

## ORIGINAL ARTICLE

## Diagnostic accuracy of ultrasonography in diagnosing acute appendicitis taking histopathology as gold standard

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### Abstract:

Acute appendicitis is one of the most common surgical emergencies, and timely diagnosis is essential to prevent complications such as perforation, peritonitis, and unnecessary appendectomy. However, its diagnostic performance can vary according to operator expertise, patient characteristics, and visualization of the appendix. Histopathological examination of the removed appendix provides definitive confirmation of acute appendicitis and is commonly used as the reference standard. Objective: To determine the diagnostic accuracy of ultrasonography for detecting acute appendicitis by comparing preoperative ultrasonographic findings with postoperative histopathological examination as the gold standard. Methods: This diagnostic accuracy study included patients presenting with clinical suspicion of acute appendicitis who underwent abdominal ultrasonography followed by appendectomy. Ultrasonographic findings suggestive of appendicitis, including a non-compressible blind-ending tubular structure, increased appendiceal diameter, wall thickening, periappendiceal inflammation, and associated fluid collection, were recorded. Resected appendix specimens were subjected to histopathological examination. Results: Ultrasonography demonstrated useful diagnostic performance in identifying acute appendicitis. Published evidence using histopathology as the reference standard has reported variable sensitivity and specificity, reflecting differences in patient populations and operator expertise. A meta-analysis reported pooled sensitivity of approximately 77% and specificity of 60%, while other systematic reviews have demonstrated higher diagnostic performance in experienced settings. Conclusion: Ultrasonography is a valuable first-line imaging modality for suspected acute appendicitis and can provide clinically useful diagnostic information without radiation exposure. Nevertheless, because diagnostic accuracy may vary, equivocal ultrasonographic findings should be interpreted alongside clinical assessment and, when appropriate, further diagnostic evaluation. Histopathological examination remains an important reference standard for definitive confirmation. Keywords: Acute appendicitis; ultrasonography; abdominal ultrasound; diagnostic accuracy; histopathology; sensitivity; specificity; appendectomy.

### INTRODUCTION

Acute appendicitis is a quite common abdominal disorder with a lifetime incidence of 7%. Based on clinical and laboratory data, acute appendicitis is considered as a difficult diagnosis and can mimic various medical conditions of urologic, gastrointestinal, or gynecologic origin.<sup>1</sup> In pregnant patients, misdiagnosis and unneeded laparotomy may lead to severe complications and have detrimental consequences on fetal outcome. The degree of inflammation can lead to inconsistent clinical presentation. It has been

reported that the perforation risk in acute appendicitis can increase by 5% every 12 h, meaning that an appendectomy should be performed no later than 36 h after a diagnosis of acute appendicitis is confirmed.<sup>2</sup> Therefore, any delay in diagnosis can lead to adverse effects such as perforation and wound abscesses. On the other hand, mortality rate caused by acute appendicitis is reported to be about 0.25% taking into account all age groups.<sup>3</sup>

Among imaging modalities, computed tomography (CT) is the most sensitive and specific for appendicitis diagnosis. However, exposure to ionizing radiation limits its use, especially in pregnant women and children.<sup>4</sup> A good substitute is ultrasound (US), a non-ionizing imaging method. Its use in pediatric patients has resulted in a significant drop in negative appendectomy rates, which helps to minimize radiation exposure which is especially important in cases involving young patients.<sup>5</sup> The safety profile, affordability, and real-time imaging capabilities of US have

appendicitis specifically within our clinical setting. By comparing ultrasound findings with post-appendectomy histopathology results, we aim to provide locally relevant evidence that can guide clinical decision-making and potentially reduce the rate of negative appendectomies in settings where CT is not a feasible option.

Below is a **sample Results section** with four tables.

made it a popular diagnostic tool for appendicitis since its inception in the 1980s. But when it comes to identifying probable cases of acute appendicitis, graded compression ultrasonography's performance varies greatly.<sup>6</sup> In a study, prevalence of acute appendicitis was found to be 33.33% and sensitivity, specificity of USG in diagnosing acute appendicitis was 38.90% and 89.50% respectively taking histopathology as gold standard.<sup>7</sup> In a local study, sensitivity of ultrasonography was 80% and specificity of ultrasound was 60%.<sup>8</sup> In another local study, overall diagnostic accuracy of ultrasound in the diagnosis of acute appendicitis was 82%, sensitivity 84%, specificity 57%.<sup>9</sup> Sung C et al<sup>10</sup> has shown the sensitivity and specificity of 81.0% and 87.0% respectively.

Although extensive literature exists on the use of ultrasonography in diagnosing acute appendicitis (AA), the findings remain inconsistent across various populations and healthcare settings. Some studies report high diagnostic accuracy, while others highlight limitations in sensitivity and specificity. This variation is largely attributed to factors such as operator dependency, equipment quality, and patient body habitus. Furthermore, in low-resource settings — such as rural or basic health units — CT scans are often unavailable due to cost, infrastructure limitations, or lack of trained personnel. In such contexts, ultrasound remains the most accessible and non-ionizing imaging modality. However, there is a scarcity of locally generated data assessing its diagnostic accuracy when compared to the gold standard of histopathology. Therefore, this study aims to evaluate the diagnostic accuracy of ultrasonography in detecting acute

84

Since you have not provided actual patient-level data, the numerical values are illustrative and should be replaced with your study's real findings. **Results**

A total of **150 patients** with clinical suspicion of acute appendicitis were included in the study. All patients underwent preoperative ultrasonographic examination followed by appendectomy, and the resected specimens were examined histopathologically. Histopathology confirmed acute appendicitis in **126 (84.0%)** patients, whereas **24 (16.0%)** patients had no histopathological evidence of acute appendicitis. Ultrasonography was able to identify features suggestive of acute appendicitis in the majority of patients.

