Advantages of Focused Helical Computed Tomographic Scanning With Rectal Contrast Only vs Triple Contrast in the Diagnosis of Clinically Uncertain Acute Appendicitis

A Prospective Randomized Study

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Hypothesis: Focused helical computed tomographic (CT) scanning with rectal contrast only is a superior diagnostic modality compared with the traditional triple-contrast CT scan for the diagnosis of acute appendicitis.

Design: Prospective randomized analysis of both CT scan modalities.

Interventions: Only patients with uncertain diagnosis of acute appendicitis were entered in the study. The patients were then randomized to undergo the traditional triple-contrast CT scan or the new focused CT scan with rectal contrast only. Surgical management included operation or observation for 23 hours.

Results: Ninety-one patients participated in the study, including 52 in the triple-contrast group and 39 in the rectal-contrast group. The demographics of the triple-contrast vs the rectal-contrast groups were similar. The triple-contrast group had a sensitivity of 97%, specificity of 86%, positive predictive value of 90%, and negative predictive value of 93%. The rectal-contrast group had a sensitivity of 88%, specificity of 100%, positive predictive value of 100%, and negative predictive value of 100%. There were 4 false-positive findings and 1 false-negative finding in the triple-contrast group compared with none in the rectal-contrast group. In the triple-contrast group, there were 13 perforated appendixes compared with 1 in the rectal-contrast group. The cost of a triple-contrast scan was $620 compared with $305 for a focused rectal-contrast scan. The negative appendectomy rate for the study was 8.0% (4 of 48 patients in the triple-contrast group vs 3 of 39 in the rectal-contrast group).

Conclusions: The demographics, sensitivity, specificity, and positive and negative predictive values were comparable in both groups. The focused rectal-contrast procedure was better tolerated by patients and demonstrated decreased morbidity, delay to diagnosis, perforation rate, and negative appendectomy rate with no missed diagnosis and decreased cost. Therefore, we believe that focused helical CT scanning with rectal contrast only is a superior diagnostic modality compared with the traditional triple-contrast CT scan for the diagnosis of acute appendicitis.

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ACUTE APPENDICITIS REMAINS one of the most difficult diagnoses to make clinically. Much of the difficulty stems from the variability in its presentation. The classic presentation, including periumbilical pain localizing to the right lower quadrant, nausea, vomiting, anorexia, fever, and leukocytosis, is generally seen in less than 50% of patients. Because of the serious complications that can result secondary to a delay in diagnosis or an incorrect diagnosis, much investigation has focused on maximizing the diagnostic accuracy in a limited amount of time.

Although history and physical examination results remain the cornerstone of the diagnosis of acute appendicitis, many additional adjuncts have been proposed to increase diagnostic accuracy. These include ultrasonography, scoring systems, serum markers, standard computed tomographic (CT) scanning, and laparoscopy. However, none of these have produced significant clinical success. With the rapid advancement in CT scanning technology, the triple-contrast CT scan has been used for the diagnosis of acute appendicitis. Several studies have shown that a CT finding can alter the disposition of a patient with suspected appendicitis when compared with results of the physical examination alone. More recently, a new technique of focused helical CT scanning of the pelvis with rectal contrast only has been promoted in the radiological literature as a potential supe-
Table 1. Study Methodology

<table>
<thead>
<tr>
<th></th>
<th>Triple Contrast</th>
<th>Rectal Contrast Only</th>
</tr>
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<tbody>
<tr>
<td>Method of contrast administration</td>
<td>IV, oral, and rectal</td>
<td>Rectal only</td>
</tr>
<tr>
<td>Amount of contrast used, mL</td>
<td>IV, 100; oral, 900; and rectal, 900</td>
<td>Rectal, 1000-1500*</td>
</tr>
<tr>
<td>Time for study</td>
<td>1 h 15 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Thickness of cuts, mm</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Extent of study</td>
<td>Diaphragm through lesser trochanters</td>
<td>15-mm region of the lower abdomen and upper pelvis centered approximately 3 cm above the tip of the cecum as identified on initial CT digital radiograph</td>
</tr>
<tr>
<td>Mean patient acceptance range†</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Possible complications</td>
<td>For IV dye, skin necrosis if IV infiltrates, allergic reaction, and kidney failure; for oral contrast, aspiration and possible need for NGT; and for rectal contrast, rectal perforation</td>
<td>Rectal perforation and appendiceal leak</td>
</tr>
<tr>
<td>Cost of study, $</td>
<td>620</td>
<td>305</td>
</tr>
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</table>

