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Original Research Article

Ultrasound as a first-line imaging tool in paediatric appendicitis: diagnostic yield and limitations

Mohammad Mahbub Hossain*, Mahmuda Monowara

Department of Radiology and Imaging, Bangladesh Shishu Hospital & Institute, Dhaka, Bangladesh

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***Correspondence:**
Dr. Mohammad Mahbub Hossain,
E-mail: goldenjutemahbub@gmail.com

ABSTRACT

Background: Acute appendicitis remains a common and clinically significant cause of abdominal pain in children and despite widespread use of ultrasound as the preferred first-line imaging modality, its diagnostic performance continues to show variability across different clinical settings due to factors such as operator dependence and appendix visualization rates. The purpose of the study is to evaluate the diagnostic yield and limitations of ultrasound as a first-line imaging modality in children with suspected acute appendicitis.
Methods: This prospective observational study at the Department of Radiology and Imaging, Bangladesh Shishu hospital and institute, Bangladesh (June 2023–July 2024) included 100 pediatric patients with suspected appendicitis. All underwent abdominal ultrasound and final diagnosis was confirmed by surgery, histopathology or clinical follow-up. Diagnostic performance was calculated using 2×2 tables and analyzed with SPSS 25.0.
Results: The study included 100 pediatric patients (mean age 10.27±3.33 years), with 58% males. The appendix was visualized on ultrasound in 78% of cases; 55% showed features suggestive of appendicitis and 23% appeared normal. Acute appendicitis was confirmed in 60% of patients. Ultrasound yielded 52 true positives, 35 true negatives, 8 false negatives and 5 false positives, resulting in a sensitivity of 86.7%, specificity of 87.5%, positive predictive value of 91.2%, negative predictive value of 81.4% and an overall diagnostic accuracy of 87.0%.
Conclusions: Ultrasound is a reliable first-line imaging tool for pediatric appendicitis, effectively identifying most cases while minimizing the need for invasive or radiation-based investigations.

Keywords: Diagnostic accuracy, Paediatric appendicitis, Ultrasonography

INTRODUCTION

Each year, approximately 70,000 children in the United States are diagnosed with appendicitis, making it one of the most frequent surgical emergencies presenting as abdominal pain in pediatric patients.[1,2] Appendicitis represents a common etiology of acute abdomen among children.[3] If not treated promptly, there is a significant risk of appendix rupture, which can lead to peritonitis and consequently increase morbidity and mortality. Therefore, timely recognition and diagnosis are essential to ensure appropriate management and improve patient outcomes.[4,5] Diagnosing acute appendicitis in children can be challenging due to atypical or variable presentations.[6] While the underlying pathophysiology of appendicitis is well understood, its clinical signs and symptom patterns are often less straightforward, complicating diagnosis. The disease can mimic several other conditions with similar clinical manifestations, prompting the development of clinical scoring systems to aid detection and management.[7] This challenge is particularly pronounced in pediatric patients, who may struggle to communicate symptoms or describe the criteria used in such scoring systems.

Given the risks associated with ionizing radiation from computed tomography (CT), ultrasound (US) has emerged as the preferred first-line imaging modality for evaluating suspected appendicitis in children. Professional guidelines, including those from the

American college of emergency physicians and the American college of radiology, recommend ultrasound as the primary imaging approach for pediatric appendicitis.[8-10] Ultrasound provides dynamic visualization of the abdominal organs, avoids exposure to radiation and is generally more cost-effective compared to CT.[11-13] While other imaging modalities such as magnetic resonance imaging (MRI) and CT can complement the clinical diagnosis and offer higher sensitivity and specificity, their limited availability, cost and, in the case of CT, radiation exposure make ultrasound the preferred initial choice.[14]

Multiple studies have demonstrated that ultrasound achieves high sensitivity and specificity in diagnosing appendicitis, with reported ranges between 85–100% for sensitivity and 89–98% for specificity, particularly when examinations are performed by radiologists skilled in pediatric sonography.[15-20] However, the operator-dependent nature of ultrasound may result in lower accuracy in some settings.[21] Despite being considered a first-line, safe and cost-effective diagnostic tool, limitations remain, including variability in visualizing the appendix and potential for false-positive or false-negative findings.[22,23]

