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Diagnostic utility of ultrasonography in acute appendicitis: A prospective study

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Abstract

Background: Acute appendicitis is a common cause of acute abdominal pain, requiring accurate and timely diagnosis. Ultrasonography (USG) offers a non-invasive, cost-effective diagnostic tool. This study aimed to evaluate the role of direct and indirect USG signs in diagnosing acute appendicitis and predicting complications such as perforation.

Materials and Methods: This prospective study was conducted at the Department of Radio-diagnosis, Madha Medical College, Chennai, over one year. Seventy-five patients with suspected acute appendicitis were included based on predefined criteria. All patients underwent ultrasonographic evaluation using Toshiba Xario with graded compression techniques. Histopathological examination of resected specimens served as the diagnostic gold standard. Data were analyzed using SPSS, with $p < 0.05$ considered significant.

Results: Direct signs, including an enlarged and non-compressible appendix, were highly prevalent (91%), confirming their reliability. Indirect signs such as probe tenderness (95%) and mesenteric fat echogenicity (92%) were most common. Hypoperistalsis emerged as a significant predictor of perforation ($P=0.003$). Pediatric patients exhibited higher rates of mesenteric lymphadenopathy (52%) and appendicolith (32%) compared to adults. Overall, 92% of cases were unequivocally diagnosed using USG.

Conclusion: USG demonstrates high diagnostic accuracy in acute appendicitis, with indirect signs playing a critical role in complex cases. Hypoperistalsis and thickened caecal wall were reliable markers for predicting perforation. These findings support the utility of USG in diverse clinical settings.

Keywords: Acute appendicitis, ultrasonography, perforation, direct signs, indirect signs, diagnostic imaging

Introduction

Acute Appendicitis (AA) is among the most common causes of acute abdominal pain requiring surgical intervention, with accurate and timely diagnosis being critical to patient outcomes. Ultrasonography (US) has emerged as a widely used, non-invasive diagnostic modality due to its accessibility, safety, and cost-effectiveness. Its ability to provide real-time imaging of the appendix and surrounding structures makes it particularly valuable in settings where radiation exposure or contrast use is undesirable, such as in pediatric and pregnant populations [1]. Despite its advantages, the diagnostic accuracy of US varies significantly, often influenced by operator experience, patient factors, and the ultrasonographic criteria used. Studies have explored various US findings, including appendiceal diameter, wall thickness, peri-appendiceal fluid, and echogenicity, to establish their individual and combined diagnostic value [2]. These findings are not universally conclusive; their sensitivity and specificity depend on factors such as appendiceal location, coexisting pathologies, and even patient body habitus [3].

For example, an appendiceal diameter exceeding 6 mm, considered a hallmark of AA, has shown variability in sensitivity across different populations and clinical settings [4]. Other findings, such as the presence of free fluid, increased echogenicity in peri-appendiceal fat, and a non-compressible tubular structure, often complement the diameter criterion to enhance diagnostic precision [5]. However, challenges persist in interpreting equivocal cases where these findings overlap with other inflammatory or gastrointestinal conditions [6]. This necessitates the critical appraisal of each ultrasonographic sign to delineate its role in accurate diagnosis.

Furthermore, integrating ultrasonographic findings with clinical scoring systems like the Alvarado score or advanced imaging modalities like computed tomography has been proposed to improve diagnostic reliability [7]. Yet, balancing diagnostic efficacy with resource constraints and patient safety remains a critical consideration, particularly in low-resource settings where US often serves as the primary diagnostic tool [8]. This study aims to systematically evaluate the diagnostic significance of individual ultrasonographic findings in acute appendicitis, identifying their strengths, limitations, and potential roles in refining diagnostic algorithms.

Materials and Methodology

This prospective study was conducted in the Department of Radio-diagnosis, Madha Medical College, Chennai, over one year from March 2018 to February 2019. The sample size comprised 75 patients who were recruited based on predefined inclusion and exclusion criteria. The study included patients presenting with suspected acute appendicitis to the emergency department, general surgery outpatient department (OPD), or pediatric surgery OPD. Only those who underwent emergency surgery within the institution were considered eligible for inclusion. Patients managed conservatively, those refusing ultrasound or surgery, and individuals with alternate diagnoses on Ultrasonography (USG) were excluded. Cases where all direct and indirect signs of acute appendicitis were not assessed or documented were also excluded.