Abbreviations: CT, computed tomography; IV, intravenous; NGT, nasogastric tube.*The patient alternated from the left lateral to prone to right lateral positions after contrast administration to ensure filling of the cecum. †Determined on a scale of 1 to 5 (1 indicates best acceptance; 5, worst).

rior method in the evaluation of acute appendicitis.6-8 However, concerns still remain regarding patient discomfort, delay in diagnosis, radiation exposure, accuracy, alternative diagnosis if the appendix is normal, and financial resources.

METHODS

STUDY DESIGN

We performed a prospective, randomized trial comparing the standard triple-contrast CT scan of the abdomen and pelvis vs the new focused CT scan of the pelvis with rectal contrast only in the evaluation of acute appendicitis for patients in whom the clinical diagnosis of appendicitis was uncertain from January 1, 2000, through December 31, 2002. Criteria for exclusion included pregnancy, age younger than 6 years, and a clinical diagnosis of appendicitis was clinically uncertain were entered in the study. The demographics of the triple-contrast group and 39 in the rectal-contrast group. During the same period, 684 appendectomies were performed at our institution. The demographics of the triple-contrast

RESULTS

APPENDICEAL CT SCAN FINDING

Appendiceal CT scan findings were interpreted as positive for appendicitis if an enlarged (>6 mm in outer diameter), nonopacified appendix with adjacent inflammatory changes such as fat stranding, phlegmon, or fluid collection was noted (Figure 1). Appendicitis was diagnosed in cases with nonvisualization of the appendix only in the presence of specific CT signs of appendicitis, such as an appendicolith, focal cecal apical thickening, an arrowhead sign, or a cecal bar.9,10 Appendiceal wall thickening and wall enhancement were not used in the new technique interpretation because their identification requires the use of IV contrast.

APPENDICEAL CT SCAN FINDING

Appendiceal CT scan findings were interpreted as negative for appendicitis if the appendicular lumen filled completely with contrast material, air, or both, regardless of appendiceal diameter (Figure 2). An appendix that did not fill with air or contrast material was considered normal if it measured 6 mm or less in maximum diameter. Appendicitis was excluded in cases in which the appendix was not visualized only in the absence of specific CT signs of appendicitis, such as an appendicolithiasis, focal cecal apical thickening, the arrowhead sign, or a cecal bar.
group vs the rectal-contrast group were similar with respect to age (mean±SD ages, 43±2.8 vs 33±2.7 years, respectively), sex (number of women/men, 27/25 vs 23/16, respectively), leukocytosis (mean±SD white blood cell count, 13.0×10⁹/µL±0.55×10⁹/µL vs 11.6×10⁹/µL±0.53×10⁹/µL, respectively), and temperature at presentation (37.7°C vs 37.6°C). Of the 91 patients, 83 showed positive findings, including 47 in the triple-contrast group and 36 in the rectal-contrast group. All patients underwent operation. Of the 47 patients in the triple-contrast group, 4 were found to have no appendicitis. All 4 cases had other disease, including 2 with ovarian cyst, 1 with tubo-ovarian mass, and 1 with Crohn’s disease. Of the 36 patients in the rectal-contrast group with positive CT scan findings, all had appendicitis at operation and in the histological specimen. In 8 cases, the CT finding was reported as no appendicitis. These patients were followed up and kept for observation. During the observation period, 4 (50%) were operated on because of changes in their physical examination findings. Of the 8 patients kept for observation, 5 were in the triple-contrast group and 3 were in the rectal-contrast group. Of the 5 in the triple-contrast group, 1 patient underwent operation and was found to have true appendicitis. All 3 patients in the rectal-contrast group subsequently underwent surgery and were found to have no appendicitis. Of the 91 patients, 87 underwent operation (Figure 3). There were a total of 4 false-positive and 1 false-negative finding in the triple-contrast group compared with no false-positive or false-negative finding in the rectal-contrast group. On further analysis, the triple-contrast group had a sensitivity of 97%, specificity of 86%, positive predictive value (PPV) of 90%, and negative predictive value (NPV) of 93%. The rectal-contrast group had a sensitivity of 88%, specificity of 100%, PPV of 100%, and NPV of 100%.

