Clinical paper

Ultrasonography in suspected acute appendicitis in childhood—report of 1285 cases

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Abstract

Objective: For the assessment of the diagnostic value of real-time ultrasonography (US) in children with suspected acute appendicitis (a.A.) the results of graded compression US are compared with clinical and histological final diagnoses. Methods: In a prospective study over nearly 9 years we examined 1285 children aged 1–15 years (m = 514, f = 771). Using a 5-MHz curved array transducer the right lower quadrant was examined in a graded compression technique. Results: Prevalence of histologically proven a.A. was remarkably low (9%). In diagnosis of acute appendicitis in childhood US achieves a sensitivity of 92%, specificity of 98%, a positive predictive value of 90% and a negative predictive value of 98%. The overall accuracy was 98%. Mesenteric lymphadenitis was seen in 181 cases (prevalence 12%) and terminal ileitis occasionally accompanied by mesenteric lymphadenitis was seen in 116 cases (prevalence 9%). Conclusion: In children with suspected appendicitis US of the abdomen gives great diagnostical value for differential diagnosis of a.A. and other more frequent inflammatory diseases of the ileocecal region. Thus US provides further reliable information to the referring physician. Consequently it is necessary to perform US in each child with acute abdominal pain, even if clinical diagnosis seems to be well established. © 1998 Elsevier Science Ireland Ltd. All rights reserved.

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1. Introduction

Abdominal pain is one of the most frequent and challenging complaints in children, often leading to admission to the hospital for observation and further testing and treatment. Suspected acute appendicitis remains the most common condition requiring abdominal surgery in children (Janik and Firor, 1979; Siegel et al., 1991). The diagnosis of appendicitis has traditionally been based on clinical criteria. But accurate clinical diagnosis is still difficult as physical examination may be nonspecific and ambiguous (Lewis et al., 1975; Siegel, 1992). In general, the younger the child, the more difficult it will be to make an accurate clinical diagnosis. As a result the preoperative clinical diagnostic accuracy rate is in the range of 70% with an unnecessary laparotomy rate of 30% (Puylaert et al., 1987; Vignault et al., 1990; Chesbrough et al., 1993). Indeed, the markedly increased incidence of complications that ensue when perforation of the appendix occurs has justified early surgical exploration even in cases when the preoperative diagnosis is still uncertain. Therefore the surgeon tries to make an accurate diagnosis as early as possible and at the same time tries to reduce the number of false-positive appendectomies. The technique of graded compression ultrasonography (US), first described by Puylaert in 1986, is the best imaging method that provides reliable information to establish the diagnosis of acute appendicitis (Puylaert, 1986; Puylaert et al., 1987). Several studies confirmed the value of US in the diagnosis of acute appendicitis (Jeffrey et al., 1988; Schwerk et al., 1990; Vignault et al., 1990; Spear et al., 1992; Sivit et al., 1992; Chesbrough et al., 1993; Kao et al., 1989; Beyer et al., 1993).

The purpose of this study was to assess the sensitivity, specificity and accuracy of US in the diagnosis of acute appendicitis in a large series of consecutive pediatric patients. Special emphasis is focused on the characteristic features concerning the diagnosis of acute appendicitis in the pediatric population including its capacity to provide additional information in patients with complicated appendicitis or to detect other causes of acute abdominal pain in the right lower quadrant (Table 1).

2. Materials and methods

In our prospective study in the course of nearly 9 years, 1285 pediatric patients with suspected appendicitis were referred to the Department of Radiology for ultrasound examination. The study group includes 514 male and 771 female patients with ages ranging from 1 to 15 years (mean 10.4 years). Fig. 1 depicts the age distribution of clinically suspected and proved acute appendicitis.

Initially in all studies a complete examination of the abdomen was performed with a 5 MHz transducer. Scans of the right lower quadrant were obtained with a 5-MHz curved array transducer (Picker CS 9500; Toshiba eccocee) by means of a graded compression US technique (Puylaert, 1986; Puylaert et al., 1987). Thus bowel gas is compressed and displaced from the right side of the abdomen. Demonstration of retroperitoneal structures such as the iliopsoas muscle and iliac vessels indicate adequate compression.

Appendicitis was diagnosed by visualization of a noncompressible inflamed appendix with typical mural thickening (Figs. 2–4). In the absence of acute appendicitis particular attention was paid to differential diagnoses. The final diagnoses were established by means of surgical and histological evaluation and by means of clinical follow-up in case of non-operative management.

