relative expense.

If a hospital's negative appendectomy rate is 13% to 15% or higher, it would be less expensive, according to Medicare figures, to perform ACTS on every patient and achieve a 7% negative appendectomy rate.


We express our appreciation to Deborah Lowe and Elizabeth Gordon for their assistance in preparation of the manuscript.

REFERENCES


DISCUSSION

Dennis W. Vane, MD, Burlington, Vt: The authors present a case for utilization of abdominal CT scan to diagnose appendicitis. The paper is interesting, but I disagree with some of the conclusions and recommendations. There are several questions I have about the manuscript and also some points of issue with the methods.
First, how was determination made of who underwent CT scan? You sort of address this here, but my question is: of the patients who were taken to the operating room on the surgeon's impression, was that somewhat surgeon-dependent? Were there surgeons more consistently going on their clinical judgment and relying less on CT scan, or was this sort of an across-the-board situation with all your surgeons?

The negative appendectomy rate of 21% is really pretty high. Some of the more recent literature and some of the textbooks today are suggesting that in community hospitals a 12% to 14% rate is closer to the norm and that in some academic medical centers reporting 7% to 9% is really becoming more consistently visualized. Again, the presence of residents and repeated examinations as well as medical students increases the accuracy of patients admitted for observation.

In group 2, the ACTS was only positive in 49 of 53 appendectomies. This was from the manuscript and again I apologize if some of this was answered but it is a little bit unclear. You only reported 1 false-positive. I would like you to explain that a little bit better. Why did the other 3 patients go to surgery and have their appendices out if they had a negative CT scan? I guess that is the real issue.

The ACTS had a 10% false-positive rate across the board when you include those patients that ACTS could not rule out appendicitis and who underwent surgery. You report that ACTS really only impacted the care of your patients in 60% of the cases. This is the real number that really predicts the usefulness. If only 60% of the patients have their cases impacted by ACTS, really change the management of that patient, then that's the number we ought to be using for the evaluative capacity of the test.

You mention that 10 patients in the manuscript were either discharged or sent home early, which means that some of those patients had to have been observed for a period of time. Doesn't observation in itself change the predictive utilization of the physical examination? How many patients were admitted to the hospital, observed for a period of time, and then sent home without ACTS?

There isn't any statistical significance demonstrated in the results of this manuscript. Some of the purported savings are a bit distorted because you are using a Medicare reimbursement for a CT scan which is clearly artificially low. In our hospital, certainly a CT scan would cost well over $1500 and one includes the radiologist's fee if not significantly more than that, and I really question whether or not this is really adding anything to our armamentarium. In spite of the Time magazine report regarding the lack of skill in performing a physical examination exhibited by today's medical students, this art is the most cost-effective and accurate methodology of diagnosing appendicitis and in fact most other conditions.

Dr Schuler: There was a lot of resistance to do CT scans at first. The patients who underwent surgery were managed the way we normally managed them. There was nothing different about their management and all the surgeons on our staff participated. We were quite resistant to doing CTs early on but as time went on we developed more confidence in them.

Three patients had equivocal studies and 2 of them underwent surgery. Ovarian cysts were found, which required surgical treatment. One patient underwent a laparoscopy. The patient who had a negative CT had a cecal diverticulitis. So there were essentially 3 patients who had negative appendectomies and 1 patient underwent a laparoscopy, which actually raised the negative appendectomy rate a little bit higher.

I don't know how to answer the question about cost because I don't know what the cost is in our hospital of a CT scan. Approximately half the patients who had CTs and were sent home were sent home from the emergency room. The others had been admitted for variable amounts of time, for 1 or 2 days. Because there was no change in their condition, because they were still clinically indeterminate, the CT scan was ordered in part out of frustration to make a decision. And the CT scan resolved the issue in those cases.

This reviewer always gets a bit uneasy when a group of clinicians and radiologists team up to tout a new diagnostic procedure for an old disease. There now exist dozens of articles in the surgical literature proclaiming the clinical and economic advantages of the performance of ultrasonography, barium enema, nuclear medicine scans, and laparoscopy in the treatment of patients with suspected acute appendicitis. The present article presents a persuasive case for the use of CT scanning in patients with signs and symptoms insufficient to warrant emergency department discharge or appendectomy. Of the 149 patients studied, 52 underwent immediate appendectomy; 97, or nearly two thirds of the group, were “equivocal” and underwent CT scans. This seems like a very high percentage of equivocal cases, suggesting to me that a bit more clinical rigor might have been exercised in the management of these cases. Having said that, I must admit that the authors have proved their case that CT scans are highly accurate in diagnosing appendicitis and delineating other pathological processes. I am less convinced by their data that a significant lowering of the negative appendectomy rate would result from the performance of this study in all such patients. I am even less convinced that routine use of CT scans would translate into any cost savings, as witnessed by their Scrooge-like Medicare reimbursement figures. The take-home value of this article is that CT scanning may be useful in a small subset of patients, often female or elderly, who manifest truly equivocal signs of appendicitis. Do not let the foregoing imply that I do not respect that 6-cm beast that lurks in everyone's abdominal cavity. Like all surgeons, I have spent many nights slaying the beast, being fooled by the beast, and occasionally being significantly embarrassed by it. But after each such misadventure, I admonish myself, not that I should have ordered 1 more preoperative test but rather that I should have not so quickly read Cope's Early Diagnosis of the Acute Abdomen.

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