Accuracy of ED Sonography in the Diagnosis of Acute Appendicitis

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The objective was to compare the accuracy of abdominal sonography performed by emergency physicians in the diagnosis of acute appendicitis with that of the surgeons’ clinical impression. Three hundred seventeen patients with right lower abdominal pain admitted to the Department of Emergency Medicine at National Taiwan University Hospital in Taipei, Taiwan were prospectively included in this study. Patients were divided into two groups according to the time of day they visited the emergency department. Those patients visiting the emergency department during the day were divided into group I and those during the night were in group II. Group I was diagnosed by sonography. Group II was diagnosed by surgeons’ clinical impression without sonographic examination. The definitive diagnosis of acute appendicitis was confirmed by the pathological reports. In the diagnosis of acute appendicitis, group I had a sensitivity of 96.4%, a specificity of 67.6%, a positive predictive value of 89.8%, a negative predictive value of 86.2%, and an accuracy of 89.1% and group II had a sensitivity of 86.2%, a specificity of 37.0%, a positive predictive value of 74.6%, a negative predictive value of 55.6%, and an accuracy of 70.6%. The overall accuracy of sonography performed by emergency physicians in the diagnosis of acute appendicitis was superior to that of the surgeons’ clinical impression. (Am J Emerg Med 2000;18:449-452. Copyright © 2000 by W.B. Saunders Company)

Acute appendicitis is one of the most common abdominal emergencies and is a challenging diagnosis in emergency practice. Although this disease entity has been recognized for more than 100 years, as of yet there has been no definitive test to diagnose an acute appendicitis. Many modalities have been used to aid the diagnosis of acute appendicitis, however, they are nonspecific and can not be used as a definitive test. Several reports showed that when sonography is used to aid in the diagnosis of different diseases there has been high sensitivity, specificity, and accuracy. Therefore, all physicians should consider training in sonography to use it within their practice. Thus, sonography performed by physicians, including internists, surgeons, gynecologists, pediatricians, and urologists has become a new trend in clinical practice. Abdominal sonography was first performed in 1981 to show the inflamed appendix. Some studies have shown the promising value of sonography in the diagnosis of acute appendicitis.

Because radiologists are not always available in the emergency department, emergency sonography performed by emergency physicians is an inevitable clinical practice. To our knowledge, no study has compared the accuracy of sonography performed by emergency physicians with that of surgeons’ clinical diagnosis.

In this study, we tried to determine whether abdominal sonography performed by emergency physicians in the diagnosis of acute appendicitis is superior to that of clinical impressions and as effective as that of radiologists.

MATERIALS AND METHODS

Between September 1997 and June 1999, 317 patients with right lower abdominal pain admitted to the Department of Emergency Medicine at the National Taiwan University Hospital (NTUH) in Taipei, Taiwan were prospectively enrolled on this study. When patients came to the Department of Emergency Medicine, they were first evaluated by one of the emergency physicians (emergency residency training in NTUH is a 5-year program). After taking a detailed history, performing a complete physical examination, and taking blood sample for complete blood count, a plain abdominal radiography examination was performed. Patients were divided into two groups according to the time of day they visited the emergency department.

Group I consisted of 147 patients admitted to the emergency department during the day shift (8 A.M. to 6 P.M.). If an acute appendicitis was diagnosed or suspected by emergency physicians, usually at the midresident level, they received further abdominal sonography examinations. Sonography was performed by staff members or senior emergency physicians, who had completed the fundamental gastrointestinal sonographic training course provided by The Society of Ultrasound in Medicine of the Republic of China (Table 1). They also had more than 12 months of experience on sonographic examinations. At the point of the maximal tenderness area, sonography was performed with a handheld 3.75 MHz curved array transducer (Toshiba SSA-340A, Tochigi-Ken, Japan) using graded compression technique in both longitudinal and transverse image. The sonographic criteria of acute appendicitis are a noncompressible appendix with an anteroposterior diameter that is consistently 7 mm or greater, an appendicolith, and an interruption in the continuity of the echogenic submucosa, or a localized periaappendiceal fluid collection. Based on the sonographic findings, the patient was placed into one of three categories: (1) appendicitis, including suppurative, gangrenous, perforated, or tumor formation; (2) other diseases; or (3) normal abdominal sonographic screening.
TABLE 1. The Fundamental Gastrointestinal Sonographic Training Course

| Basic physics and instrument in ultrasonography |
| Normal tomographic anatomy and examination technique in diagnostic abdominal ultrasound |
| Ultrasonography of the bowel great vessels, lymphoid system, mesentery, and abdominal wall |
| Ultrasonography in diffuse parenchymal lesions of the liver, portal system, and spleen |
| Ultrasonography of the pancreas |
| Ultrasonography in focal lesions of the liver |
| Doppler ultrasound in digestive system |
| Ultrasonography of the gallbladder and biliary system |
| Ultrasonography of the general abdomen: surgical point of view |
| The impact of ultrasonography on other diagnostic modalities in abdominal diseases |

Surgery was determined by the sonographic diagnosis. Patients with sonographic diagnosis of acute appendicitis were taken to surgery. Patients with other diseases diagnosed by sonography received appropriate treatment for their conditions. Patients with normal screenings were discharged from the hospital and were followed up at outpatient clinic within the following 2 weeks.

Group II consisted of 170 patients admitted to the emergency department during the night shift (6 P.M. to 8 A.M.). They received initial clinical examinations by senior emergency physicians. If an acute appendicitis was diagnosed or suspected, the patients received a follow-up examination by a senior surgical resident. No additional diagnostic test was arranged. Surgery was determined by the surgeons’ clinical impression. Patients with a surgeon’s clinical diagnosis of acute appendicitis were taken to surgery. Complete blood cell count and clinical examinations were repeated 4 hours later in patients with suspected clinical appendicitis. Surgery was arranged if appendicitis was later diagnosed. Those patients without appendicitis were discharged and followed up at outpatient clinic within the following 2 weeks.

The results of the sonographic examination and the surgeon’s clinical diagnosis were analyzed to determine sensitivity, specificity, positive and negative predictive values, and overall accuracy. The definitive diagnosis of appendicitis was confirmed by the pathological reports. The statistical difference between the two groups in this study was determined by the logistic regression with analysis of maximum-likelihood estimates method. A P value of < .05 was considered significant.

RESULTS

Three hundred-seventeen patients were included in this study. There were 82 male (55.8%) and 65 female patients (44.2%) in group I and the mean age was 37.1 years (ages ranged from 8 to 84 years) (Table 2). Diagnostic results of graded compression sonography are shown in Table 3. The number of patients with sonographic diagnosis of appendicitis, other diseases and normal screening were 118 patients (80.3%), 12 patients (8.2%), and 17 patients (11.5%), respectively. Of the 118 patients, 106 underwent surgery and were proven to have appendicitis by the pathological examinations. Of the other 12 patients who underwent surgery without appendicitis, 9 were found to have a normal appendix, and 3 had fecal impaction. Among the other 12 patients with other diseases, 5 had pelvic inflammatory diseases, 3 had hydronephrosis, 2 had colitis, 1 had enteritis, and 1 had renal colic. One patient with colitis was proven to have appendicitis 3 days later. Three of 17 patients (17.6%) with normal sonographic screenings were found to have appendicitis during their second visit to the outpatient clinic.

Group II had 99 male (58.2%) and 71 female patients (41.8%) and with a mean age of 35.5 years (ages ranged from 5 to 85 years). Of the 134 patients who underwent surgery: 100 patients had appendicitis, 30 patients had no identifiable pathological process and 4 patients were found to have other pathological intraabdominal processes at surgery, including 2 pelvic inflammatory diseases, 1 ovarian cyst, and 1 mesenteric lymphadenitis. Sixteen patients who were diagnosed without appendicitis by a surgeon were found to have appendicitis within 1 week at outpatient clinics and emergency departments which was confirmed during laparotomy.

A total of 110 (74.8%) patients with pathological findings were diagnosed with appendicitis in group I and 116 (68.2%) patients in group II. Both groups had approximately the same incidences of appendicitis. The overall sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for sonographic examinations and surgeon’s clinical impressions are displayed in Table 4. A comparison of calculations showed that sonography was superior to the surgeon’s clinical impression in the diagnosis of appendicitis (P < .005).

