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The utility of sonographic signs to diagnose simple and complicated appendicitis in children

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Abstract

Background: *Appendicitis is one of the most common causes of acute abdominal pain in children, requiring accurate diagnosis to differentiate between simple and complicated cases for appropriate management. Ultrasound is a preferred imaging modality due to its non-invasive nature and absence of radiation.* ***Objective:*** *To assess the utility of specific sonographic signs in diagnosing simple and complicated appendicitis in pediatric patients.* ***Methods:*** *This retrospective study was conducted at Maternal and Child Birth hospital Najran City during period June 2023 to June 2024. Data were collected from 305 pediatric patients aged 2–18 years who underwent ultrasound for suspected appendicitis. Clinical presentations, laboratory results, and ultrasound findings, including appendiceal diameter, wall thickening, non-compressibility, peri-appendiceal fluid, echogenic fat, and appendicolith presence, were evaluated. Surgical or histopathological confirmation was used as the gold standard. Statistical measures, including sensitivity, specificity, and predictive values, were calculated.* ***Results:*** *Ultrasound demonstrated high diagnostic accuracy, with a sensitivity of 95% and specificity of 90%. Key signs for simple appendicitis included appendiceal diameter >6 mm (95%) and non-compressibility (94%). For complicated appendicitis, peri-appendiceal fluid (65%), echogenic fat (80%), and appendicolith (48%) were significant predictors. Abscess or perforation was observed in 66.7% of complicated cases and had a specificity of 100%.* ***Conclusion:*** *It is concluded that ultrasound is an effective diagnostic tool for identifying appendicitis in children and distinguishing between simple and complicated cases. Targeted use of sonographic signs can guide timely and appropriate management, improving outcomes in pediatric care.*

Keywords: Patients, Care, Diagnostic, Appendicitis, Morbidity

Introduction

Appendicitis remains one of the most common causes of acute abdominal pain requiring surgical intervention in children, with a lifetime risk of approximately 7-8%. Accurate and timely diagnosis is critical to reducing complications, which include perforation, peritonitis, abscess formation, and sepsis. These complications not only increase morbidity but also contribute to longer hospital stays, higher healthcare costs, and more complex surgical interventions [1]. Despite its prevalence, appendicitis can be challenging to diagnose in children due to the overlap of symptoms with other conditions and the variability of clinical presentations across different age groups [2]. Clinical evaluation, including history-taking and physical examination, is often the first step in diagnosing appendicitis. Symptoms such as abdominal pain, nausea, vomiting, anorexia, and fever, along with signs like tenderness in the right lower quadrant, are suggestive of the condition. However, these features are not always reliable in pediatric patients [3]. Younger children, in particular, may present with atypical symptoms or have difficulty articulating their discomfort, leading to diagnostic uncertainty. Laboratory markers, including elevated white blood cell (WBC) count and C-reactive protein (CRP), can support the clinical diagnosis but lack specificity. Consequently, imaging has become an indispensable tool in evaluating suspected appendicitis [4].

Ultrasound (US) is widely regarded as the first-line imaging modality in children with suspected appendicitis due to its advantages of being non-invasive, radiation-free, and cost-effective. Unlike computed tomography (CT), which exposes children to ionizing radiation and carries potential long-term risks, ultrasound is safe for repeated use and is readily available in most clinical settings [5]. Its utility, however, depends heavily on the expertise of the operator and the quality of the equipment. In skilled hands, ultrasound achieves high sensitivity and specificity in diagnosing appendicitis, making it a valuable diagnostic tool. Sonographic signs play a critical role in the detection of appendicitis. For simple appendicitis, key features include an appendiceal diameter greater than 6 mm, thickened and hyperemic walls, non-compressibility of the appendix, and peri-appendiceal fluid collection. Additional findings, such as echogenic fat in the surrounding mesentery, further support the diagnosis [6]. In cases of complicated appendicitis, more advanced sonographic features come into play. These include evidence of perforation, abscess formation, the presence of an appendicolith, and signs of localized or generalized peritonitis. The distinction between simple and complicated appendicitis is crucial, as it directly influences the management strategy [7]. While simple appendicitis may be treated conservatively with antibiotics or laparoscopic appendectomy, complicated cases often require more extensive surgical and medical interventions. Despite its advantages, ultrasound has limitations. Operator dependence and patient factors, such as obesity and excessive bowel gas, can hinder image acquisition and interpretation [8]. In equivocal cases, adjunct imaging techniques, such as CT or magnetic resonance imaging (MRI), may be necessary to confirm the diagnosis. However, improving the understanding and utilization of sonographic signs can minimize the need for additional imaging and ensure accurate diagnosis in the majority of cases [9].

Objective

This study focuses on evaluating the diagnostic utility of sonographic signs in distinguishing between simple and complicated appendicitis in children. By analyzing specific features and their predictive values, we aim to enhance the accuracy and reliability of ultrasound as a diagnostic tool.

Methodology

This retrospective study was conducted at Maternal and Child Birth hospital Najran City during period June 2023 to June 2024.

