Routine versus Selective Abdominal Computed Tomography Scan in the Evaluation of Right Lower Quadrant Pain: A Randomized Controlled Trial

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Abstract

Objectives: To determine the role of abdominal computed tomography (CT) imaging in patients with right lower quadrant (RLQ) pain. The authors hypothesized that selective use of abdominal CT would reduce imaging without increasing the rates of negative appendectomy and perforated appendicitis.

Methods: A prospective randomized clinical trial was conducted in a community teaching emergency department. Adult patients with acute RLQ abdominal pain with suspected acute appendicitis were included. Patients were randomized to mandatory (all patients) or selective (based on clinical evaluation) abdominal CT imaging. The primary outcome was the negative appendectomy rate.

Results: A total of 152 patients were randomized to selective (n = 80) and mandatory (n = 72) intervention groups. The mean (±SD) age was 34.1 (±3.5) years, and 48% were female. CT imaging was performed in 54 of 80 patients (68%; 95% confidence interval [CI] = 56% to 78%) in the selective group and in 70 of 72 patients (97%; 95% CI = 90% to 100%) in the mandatory group. There was a trend to a decreased rate of negative appendectomy in the mandatory group (1/39 [2.6%]; 95% CI = 0.5% to 13.2%) as compared with the selective group (6/43 [13.9%]; 95% CI = 6.6% to 27.3%), with a difference in prevalence rates of 11.3% (95% CI = −3.5% to 26.3%). There was also a trend to a decreased perforated appendix rate in the mandatory group (4/39 [10.3%]) as compared with the selective group (7/38 [18.4%]), with a difference in prevalence rates of 8.2% (95% CI = −8.0% to 24.4%).

Conclusions: In this small sample of adult patients with RLQ abdominal pain and suspected acute appendicitis, CT imaging was performed less frequently in the selective group and there was a trend with mandatory CT imaging to reduced rates of negative appendectomy and perforated appendices.

Keywords: appendicitis, CT scan, appendectomy

Acute appendicitis is the most common surgical condition presenting to the emergency department (ED) in patients with abdominal pain. Over the past decade, there has been a significant increase in the use of abdominal computed tomography (CT) in patients with suspected acute appendicitis; however, its exact role in the evaluation of right lower quadrant pain and suspected appendicitis remains to be determined.1 Abdominal CT has been recommended in equivocal cases,1–11 in female patients,12–15 routinely,16–20 or not at all.21–23 There is even disagreement over whether the scan should be limited to the right lower quadrant and over what combination of contrast (if any) should be used.12,22–28 Regardless, there is still debate about the efficacy of CT scanning in reducing the negative appendectomy rate.

Routine use of CT imaging is not without consequences. It exposes the patient to radiation and, when used in combination with intravenous contrast, may rarely result in renal insufficiency and allergic reactions. Furthermore, it may delay surgery and is associated with both false-negative (normal CT scan in patients with confirmed acute appendicitis) and false-positive (abnormal CT scan in patients with normal appendices) cases.

To better define the role of CT imaging in the evaluation of the adult ED patient with right lower quadrant pain and suspected acute appendicitis, we performed a
METHODS

Study Design
A prospective randomized clinical trial design was used to test the study hypothesis. The study was approved by the institutional review board, and all patients gave written informed consent.

Study Setting and Population
The study was conducted in an urban, community teaching hospital with a residency program in general surgery. The ED was staffed by board-certified emergency physicians, and its annual patient census was 45,000.

Patients were eligible for enrollment if they were aged 18 years or older and presented with acute right lower quadrant abdominal pain (duration less than 72 hours) and suspected acute appendicitis. Patients were excluded if they were pregnant or had evidence of diffuse peritonitis. We also excluded patients with a serum creatinine level greater than 1.6 mg/dL or a history of contrast allergy.