3. Results

The results of this study are summarized in Table 2. On the basis of histopathological examination Table 1 Sonographic findings in clinically suspected acute appendicitis

| Mesenteric lymphadenitis |
| Enteritis |
| Terminal ileitis, ileocoecitis (Yersinia enterocolitica, Campylobacter jejuni) |
| Ileocolic intussusception |
| Meckel’s diverticulum |
| Gastrointestinal obstruction due to postoperative adhesions |
| Duplication cyst of the intestinal wall |
| Pyelonephritis due to vesicoureteral reflux |
| Atresia of vaginal hymen |
the diagnosis of acute appendicitis was made in 119 children (prevalence 9%). US yielded 110 true-positive and 1154 true-negative sonographic findings for acute appendicitis. There were 12 false-positive and 9 false-negative diagnoses. Of the 1285 diagnostic studies in this series, the sensitivity for sonography was 92%, with a specificity of 98%. The accuracy was 98%. The predictive value of a positive study was 90%, and the predictive value of a negative study was 98%.

In the absence of acute appendicitis alternative diagnoses could be established with US (Table 1). Most of the children suffered from nonspecific gastrointestinal infections. In 181 (14%) cases a mesenteric lymphadenitis and in 116 (9%) cases terminal ileitis was seen. Furthermore, obstructions of the urogenital tract that caused acute abdominal pain were demonstrated as well as obstructions of the gastrointestinal tract. In two cases of clinically suspected acute appendicitis intussusception was visible by US. Two cystic findings revealed to be a Meckel’s diverticulum and a duplication the cyst of the intestinal wall. Other causes of acute abdominal pain like gynecologic disorders (ovarian cyst, hematocolpos) were demonstrated as well.

4. Discussion

The most common surgical problem encountered in childhood is appendicitis, nonetheless it is responsible for a great number of errors in surgical diagnosis. Thus, the persistent challenge is to establish the diagnosis of acute appendicitis early enough to prevent progression to perforation, with its associated morbidity, and to reduce the frequency of negative findings at exploratory surgery (Schwerk et al., 1990).

A graded compression US technique to diagnose appendicitis was first described by Puylaert (1986). By slowly compressing the transducer to the site of maximal tenderness it is possible to approach closer to the region of interest. If possible it is useful to ask the child to indicate the point of maximum abdominal pain (Chesbrough et al., 1993).

The criteria for diagnosis (Schulte et al., 1994) is a tubular structure with one blind end in the
longitudinal plane and a target appearance in the axial plane. The lumen is filled with hypoechoic inflammatory liquid sometimes accompanied by hyperechoic foci and dorsal acoustic shadowing due to appendicoliths. The thickened mucosa appears as an echogenic ring which is surrounded by an hypoechoic peripheral zone caused by the appendical wall (Figs. 2–4). The inflamed appendix was demonstrated by US in 93 of 119 patients with pathologically confirmed appendicitis.

Based on our results, the sensitivity of US for aiding in the diagnosis of acute appendicitis was 91% and the specificity was 98%. Accordingly, the positive predictive value of US in our series was 91% and the negative predictive value was 98% with an overall accuracy of 98%. Prevalence of acute appendicitis was surprisingly low (9%). In our experience, the majority of children referred for suspected appendicitis did not suffer from appendicitis. Additionally, in most of these cases US has been helpful in suggesting and establishing alternative diagnoses. This emphasizes that US is valuable not only to confirm or exclude appendicitis but also to establish the diagnosis in other cases of acute abdominal pain. Therefore, it is indispensable to examine the pelvis and the upper abdomen.

### Table 2
Results of ultrasonography in suspected acute appendicitis

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<table>
<thead>
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<tbody>
<tr>
<td>Number of patients</td>
<td>1285 (m: 514, f: 771)</td>
</tr>
<tr>
<td>Acute Appendicitis</td>
<td>119</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>9</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>92</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>98</td>
</tr>
<tr>
<td>Positive predictive value (%)</td>
<td>90</td>
</tr>
<tr>
<td>Negative predictive value (%)</td>
<td>98</td>
</tr>
<tr>
<td>Overall accuracy (%)</td>
<td>98</td>
</tr>
<tr>
<td>Mesenteric Lymphadenitis (n)</td>
<td>181 *</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>14</td>
</tr>
<tr>
<td>Terminal ileitis (n)</td>
<td>116</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>9</td>
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</tbody>
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Fig. 3. Acute appendicitis in a girl aged 15 years. The transverse sonogram shows an inflamed appendix with thickening of the mucosal and muscular layers. Surrounding fluid collection demonstrates focal perforation (arrows).

Fig. 4. Acute appendicitis with focal perforation in a boy aged 12 years. The sonogram shows enlargement of the appendix and loculated fluid collection around the appendical tip (arrows).