Appendix visualization on ultrasound has been reported to range widely from 29% to 99% of cases. In situations where the appendix is not directly seen and the imaging result is inconclusive, secondary sonographic indicators, such as free fluid, periappendiceal fat changes or the presence of an appendicolith, can help support a diagnosis, although their absence may indicate a negative study. Variability in operator skill and interpretation underscores the importance of experience and expertise in obtaining reliable diagnostic results with ultrasound.[24]

Despite the widespread acceptance of ultrasound as the preferred first-line imaging modality for suspected pediatric appendicitis, considerable variability persists in its diagnostic performance across different clinical settings. Reported differences in sensitivity, specificity and appendix visualization rates reflect the influence of factors such as operator expertise, patient characteristics and institutional imaging protocols. Moreover, most published data originate from high-resource settings and there remains limited evidence evaluating the real-world diagnostic yield of ultrasound in pediatric populations from developing countries, where access to advanced imaging modalities may be restricted and ultrasound often serves as the primary diagnostic tool.

The absence of consistent local data assessing both the strengths and limitations of ultrasound underscores the need for institution-specific evaluation to better define its diagnostic reliability and practical challenges in routine clinical practice. The purpose of the study is to evaluate the diagnostic yield and limitations of ultrasound as a first-line imaging modality in children with suspected acute appendicitis.

Objective

To evaluate the diagnostic yield and limitations of ultrasound as a first-line imaging modality in children with suspected acute appendicitis.

METHODS

This prospective observational study was conducted at the Department of Radiology and Imaging, Bangladesh Shishu Hospital & Institute, Bangladesh, from June 2023 to July 2024. A total of 100 pediatric patients suspected of acute appendicitis were enrolled, selected based on predefined inclusion and exclusion criteria. Data were collected to evaluate the diagnostic yield and limitations of ultrasound as a first-line imaging tool in children with suspected appendicitis.

Inclusion criteria

It includes children aged 4–16 years, presenting with clinical signs suggestive of appendicitis, including: abdominal pain, tenderness, vomiting, elevated inflammatory markers, suspected acute appendicitis based on initial clinical evaluation.

Exclusion criteria

Prior abdominal surgery, known congenital abdominal anomalies, contraindications to ultrasound examination, patients who declined participation or whose guardians did not provide consent.

All participants underwent abdominal ultrasound examination performed by experienced radiologists using high-frequency linear and curvilinear transducers. The appendix was assessed for visualization, wall thickness, diameter, compressibility, periappendiceal fluid and secondary signs of inflammation and findings were categorized as appendix visualized, appendix not visualized, features suggestive of appendicitis or normal appendix. The final diagnosis of appendicitis was confirmed by surgical findings and histopathology for patients who underwent appendectomy. For patients managed conservatively, the diagnosis was based on clinical follow-up and symptom resolution.

Demographic information, ultrasound findings and final diagnoses were recorded using a standardized data collection form. The correlation between ultrasound results and final diagnosis was analyzed and diagnostic performance metrics, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and overall accuracy, were calculated. All data were analyzed using SPSS version 25.0, with continuous variables presented as mean±standard deviation (SD) and categorical variables expressed as frequency (n) and percentage (%). Diagnostic performance metrics were derived from 2×2 contingency tables comparing ultrasound findings to the final diagnosis.

RESULTS

Table 1 summarizes the demographic characteristics of the study participants. The mean age of the children was 10.27±3.33 years, with nearly half (48%) aged 11–16 years. There was a slight male predominance, with 58% of participants being male. Table 2 shows the ultrasound findings of the study participants. The appendix was visualized in 78% of cases, while it was not visualized in 22%. Among visualized appendices, 55% showed features suggestive of appendicitis, whereas 23% appeared normal.

Figure 1 presents the final diagnosis of the study participants. Acute appendicitis was confirmed in 60% of cases based on surgical findings, histopathology and/or clinical follow-up, while 40% were diagnosed as not having appendicitis.