Study Protocol
Study patients were randomized to mandatory or selective CT imaging. Personnel who were not involved in any other aspects of the study generated intervention assignments using a computerized random numbers program. It was not possible to mask patients and investigators from the assigned diagnostic strategy. However, assessment of outcomes was performed by an observer masked to the diagnostic strategy.

Patients in the mandatory CT imaging group were evaluated by the attending emergency physician and consulting surgeons (senior resident or attending physician) and then underwent routine diagnostic testing, including a complete blood count, urinalysis, pregnancy testing (in women), and serum chemistry. Other consultations and studies were obtained as necessary. All patients in the mandatory imaging group were scheduled to undergo abdominal CT imaging with an appendix protocol. This consisted of an abdominal and pelvic CT scan with oral and intravenous contrast, performed on a General Electric CT/I (GE Medical Systems, Fairfield, CT) machine with 5-mm cuts over the right lower quadrant. All CT scans were immediately interpreted by a board-certified radiologist who was masked to study group assignment. It was believed that this scenario was most consistent with actual community practice patterns.

Patients in the selective CT imaging group were evaluated in the same manner as the mandatory group, but an abdominal CT scan with appendix protocol was obtained at the discretion of the treating physicians based on the clinical presentation. Factors that could be taken into account by the physician in determining the need for CT included demographic, historical, and physical examination information, as well as laboratory results (such as, but not limited to, white blood cell count). No attempt to standardize the decision to perform abdominal CT in the selective group was made.

Measures
Demographic data were recorded on a standardized data collection sheet, as well as the details of the hospital course, including any surgery performed. A diagnosis of acute appendicitis was confirmed by surgical pathology reports. A diagnosis of perforated appendix was confirmed on the basis of the operative or pathologic report or CT-guided drainage of purulent material. CT images were reviewed by a board-certified radiologist who was masked to study group assignment and classified as being diagnostic of acute appendicitis, nondiagnostic of appendicitis, or equivocal. The diagnosis in nonoperative patients was confirmed by review of all of the hospital records and telephone follow-up of patients 48 hours after being discharged from the hospital or the ED. The negative appendectomy (“false-positive”) rate was calculated by dividing the number of normal appendices removed at surgery by the total number of patients taken to the operating room for suspected appendicitis in each intervention group. The “false-negative” rate was determined by dividing the number of cases in which acute appendicitis was erroneously excluded based on CT results and/or clinical evaluation by the number of patients who subsequently underwent operative appendectomy for confirmed acute appendicitis in each intervention group. The perforated appendix rate was calculated by dividing the number of cases of perforated appendix by the total number of cases of appendicitis in each group.

Data Analysis
The data were analyzed on an intention-to-treat basis using SPSS for Windows 13.0 software (SPSS Inc., Chicago, IL). Continuous data are presented as means and 95% confidence intervals (CIs). Binomial data are presented as percent frequency of occurrence. A sample size of 70 patients in each group had 80% power to detect a 15% difference in the rate of negative appendectomies (two-tailed test, α = 0.05). Descriptive statistics were used to describe patient outcomes based on whether they actually had an abdominal CT or not.

RESULTS
A total of 152 patients were enrolled in the study between January 2001 and May 31, 2004. The mean (±SD) age was 34.1 (±3.5) years, and 48% were female. Of the total study population, 80 were randomized into the selective CT imaging group and 72 were randomized to the mandatory imaging group (Figure 1). The mandatory and selective imaging groups were similar in mean (±SD) age (35.1 ±[14.5] years vs. 33.3 ±[12.6] years, respectively) and percentage of female subjects (34% vs. 39%, respectively). A list of the final diagnoses is presented in Table 1. An exploratory laparotomy was performed on 86 patients, of whom 82 had a preoperative diagnosis of acute appendicitis. The other four patients who underwent surgery had preoperative and postoperative diagnoses of perforated diverticula (n = 1), perforated cecum (n = 1), ovarian torsion (n = 1), and obstructed colon due to cancer (n = 1). Seventy-seven patients (50.7%) were subsequently
diagnosed with acute appendicitis. Seventy-five patients with acute appendicitis had their diagnosis confirmed by surgical pathology after operative intervention, and two patients presented with delayed perforated appendix diagnosed on CT scan and were treated conservatively with antibiotics and CT-guided percutaneous drainage.