**Table 1. Demographic Characteristics of the Study Participants**

| Characteristic  | Frequency (n) | Percentage (%) |
|-----------------|---------------|----------------|
| Male            | 92            | 61.3           |
| Female          | 58            | 38.7           |
| Age ≤20 years   | 32            | 21.3           |
| Age 21–40 years | 76            | 50.7           |
| Age 41–60 years | 31            | 20.7           |
| Age >60 years   | 11            | 7.3            |
| <b>Total</b>    | <b>150</b>    | <b>100.0</b>   |

**Interpretation:** The study population consisted of 92 males (61.3%) and 58 females (38.7%). The largest proportion of participants belonged to the 21–40-year age group (50.7%), followed by patients aged  $\leq 20$  years (21.3%). Older patients represented a smaller proportion of the study population. Overall, acute appendicitis was more frequently suspected among younger and middle-aged adults, with a male predominance.

Table 2. Comparison of Ultrasonographic Findings with Histopathological Diagnosis

| Ultrasonography | Histopathology Positive | Histopathology Negative | Total      |
|-----------------|-------------------------|-------------------------|------------|
| Positive        | 112                     | 8                       | 120        |
| Negative        | 14                      | 16                      | 30         |
| <b>Total</b>    | <b>126</b>              | <b>24</b>               | <b>150</b> |

**Interpretation:** Ultrasonography correctly identified 112 of the 126 patients with histopathologically confirmed acute appendicitis, representing the true-positive group. Eight patients had positive ultrasonographic findings despite negative histopathology and were categorized as false-positive cases. Fourteen patients with confirmed appendicitis had negative ultrasonographic findings, constituting false-negative cases. Sixteen patients were correctly identified as negative by ultrasonography.

Table 3. Diagnostic Performance of Ultrasonography

| Diagnostic Parameter      | Value (%) |
|---------------------------|-----------|
| Sensitivity               | 88.9      |
| Specificity               | 66.7      |
| Positive Predictive Value | 93.3      |
| Negative Predictive Value | 53.3      |
| Diagnostic Accuracy       | 85.3      |

**Interpretation:** Ultrasonography demonstrated a sensitivity of 88.9%, indicating that it correctly detected most patients with histopathologically confirmed acute appendicitis. Its specificity was

66.7%, demonstrating moderate ability to exclude appendicitis among patients without histopathological confirmation. The positive predictive value was high at 93.3%, while the negative predictive value was 53.3%. The overall diagnostic accuracy of ultrasonography was 85.3%.

Table 4. Distribution of Histopathological Findings

| Histopathological Finding          | Frequency (n) | Percentage (%) |
|------------------------------------|---------------|----------------|
| Acute appendicitis                 | 98            | 65.3           |
| Acute suppurative appendicitis     | 18            | 12.0           |
| Gangrenous/perforated appendicitis | 10            | 6.7            |
| Normal appendix                    | 24            | 16.0           |
| <b>Total</b>                       | <b>150</b>    | <b>100.0</b>   |

**Interpretation:** Histopathological examination confirmed inflammatory changes consistent with acute appendicitis in 126 patients (84.0%). Simple acute appendicitis was the most frequently observed diagnosis, accounting for 98 cases (65.3%), followed by acute suppurative appendicitis in 18 cases (12.0%). Gangrenous or perforated appendicitis was identified in 10 patients (6.7%). A histologically normal appendix was found in 24 patients (16.0%).

Overall, the findings indicate that ultrasonography provided good diagnostic performance for acute appendicitis when histopathological examination was used as the reference standard. Its relatively high sensitivity and positive predictive value suggest that ultrasonography can be an effective initial imaging modality in patients presenting with suspected acute appendicitis.

If you provide your **actual sample size and ultrasound/histopathology numbers**, I can calculate

the exact sensitivity, specificity, PPV, NPV, accuracy, and **p-values** for your paper.

#### **MATERIAL AND METHODS:**

**Study Design:** Cross Sectional validation study.

**Settings:** Department of Surgery, Sheikh Khalifa Bin Zahid Al Niyah Hospital/CMH, Rawalakot, AJK.

**Duration of study:** 6 months after approval of synopsis

**Sample Size:** By using sensitivity and specificity calculator, the calculated sample size is 277 with 95% confidence level, 10% margin of error, prevalence of acute appendicitis as 33.33%<sup>7</sup> and the sensitivity and specificity of USG in diagnosing acute appendicitis as 38.90% and 89.50% respectively.<sup>7</sup>

**Sampling technique:** Non probability, consecutive sampling.

#### **Sample Selection:**

##### **INCLUSION CRITERIA:**

- All patients with suspected acute appendicitis (as per operational definition).
- Patients between 20-60 years of either gender.

##### **EXCLUSION CRITERIA:**

- Appendicular lump
- History of previous abdominal surgery.
- Patients who do not undergo appendectomy
- Pregnant women
- Patients with previously removed appendix (history of appendectomy)
- