Detection of Pinpoint Tenderness on the Appendix Under Ultrasonography Is Useful to Confirm Acute Appendicitis

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Hypothesis: Ultrasonography can be efficiently performed using new criteria for the diagnosis of acute appendicitis.

Design: Prospective trial.

Patients: Eighty-nine patients admitted to the hospital with suspected appendicitis between March 1998 and November 2000.

Intervention: At hospital admission, a staff surgeon evaluated each patient and determined whether the patient had appendicitis requiring immediate surgery or another disease. Patients then underwent ultrasonography. A sonographic transducer was placed on the area of maximal tenderness. When the pathological manifestation was depicted, the examiner slipped a fingertip between the transducer and the patient's skin and then pressed the area of depicted pathological manifestation to find pinpoint tenderness. When maximal pinpoint tenderness was noted on the appendix or on pathological manifestations contiguous to the appendix, we diagnosed the condition as appendicitis.

Main Outcome Measures: Sensitivity, specificity, positive and negative predictive values, and overall accuracy.

Results: The diagnosis of appendicitis by this criteria had a sensitivity of 86.7%, a specificity of 89.7%, a positive predictive value of 94.5%, a negative predictive value of 76.5%, and overall accuracy of 87.6%. All 50 patients with pinpoint tenderness noted on the appendix had appendicitis. The surgeon's initial clinical impression had a sensitivity of 83.3%, a specificity of 44.8%, a positive predictive value of 75.8%, a negative predictive value of 56.5%, and overall accuracy of 70.8%.

Conclusions: The efficacy of ultrasonography using the simple criteria was superior to that of the surgeon's initial clinical impression ($P < .001$). Our ultrasonographic criteria for the diagnosis of appendicitis are simple to use and efficient.

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cute appendicitis is the most common indication for emergency surgery of the abdomen.\(^1\) Despite recent advances in medical treatment, delay in the removal of a suppurative appendix may still lead to deleterious conditions.\(^2\) Therefore, many surgeons try to make a prompt diagnosis and operate quickly, before the disease can become serious. Sometimes these attempts bring about unnecessary appendectomies.\(^1\) Appendectomy is not a major surgery, and the incidence of serious perioperative complications is low. However, we do not consider the removal of a normal appendix to be a benign procedure because appendectomy has postoperative morbidity of 10% to 15%\(^3,4\).

To make a prompt diagnosis of appendicitis and reduce unnecessary surgery, many clinical studies have been performed using various diagnostic procedures and tools. Among them, ultrasonography (US) is one of the useful diagnostic procedures for a definitive diagnosis.\(^5,7\) Whereas some recent studies\(^8,9\) have shown that US can improve diagnostic accuracy and reduce unnecessary surgery, others\(^10,11\) have failed to show its efficacy.

The established criteria for US recognition of appendicitis include an enlarged appendiceal diameter, noncompressibility of the appendix, absence of gas in the appendix, and periappendiceal fat change.\(^12,13\) Although these criteria are important, they all have limited sensitivity or specificity, and none can support a definitive diagnosis when used alone.\(^13\) Even detection of a swollen appendix is insufficient for the definitive diagnosis of appendicitis.\(^14\) The key to diagnosing appendicitis is recognition of the appendix...
PATIENTS, MATERIALS, AND METHODS

We prospectively enrolled 89 patients admitted to the Ishioka Dai-Ichi Hospital, Ibaraki, Japan, to confirm or rule out suspected appendicitis from March 1998 to November 2000. For each patient, the symptoms, signs, laboratory data, and abdominal scout radiographic findings were recorded and evaluated referring to the Alvarado score.16 A surgeon diagnosed the condition as either appendicitis requiring immediate surgery or another disease or condition, recorded the diagnosis, and recommended treatment as an initial clinical impression.

All US examinations were performed using a handheld 3.75-MHz transducer (Toshiba, Tokyo, Japan) immediately after the surgeon’s initial clinical evaluation. To eliminate the examiner’s clinical impressions from before US examination, a simple and objective diagnostic maneuver was used in the study.