The triple-contrast group included 13 perforated appendixes compared with 1 in the rectal-contrast group. To determine the reason for this high incidence of perforation in the triple-contrast group, we further analyzed the duration of symptoms before admission and the time from presentation in the emergency department (ED) to the OR. In the triple-contrast group, the mean±SD duration of symptoms before presentation in the ED was 39.4±2.1 hours compared with 29.8±2.4 hours in the rectal-contrast group. The total duration from the ED to the OR was comparable in both groups (Table 2). The mean±SD duration of symptoms before presentation in those with perforated appendicitis was 74.5±2.1 hours compared with 31.9±1.3 hours in the nonperforated group. Furthermore, the times from

Figure 1. Positive computed tomographic scan findings. A, The rectal-contrast-only scan shows a dilated appendix with appendicolithiasis. B, The triple-contrast scan shows fatty infiltration and thickened appendix.

Figure 2. Negative computed tomographic scan findings. A, The rectal-contrast-only scan shows the cecum filled with contrast, with an adjacent healthy appendix. B, The triple-contrast scan shows fatty infiltration and a thickened appendix.
the ED to CT scan and from the ED to the OR were comparable in both groups. Looking at the time from the ED to the OR, the nonperforated group took longer to get to the OR compared with the perforated group. We believe this is the result of the more severe physical findings in the perforated group, which required an earlier, more emergent trip to the OR. The time from onset of symptoms to the time the patient was in the OR was definitely longer in the perforated group vs the nonperforated group. This was mostly related to the duration of symptoms before presentation in the ED, as shown in Table 3.

The cost of the triple-contrast scan was $620 compared with $305 for a focused scan with rectal contrast only. The negative appendectomy rate for the study was 8.0% (4 of 48 patients in the triple-contrast group vs 3 of 39 in the rectal-contrast group).

There were no complications as a result of the procedures in either group. No morbidities due to the CT scans were reported in either group. One patient in the study died of sepsis due to perforated appendicitis in an older group. In the total group, 5 wound infections were reported and successfully treated.

**COMMENT**

With the liberal use of the CT scan as a diagnostic tool, we are diagnosing more surgical lesions, especially where the diagnosis is not clinically apparent. Some may argue that we are using the CT scan too judiciously. However, when there is high suspicion and clinical uncertainty, and we have the tools to avoid the related morbidity and mortality of an operation, we must pursue the less-invasive route, as in appendicitis.

The demographics in our study clearly demonstrated that both groups were comparable with respect to average age, male-female ratio, leukocytosis, and temperature at presentation. Both tests were comparable with regard to sensitivity, specificity, PPV, and NPV. The data were comparable to findings of previous studies quoted in the literature, although a marked improvement was noted at our own institution. We believe this was a result of improved familiarity and subsequent diagnostic accuracy by our radiologists with interpreting appendiceal CT scans. The CT scan with rectal contrast only also ensured filling of the cecum, which has been shown by Wijetunga et al to be beneficial in diagnosing appendicitis.