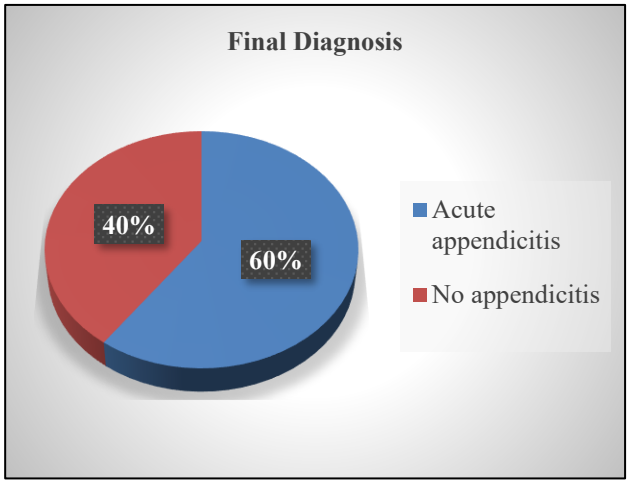

Figure 1: Final diagnosis of the study participants (n=100).

Table 3 demonstrates the correlation between ultrasound findings and the final diagnosis. Ultrasound correctly identified appendicitis in 52 cases, while 8 cases were false negatives. There were 5 false-positive cases.

Table 4 summarizes the diagnostic performance of ultrasound in detecting paediatric appendicitis. Ultrasound demonstrated high sensitivity (86.7%) and specificity (87.5%), with a positive predictive value of 91.2% and an overall diagnostic accuracy of 87.0%.

Table 1: Demographic characteristics of the study population (n=100).

Variable		Number (N)	(%)
Age (in years)	4–6	18	18.0
	7–10	34	34.0
	11–16	48	48.0
	Mean age (in years) 10.27±3.33		
Sex	Male	58	58.0
	Female	42	42.0

Table 2: Ultrasound findings in the study population (n=100).

Ultrasound finding	Number (N)	(%)
Appendix visualized	78	78.0
Appendix not visualized	22	22.0
Features suggestive of appendicitis	55	55.0
Normal appendix	23	23.0

Table 3: Correlation between ultrasound findings and final diagnosis (n=100).

Ultrasound result	Appendicitis present	Appendicitis absent	Total
Positive	52 (True positive)	5 (False positive)	57
Negative	8 (False negative)	35 (True negative)	43
Total	60	40	100

Table 4: Diagnostic performance of ultrasound in detecting paediatric appendicitis.

Parameter	Value (%)
Sensitivity	86.7
Specificity	87.5
Positive predictive value (PPV)	91.2
Negative predictive value (NPV)	81.4
Diagnostic accuracy	87.0

DISCUSSION

Acute appendicitis is a frequent surgical emergency in children and timely diagnosis is essential to reduce morbidity and prevent complications such as perforation and peritonitis. Ultrasound, as a radiation-free and readily available imaging modality, plays a pivotal role in the initial evaluation of children with suspected appendicitis. The findings of the present study demonstrate that ultrasound offers good diagnostic performance, with high sensitivity, specificity and overall accuracy in detecting pediatric appendicitis. These results highlight the clinical value of ultrasound as a first-line imaging tool while also emphasizing the need to recognize its limitations, particularly in cases of non-visualization, to ensure optimal diagnostic decision-making.

The demographic characteristics of our study population were consistent with previous reports in pediatric appendicitis. The mean age in our cohort was 10.27±3.33 years, with nearly half of the patients (48%) aged 11–16 years, which is comparable to Pedram et al who reported a mean age of 11.44 ± 2.90 years among 230 children aged 5–15 years and Gilligan et al with a mean age of 9.9±4.2 years in 9,283 pediatric ultrasound exams.[25,26] Our population was slightly male-predominant (58% males), aligning closely with Hajalioghli et al who

reported 61.2% males among 121 children and Gilligan et al, who observed 58.2% boys.[27] These findings indicate that the age distribution and male predominance in pediatric appendicitis are broadly consistent across different cohorts, supporting the representativeness of our study population. Building on this, the evaluation of appendiceal visualization on ultrasound provides further insight into diagnostic accuracy.