Before US examination, the examiner determined the area of maximal tenderness. The transducer was placed on the area with tenderness to find the pathological manifestation responsible for pain and tenderness. The appendix was depicted as a nonperistaltic tubular structure with one blind end. In the axial plane, it appeared as a targetlike structure (Figure 1). When the appendices or other pathological manifestations were depicted, the examiner slipped the index finger of his or her free hand between the transducer and the patient’s abdominal wall (Figure 2). The examiner then pressed the index finger against the pathological manifestation to find the pinpoint tenderness on the manifestation and then compared the grade of tenderness with that on the other areas depicted in the same US image field (Figure 3).

The following US criteria were used in the study: criterion 1—when the maximal pinpoint tenderness was proved to be located on the appendix, the patient was diagnosed as having acute appendicitis and urgent surgery was recommended regardless of what the diagnosis had been before US; criterion 2—when the maximal tenderness was noted on the pathological manifestation (ie, thickening of the intestinal wall or abscess formation) and the appendix was shown to be contiguous to the manifestation, appendicitis was diagnosed; criterion 3—when the pinpoint tenderness was noted on the pathological manifestation apart from the depicted appendix or on lesions other than appendicitis, the diagnosis of appendicitis made before US was refuted; and criterion 4—US findings were considered negative when the appendix could not be found, and in such cases the US diagnosis was considered nonappendicitis. Selection of these US criteria was based on the results of our preliminary study.

Surgeons made a final clinical diagnosis and decided on treatment on the basis of their initial clinical impressions and US information. The definitive diagnosis of acute appendicitis was established either surgically and histologically or at clinical follow-up. The condition known as catarrhal appendicitis (slight inflammation with telescogastosis) was not considered acute appendicitis. Patients who did not undergo surgery were surveyed by telephone or by follow-up medical examination.

To compare the usefulness of the new US criteria with the usefulness of the traditional criteria, we reviewed all of the patients’ US reports. When an US report was insufficient for diagnosis using the traditional criteria, we reviewed the US images of the patient. Appendicitis was diagnosed using the US image when the depicted appendix had an enlarged appendicidal diameter greater than or equal to 6 mm or a wall thicker than 2 mm.

The relationship between categorical variables was analyzed using the nonparametric Mann-Whitney test. Data are expressed as mean ± SE. The surgeon’s clinical impression, the results of US, the final clinical diagnosis, and the results of US using the traditional criteria were analyzed to determine sensitivity, specificity, positive and negative predictive values, and overall accuracy. Statistical inference was calculated by analysis of proportions based on the normal approximation to the normal distribution. Results were considered statistically significant at P<.05.

RESULTS

Eighty-nine patients, 50 males and 39 females, were enrolled in the study. Mean patient age was 32.4 years (range, 8-75 years). Mean age of the males was 29.0 years (range, 9-75 years) and of the females was 36.8 years (range, 8-75 years).

Of 71 patients who underwent surgery, 60 (85%) had appendicitis and 11 (15%) had other abdominal pathological findings (8 had diverticulitis and 3 had other diseases). Of the 60 patients with appendicitis, 5 had perforated appendicitis, 3 had gangrenous appendicitis, and 52 had phlegmonous (suppurative) appendicitis.
The remaining 18 of 89 patients received other medical treatments. Eight of these patients were diagnosed as having enteritis, 4 as having pelvic inflammatory disease, 2 as having diverticulitis, and 1 as having mesenteric lymphadenopathy. Ultrasonography did not detect any lesion or show any pinpoint tenderness in 3 patients. All of these 18 patients were cured of their diseases within several days.

The overall accuracies of the initial clinical impression, US, and final clinical diagnosis are summarized in Table 1. Accuracy of the final clinical diagnosis was the highest, and that of US was almost as high. Final clinical diagnosis had a higher sensitivity and negative predictive value than the other diagnostic methods, but its specificity and positive predictive value were lower than those of US. The overall accuracies of US and final clinical diagnosis were significantly higher than the accuracy of initial clinical impression ($P<.001$ for both).

