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Can ultrasound reliably identify complicated appendicitis in children?



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ABSTRACT

Background: The ability of ultrasound to identify specific features relevant to nonoperative management of pediatric appendicitis, such as the presence of complicated appendicitis (CA) or an appendicolith, is unknown. Our objective was to determine the reliability of ultrasound in identifying these features.

Methods: We performed a retrospective study of children who underwent appendectomy after an ultrasound at four children's hospitals. Imaging, operative, and pathology reports were reviewed. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ultrasound for identifying CA based on pathology and intraoperative findings and an appendicolith based on pathology were calculated. CA was defined as a perforation of the appendix. Equivocal ultrasounds were considered as not indicating CA. **Results:** Of 1027 patients, 77.5% had simple appendicitis, 16.2% had CA, 5.4% had no evidence of appendicitis, and 15.6% had an appendicolith. Sensitivity and specificity of ultrasound for detecting CA based on pathology were 42.2% and 90.4%; the PPV and NPV were 45.8% and 89.0%, respectively. Sensitivity and specificity of ultrasound for detecting CA based on intraoperative findings were 37.3% and 92.7%; the PPV and NPV were 63.4% and 81.4%, respectively. Sensitivity and specificity of ultrasound for detecting an appendicolith based on pathology were 58.1% and 78.3%; the PPV and NPV were 33.1% and 91.0%, respectively. Results were similar when equivocal ultrasound and negative appendectomies were excluded.

Conclusions: The high specificity and NPV suggest that ultrasound is a reliable test to exclude CA and an appendicolith in patients being considered for nonoperative management of simple appendicitis.

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Introduction

Nonoperative management of appendicitis with antibiotics may be an alternative treatment option for children with acute appendicitis. Over the last 2 decades, several studies have reported the results of trials investigating nonoperative management in different subsets of patients with appendicitis.¹⁻⁷ In patients with uncomplicated appendicitis, specific criteria, including length of symptoms, laboratory values, and imaging characteristics, can be used to select patients for nonoperative management to minimize the risk of harm and maximize the likelihood of success. The presence of features of complicated appendicitis (CA) or an appendicolith on imaging has been shown to be a risk factor for failure of nonoperative management.^{2,8,9} Accurate identification of CA or the presence of an appendicolith on preoperative imaging can assist with treatment decision-making for patients with uncomplicated appendicitis.

At U.S. children's hospitals, ultrasound is a widely used tool to diagnose appendicitis in children. Concerns regarding radiation exposure have prompted pediatric health care providers, including the American Academy of Pediatrics and the American Pediatric Surgical Association, to recommend the consideration of ultrasound as the initial imaging study in children with suspected appendicitis.¹⁰ Numerous studies have validated ultrasound as a reliable diagnostic modality for children with suspected appendicitis. However, the accuracy of ultrasound in distinguishing simple appendicitis (SA) from CA and identifying appendicoliths is not well established. The objective of this study was to determine the reliability of ultrasound for identifying CA and appendicoliths in a multi-institutional cohort of children.

Methods

Cohort development and methods

A retrospective review of children aged 2-18 y who underwent an appendectomy for acute appendicitis during 2015 at four children's hospitals was performed. All patients who underwent a preoperative abdominal ultrasound were included. Patients who underwent incidental or interval appendectomies, as well as patients who did not have available imaging reports, operative reports, or pathology reports, were excluded. Patients were identified using Current Procedural Terminology codes (44950, 44955, 44960, and 44970) or International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes (47.0x).

An in-depth chart review was performed. Collected data included patient demographics, admission characteristics, ultrasound report findings, operating report findings, final pathology reports, length of stay, readmission within 30 d, and need for additional procedures (including reoperation or percutaneous drain placement). Data were recorded in a Research Electronic Data Capture database.¹¹ This study was approved by the Institutional Review Board with a waiver of informed consent at each participating institution.

Definitions

On ultrasound, SA was defined as presence of a dilated, noncompressible appendix without evidence of a phlegmon, abscess, or perforation. Intraoperatively, SA was defined as presence of a hyperemic, inflamed/gangrenous appendix without perforation. Pathologically, SA was defined as presence of appendiceal inflammation or gangrene without evidence of perforation. Gangrenous appendicitis was considered SA unless there was a clear perforation of the appendix or evidence of a fluid collection.¹² CA included cases with evidence of rupture, phlegmon, or abscess formation as reported in ultrasound, operative, and pathology reports.

Outcomes

The outcome of interest of this study was the concordance of ultrasound findings of CA with a pathologic diagnosis of CA. Other outcomes of interest included the concordance of ultrasound findings with additional pathologic findings, including SA, appendicolith, and gangrene, and the concordance of ultrasound findings with intraoperative findings, including SA, CA, gangrene, free fluid, and abscess. In addition, the associations between ultrasound findings and

Table 1 – Characteristics of study cohort.

Variable	Overall cohort (N = 1027)
	N or median (% or Q1, Q3)
Hospital	
Hospital 1	198 (19.3)
Hospital 2	354 (34.5)
Hospital 3	379 (36.9)
Hospital 4	96 (9.3)
Male	624 (60.8)
Age (years)	10 (7, 13)
Length of symptoms (hours)	24 (22, 48)
Days from admission until imaging study	0 (0, 0)
Days from admission to surgery	0 (0, 1)
Length of stay (days)	1 (1, 3)
Transferred from other facility	222 (21.6)
CT scan performed after ultrasound	168 (16.4)
Readmitted within 30 days	52 (5.1)
Required additional procedures	38 (3.7)
Type of appendicitis (n = 1017) [*]	
SA	796 (78.3)
CA	166 (16.3)
No appendicitis	55 (5.4)
Presence of appendicolith [†]	160 (15.6)

^{*} Pathology confirmed.

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