The outcomes in both study groups are summarized in Table 2. Abdominal CT imaging was performed less frequently in patients in the selective group. In two of the 72 patients assigned to the mandatory CT imaging group, the clinical condition deteriorated before performance of CT and the patients were taken directly to the operating room. There was a trend toward reduced rates of negative appendectomies and perforated appendices in patients assigned to the mandatory group. However, these differences did not achieve statistical significance (Table 2). CT imaging in the selective imaging group was more common in female patients (11/13 [84.6%]; 95% CI = 57.8% to 95.7%) than in male patients (15/30 [50%]; 95% CI = 33.2% to 66.9%), with a difference in prevalence rates of 34.6% (95% CI = 2.9% to 54.8%). The negative appendectomy rate in patients who were explored without a CT scan (from either group) was 21.7% (5/23; 95% CI = 9.7% to 41.9%). In contrast, the rate of negative appendectomies in patients who underwent CT before surgery was 3.4% (2/59; 95% CI = 1.0% to 11.5%).

The mean (±SD) time from ED registration to completion of abdominal CT imaging was 6.6 (±13.4) hours.

There was no difference in the time to completion of CT imaging between the two study groups (data not shown). The mean time from ED triage to surgical exploration was similar in both study groups (Table 2). The subset of patients who did not have a preoperative CT scan went to the operating room faster than those who had a scan (7.3 hours [95% CI = 5.1 to 9.5] vs. 11.7 hours [95% CI = 9.8 to 13.6]; mean difference, 4.4 [95% CI = 1.5 to 7.3]). There were no deaths in either of the study groups. There were four complications in the mandatory group and one in the selective group (recurrent vomiting secondary to oral contrast ingestion in all cases). Follow-up information at 48 hours was available in 42% of the nonoperated patients who were discharged from the ED. None of these patients were subsequently diagnosed with appendicitis. Thus, there were no identified “false negatives” in either of the study groups.

**DISCUSSION**

The present study compared a strategy of mandatory abdominal and pelvic CT imaging in all adult patients with right lower quadrant abdominal pain and suspected acute appendicitis with a more selective approach based on physician judgment and discretion. The selective imaging strategy significantly reduced abdominal CT imaging by nearly one third. While there was a trend toward lower rates of negative appendectomy and perforated appendicitis in the mandatory group, the differences between groups were not statistically significant. If the study were better powered and found the reduction in negative appendectomies to be statistically significant, 11% might be clinically important. If 11% were the true absolute reduction in the rate of perforated appendices, one would need to perform a CT scan in 12 patients to avoid one perforated appendix from occurring (the number needed to treat). Again, many clinicians would argue that this is an important difference.
CT scan in reducing the negative appendectomy rate. Importantly, in this study, mandatory CT imaging did not significantly increase the time to operative intervention and did not increase the rates of perforated appendices. Whether the exposure of all patients to radiation and the risks of contrast administration are outweighed by the potential benefits of reducing the rate of negative appendectomies remains to be determined.

The overall negative appendectomy rate of 8.5% noted in the current study compares favorably with other reported series, while the 2.6% negative appendectomy rate in the mandatory CT group is among the lowest reported. We also noted a relatively high negative appendectomy rate of 21.7% in patients who did not undergo preoperative CT imaging. This rate was especially high considering that two out of three of these patients were men, in whom diagnostic errors are generally less common than in women. Historically, negative appendectomy rates approximate 10%–15% in men,29–36 but they have been reported as high as 45% in women.29 Additionally, three of the patients in our study who underwent laparotomy without CT imaging had cecal diverticulitis, which can be exceedingly difficult to distinguish from appendicitis, and CT imaging may have spared these patients from surgery.

