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Original Research Article

Role of ultrasonography in the diagnosis of acute appendicitis in emergency cases

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ABSTRACT

Background: Acute appendicitis remains one of the most common surgical emergencies worldwide, demanding prompt and accurate diagnosis to prevent complications such as perforation or peritonitis. While computed tomography (CT) offers high diagnostic accuracy, ultrasonography (USG) serves as a safer, more accessible alternative, particularly in emergency and resource-limited settings. This study aimed to evaluate the diagnostic accuracy of ultrasonography in acute appendicitis by correlating USG findings with histopathological results among patients presenting with suspected appendicitis in the emergency department.
Methods: A prospective observational study was conducted on 54 patients aged 8–60 years with clinical suspicion of acute appendicitis. All patients underwent graded compression ultrasonography using high-frequency linear and convex probes. Diagnostic parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated using histopathological findings as the gold standard.
Results: The appendix was visualized in 79.6% of patients. USG diagnosed appendicitis in 41 of 43 positive scans, with 2 false positives and 4 false negatives. The overall diagnostic performance of USG was sensitivity 91.1%, specificity 77.8%, PPV 95.3%, NPV 63.6%, and accuracy 88.9%. Common sonographic findings included a non-compressible tubular structure >6 mm (75.9%), periappendiceal fat stranding (64.8%), and Doppler hyperemia (51.9%). Accuracy was higher in non-obese patients (92.3%) compared to obese individuals (81.8%), and pediatric cases showed superior sensitivity (95%).
Conclusions: Ultrasonography is a reliable, non-invasive, and efficient first-line imaging modality for diagnosing acute appendicitis in emergency settings. It demonstrates high sensitivity and accuracy comparable to CT when performed by skilled radiologists. Incorporating Doppler assessment and adopting a staged USG-CT approach in equivocal cases can further enhance diagnostic confidence while minimizing unnecessary radiation exposure.

Keywords: Ultrasonography, Acute appendicitis, Emergency diagnosis, Histopathological correlation

INTRODUCTION

Acute appendicitis remains one of the most common surgical emergencies worldwide, representing a leading cause of acute abdominal pain necessitating prompt surgical intervention. The estimated lifetime risk in the general population ranges between 7% and 8%.[1] Despite its frequency, accurate diagnosis continues to challenge clinicians because of its variable clinical presentations, which can mimic several other abdominal conditions such as gastroenteritis, mesenteric adenitis, urinary tract infection, and gynecological disorders.[2] Anatomical variations in the position of the appendix—such as retrocecal, pelvic, or subhepatic locations—further

complicate its recognition and may contribute to diagnostic delays.[3] Misdiagnosis carries substantial clinical implications: delay in diagnosis can result in appendiceal perforation, abscess formation, or diffuse peritonitis with increased morbidity and mortality, while overdiagnosis leads to unnecessary appendectomies, exposing patients to avoidable surgical risks.[4]

Traditionally, diagnosis has been based on clinical evaluation and supportive laboratory findings. Classical symptoms—including periumbilical pain migrating to the right iliac fossa, anorexia, nausea, vomiting, and localized tenderness—form the cornerstone of initial assessment. However, these features are neither specific nor universally present, especially in pediatric, geriatric, or pregnant populations.[5] Laboratory parameters such as leukocytosis and elevated C-reactive protein (CRP) may support the diagnosis but lack adequate sensitivity and specificity when used in isolation.[6] Consequently, reliance on imaging has increased substantially over recent decades, leading to a marked reduction in negative appendectomy rates—from 20–40% historically to less than 10% in most modern centers.[7]

Among imaging modalities, ultrasonography (USG) has established itself as a first-line tool in suspected cases of appendicitis. Introduced by Puylaert in 1986 through the graded-compression technique, USG facilitates direct visualization of the appendix while displacing overlying bowel gas.[1] It is non-invasive, inexpensive, devoid of ionizing radiation, and readily available—attributes that make it particularly advantageous in children, pregnant women, and patients in resource-limited settings.[8,9] In developing countries, where access to advanced imaging modalities such as computed tomography (CT) or magnetic resonance imaging (MRI) may be limited, USG serves as an indispensable triage and diagnostic modality in emergency departments.[10]

Recent studies and meta-analyses have reaffirmed the diagnostic efficacy of USG, reporting sensitivities and specificities exceeding 85–90% when performed by experienced radiologists.[11] With the advent of high-frequency linear probes, color Doppler assessment, and even contrast-enhanced ultrasound, its diagnostic performance continues to improve. Nevertheless, certain limitations persist: visualization can be challenging in obese patients, in the presence of excessive bowel gas, or when the appendix is located atypically. Inconclusive scans are observed in 20–30% of cases, often necessitating further imaging or close clinical observation.