Sampling and Consent

Patients referred from various departments were screened against the inclusion and exclusion criteria. No specific sampling strategy was applied, ensuring the selection process was unbiased by the histopathological findings. Baseline demographic and clinical data were recorded using a structured proforma. Written informed consent was obtained from each patient or their guardians, as applicable. For pediatric patients, assent was secured in accordance with ethical guidelines.

Ultrasonography Protocol

All ultrasonographic examinations were conducted using the TOSHIBA XARIO ultrasound scanner. A low-frequency curved array transducer (1.9-6 MHz) was employed for initial abdominal surveys, while a high-frequency linear transducer (5-11 MHz) was used for focused scanning of the right iliac fossa (RIF) with graded compression techniques. The graded compression method introduced by Puylaert in 1986 was utilized to improve the visualization of the appendix. Additional techniques, including posterior manual compression and scanning in the left lateral decubitus position, were employed when necessary, especially in patients with retrocecal or subhepatic appendix locations. All scans were performed and interpreted by experienced radiologists who were aware of the patients' clinical presentations. Representative images were documented, and discrepancies, if any, were reviewed collectively. Histopathological examination of the resected appendix served as the gold standard for diagnosis, and data on histological findings were systematically recorded for comparison. Data were analyzed using SPSS software. Continuous variables were compared using the t-test, while categorical

variables were assessed using the chi-square test. Multivariate analysis was conducted for significant variables from bivariate analysis, with a p-value < 0.05 considered statistically significant.

Results

This study highlights the diagnostic accuracy of Ultrasonography (USG) in evaluating acute appendicitis, demonstrating the importance of both direct and indirect signs in clinical decision-making.

A larger proportion of patients belonged to the adult group (60%) compared to the pediatric group (40%), with a mean age of 23 years. Male patients predominated (61%), and the majority underwent surgery within 12 hours of USG (55%), reflecting the emphasis on timely intervention. Uncomplicated appendicitis accounted for 60% of cases, while 36% presented with complications, demonstrating the spectrum of disease severity.

Table 1: Baseline Characteristics of the Study Population (N=75)

Characteristic		Frequency
Age (in years)	Pediatric (< 18 years)	30 (40%)
	Adult (≥ 18 years)	45 (60%)
Gender Distribution	Male	46 (61%)
	Female	29 (39%)
Time Between USG and Surgery	Within 12 hours	41 (55%)
	Between 12-24 hours	34 (45%)
Surgical Findings	Uncomplicated appendicitis	45 (60%)
	Complicated appendicitis	27 (36%)
	No appendicitis detected	3 (4%)

Direct signs, including an enlarged appendix and non-compressibility, were highly prevalent (91% each), establishing their reliability as diagnostic markers. Among indirect signs, probe tenderness (95%) and mesenteric fat echogenicity (92%) were most common, underscoring their diagnostic significance. Other indirect signs such as free fluid (52%), hypoperistalsis (48%), and mesenteric lymphadenopathy (36%) provided additional diagnostic value, particularly in more severe cases.

Table 2: Incidence of Ultrasonographic Signs

Sign		Frequency
Direct Signs	Enlarged appendix (>6mm)	68 (91%)
	Non-compressible appendix	68 (91%)
	Appendicular wall hyperemia	38 (50.6%)
	Appendicolith	16 (21%)
Indirect Signs	Loss of wall stratification	14 (19%)
	Probe tenderness	71 (95%)
	Increased mesenteric fat echogenicity/thickness	69 (92%)
	Free fluid	39 (52%)
	Hypoperistalsis	36 (48%)
	Mesenteric lymphadenopathy	27 (36%)
	Increased vascularity	38 (50%)
Focal fluid collection	6 (8%)	

While probe tenderness and mesenteric fat echogenicity were consistently high across both groups, differences emerged in other signs. Pediatric patients exhibited a higher incidence of mesenteric lymphadenopathy (52%) and appendicolith (32%), while adults showed more frequent hypoperistalsis (57%). These variations suggest age-specific diagnostic patterns that could influence clinical assessment.