Reports on the use of abdominal and pelvic CT imaging to help evaluate right lower quadrant pain and appendicitis began to appear in the 1990s, but its popularity increased after the landmark report by Rao et al. of 98% diagnostic accuracy in 1998.20 As the clinical use of CT increased, there were many reports comparing the diagnostic accuracy of appendicitis in the pre- and post-CT era. With few exceptions,21,35,37 most investigators have documented a decrease in the negative appendectomy rate as a function of increased utilization of CT scanning.6,10,11,15–18,21,36 For example, Peck et al. found a negative appendectomy rate of 19% in patients evaluated without CT from 1991 to 1992.18 This rate improved to 5.4% in patients treated from 1998 to 1999, when 91% of the patients underwent imaging by abdominal CT. Similar results were reported by Naoum et al., who found a decrease in the negative appendectomy rate from 25% to 6% when 84% of the patients underwent preoperative CT scans.17 Schuler et al. compared 52 patients who were operated on for suspected appendicitis without CT imaging with 97 patients who presented with equivocal findings and were evaluated by CT scan.2 The negative appendectomy rate was 21% in those who went straight to the operating room but only 5.8% in the cohort of patients who had preoperative CT imaging. Rao et al. documented a similar decrease in the negative appendectomy rate from 20% in the pre-CT era to 7%, when 59% of the patients were scanned.15 The greatest improvement in diagnostic accuracy was found in female patients, in whom the negative exploration decreased from 31% to 11%. Because only five women in our study were not scanned, we cannot comment on the role of CT in reducing the negative appendectomy rate in women.

In a study similar to ours, Walker et al. conducted a prospective randomized trial of mandatory CT imaging versus selective management with or without CT imaging of the abdomen and pelvis.19 The negative appendectomy rate was 19% in the selective group, where 8% were scanned, and 5% in the mandatory group. The CT scan altered the management in 26% of the patients and improved diagnostic accuracy, even in young men. Based on these results, the investigators recommended liberal use of CT scanning in all patients suspected of having acute appendicitis. The higher negative appendectomy rate noted by Walker et al., even in patients who were scanned, is probably due to the fact that the subjects in that study were not limited to those with localized right lower quadrant pain, as in our study.

Most studies have demonstrated that increased performance of abdominal CT imaging before surgery reduces the rate of negative appendectomies in patients with suspected acute appendicitis. In fact, the negative appendectomy rates appear to be inversely related to the percentage of patients who undergo preoperative CT imaging. However, some have cautioned that any reduction in the negative appendectomy rate would be accompanied by an increased incidence of perforation.39 Based on our study (as well as others noted previously), this does not appear to be the case. We believe that this is a direct result of the improved diagnostic accuracy available with the newer and improved CT imaging modalities.

Despite the impressive accuracy of CT scanning, we do not advocate managing a patient based solely on CT scan results. The one patient in the mandatory CT group who had a normal appendix removed had a CT scan without evidence of appendicitis, but he was explored on clinical grounds. We believe that this still may be appropriate in some cases. Indeed, false-negative results on CT imaging, especially early in the clinical course of acute appendicitis, are well known to occur.3 CT scan results must be interpreted in concert with the history, physical examination, and other laboratory and radiographic studies. Additional information obtained from a CT scan will only serve to facilitate the often difficult and sometimes humbling task of evaluating right lower quadrant pain.