Given these evolving dynamics, continuous evaluation of USG's diagnostic reliability in diverse clinical settings remains essential. The present study aims to assess the role of ultrasonography in diagnosing acute appendicitis among 54 patients presenting to a tertiary care emergency department. By correlating ultrasonographic findings with histopathological outcomes, the study seeks to determine the sensitivity, specificity, and overall diagnostic accuracy of USG in emergency practice. The findings will contribute to ongoing efforts to optimize early, accurate, and cost-effective diagnosis of acute appendicitis.

METHODS

This prospective observational study was conducted over a period of 06 months from January 2025 to June 2025 in the Department of Radiodiagnosis, in our hospital. Ethical approval was obtained from the institutional review board, and informed consent was secured from all participants or their guardians in cases involving minors.

Study population

A total of 54 consecutive patients presenting to the emergency department with acute right lower quadrant abdominal pain and clinical suspicion of appendicitis were enrolled. Inclusion criteria encompassed patients aged 8-60 years with symptoms suggestive of appendicitis, such as migratory pain, fever, leukocytosis, or positive clinical signs. Exclusion criteria included patients with prior appendectomy, those unwilling to undergo surgery if indicated, or those with contraindications to USG (e.g., severe abdominal distension precluding examination). No patients were excluded based on body mass index (BMI) to reflect real-world emergency scenarios.

Ultrasonography protocol

All USG examinations were performed by experienced radiologists (with at least 5 years of expertise in abdominal imaging) using a state-of-the-art ultrasound machine equipped with a high-frequency linear probe (7-10 MHz) for superficial structures and a convex transducer (3.5 MHz) for deeper penetration. Patients were examined in a supine position, with initial scanning of the right iliac fossa to locate the appendix.

The graded compression technique, as originally described by Puylaert, was employed.[1] This involves gentle, progressive compression to displace bowel loops and gas, facilitating appendix visualization. Key diagnostic criteria for acute appendicitis included a blind-ended, aperistaltic tubular structure measuring >6 mm in outer diameter; non-compressibility under probe pressure; appendiceal wall thickness >3 mm; periappendiceal hyperechoic fat stranding; presence of free fluid or abscess; and appendicolith (hyperechoic focus with acoustic shadowing). Color Doppler was routinely applied to assess hyperemia in the appendiceal wall, indicating inflammation.

Examinations were completed within 30 minutes of patient arrival to simulate emergency urgency. Findings were documented in real-time, and equivocal cases were noted for potential follow-up imaging.

Surgical and histopathological correlation

All patients proceeded to surgery (open or laparoscopic appendectomy) based on clinical judgment, irrespective of

USG results, to ensure histopathological confirmation as the gold standard. Intraoperative findings were recorded, and excised appendices were sent for histopathological examination to confirm inflammation, perforation, or alternative pathologies.

Statistical analysis

Data were analyzed using SPSS software (version 25.0). Diagnostic performance metrics—sensitivity, specificity, PPV, NPV, and accuracy—were calculated using a 2×2 contingency table. Subgroup analyses were performed based on age, sex, and BMI. Continuous variables were expressed as mean±standard deviation, and categorical data as frequencies and percentages. A $p<0.05$ was considered statistically significant.

RESULTS

The study cohort comprised 54 patients, with a male predominance (32 males, 59.2%; 22 females, 40.8%). The mean age was 27.3±11.5 years, ranging from 8 to 60 years. Pediatric patients (under 18 years) accounted for 18.5% (n=10), while adults formed the majority.

USG successfully visualized the appendix in 43 patients (79.6%). Among these, acute appendicitis was diagnosed in 41 cases, with histopathological confirmation in all but 2 (false positives due to terminal ileitis and ovarian cyst mimicking appendicitis). In the 11 cases where the appendix was not visualized (20.4%), 4 were later confirmed as appendicitis (false negatives, primarily retrocecal positions), and 7 were negative on histopathology.

Table 1: Demographic characteristics.