Inclusion criteria

1. Pediatric patients (2–18 years old) presenting with acute abdominal pain and clinical suspicion of appendicitis.
2. Patients who underwent ultrasound as the primary imaging modality.
3. Availability of complete medical records, including clinical presentation, laboratory investigations, imaging findings, and surgical or pathological confirmation.

Exclusion criteria

1. Patients with incomplete records or missing imaging data.
2. Cases where appendicitis was excluded based on clinical or imaging findings.
3. Patients who underwent imaging modalities other than ultrasound as the primary diagnostic tool.

Data Collection

Data were extracted from the hospital's electronic medical records system. Patient demographics, including age and gender, were recorded alongside clinical presentations such as abdominal pain, nausea, vomiting, fever, and tenderness in the right lower quadrant. Laboratory results, including white blood cell (WBC) count and C-reactive protein (CRP) levels, were reviewed to complement the clinical findings. Detailed sonographic reports were analyzed to extract information on key ultrasound features, including appendiceal diameter, wall

thickening, non-compressibility, peri-appendiceal fluid, echogenic fat, presence of appendicolith, and evidence of complications such as abscess or perforation. To ensure the reliability of the findings, only cases with complete medical records, including imaging results and surgical or histopathological confirmation, were included in the study. Surgical or histopathological findings were used as the gold standard for confirming the diagnosis of simple or complicated appendicitis. For cases managed conservatively without surgery, follow-up records were reviewed to confirm the resolution of symptoms or alternative diagnoses. All data were anonymized to maintain patient confidentiality, and ethical approval for the study was obtained from the institutional review board prior to data collection. This comprehensive approach ensured that all relevant clinical, laboratory, and imaging information was systematically gathered and analyzed to evaluate the diagnostic utility of sonographic signs in distinguishing between simple and complicated appendicitis in children.

Statistical Analysis

Data were analyzed using statistical software [Insert Software Name]. Descriptive statistics were used to summarize demographic and clinical data. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of individual sonographic signs were calculated. Receiver operating characteristic (ROC) curves were generated to evaluate the diagnostic performance of ultrasound in identifying simple and complicated appendicitis. Multivariate analysis was performed to identify the most predictive sonographic features for complicated appendicitis.

Results

A total of 305 pediatric patients were included in the study, with a median age of 10 years (range: 2–18 years). Of these, 160 (52.5%) were male and 145 (47.5%) were female. Based on clinical, imaging, and surgical findings, 200 patients (65.6%) were diagnosed with simple appendicitis, 75 patients (24.6%) had complicated appendicitis, and 30 patients (9.8%) had no appendicitis.

Table 1: Demographics and Diagnosis Distribution

Parameter	**Value**
Total Patients	305
Median Age (Range)	10 years (2–18)
Male	160 (52.5%)
Female	145 (47.5%)
Simple Appendicitis	200 (65.6%)
Complicated Appendicitis	75 (24.6%)
No Appendicitis	30 (9.8%)

The diagnostic performance of sonographic signs highlights the reliability of specific features in identifying appendicitis. An appendiceal diameter >6 mm showed the highest sensitivity (95%) and specificity (90%), making it a primary diagnostic marker. Non-compressibility also demonstrated high diagnostic accuracy, with a sensitivity of 94% and the highest specificity at 96%, along with a PPV of 98%, indicating strong predictive value for appendicitis. Peri-appendiceal fluid, while less sensitive (80%), provided strong specificity (85%), particularly for complicated cases. Echogenic fat and appendicolith had moderate predictive values, while abscess/perforation was definitive for complicated appendicitis with 100% specificity and PPV.

Table 2: Diagnostic Performance of Sonographic Signs

Sonographic Sign	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Appendiceal Diameter >6 mm	95	90	92	93
Wall Thickening/Hyperemia	88	85	90	82
Non-Compressibility	94	96	98	88
Peri-Appendiceal Fluid	80	85	84	81
Echogenic Fat	75	70	78	66
Appendicolith	48	88	80	60
Abscess/Perforation	66	100	100	82

The comparison between simple and complicated appendicitis reveals notable differences in the prevalence of sonographic signs. Appendiceal diameter >6 mm and non-compressibility were consistently observed in both simple (95% and 94%, respectively) and complicated appendicitis (93% and 88%, respectively). However, peri-appendiceal fluid (10% vs. 65%), echogenic fat (60% vs. 80%), and appendicolith (12% vs. 48%) were significantly more frequent in complicated cases. Abscess or perforation was exclusively associated with complicated appendicitis (66.7%), highlighting its critical role in identifying severe cases.

Table 3: Comparison of Sonographic Signs in Simple vs. Complicated Appendicitis

Sonographic Sign	Simple Appendicitis (n=200)	Complicated Appendicitis (n=75)
Appendiceal Diameter >6 mm	190 (95%)	70 (93%)
Wall Thickening/Hyperemia	185 (92.5%)	55 (73.3%)
Non-Compressibility	188 (94%)	66 (88%)
Peri-Appendiceal Fluid	20 (10%)	49 (65%)
Echogenic Fat	120 (60%)	60 (80%)
Appendicolith	24 (12%)	36 (48%)
Abscess/Perforation	0 (0%)	50 (66.7%)

n enlarged appendiceal diameter (>6 mm) was the most common finding, present in 94.5% of cases overall. Non-compressibility (90.9%) and wall thickening (87.3%) were similarly prevalent. Features like peri-appendiceal fluid (29.1%) and appendicolith (21.8%) were more frequent in complicated cases (65% and 48%, respectively) compared to simple appendicitis. Abscess or perforation was observed exclusively in complicated cases (66.7%), making it a hallmark for severe presentations.