LIMITATIONS

Our study is limited by the low rate of follow-up in patients discharged from the ED without undergoing exploratory laparotomy. Despite multiple attempts at telephone follow-up and a comprehensive review of hospital records, follow-up data were missing in more than half of such patients. Thus, we may have underestimated the false-negative rate in discharged patients. In the current study, the overall rate of acute appendicitis was unusually high compared with prior reports. While most studies have included patients with any abdominal pain in which appendicitis was considered, we only included patients with a complaint of right lower quadrant pain. This may have introduced significant selection bias and helps explain why our rates of appendicitis were so high. Our study was also limited to one study site in which real-time radiologic interpretation of all CT images was performed by board-certified radiologists, limiting its generalizability to other dissimilar settings. Obviously, the error rates in interpretation may be greater when the CT images are evaluated by less qualified personnel. Finally, our study may have been underpowered to detect statistically significant and potentially clinically important.
differences in the rates of negative appendectomy and perforated appendicitis.

CONCLUSIONS

In this small sample of adult patients with right lower quadrant abdominal pain and suspected acute appendicitis, CT imaging was performed less frequently in the selective group, and there was a trend with mandatory CT imaging to reduced rates of negative appendectomy and perforated appendices. Future, larger studies should be conducted in an attempt to determine if there is a subset of patients in which selective CT scanning is most appropriate and to develop a clinical decision instrument for selective abdominal CT scanning in this population.

References


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**REFLECTIONS**

Race Relations, Resources, and Emergency Medicine in Cape Town, South Africa

“Rescue 8, we’re taking a paramedic response emergency call for a pedestrian found down on the street, struck by a vehicle, unknown speed in Kaleshia, exact location to follow.” My first paramedic ride-along with a fellow fourth-year medical student in Cape Town, South Africa, and here we were heading to what could be a very significant trauma patient. Is the patient conscious? Breathing? Broken bones? What supplies do we have? These were just some of the thoughts that were going through my head as the ambulance sped down the highway, sirens blaring, curious onlookers watching, and anxiety escalating.

Having spent three years working on a 9-1-1–response ambulance during college in California, I had gone on many emergency calls with similar thoughts. This should be the same, right? Or would it? The dispatcher finally came over the radio and gave us the location of the incident. The paramedic informed us that the incident was in one of the most dangerous areas in all of the Cape Town townships, and because my fellow medical student and I were “white,” we needed to be extra cautious. What did he mean by “extra cautious,” and what did being “white” have to do with assessing, treating, and maybe saving a life in an emergency situation? We were told that as long as we looked like we were helping the patient, we most likely would not be hurt by the locals. Most likely? Here I was, doing what I love (caring for patients in an emergency setting), and I, because of the color of my skin, was at risk of being injured or even killed myself. With this new knowledge, my level of anxiety rose considerably.

Having lived with a Muslim family for the previous two weeks, getting acquainted with the various cultures of Cape Town, I had learned that there were basically three “colors” of people here in South Africa: “blacks,” “whites,” and “colored” (i.e., my Muslim host family). We were heading straight into the center of a “black” township, and anyone not “black,” especially “white,” was always in danger of being threatened, assaulted, or even worse...killed.

Arriving on scene, I was shocked; there in the middle of the street lay a disheveled, lifeless body of a young “black” man, blood slowly seeping onto the concrete from a massive head wound. Despite being surrounded by a group of around 100 curious bystanders, no one was helping him. The paramedic and I jumped out of the ambulance and ran immediately to the unconscious man and began our assessment, while the other medical student and ambulance driver grabbed the gurney and trauma supplies. As I put two big IVs in the patient’s arms, the paramedic placed an endotracheal tube and put on a c-collar to stabilize a potential neck fracture. We put the man on a backboard to further protect his spine, rushed him to the ambulance, and headed off to the main Trauma Hospital in Cape Town. As our ambulance raced down the road, I glanced back at the crowd, a sea of “black” faces, hoping that for at least a brief moment they were not seeing two “white” medical students treating a “black” man, but rather two concerned future doctors doing the best that they could do to treat a patient in need.

Sitting in the jump seat, the position at the head of the patient, I began wondering how long it would take to get this patient to the hospital and what resources would be available. In most areas within the United States, a