Original Article

Diagnostic Role of Ultrasonography in Severe Acute Appendicitis and Correlation with Age

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Abstract

Background*: The appendix is a narrow, tube-like organ extending from the caecal section of the colon, exhibiting considerable anatomical variation. It contributes to intestinal flora balance, immunological function and the connection between the brain and the digestive system. Appendicitis, inflammation of the appendix, causespain usually starting around the naveland moving to the lower abdomen, worsening withinflammation sometimes develops severe acute condition. The incidence is about 233 per 100,000 annually, peaking in late teens. Acute appendicitis often necessitates emergency surgery, with appendectomy being the preferred treatment. Diagnosis can be challenging without classic symptoms. Diagnosis is supported by ultrasound, complete blood count, CRP testing and computed tomography, with ultrasound preferred due to its safety.*

Objective*: This research aims to analyze the utility of sonography in identifying severe acute appendicitis and to examine its relationship with patient age.*

Methods and Materials*: A cross-sectional study evaluated the role of ultrasonography in detecting acute and severe appendicitis and its correlations with patient age at Community Medical College and Hospital, Mymensingh, Bangladesh, over a one-year period (September 2023 to August 2024). It involved 150 patients, with 113 diagnosed with severe acute appendicitis. Diagnosis relied on clinical assessments and pelvic ultrasonography using high-resolution probes. Histological examination confirmed appendicitisin 100 of 113 cases. Ethical approval and informed consent were obtained. Inclusion criteria included patients below 35 years. Exclusion criteria covered moribund, complicated, unwilling, non-consenting and pregnant patients. Statistical analysis was conducted utilizing SPSS software, version 26, applying descriptive statistical methods.*

Results*: This study involved 150 patients with appendicitis, of whom 113 had acute appendicitis, confirmed in 100 cases by histopathology. The 16-25 age group had the highest incidence of severe acute appendicitis (44% of cases). The majority of patients were male(60%). Ultrasound (USG) showed the appendix in 95% of cases, with a target sign in 95% and 100% had sonographic McBurney's tenderness. USG accuracy included a sensitivity of 94.24% and a specificity of 91.7%. Among 14 USG-negative cases, five were histopathology-positive and nine were negative. Overall, USG demonstrated a diagnostic accuracy of 92.1%.*

Conclusions*: The study confirms ultrasonography (USG) as an effective, non-invasive and cost-efficient tool for diagnosing acute appendicitis. USG aligns well with histopathological findings, showing high sensitivity and specificity. It helps reduce unnecessary surgeries and aids in timely decision-making. Younger males are more frequently affected by appendicitis.*

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Introduction

The appendix is a slender tube originating from the cecum of the colon[1]. Adult appendices are pencil-shaped structures[2]. The appendix extends from the inner rear wall of the cecum and its location can vary[3]. This organ plays a key part in managing the intestinal microbiome. It is crucial for supporting immune function and the neurological connection with the gu[4]. Appendicitis refers to the inflammatory condition of this organ[5]. Pain in the lower right abdomen is most frequently linked to appendicitis. Typically, discomfort begins near the belly button before migrating to the lower abdomen. Symptoms commonly intensify as the inflammation progresses[6]. The incidence of rate of

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appendicitis at 1,349.8 cases per 100,000 population[7]. The incidence of appendicitis gradually rises from birth, peaks in the late teens and declines in the geriatric years[8]. Severe acute appendicitis represents grossly increased wall thickness and irregularity, luminal fecoliths associated with dense collection, likely pus beside the appendix. Appendicitis most frequently occurs in younger individuals. With the current rise in life expectancy, its incidence seems to be increasing within this population[8]. Acute inflammation of the appendix represents the predominant reason for urgent surgical intervention within the abdomen. It ranks among the primary origins of an acute surgical abdomen[9]. Surgical removal of the appendixremains the standard therapy for both acute appendicitis (AA) and its severe form (SAA), carrying a complication rate of 3.1%. When associated with issues such as perforation, this rate can escalate significantly, potentially reaching 47.2%. These adverseoutcomes often result from delayed medical consultation and treatment initiation, alongside individual patient characteristics. AA and SAA pose significant hazards because of their potentially fatal consequences. Therefore, meticulous evaluation is essential in surgical practice to reduce avoidable complications from appendicitis[10]. Typical clinical features are evident in merely 60.0-70.0% of cases[11]. Diagnosis can be challenging when the classic symptom pattern- pain beginning near the navel and shifting to the lower right abdomen- is absent. Conditions related to gynecology can further complicate the diagnostic process[9]. Diagnostic accuracy is enhanced by specific tests, including a complete blood count, CRP level, abdominal ultrasound and helical CT scanning[12]. Ultrasonography has demonstrated high diagnostic accuracy not only for acute appendicitis but also for other pathologies causing right lower quadrant pain[13] .The clear advantages of ultrasound include the absence of ionizing radiation, its non-invasive nature, minimal patient discomfort, ease of acquisition, portability, repeatability and lack of required special preparation. Consequently, in numerous medical facilities, ultrasound has become the preferred initial imaging modality for evaluating suspected acute appendicitis with unclear clinical signs, especially in children and women of reproductive age[9]. Thus, this research seeks to analyze the diagnostic utility of ultrasound in identifying severe acute appendicitis and to determine its relationshipwith the age of patients.

