APPENDICITIS IN CHILDREN: IS THERE A ROLE FOR ROUTINE ULTRASONOGRAPHY?

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INTRODUCTION

Acute appendicitis and acute non-specific abdominal pain account for 95% of cases in children presenting with acute abdominal pain (Hayes, 2004). During the 2008-2009 financial year in the UK, there were over 34,000 cases of acute appendicitis, and 97% of procedures and interventions on the appendix were emergency appendicectomies [HES online]. Therefore, appendicitis is the most common abdominal emergency (Humes & Simpson, 2006) and approximately 20% of patients are aged between 0-14 years [HES Online]. History and clinical examination currently remains the mainstay of diagnosis. In cases of suspected acute appendicitis, imaging either in the form of ultrasonography (US) or computed tomography (CT), aims to reduce negative appendicectomies and perforation rates by enabling the establishment of a prompt diagnosis (Rosendahl et al., 2004). This article aims to describe the role of US as a first-choice imaging modality in cases of suspected acute appendicitis within the paediatric population.

Presenting features in suspected cases of acute appendicitis

Adults and older children present with the characteristic triad of clinical features – abdominal pain, low-grade fever and tenderness with guarding in the right iliac fossa (Acheson & Banerjee, 2010). Nance et al., (2000) observed that 94% of young children presented with pain as the main symptom, while tenderness (diffuse or focal) and guarding were the most common presenting signs. However, infants are more likely to have a history of recent respiratory infection followed by poor feeding, vomiting, abdominal distension, irritability, grunting, right hip pain with or without limp and high fever (Acheson & Banerjee, 2010). Perforation instead of abdominal pain may be the presenting feature in infants. A higher rate of perforation has been shown to be associated with younger age, and while there is an increased

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likelihood of the youngest patients presenting with perforation (Nance et al., 2000, Colvin et al., 2007).

ULTRASONOGRAPHY IN SUSPECTED CASES OF ACUTE APPENDICITIS

When acute appendicitis is suspected, US is performed using a 5-12MHz linear-array transducer combined with the graded compression technique – first introduced by Puylaert in 1986 (Puylaert, 1986). The ultrasonographic features of acute appendicitis include: (i) a target-sign with a diameter >6mm on transverse plane, (ii) a blind-ending tubular structure with a diameter >6mm on longitudinal plane, (iii) distension or obstruction of the lumen of the appendix, with the presence of an appendicolith, (iv) non-compressibility, (v) absent peristalsis or signs of localised paralytic ileus and, (vi) secondary signs such as high echogenicity of the area surrounding the appendix (hyperechoic mesenteric fat) and pericaecal and/or perivesicular fluid collections suggesting an appendicular abscess (Hahn et al., 1998, Holscher & Heij, 2009). Wiersma et al., (2009) concluded that secondary signs are a strong indicator of acute appendicitis in cases where secondary signs are present without the US depiction of the appendix.

ADVANTAGES OF ULTRASONOGRAPHY

US confers the advantages that it is widely and readily available, relatively inexpensive, non-invasive, short acquisition time, potential for discovering other causes of abdominal pain and does not involve the use of ionising radiation as is the case with use of CT (Hayes, 2004, Old et al., 2005). The dangers of CT with respect to increased risk of cancer induction in children are severely underestimated, and so despite the risk of fatal cancer to an individual child following an abdominal CT scan is small, the problem lies at the public health level, where it is significant (Brenner et al., 2001, Hall, 2002). The estimated effective radiation dose delivered by an abdominal CT is 9mSv, which is the equivalent of 25.7months of background radiation (Brennan, 2006). Hall, (2009) has shown that an abdominal CT performed at a younger age in life has the highest estimated lifetime attributable cancer mortality risk compared to an abdominal CT performed at an older age in life.

CT in contrast to US, it is more costly, more invasive with the use of contrast media and some children may require sedation during imaging. Because of the lack of abdominal fat in children, CT is less desirable as it is difficult to distinguish the appendix from surrounding bowel (Holscher & Heij, 2009).
LIMITATIONS OF ULTRASONOGRAPHY

Operator-dependence, a retrocaecal appendix, abdominal guarding, excessive bowel gas, obesity, inadequate bladder filling or simply an uncooperative patient hinder the accuracy of US diagnosis of appendicitis (Rosendahl et al., 2004). Caution should be exercised when imaging the appendix of a patient with cystic fibrosis, as the outer diameter of the appendix in these patients often exceeds 8mm due to mucoid impaction (Holscher & Heij, 2009, Wiersma et al., 2009).

Lee et al., (2005) concluded that the detection rate for the appendix was higher when using posterior manual compression technique compared to lateral decubitus body position for graded compression. This could be attributed to the increased spatial resolution of the posterior manual compression technique, therefore increasingly effective in detecting a retrocaecal appendix and overcoming the limitation of obesity.

SENSITIVITY, SPECIFICITY AND PREDICTIVE ACCURACY OF ULTRASONOGRAPHY

Since the graded-compression US technique was first described (Puylaert, 1986), sensitivities and specificities of more than 90% in suspected cases of acute appendicitis have been reported (Lee et al., 2005). In their meta-analysis of 26 studies that used US as a diagnostic test for appendicitis in children, Doria et al., (2006) calculated a pooled sensitivity and specificity of 88% and 94% respectively. Table 1 shows that the sensitivity can range from 74% to 100%, while specificity varies from 84% to 98%, with predictive accuracy in the range of 76% - 98%.