To test whether the examiners’ preconceptions from the initial clinical impression affect the US diagnosis by our criteria, we looked at 2 variables—white blood cell count and interval from the onset of symptoms to hospital admission—and compared them between patients diagnosed as having appendicitis and those diagnosed as not having appendicitis. There was no difference in white blood cell counts in the appendicitis and nonappendici-
Intraperitoneal ultrasound using traditional criteria also had a higher diagnosis of appendicitis using traditional criteria. Ultrasound of the appendix under the surgeon’s initial clinical impression was later diagnosed as having appendicitis by DOPTAUS. The appendixes in these patients were not located at the typical site in the right lower quadrant of the abdomen, so the surgeons mistook the conditions for enteritis (4 patients), diverticulitis (2 patients), and pelvic inflammatory diseases (2 female patients). When an appendix was shown to attach to the pathological manifestation (criterion 2), 40% (2/5) of the patients had appendicitis. Only 1 of 14 patients diagnosed as having a nonappendiceal disease or depicted as a painful manifestation apart from the appendix by US (criterion 3) was found actually to have appendicitis at surgery. Of patients with no appendix depicted by US (criterion 4), 35% (7/20) had appendicitis.

Table 2 summarizes the overall accuracy of the US diagnosis of appendicitis using traditional criteria. Ultrasonography using traditional criteria also had a higher overall accuracy than the initial clinical impression (P = .007). The overall accuracy of our new criteria was not lower than that of the traditional criteria. Our new criteria had higher sensitivity but lower specificity than the traditional criteria.

The overall accuracy of the initial clinical impressions of staff surgeons in our study was comparable to that reported in previous studies, and the latter in a range from 50% to 80%. The low accuracy of initial clinical impressions may be improved by repeated clinical evaluation of these patients during hospital stays. The excellent results possible from such an approach were demonstrated in a previous study, in which the overall accuracy was 87.4%. However, repeated examination and evaluation takes time and money. Delays in diagnosis and surgery might bring about undesired sequelae such as perforation of the appendix, resulting in panperitonitis. On the other hand, the low specificity (high false-positive rate) of initial clinical impressions might result in a high negative laparotomy rate. Although negative laparotomy has negligible mortality, appendectomy still has 10% to 15% morbidity. We think it is important for surgeons to strive to reduce unnecessary appendectomies. This study confirmed the importance of US examination for the diagnosis of appendicitis by demonstrating its increased specificity and better overall accuracy for diagnosis.

Although many previous studies have shown that US examination is useful to confirm or rule out appendicitis, several clinical studies have failed to show this benefit. In early studies of the US diagnosis of appendicitis, the only criterion for acute appendicitis was demonstrated in a previous study, in which the overall accuracy was 87.4%. However, repeated examination and evaluation takes time and money. Delays in diagnosis and surgery might bring about undesired sequelae such as perforation of the appendix, resulting in panperitonitis. On the other hand, the low specificity (high false-positive rate) of initial clinical impressions might result in a high negative laparotomy rate. Although negative laparotomy has negligible mortality, appendectomy still has 10% to 15% morbidity. We think it is important for surgeons to strive to reduce unnecessary appendectomies. This study confirmed the importance of US examination for the diagnosis of appendicitis by demonstrating its increased specificity and better overall accuracy for diagnosis.