Methods

We performed a cross-sectional study to evaluate the diagnostic role of ultrasonography in detecting severe acute appendicitis and assess the correlation with patient age, conducted at the Department of Imaging in Community Medical College and ospital, Mymensingh, Bangladesh. The duration of the study was 1 year between September 2023 and August 2024. The study involved 150 patients diagnosed with appendicitis, of which 113 were identified as having severe acute appendicitis. The diagnosis of appendicitis and the decision to operate depends mainly on the clinical picture and investigations, such as pelvic ultrasonography. Ultrasound apparatus with high-resolution probes was used for our study. Standard histological examination was conducted for all patientswith acute appendicitis. Histopathological examination confirmed appendicitis in 100 of those 113 cases. Prior to the study, ethical approval was obtained from the institutional ethical committee. Informed consent was obtained from all the patients involved in the study and confidentiality was maintained.

Inclusion Criteria

•All individuals under the age of 35, regardless of gender, who present with clinical suspicion of appendicitis.

Exclusion Criteria

•Patients in a terminal state are unsuitable for surgical intervention.

•Individuals with appendiceal complications such as an abscess or mass.

•Cases where patients decline additional treatment.

•Patients who do not provide consent.

•Pregnant individuals.

•Standardsforassessmentand operational definitions

The detection of an inflamed appendix or a surrounding abscess on ultrasound was classified as a positive finding for severe acute appendicitis. A non-visualized appendix or one measuring under 5mm was documented as a negative finding. When visible, the inflamed appendix's maximal outer diameter was measured with on-screen calipers. The final diagnosis was confirmed by histopathological analysis. For patients not undergoing surgery, the diagnosis was established by reviewing all clinical assessments and subsequent follow-up data. All relevant data were

organized into suitable tables or charts, with explanatory text to ensure clarity. The statistical evaluation was carried out using SPSS, version 26.0. Results are summarized as means ± standard deviations for parametric data, medians with interquartile ranges for non-parametric data and frequencies (percentages) for categorical variables.

Results

This study includes 150 patients diagnosed with appendicitis. Among all, 113 participants had acute appendicitis. Of the 113 patients, 100 cases were confirmed to have appendicitis through histopathological examination. Table shows that the 16-25 age groupshowed the highest occurrence, with 66 cases (44.0%) of severe acute appendicitis, representing over half of the total cases (52.0%). The 6-15 years group had 29 cases (19.33%) and the 26-35 years group had the fewest, with 18 cases (12.00%). Overall, 113 patients (75.33%) had acute appendicitis, while 37(24.67%) had non-acute appendicitis. The study found a higher prevalence of appendicitis in males (60%) compared to females (40.0%) (Figure 1). Out of 100 histopathologically proven cases of acute appendicitis, USG findings revealed that the appendix was visible in 95.0% of the cases and the target sign was also present in 95.0%. Additionally, sonographic McBurney's tenderness (probe tenderness) was noted in all cases (100.0%).

Table I: Age distribution among patients (n=150)

Age group (years)	Acute appendicitis		Severe acute appendicitis		Total	
	n	%	n	%	n	%
6-15	11	7.33	29	19.33	40	26.67
16-25	12	8.00	66	44.00	78	52.00
26-35	14	9.33	18	12.00	32	21.33
Total	37	24.67	113	75.33	150	100.0