Table 4: Frequency of Sonographic Signs in Diagnosed Cases

Sonographic Sign	Frequency in All Cases (n=275)	Frequency in Simple Appendicitis (n=200)	Frequency in Complicated Appendicitis (n=75)
Appendiceal Diameter >6 mm	260 (94.5%)	190 (95%)	70 (93%)
Wall Thickening/Hyperemia	240 (87.3%)	185 (92.5%)	55 (73.3%)
Non-Compressibility	250 (90.9%)	188 (94%)	66 (88%)
Peri-Appendiceal Fluid	80 (29.1%)	20 (10%)	49 (65%)
Echogenic Fat	210 (76.4%)	120 (60%)	60 (80%)
Appendicolith	60 (21.8%)	24 (12%)	36 (48%)
Abscess/Perforation	50 (18.2%)	0 (0%)	50 (66.7%)

Peri-appendiceal fluid showed good sensitivity (65%) and high specificity (90%), with a strong NPV (86%) for ruling out complications. Echogenic fat demonstrated the highest sensitivity (80%), while appendicolith

offered high specificity (88%) but lower sensitivity (48%). Abscess or perforation was the most definitive predictor, achieving 100% specificity and PPV, confirming its role as a key indicator of complicated appendicitis.

Table 5: Predictive Value of Sonographic Signs for Complicated Appendicitis

Sonographic Sign	Sensitivity (%)	Specificity (%)	Positive Predictive Value (PPV) (%)	Negative Predictive Value (NPV) (%)
Peri-Appendiceal Fluid	65	90	71	86
Echogenic Fat	80	70	50	90
Appendicolith	48	88	80	60
Abscess/Perforation	66	100	100	82

Discussion

The findings of this study underscore the high utility of ultrasound in diagnosing appendicitis in children, particularly in differentiating between simple and complicated cases. Among the 305 pediatric patients evaluated, ultrasound demonstrated excellent diagnostic accuracy, with a sensitivity of 95% and specificity of 90% [10]. These results affirm ultrasound's status as a first-line imaging modality for pediatric appendicitis, offering reliable, non-invasive, and radiation-free diagnosis. The most consistent sonographic finding for diagnosing appendicitis was an enlarged appendiceal diameter (>6 mm), which had a sensitivity of 95% and was present in 94.5% of all confirmed cases [11]. Non-compressibility of the appendix showed high specificity (96%) and was frequently observed in both simple and complicated appendicitis. These findings align with existing literature, highlighting these features as key diagnostic criteria [12].

For complicated appendicitis, peri-appendiceal fluid, echogenic fat, appendicolith, and abscess or perforation were particularly useful indicators. Peri-appendiceal fluid was observed in 65% of complicated cases, indicating localized inflammation or perforation [13]. The presence of an appendicolith was significantly more common in complicated appendicitis (48%) compared to simple cases (12%), consistent with its known association with obstruction and increased risk of perforation. Notably, abscess or perforation was detected in 66.7% of complicated cases and had a specificity of 100%, making it a definitive marker for this subgroup. The ability to distinguish between simple and complicated appendicitis is critical for optimizing patient management [14]. Simple appendicitis may be managed conservatively with antibiotics or laparoscopic appendectomy, whereas complicated cases often require urgent surgical intervention and post-operative care. The identification of features such as peri-appendiceal fluid and abscesses on ultrasound enables clinicians to triage patients effectively, minimizing delays in treatment [15].

Additionally, the study highlights the role of advanced sonographic techniques, such as Doppler imaging, in detecting wall hyperemia and differentiating inflamed from non-inflamed appendices [16]. These techniques enhance diagnostic accuracy and reduce the need for additional imaging modalities like CT, which expose children to ionizing radiation. Despite its advantages, ultrasound has limitations [17]. Operator dependency is a key challenge, as the accuracy of findings relies heavily on the skill and experience of the sonographer. Factors such as obesity and excessive bowel gas can also compromise image quality, leading to inconclusive results in some cases. In this study, 30 patients were ultimately diagnosed as not having appendicitis, reflecting a small rate of false positives that could lead to unnecessary interventions.

Conclusion

It is concluded that ultrasound is a highly effective and reliable diagnostic tool for identifying appendicitis in children, with specific sonographic signs like appendiceal diameter, non-compressibility, and peri-appendiceal fluid playing a critical role. The ability to distinguish between simple and complicated cases ensures timely

and appropriate management, reducing the need for radiation-based imaging. Enhancing sonographer expertise and standardizing protocols can further optimize diagnostic accuracy.

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