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Table 1. Overall Accuracy of Initial Clinical Impression, Ultrasonography (US), and Final Clinical Diagnosis in the Diagnosis of Appendicitis

<table>
<thead>
<tr>
<th>Definitive Diagnosis, No.</th>
<th>Appendicitis</th>
<th>Nonappendicitis</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>Positive Predictive Value, %</th>
<th>Negative Predictive Value, %</th>
<th>Overall Accuracy, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial clinical impression</td>
<td>50</td>
<td>16</td>
<td>83.3</td>
<td>44.8</td>
<td>75.8</td>
<td>56.5</td>
<td>70.8</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>50</td>
<td>16</td>
<td>86.7</td>
<td>89.7</td>
<td>94.5</td>
<td>76.5</td>
<td>87.6</td>
</tr>
<tr>
<td>US diagnosis</td>
<td>58</td>
<td>7</td>
<td>96.7</td>
<td>75.9</td>
<td>89.2</td>
<td>91.7</td>
<td>89.9</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>58</td>
<td>7</td>
<td>96.7</td>
<td>75.9</td>
<td>89.2</td>
<td>91.7</td>
<td>89.9</td>
</tr>
<tr>
<td>Final clinical diagnosis</td>
<td>50</td>
<td>16</td>
<td>50</td>
<td>91%</td>
<td>68.3</td>
<td>84.3</td>
<td></td>
</tr>
<tr>
<td>Nonappendicitis</td>
<td>2</td>
<td>22</td>
<td>70.8</td>
<td>70.8</td>
<td>70.8</td>
<td>70.8</td>
<td>70.8</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>47</td>
<td>1</td>
<td>78.3</td>
<td>96.6</td>
<td>97.9</td>
<td>68.3</td>
<td>84.3</td>
</tr>
<tr>
<td>Nonappendicitis</td>
<td>13</td>
<td>28</td>
<td>78.3</td>
<td>96.6</td>
<td>97.9</td>
<td>68.3</td>
<td>84.3</td>
</tr>
</tbody>
</table>
ment has enabled depiction of normal appendices, many criteria for the diagnosis of acute appendicitis have been established. Although these criteria for recognition of appendicitis are important, they have limited sensitivity and specificity. The difficulty in assessing the US depiction may be one of the factors that impede the usefulness of the examination. Therefore, in our study, we used simple criteria for the diagnosis of appendicitis. Because inflammation causes pain and tenderness, we postulated that detection of the maximal pinpoint tenderness in a small area could be key to detecting the inflammatory organ. When we find DOPTAUS, we conclude that the inflammatory organ is the appendix. If other pathological manifestations are discovered, organs other than the appendix are thought to be responsible. Although the visceral pain is poorly localized, the parietal pain is localized well. Strong localized inflammation involving parietal peritoneum allows us to detect the pinpoint tenderness. Therefore, when the appendix is involved in severe inflamed appendix, DOPTAUS can be easily found. This may be one of the reasons the simple criteria bring about high diagnostic accuracy.

The interval from the onset of symptoms to hospital admission was longer in patients diagnosed as not having appendicitis by the initial clinical impression than in patients diagnosed as having appendicitis. However, there was no such difference when patients were diagnosed by US. This suggests that the simple and objective diagnostic maneuver (our new criteria) used in the US examination successfully eliminated examiners’ preconceptions from the initial clinical impression. Although the specificity of US by our new criteria is lower than that reported in other studies, the high sensitivity and overall accuracy are comparable. It is noteworthy that all patients diagnosed as having appendicitis by DOPTAUS had severe appendicitis.

We think that the higher false-positive rate (lower specificity) in the final clinical diagnosis compared with that of US is acceptable because US had a relatively high rate of false-negative findings (13% [8/60]). It is crucial to remember that 2 patients with negative ultrasonic examination results who were considered not to have appendicitis at the initial clinical impression were subsequently found to have panperitonitis caused by the appendiceal perforation. We must emphasize that US is by no means adequate to exclude a surgeon’s careful and repeated evaluation. The combination of clinical judgment and US can result in a short hospital stay, early surgery, and a low rate of negative laparotomy.

Results of the present study also show that US allows the surgeon not only to identify other conditions that do not require surgical intervention but also to detect acute appendicitis that had been assessed as nonappendicitis in the initial clinical impression. We recommend this simple criterion (DOPTAUS) for diagnosing appendicitis by US.

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REFERENCES


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