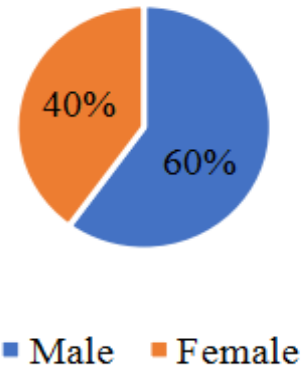


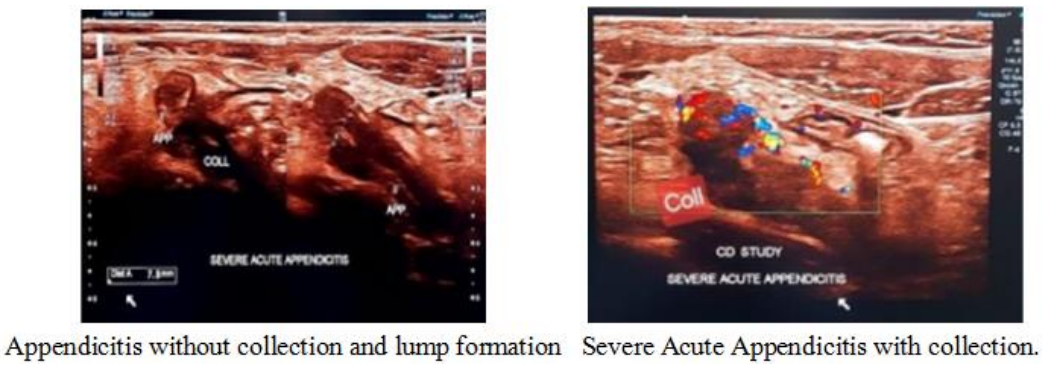
Figure 1: Gender distribution among patients (n=150)

Figure 2: Acute Appendicitis

Additional findings included freefluid in the right iliac fossa in 67.0% of cases, echogenic surrounding mesentery in 81.0%, appendicolith in 7.0% and loss of submucosal integrity in 29.0% of cases (Table II). 79.65% had good results with USG, whereas 20.35% had negative results. In 78.76% patients, HPE confirmed appendicitis, whereas in 1.77% subjects, it was negative. Of the 14 USG-negative patients that underwent surgery, 5(4.42%) were HPE-positive, while 9(7.96%) were HPE-negative. The overall results revealed 88 true positives (77.88%), 18 true negatives (15.93%), 2 false positives (1.77%) and 5 false negatives (4.42%) (Table III). Ultrasound showed a sensitivity of 94.24%, a specificity of 91.7%, a positive predictive value of 97%, a negative predictive value of 82%, and an overall diagnostic accuracy of 92.1% (refer to Table IV).

Table II: USG Findings in Histopathologically Proven Acute Appendicitis (n=100)

USG findings	Number (n)	Percentage (%)
Appendix identification on imaging	95	95.00
Concentric ring appearance in cross-sectional view	95	95.00
Sonographic McBurney's tenderness (probe tenderness)	100	100.00
Appendicolith	07	07.00
Fluid collection in the right lower quadrant	67	67.00
Echogenic surrounding mesentery	81	81.00
Loss of submucosal integrity	29	29.00



Appendicitis without collection and lump formation Severe Acute Appendicitis with collection.

Figure 3-4: Color Doppler shows increased vascularity in the wall of the appendix.

Table III: Corre lation of Ultrasound with Histopathological Examination Report (n=113)

Variables	Frequency (n)	Percentage (%)
USG positive	90	79.65
USG negative	23	20.35
HPE positive	89	78.76
HPE negative	02	01.77
USG negative cases operated	14	12.39
HPE positive	05	4.42
HPE negative	09	7.96
Results		
TRUE positive	88	77.88
TRUE negative	18	15.93
FALSE positive	02	01.77
FALSE negative	05	4.42

Table IV: Diagnostic Role of USG

Evaluation of USG	Value (%)
Sensitivity	94.24
Specificity	91.70
Positive predictive value	97.00
Negative predictive value	82.00
Diagnostic Accuracy	92.10