GRADED-COMPRESSION VERSUS NON-COMPRESSIVE TECHNIQUES

The graded-compression technique can cause significant discomfort to the child during scanning. For this reason, Baldisserotto & Marchiori, (2000) used a non-compressive US technique and a 5MHz curved-array transducer in children suspected to have acute appendicitis, yielding a sensitivity and specificity of 67.8% and 98.2% respectively. However, the non-compressive technique relies on correct positioning of the transducer and a distended urinary bladder. Therefore, visualisation of the appendix using this technique may be difficult in dehydrated or non-toilet-trained children. Visualisation, on US scanning, of a normal appendix and the absence of secondary signs of appendicitis can safely rule out acute appendicitis in suspected cases (Holscher & Heij, 2009)
<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>STUDY DESIGN</th>
<th>AGE (YRS)</th>
<th>NO. of PATIENTS</th>
<th>SENSITIVITY (%)</th>
<th>SPECIFICITY (%)</th>
<th>PPV(%)</th>
<th>NPV(%)</th>
<th>PREDICTIVE ACCURACY</th>
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<tr>
<td>(Baldisserotto &amp; Marchiori, 2000)</td>
<td>Retrospective</td>
<td>6mo-12</td>
<td>425a</td>
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<td>98.2</td>
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<td>98.7</td>
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<td>(Dilley et al., 2001)</td>
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<td>86</td>
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<td>RCT</td>
<td>5-82</td>
<td>302a, 129b</td>
<td>94.7</td>
<td>88.9</td>
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<td>3-20</td>
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<td>3859a</td>
<td>90</td>
<td>97</td>
<td>82</td>
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<td>(Kaiser et al., 2002)</td>
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<td>600a</td>
<td>86</td>
<td>95</td>
<td>91</td>
<td>92</td>
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<td>(Karukas et al., 2000)</td>
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<td>Mean:12</td>
<td>633a, 182b</td>
<td>74</td>
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<td>215a</td>
<td>88</td>
<td>96</td>
<td>90</td>
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<td>97.7</td>
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<td>(Rice et al., 1999)</td>
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<td>94</td>
<td>89</td>
<td>89</td>
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<td>(Wade et al., 1993)</td>
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<td>110a</td>
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<td>80.1</td>
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Table 1: Comparison of various parameters obtained from 15 clinical studies involving use of US in the diagnosis of acute appendicitis in children. a = All children admitted for acute abdominal pain consistent with acute appendicitis, b = equivocal cases needing US, PPV = Positive Predictive Value, NPV = Negative Predictive Value
While the diagnosis of appendicitis is still made on the base of history and examination, the sensitivity and specificity of the surgeon’s clinical impression in studies by Lessin et al., (1999), Rice et al., (1999), and Wade et al., (1993) were in the ranges of 35% -63% and 82% - 95% respectively (Table 2). Each of these studies observed a statistically significant increase in the accuracy of diagnosis when US was used as a first line imaging tool or in equivocal cases of suspected acute appendicitis. US therefore improves the diagnostic accuracy and patient management when used to complement the clinical diagnosis in addition to standard clinical examination.

<table>
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<th>REFERENCE</th>
<th>SURGEON’S CLINICAL IMPRESSION</th>
<th>ULTRASOUND DIAGNOSIS</th>
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<td></td>
<td>SENSITIVITY</td>
<td>SPECIFICITY</td>
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<tr>
<td>(Lessin et al., 1999)</td>
<td>50</td>
<td>85</td>
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<tr>
<td>(Rice et al., 1999)</td>
<td>38</td>
<td>95</td>
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<tr>
<td>(Wade et al., 1993)</td>
<td>62.9</td>
<td>82.2</td>
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Table 2: Studies comparing sensitivity and specificity of the surgeon’s clinical impression in diagnosing appendicitis in children to the diagnosis of appendicitis by using US as the first-choice imaging modality.

Furthermore, there is evidence that US would have beneficial implications in improving patient care and efficient use of hospital resources by avoiding the need for prolonged hospitalisation (Lessin et al., 1999, Rice et al., 1999).

Effect of ultrasonography on the negative appendicectomy rate, the perforation rate and cost-effectiveness

Owing to the difficulty in diagnosing appendicitis and the serious consequences associated with missed or delayed diagnosis in children, a negative appendicectomy rate of 15% - 25% has been deemed to be acceptable (Applegate et al., 2001). Conflicting evidence exists as to whether US lowers the negative appendicectomy rates in children suspected to have acute appendicitis. Based on a Markov decision model of paediatric appendicitis, Wan et al., (2009) concluded that US was the most cost-effective method of imaging paediatric appendicitis. Furthermore, they suggest that a CT examination should follow each negative US study.
The value of white cell count and inflammatory markers such as C-reactive protein (CRP) in diagnosing appendicitis, together with its effect on the rate of perforation and negative appendicectomy has been evaluated in numerous clinical studies. Beltran et al., (2007), Mohammed et al., (2004) and Stefanutti et al., (2007) concluded that the sensitivity of using white cell count and CRP together is extremely high when compared to using either of the tests alone. Therefore the combined use of these serum markers, in addition to clinical evaluation of signs and symptoms, reduces the perforation and negative appendicectomy rates.

CONCLUSION

Ultrasonography is a relatively inexpensive, non-invasive and safe imaging tool that can be routinely used in establishing the diagnosis of acute appendicitis in children presenting with acute abdominal pain. Protocols based on history and clinical examination by a surgeon, combined with the use of routine US by experienced radiologists (Figure 1) can have a significant impact on negative appendicectomy rates, hospitalisation, utilisation of
hospital resources and eventually, costs. In equivocal cases, patients should be observed and re-assessed, preferably by the same surgeon and radiologist, by repeating clinical and US examinations. Visualisation of a normal appendix and the absence of secondary signs of appendicitis can be used to rule out appendicitis. Therefore, there is an important role for US in the diagnosis and management of appendicitis in children.

REFERENCES