Table 3: Comparison of Findings in Pediatric vs. Adult Age Groups

Ultrasonographic Signs	Pediatric (N=30)	Adult (N=45)
Probe tenderness	96% (29)	93% (42)
Mesenteric fat echogenicity	90% (27)	93% (42)
Hypoperistalsis	36% (11)	57% (25)
Mesenteric lymphadenopathy	52% (16)	24% (11)
Appendicolith	32% (10)	13% (6)
Hyperemia	64% (19)	41% (18)

92% of cases were unequivocally positive, with only 1.5% classified as unequivocally negative. This high proportion of positive cases highlights the diagnostic precision of USG.

Table 4: USG Probability Criteria

Criteria	Number of Cases
Unequivocally positive	69 (92%)
Probably positive	5 (6.5%)
Unequivocally negative	1 (1.5%)

Among the indirect signs analyzed, hypoperistalsis showed the strongest association with perforation, with a sensitivity of 71% and a p-value of 0.003, highlighting its predictive significance. This indicates that hypoperistalsis, though not the most prevalent sign overall, is a critical marker for identifying more severe cases requiring urgent intervention. Mesenteric lymphadenopathy was present in 38% of cases with perforation and had a specificity of 70%, suggesting its moderate diagnostic utility. Its higher prevalence in pediatric patients compared to adults may further inform its application in different age groups. Thickened caecal wall, while less common (24% sensitivity), demonstrated high specificity (84%) and a significant p-value (0.01), making it a valuable finding when present, particularly in ruling in perforation.

Table 5: Diagnostic value of ultrasonographic signs in predicting perforation

Sign	Sensitivity	Specificity	P-Value
Hypoperistalsis	71%	62%	0.003
Mesenteric lymphadenopathy	38%	70%	0.02
Thickened caecal wall	24%	84%	0.01

Discussion

Acute appendicitis remains one of the leading causes of acute abdominal pain, requiring rapid and accurate diagnosis to mitigate complications like perforation. This study aimed to evaluate the diagnostic accuracy of Ultrasonography (USG) by examining direct and indirect signs across a diverse patient demographic. Its findings contribute to the growing body of evidence supporting USG as a reliable tool for assessing appendicitis, especially in resource-limited settings.

The results align with earlier studies. Zielke *et al.* emphasized the high sensitivity of direct signs, such as an enlarged and non-compressible appendix, findings that were consistent in this study, with both signs present in 91% of cases [9]. Similarly, Puylaert *et al.* [10] and Birnbaum *et al.* [11] demonstrated the utility of indirect signs like probe tenderness and mesenteric fat echogenicity, which were highly prevalent in this study (95% and 92%, respectively). Differences were observed in hypoperistalsis, which emerged as the most significant predictor of perforation (P=0.003). Previous studies, including Jeffrey *et al.* [11], had

not emphasized its predictive utility, suggesting a need for further evaluation. Mesenteric lymphadenopathy showed higher prevalence in pediatric cases (52%), consistent with Rettenbacher *et al.* [12] findings of age-related variations in ultrasonographic signs. However, appendicolith was less frequent in adults (13%) compared to children (32%), diverging from earlier research by Sivit *et al.* [13], which reported no significant age-based difference.

The specificity of thickened caecal wall (84%) for perforation aligns with the work of Poortman *et al.* [14], who highlighted its diagnostic significance in complicated cases. The overall high positivity rate of USG findings (92% unequivocally positive) underscores its reliability, as previously documented by Birnbaum *et al.* [11].

Conclusion

This study confirms ultrasonography as a reliable diagnostic tool for acute appendicitis, with both direct and indirect signs contributing significantly to diagnostic accuracy. Direct signs like appendix enlargement and non-compressibility remain essential markers, while indirect signs such as hypoperistalsis provide valuable insights into complications like perforation. Age-specific variations in findings underline the importance of tailored diagnostic approaches. These results reinforce the role of USG as an indispensable modality in managing suspected appendicitis.

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Conflicts of Interest: None declared.

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