Discussion

Acute inflammation of the appendix is a leading source of abdominal discomfort necessitating urgent operative care. Identifying its severe form continues to pose a significant diagnostic difficulty, especially when clinical features are atypical and mimicother intra-abdominal conditions[14]. Prompt and precise diagnosis is vital to prevent serious sequelae like perforation, abscess development, or generalized peritoneal inflammation, risks that are heightened in severe cases[15]. Traditionally, diagnosis has relied heavily on clinical evaluation, laboratory findings and imaging techniques. Among these, ultrasonography (USG) has emerged as a non-invasive, readily accessible and cost-effective imaging modality for evaluating patients with suspected appendicitis.This research assesses the utility of ultrasound for diagnosing acute appendicitis and examines how patient age influences its diagnostic accuracy. Evaluating ultrasound's performance across various age brackets aims to guide better imaging approaches for prompt and correct diagnosis, thereby enhancing patient care. Our data indicated the peak incidence of acute appendicitis was within the 16-25-year age range. Age-related prevalence demonstrated that fewer than 19.3% of cases occurred in the 6-15-year group, while over 43.8% affected those above 15 years in Lee et al.'s research[16]. Our results align with the findings of Tariq et al.[6]. Our analysis further showed a higher incidence in males, representing 60.0% of cases versus 40.0% in females. This gender distribution is consistent with the observations of Lamture et al.[17], where males were more frequently affected. Puylaert pioneered the use of graded compression sonography for diagnosing this condition[18]. High-resolution real-time ultrasound is a non-invasive, widely accessible technique that allows direct imaging of an inflamed appendix or adjacent abscess. Comprehensive sonography is also beneficial for patients without clear signs of appendicitis, as it can reveal features suggesting alternative diagnoses- such as mesenteric adenitis, terminal ileitis, or gynecological and urological disorders- as noted by Ooms et al. and Abu- Yousef[13,19]. In this series, ultrasound successfully identified the appendix in 113 out of 150 clinically suspected cases. A separate review documented 70 out of 140 cases of acute appendicitis diagnosed via ultrasound[20]. USG demonstrated its notable effectiveness in diagnosing acute appendicitis. The appendix was visualized in 95.0% of histopathologically confirmed cases and the target sign, a key diagnostic feature, was also present in 95.0%. The presence of sonographic McBurney's tenderness in all cases (100.0%) underscores USG's reliability in detecting acute appendicitis. Additional USG findings, such as free fluid in the right iliac fossa (67.0%), echogenic surrounding mesentery (81.0%), appendicolith (7.0%) and loss of submucosal integrity (29.0%), further support its diagnostic value. Our USG findings from the histological analysis are consistent with the observation of Subash et al.[9]. Among 113 patients, 79.65% of those with positive USG results were confirmed by histopathological examination, while 20.35% of USG-negative cases were also subject to histopathological evaluation. Of the 14 USG-negative patients who underwent surgery, 5(4.42%) had histopathological confirmation of appendicitis and 9 (7.96%) did not. A similar correlation between USG and histopathology was found in another research[9]. This highlights the occasional limitations of USG and the importance of histopathological confirmation in ambiguous cases. The total diagnostic precision of ultrasound for acute appendicitis in our research was 92.1%. Relative to histopathological confirmation, the sensitivity, specificity, positive predictive value and negative predictive value were

94.24%, 91.7%, 97% and 82%, respectively. This indicates that ultra-sonography possesses high diagnostic specificity and sensitivity for this condition. These overall rates align with the findings of Hahn et al. and Tarzan Z et al., where specificity ranged from 90-100% and sensitivity from 70-95%[21,22]. Our sensitivity and specificity figures are also consistent with other investigations[17,23]. These outcomes are comparable to the study by Tauro LF et al., which reported a sensitivity of 91.37%, specificity of 88.09%, positive predictive value of 91.37%, negative predictive value of 88.09% and a diagnostic accuracy of 90.0%[20]. An inflammatory mass following acute appendicitis arises from a contained perforation of the appendix[24].We present a case of acute appendicitis without an associated fluid collection or mass formation (Figure 2). Color Doppler ultrasound findings were deemed positive for appendicitis when enhanced vascularity within the appendiceal wall was observed, as illustrated in Figure 4 of this study.

Limitations of the study

Several limitations exist within this study. The ultrasonography is operator-dependent and variations in skill and experience may affect diagnostic accuracy, which was not standardized across multiple radiologists in this study. Additionally, the exclusion of pregnant patients and moribund individuals reduced the applicability of the results tothese specific groups.

Conclusion

This research underscores the efficacy of ultrasound imaging as a useful diagnostic method for identifying serious acute appendicitis. USG proved to be a reliable, non-invasive and cost-effective method for diagnosing appendicitis, particularly in patients with clear clinical presentations. The study demonstrated a strong correlation between USG findings and histopathological confirmation, supporting its use as an initial imaging modality in cases of suspected acute appendicitis and severe acute appendicitis. Furthermore, USG displayed high sensitivity and specificity, making it useful in reducing unnecessary surgeries and aiding in prompt decision-making for surgical intervention. Age emerged as a significant variable in the incidence of acute appendicitis, with a higher prevalence observed among younger populations, particularly males.

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