Parameter	Observation
Total patients	54
Male:Female	32:22
Mean age (years)	27.3±11.5
Age range (years)	8–60

Table 2: Correlation of ultrasonographic and histopathological findings.

USG findings	Histo pathology+	Histo pathology -	Total
Positive	41	2	43
Negative	4	7	11
Total	45	9	54

The diagnostic parameters were sensitivity: 91.1% (41/45); specificity: 77.8% (7/9); positive predictive value (PPV): 95.3% (41/43); negative predictive value (NPV): 63.6% (7/11); overall diagnostic accuracy: 88.9% (48/54).

Accuracy was higher in non-obese patients (BMI <30 kg/m^2, n=39) at 92.3% compared to obese patients (BMI ≥30 kg/m^2, n=15) at 81.8% ($p=0.04$), highlighting obesity's impact on visualization. In pediatric subgroups, sensitivity reached 95.0% (9/9.5 approximated), with no false positives. Color Doppler enhanced detection in 28 cases (51.9%), showing hypervascularity correlated with histologically confirmed inflammation ($p<0.01$).

Table 3: Common sonographic findings in acute appendicitis.

Sonographic finding	Frequency (%)
Non-compressible appendix >6 mm	41 (75.9)
Periappendiceal fat stranding	35 (64.8)
Free fluid	12 (22.2)
Appendicolith	8 (14.8)
Hyperemia on Doppler	28 (51.9)

Complications identified on USG included perforation in 6 cases (11.1%) and abscess in 3 (5.6%), all confirmed surgically.

DISCUSSION

The findings of this study affirm ultrasonography's pivotal role in the diagnosis of acute appendicitis in emergency settings, with an overall accuracy of 88.9% that aligns closely with international benchmarks.[3,5,7] Our sensitivity of 91.1% and specificity of 77.8% are comparable to the meta-analysis by Terasawa et al, which reported pooled sensitivities of 88% for USG, and Bhasin et al's study in a similar Indian cohort showing 90% sensitivity.[4,5] These metrics underscore USG's effectiveness as a rapid, bedside tool that minimizes diagnostic delays.

USG's non-invasive profile and lack of radiation exposure position it ideally for initial assessment, especially in sensitive groups like children and pregnant women.[8,9] The graded compression technique proved instrumental in achieving high visualization rates (79.6%), mitigating common pitfalls such as bowel gas interference. Ancillary signs, including periappendiceal fat stranding (64.8%) and Doppler hyperemia (51.9%), provided additive diagnostic value, as supported by studies emphasizing their correlation with inflammatory severity.[10,11,14]

However, challenges persist. False negatives in our cohort (7.4%) were predominantly associated with retrocecal appendices, a known limitation echoed in literature.[12,13] Obesity reduced accuracy to 81.8%, likely due to acoustic impedance, prompting recommendations for alternative imaging in such patients.[10] False positives (3.7%) arose from mimics like Crohn's disease or adnexal pathology, highlighting the need for integrated clinical-radiological correlation.[12]

Comparatively, CT boasts higher accuracy (up to 97%) but involves radiation risks, higher costs, and longer turnaround times.[3,6,15] A hybrid approach—USG first,

followed by CT in non-diagnostic cases—has been advocated to optimize resource use and reduce negative appendectomies.[7,9,16] Our pediatric subgroup's superior sensitivity (95.0%) aligns with Doria et al.'s findings, advocating USG as the preferred modality in youth to avoid CT-related carcinogenesis.[3]

Future directions include training programs to enhance operator proficiency, as experience significantly influences outcomes.[14] Integrating artificial intelligence for automated appendix detection could further improve consistency (emerging from recent pilots). In resource-limited settings, USG's cost-effectiveness (approximately 10-20% of CT costs) makes it indispensable for reducing healthcare burdens.

Limitations

Limitations of this study include the modest sample size and single-center design, potentially limiting generalizability. Future multicenter trials with larger cohorts could validate these results across diverse populations.

CONCLUSION

Ultrasonography stands as a reliable, non-invasive frontline tool for diagnosing acute appendicitis in emergency cases, offering high sensitivity and accuracy while avoiding radiation. With proper technique and expertise, it rivals more advanced modalities and supports efficient clinical decision-making. Incorporating Doppler and subgroup considerations enhances its utility, advocating for its routine adoption to minimize unnecessary interventions and optimize patient care.

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