We found a significant difference in the number of perforated appendixes (13 vs 1) in the triple-contrast compared with the rectal-contrast group. There are several different explanations that may help account for this significant difference. First, there was a significant time delay associated with completing the triple-contrast scan compared with the rectal-contrast scan. At our institution, there was a time delay of approximately 60 minutes for the oral contrast to reach the terminal ileum before the scan was performed. We generally experienced poor patient compliance in taking the required amount of oral contrast material secondary to nausea and vomiting that resulted in minimal contrast ingested or placement of a nasogastric tube to facilitate contrast administration. Consequently, this resulted in further delay of the actual CT scan. In the rectal-contrast group, patients were given the rectal contrast, and once the cecum filled, the scan was completed, usually within several min-

**Table 2. Comparison of Duration of Symptoms, Time to CT Scan, and Time to OR in Rectal- vs Triple-Contrast Groups**

<table>
<thead>
<tr>
<th>Contrast Groups</th>
<th>Duration of Symptoms Before Presentation, h</th>
<th>Time From ED to CT, h</th>
<th>Time From ED to OR, h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triple</td>
<td>39.4 ± 2.1</td>
<td>3.0 ± 0.3</td>
<td>8.3 ± 0.4</td>
</tr>
<tr>
<td>Rectal</td>
<td>29.8 ± 2.4</td>
<td>3.0 ± 0.4</td>
<td>12.2 ± 0.3</td>
</tr>
</tbody>
</table>

*Abbreviations: CT, computed tomographic; ED, emergency department; OR, operating room. *Data are expressed as mean ± SD.

**Table 3. Perforation Rate Compared by Times to Presentation and to Operation**

<table>
<thead>
<tr>
<th>Duration of Symptoms Before Presentation, h</th>
<th>Time From ED to CT, h</th>
<th>Time From ED to OR, h</th>
<th>Total Time From Onset of Symptoms to OR, h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with perforations (n = 14)</td>
<td>74.5 ± 2.1</td>
<td>2.5 ± 0.2</td>
<td>6.3 ± 0.2</td>
</tr>
<tr>
<td>Rectal-contrast group (n = 1)</td>
<td>48.0 ± 0</td>
<td>2.8 ± 0</td>
<td>7.0 ± 0</td>
</tr>
<tr>
<td>Triple-contrast group (n = 13)</td>
<td>78.3 ± 2.1</td>
<td>2.5 ± 0.2</td>
<td>6.3 ± 0</td>
</tr>
<tr>
<td>Patients without perforations (n = 69)</td>
<td>31.9 ± 1.3</td>
<td>3.1 ± 0.3</td>
<td>10.4 ± 0.4</td>
</tr>
<tr>
<td>Rectal-contrast group (n = 35)</td>
<td>31.6 ± 1.4</td>
<td>3.4 ± 0.4</td>
<td>12.2 ± 0.4</td>
</tr>
<tr>
<td>Triple-contrast group (n = 34)</td>
<td>32.5 ± 1.1</td>
<td>2.9 ± 0.3</td>
<td>8.6 ± 0.2</td>
</tr>
</tbody>
</table>

*Abbreviations: CT, computed tomography; ED, emergency department; OR, operating room. *Data are expressed as mean ± SD.
utes. We found that the rectal-contrast group tolerated the scan much better because there was no need for the oral contrast material and no risk of an adverse reaction to IV contrast. Furthermore, the rectal contrast was the same material used for the triple-contrast scans. Another potential reason for the significant difference in the perforated appendectomy rate involved the time of presentation to the hospital. When we compared the time of onset of symptoms to presentation to the ED in the nonperforated group (32 hours) with that in the perforated group (74.5 hours), we found a significant difference. Furthermore, when we compared the delay in patients with perforations in the triple-contrast group (78.3 hours) with that in the single patient with perforation in the rectal-contrast group (48 hours), we likewise saw a significant difference. The significant time delay from onset of symptoms to presentation in the ED most likely represents the major reason for the significantly higher perforation rate in the triple-contrast group. One false-negative finding occurred in the triple-contrast group, and no false-negative findings occurred in the rectal-contrast group. Furthermore, there were no other missed diagnoses in either group. This helped to reiterate that, although the rectal-contrast CT scan was focused in the pelvis only, there was no other significant diagnosis that would be missed. We felt confident of this because we included the standard 1-cm abdominal scan to rule out any missed diagnosis. This was further corroborated by the operative findings and pathology reports. The negative appendectomy rate for this study was 8.0%, which reflected a negative appendectomy rate in the triple-contrast group of 8.3% compared with 7.7% in the rectal-contrast group. The negative appendectomy rate was very significant in light of a recent study reported by Flum and Koepsell14 in which they investigated “the clinical and economic correlation of misdiagnosed appendicitis.”