In our study, the appendix was visualized on ultrasound in 78% of cases, which is higher than the visualization rates reported by Reddan et al, (~40.7%) and Pop et al, (65.3%).[28] This difference may reflect variations in sonographer experience, patient body habitus or imaging protocols. Consistent with Pop et al also included secondary sonographic findings when the appendix was not visualized, which accounted for 22% of cases.[29] Among visualized appendices, 55% demonstrated features suggestive of appendicitis, while 23% appeared normal, supporting the utility of ultrasound not only in direct visualization but also in identifying pathological changes. This evidence reinforces that, although visualization rates may vary across studies, ultrasound remains a valuable first-line tool in the evaluation of pediatric appendicitis.

Acute appendicitis was confirmed in 60% of cases in our study, while 40% of children with suspected appendicitis were ultimately found not to have the disease. This finding aligns with previous studies highlighting that a substantial proportion of clinically suspected cases do not result in confirmed appendicitis. For instance, Kaymakci et al reported that among 449 children, 392 (91.6%) had confirmed appendicitis, with 8.4% showing a normal appendix on histopathology, whereas Aman et al found that 78.5% of suspected cases were confirmed, leaving a notable fraction negative.[30,31] These studies, together with our findings, emphasize that while clinical suspicion is critical, definitive diagnosis often requires imaging and/or histopathological confirmation, underscoring the importance of accurate diagnostic modalities such as ultrasound in pediatric appendicitis evaluation.

In the study, ultrasound findings demonstrated good concordance with the final diagnosis, with 52 true positives, 35 true negatives, 5 false positives and 8 false negatives. These results are comparable to previous studies: Hajalioghli et al reported 54 true positives and 62 true negatives among 121 children, with minimal false results, highlighting the reliability of ultrasound in pediatric appendicitis.[27] Similarly, Reddan et al documented a large number of true positive and true negative findings, supporting the general accuracy of sonographic assessment.[28] Palhapati et al in a cohort of 100 children, observed 65 true positives and 35 true negatives, further confirming that ultrasound consistently identifies the majority of appendicitis cases while minimizing misdiagnoses.[32] Together, these studies and our results underscore that ultrasound is a dependable first-line imaging tool for evaluating suspected appendicitis in children, demonstrating strong correlation with surgical and pathological outcomes. The diagnostic performance of ultrasound in our study demonstrated a sensitivity of 86.7%, specificity of 87.5%, PPV of 91.2%, NPV of 81.4% and an overall accuracy of 87.0%, indicating good reliability in detecting pediatric appendicitis. These findings are consistent with previous reports: Jangid et al, found slightly higher performance with a sensitivity of 93.6%, specificity of 90.9%, PPV of 93.6%, NPV of 91.0% and overall accuracy of 92.5%, highlighting the excellent diagnostic capability of ultrasound in children.[33]

Similarly, Oh et al in a meta-analysis including over 1,000 pediatric patients, reported pooled sensitivity and specificity of approximately 87% and 93%, respectively, supporting the moderate to high diagnostic value of ultrasound across diverse settings.[34] Balbo et al evaluating 62 children with point-of-care ultrasound in the emergency department, observed a sensitivity of 88%, specificity of 90%, PPV of 90.6% and NPV of 86.6%, emphasizing that ultrasound is highly effective when performed by trained clinicians.[35] Collectively, this body of evidence corroborates our results, confirming that ultrasound is a reliable first-line imaging modality for the evaluation of suspected appendicitis in the pediatric population.

Limitations

Single-center study with a limited sample size, which may limit the generalizability of the results. The sample size was relatively small.

CONCLUSION

Acute appendicitis is a common cause of abdominal pain in children and timely, accurate diagnosis is crucial to prevent complications. Ultrasound is an effective first-line imaging tool, demonstrating high diagnostic performance. Although the appendix could not be visualized in some cases, ultrasound reliably identified the majority of true appendicitis cases and can reduce the need for more invasive or radiation-based imaging. Awareness of its limitations is essential for optimal clinical decision-making.

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