

Original Contributions

ACUTE APPENDICITIS: INVESTIGATING AN OPTIMAL OUTER APPENDICEAL DIAMETER CUT-POINT IN A PEDIATRIC POPULATION

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Abstract—Background: Acute appendicitis is the most common cause of abdominal pain in children requiring operative intervention. Among a number of sonographic criteria to aid in the diagnosis of appendicitis, an outer diameter >6 mm is the most objective and widely accepted. However, there is a lack of evidence-based standards governing this consensus. **Study Objectives:** The aim of this study was to determine the outer appendiceal diameter that maximizes sensitivity and specificity in a pediatric population. **Methods:** A retrospective review of all urgent diagnostic ultrasounds (US) was performed over 2 years in children aged <18 years. The diagnostic accuracy of various cut-points was assessed by calculating the sensitivity and specificity and plotting a receiver operating characteristic (ROC) curve. **Results:** The study sample consisted of 398 patients in whom the appendix was visualized on US. The median outer appendiceal diameter was significantly higher in the surgical group compared to the nonsurgical group (9.4 mm; range = 8.1–12.0 vs. 5.5 mm; range = 4.4–6.5, $p < 0.01$). The optimal cut-point with the greatest area under the ROC curve was determined to be an outer appendiceal diameter of 7.0 mm. **Conclusions:** In our patients, adopting a 7-mm rather than a 6-mm appendiceal diameter threshold would balance a greater number of missed cases of acute appendicitis for a reduction in the number of unnecessary surgeries. © 2014 Elsevier Inc.

Keywords—ultrasound; pediatric; appendicitis; diagnosis

INTRODUCTION

Acute appendicitis is an important diagnosis in an emergency department (ED) and is the most common cause of abdominal pain requiring surgical intervention. Acute appendicitis has a lifetime risk of 7% and is particularly important in the pediatric population, given that it is primarily a diagnosis of adolescents and young adults (1–9). In the ED, an estimated 70,000 pediatric cases of acute appendicitis are observed per year in the United States (10). An accurate and timely diagnosis by the clinician is crucial due to the risk of perforation, abscess formation, peritonitis, sepsis, bowel obstruction, infertility, and death (11–13).

A number of imaging criteria have been established to aid in the preoperative evaluation of suspected appendicitis with ultrasonography. Major ultrasound (US) findings of acute appendicitis in the right lower quadrant include: an aperistaltic, noncompressible, blind-ended, sausage-shaped structure that arises from the base of the cecum, distinct appendiceal wall layers, a target appearance, appendicolith(s), periappendiceal fluid collection, echogenic prominent pericecal fat, and an outer diameter > 6 mm (14–17).

There is no evidence-based standard governing the sonographic criteria used to diagnose appendicitis. Accordingly, large interrater variability exists as different

radiologists and experimental protocols have used various constellations of findings to arrive at a diagnosis of acute appendicitis (18–20).

Potentially, the most important criterion is the outer diameter of the vermiform appendix. Studies in adult populations have found that this criterion provides high sensitivity but low specificity (21). One small study of 70 children concluded that the diagnosis of acute appendicitis could be made with the same accuracy in children as in adults (22). Another small Korean study reported an optimal maximal outer diameter of 5.87 mm for pediatric patients (23). This study has not been repeated in a larger sample and thus, a paucity of evidence-based support for the 6-mm criterion exists in a pediatric population.

Because a diagnostic radiologist may need to guide an emergency physician and surgeon's management using only an outer appendiceal diameter, a clearer description as to the sensitivity and specificity of different outer appendiceal diameters may help the clinician and radiologist in real time understand how to best interpret US results. The aim of this study was to determine the optimal value of the outer appendiceal diameter that maximizes the trade-off between sensitivity and false positives in a pediatric population.

MATERIALS AND METHODS

A retrospective review was conducted of all urgent abdominal and pelvic USs performed between July 1, 2008 and June 30, 2010 at the pediatric ED of an urban, tertiary care pediatric teaching hospital. The pediatric ED has a census of approximately 40,000 visits per year. The hospital serves as a referral center covering a catchment area with a population of 1.5 million.

All urgent abdominal and pelvic USs assessing the appendix in patients < 18 years of age performed at the pediatric ED were included. Patients with cystic fibrosis were excluded from the present study because the appendiceal lumen in these children is often filled with mucoid content, resulting in an outer appendiceal diameter up to 14 mm when not inflamed. Repeat examinations were also excluded.

All US examinations were performed by US technicians and interpreted by a pediatric radiologist. To visualize the appendix on US, Puylaert's graded compression technique was performed using commercially available US equipment (24). Puylaert's technique applies graded compression and high-frequency transducers to visualize the appendix. It has become the standard in sonographic studies of appendicitis due to its high sensitivity and specificity (25–31).

The outer appendiceal diameter was measured as the distance between the outer boundaries of the hypoechoic tunica muscularis by radiologists using electronic



Figure 1. Sonographic image of an enlarged, noncompressible appendix with concentric layers suggestive of acute appendicitis.

calipers. Outer appendiceal measurements (in mm) were reported to two decimal places. The reporting radiologist was blinded to the final pathology report. Sample positive and negative US images are presented in Figures 1 and 2, respectively.

Data were analyzed using StatsDirect™ (Cheshire, UK) statistical software package. The mean and SD were used to summarize normally distributed continuous variables, whereas the median and range were used for skewed continuous variables. Categorical outcomes were reported as percentages. A chi-squared test was used to compare categorical outcomes between the surgical and nonsurgical groups, and the independent samples *t*-test or Mann-Whitney *U*-test was used to compare continuous outcomes between groups. A *p* value < 0.05 was considered statistically significant.

In patients where the appendix was visualized and the outer appendiceal diameter was measured, children were divided into two groups: patients who underwent surgery for possible appendicitis (surgical group) vs. patients not



Figure 2. Sonographic image of a normal appendix.

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