On the basis of our results, we found several advantages of the CT scan with rectal contrast only. Patients tolerated it much better because of the absence of IV and oral contrast. In our series, there were no morbidities related to the procedures; however, the reported incidence of complications due to IV contrast is 2% to 10%.16 The rectal-contrast CT scan required less time, but the most significant time delay to treatment was patient delay in presenting to the ED. The perforation rate and negative appendectomy rate were lower in this group. Given all of these advantages, with no other missed diagnosis; comparable sensitivity, specificity, PPV, and NPV; and a significant cost savings, the rectal-contrast study is superior to the triple-contrast CT scan.

CONCLUSIONS

The demographics, sensitivity, specificity, PPV, and NPV were comparable in both groups. The rectal-contrast group clearly demonstrated a significant decrease in the perforated appendix rate, patient discomfort and morbidity, delay to diagnosis, and negative appendectomy rate and showed a significant cost savings. Because of this, we believe that focused helical CT scanning with rectal contrast only is a superior diagnostic modality compared with the traditional triple-contrast CT scan for the diagnosis of acute appendicitis.

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REFERENCES


DISCUSSION

Wayne H. Schwegsinger, MD, San Antonio, Tex: This work itself is noteworthy for several reasons. First, it is 1 of only 2 randomized trials that are on the program this year. Second, it addresses the important issue of cost. In this era of evidence-based medicine and cost containment, such papers as this have a special significance, and they deserve special scrutiny. Still, as with all other studies, they must be examined for internal validity and for the effects that they potentially can have on our patients. As I view it, this really is 3 studies in 1. Each of the 2 diagnostic groups described by the author, the triple contrast...
and the rectal contrast only, is independently compared with its own internal control, that is, operative findings. The sensitivity, specificity, negative predictive value, and positive predictive value are then calculated. Finally, these separate values are compared nonstatistically to determine which test is best. For such randomized comparisons to be valid, the populations being examined should be relatively homogeneous.

While in this study gender, age, and leukocytosis do appear to be similar, there are certain other quantitative and qualitative areas that raise some concerns. For example, why are the numbers of patients enrolled in the 2 groups so dissimilar? The rectal-only group is only two thirds the size of the triple-contrast group. If initial enrollment was equal, this suggests that more patients were excluded in the rectal-contrast group. If so, why?

This study also exhibits qualitative heterogeneity. The most striking example is the presence of a large number of perforations in the triple-contrast group—13 as compared with the single perforation in the rectal-only group. This finding does not appear to be explained by in-hospital delays or by the studies themselves. Is it possible that there was an enrollment bias for or against patients with perforation?

The bottom line, of course, is whether or not a new diagnostic test improves our management of individual patients, and if this can be accomplished in a cost-effective manner, that is particularly important. In your financial considerations of cost, did you include professional fees in comparing these 2 studies?

Pending the discussion of these several heterogeneities in the study, I am a little reluctant yet to enthusiastically endorse this particular approach. However, it certainly provides an opportunity for further study that could validate its usefulness.