DISCUSSION

Acute appendicitis is one of the most common abdominal emergencies requiring surgery. Over the past 100 years the mortality and morbidity rates related to this disease have been markedly reduced. A large measure of this progress has been the recognition of the serious effect of perforated appendicitis. Early surgical intervention has been recommended to prevent the perforation of the appendix; however,

<table>
<thead>
<tr>
<th>Final Diagnosis</th>
<th>Appendicitis</th>
<th>Nonappendicitis</th>
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</thead>
<tbody>
<tr>
<td>Appendicitis</td>
<td>118</td>
<td>106</td>
</tr>
<tr>
<td>Other diseases</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Normal screening</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>147</td>
<td>110</td>
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</table>
A high negative laparotomy rate was increased with aggressive surgical treatment. To prevent the delayed diagnosis, many modalities have been used to aid in the diagnosis of acute appendicitis. Many studies have showed the promising value of sonography in the diagnosis of appendicitis. Although these results have been highly encouraging, no study has tested sonography performed by emergency physicians against the surgeons’ clinical diagnosis.

Abdominal sonography examinations performed by staff radiologists have variable sensitivity, specificity, and accuracy in the diagnosis of acute appendicitis. These studies show a sensitivity of 36% to 99%, a specificity of 68% to 100%, and an accuracy of 64% to 96%. Our emergency sonography performed by emergency physicians showed a sensitivity of 96.4%, a specificity of 67.6%, an accuracy of 89.1%, a positive predictive value of 89.8% and a negative predictive value of 86.2%. Our results are comparatively better than most other studies of abdominal examinations performed by radiologists. This study shows the reliability for emergency physicians to perform sonographic examinations provided that emergency physicians received sonography training and underwent a period of sonography practice. It is possible that if surgeons receive sonographic training, they will also have as good results as those of emergency physicians. If sonography is performed by surgeons and the sonographic diagnosis of appendicitis compared with their clinical impression, the results will be more accurate.

Studies have shown that the accuracy of sonographic examination is operator-dependent and requires skill and experience. For an independent sonographer to perform sonography and interpret the sonographic results with accuracy, adequate training is required. We consider 3 to 6 months of sonographic practice under a skilled sonographer’s supervision and at least 50 cases experience of sonographic diagnosis of appendicitis as a minimal training for a sonographer to show an accurate diagnosis of appendicitis. Several studies reported that allowing the patients themselves to localize the point of maximal tenderness with the sonography transducer expedited the examination and helped identify the intraabdominal pathologies. There are two disadvantages of sonographic examinations. First, the sonography beam can not penetrate gas and bone. Second, sonography is limited in obese patients. These drawbacks are likely to be amended with the advancement in electronic technology in the near future.

Three of 17 patients (17.6%) with normal sonographic screening were subsequently found to have appendicitis within the following 3 to 6 days. Wade et al also reported that 24% of patients with normal screening were proven to have appendicitis. The reasons for these misdiagnoses may be attributed to early stages of appendicitis with minimal edematous change which failed to meet the diagnostic criteria, edematous appendix masked by bowel gases, inexperienced sonographers, or the working limitations of sonography. Repeated sonographic examinations of patients with normal screenings were suggested when their symptoms continued to persist after 4 to 6 hours of observation. One patient with appendicitis was misdiagnosed as colitis by sonography. The reactive thickness of colonic wall adjacent to the inflammatory appendix resulted in the sonographic misdiagnosis of colitis. More attention should be paid to patients with sonographic diagnosis of colitis which is localized in the cecal area.

There are two drawbacks in this study. This is not a randomized study but patients comprised a convenience sample. Daily emergency visits in our department are approximately 250 patients. More than six emergency physicians staff work during the day shift and only one works during the night shift. It is difficult for the emergency physician staff to perform sonography at night. Therefore, only those patients who came to the emergency department during the day received sonographic examinations. Another drawback is lacking for follow-up on all patients not taken to surgery. Only those patients their symptoms recurrence came to outpatient clinics.

In conclusion, on the basis of our results, we have found that sonography performed by an emergency physician in the diagnosis of acute appendicitis is superior to that of a surgeon’s clinical impression. We suggest that sonographic training should be included in the emergency residency and surgical residency training program. However, it is crucial to remember that sonography cannot be completely relied on and sonographic findings should be incorporated with other clinical information about the patient to prevent misdiagnoses.

**REFERENCES**