Fig. 5. Mesenteric lymphadenitis in a boy aged 5 years. Enlarged mesenteric lymph nodes (arrows) in the right lower quadrant are often accompanied by thickening of the terminal ileum. Psoas muscle (*).
abdomen including the retroperitoneal space if the examination of the right lower quadrant is negative for appendicitis. Most of the children suffered from uncomplicated common infections of the gastrointestinal tract. In young female patients gynecologic disorders (complicated ovarian cyst and hematocolpos) are of particular importance. These conditions should be seriously considered in US of female patients, as complications following unnecessary laparotomy may lead to infertility. Furthermore, obstructions of the urogenital tract that cause acute abdominal pain can be demonstrated as well as obstructions of the gastrointestinal tract. In two cases of clinically suspected acute appendicitis intussusception was visible by US. Two cystic findings were revealed to be a Meckle’s diverticulum and a duplication cyst of the intestinal wall.

Three times more frequent than acute appendicitis are US findings consisting of enlarged mesenteric lymph nodes (Fig. 5), mural thickening of the terminal ileum without demonstration of the inflamed appendix. The diagnosis is mesenteric lymphadenitis (Fig. 5) and nonspecific terminal ileitis, an entity that should be treated conservatively. Puylaert et al., report that in most cases *Yersinia enterocolitica* and *Campylobacter jejuni* are responsible for this condition that mimics acute appendicitis (Baier et al., 1982; Puylaert et al., 1988). US enables differentiation between acute appendicitis and ileocolitis or mesenteric lymphadenitis, which compose the largest part of alternative diagnoses. This is of vital importance, since surgery is certainly not indicated for the latter.

It is also noteworthy that symptoms subside spontaneously in a small percentage of patients with visualized appendicitis (Heller and Skolnick, 1993). These cases may represent the resolution of true appendicitis rather than a false positive US examination. In the clinical course of patients with apparently false positive sonographic findings a spontaneous improvement without surgery underscores the fact that the decision for laparotomy can not be made on the basis of US alone. On the other hand this experience contradicts the surgical precept that acute appendicitis inevitably progresses to gangrene and necrosis.

Conclusively the predictive value for the diagnosis of acute appendicitis may be even higher than the calculated 91%. The remaining false positive results in US may be due to the terminal ileum mistaken for a distended appendix. A precise examination technique should allow exact identification of the terminal ileum to avoid misunderstandings.

The condition of ruptured appendicitis is the most difficult diagnostic entity that leads to a number of false negative US results (Brender et al., 1985; Blane et al., 1986; Schwerk et al., 1990). Once realized that US allows the evaluation of the degree and extent of the inflammatory process (Lee et al., 1996) another important factor emphasizing the value of US arises. In early appendicitis the mild local peritonitis permits good sonographic visibility and easy demonstration of the inflamed wall thickened appendix. If the inflammation has extended transmurally disruption of the adjacent mural layers or marked asymmetry of the wall thickening will be seen (Fig. 4). Sometimes echogenic mesenteric fatty tissue that encloses the local inflammatory process can be depicted (Fig. 2). In perforated appendicitis or periappendical abscess formation reflex rigidity may prevent adequate compression. In these cases local retrocecal fluid collection and atonic dilatation of the bowel loops occasionally accompanied by distorted structures within an inflammatory mass may be present. Fortunately the poor sonographic results in perforated appendicitis do not affect therapeutic management, since severe peritonitis is clinically apparent. Thus the technique is most precise in the uncomplicated case of appendicitis. Findings in the studies of Sivit et al. (1992) reaffirm that US is useful in the diagnosis of appendicitis in children judged to have a low or intermediate probability of appendicitis based on clinical findings. Nevertheless US is indispensable, even if the diagnosis of acute appendicitis is clinically obvious. Sometimes unexpected alternative diagnosis may be easily demonstrated.

Unfortunately a major limitation of sonographic evaluation of the appendix is its technical difficulty when performed by inexperienced persons. On the other hand it is not acceptable that
US examination of appendicitis remains in the hands of only a few very skilled doctors who can not be present at admission all the time. Therefore it is necessary that the skill of US for acute appendicitis is passed on to junior staff on the admitting team who can also use this technique to help attain a diagnosis in patients presenting with an acute abdomen.

Ultimately findings of a skillfully performed US examination improve the quality of care in children with acute abdominal pain. Low cost, lack of ionizing radiation and a high positive predictive value underscore the need for US examination. In the absence of compelling clinical and sonographic findings the patient should undergo a period of close observation with following US studies rather than immediate surgery.

References