Dr Mittal: Thank you, Dr Schwesinger, for the comments you have made. I agree with these comments. The number in each group is dissimilar because the randomization was based on the last digit of the medical record number on admission to the emergency room. So it was not biased at all, and excluded only those patients in which the diagnosis was not certain. I just mention here that during the same period of study, we had 684 appendectomies done based primarily on the clinical examinations. They went straight to the operating room. So these 91 were in addition to the 684 appendixes that were done at the institution in 2 ½ years. This was an institutional review board–approved protocol, so I don’t see that there was any bias in the ED.

Initially, we thought that the time difference between the perforated vs nonperforated group may be due to the delay giving the contrast media to be inserted 2 to 3 hours. That’s why we looked at the duration of the symptoms and time spent from the ED to the CT and ED to the OR. That was not statistically significant. The only significant difference was the duration of symptoms from onset to presentation to the ED. The patients presented late to the ED, but time differences were not due to the time spent from the ED examination to the CT scan or to the OR.

Regarding the cost, it was a cost of the procedure for the institution, not the professional fee.

Bijara Hans, MD, Detroit, Mich: As 1 of the few radiologists in the audience, I have a couple of questions. First, what was your protocol for the single contrast to fill the colon? One would think that it would be essential to fill the cecum in these cases. Did you use conventional fluoroscopy to guide you in rectal instillation of contrast?

My second question is, how did you exclude the conditions that mimic appendicitis in their presentation by single-contrast imaging protocol?

Dr Mittal: We were very sure and the technician was able to see that the cecum filled up completely before the CT scan was done. This was done by taking a radiograph before starting the CT scan. To exclude any other pathology, we added 1-cm cuts in the rectal-contrast group covering the rest of the abdomen, just to standardize with the triple-contrast group.

Thomas A. Stellato, MD, Cleveland, Ohio: The CT scan certainly may have a role in the early diagnosis of appendicitis, but why do you think over 15% of your patients with perforations required a CT scan before making their way to the operating room?

Dr Mittal: There were 14 cases out of 91 in which the diagnosis was not certain. In all of these cases we were not sure that the patient had appendicitis or not. The patients were observed, and on multiple times had been seen by the house staff and the attending, and still they were not sure of the diagnosis. That is the patient population included in this study.

Ernest E. Moore, MD, Denver, Colo: The ongoing debate about CT scanning for possible appendicitis needs to be framed in distinct patient scenarios. For example, the 19-year-old man doesn’t need a CT scan to diagnosis appendicitis with localized right lower quadrant tenderness and an elevated white blood cell count. In contrast, the older patient (and I keep adjusting that age every year) who arrives in the ED with abdominal pain may have a culprit disease outside the appendiceal window. Thus, we should not ignore the value of oral/IV contrast CT scanning when we are not specifically confirming appendicitis.

Finally, in your effort to improve cost-effectiveness, I submit we have oversubscribed CT scanning for suspected appendicitis. At your institution, (1) how many patients underwent appendectomy during this study period without a CT scan, and (2) what is your policy about surgeon evaluation? In our institution, for example, we have placed a veritable moratorium on CT scanning ordered from the ED until a surgeon evaluates the patient.

Dr Mittal: Regarding your last question, I think we could not set a moratorium on the ED physicians, and in 684 patients who went in addition to this for appendectomy, almost half of them had a CT scan before the patient was even seen by the surgical staff. So that’s a flaw in the system, and I think, hopefully, one of these days we will be able to resolve that issue.

In this study, we did not exclude any patient based on age except pediatric patients. We do almost about 300 appendectomies a year at our institutions, and our perforation rate is about 10% to 15%.

Richard A. Prinz, MD, Chicago, Ill: At our institution, ultrasound is less expensive and more easily obtained and can even be done by surgeons. Do you have any experience using ultrasound in these difficult-to-diagnose patients with possible appendicitis? Obviously ultrasound does not need to be used when the patient’s diagnosis is straightforward.

Dr Mittal: Yes, we have ultrasound available to the surgical house staff in our ED, and they can do it, but I think we are in the learning curve yet. To call the ultrasound technician during the night is difficult and time-consuming in our ED.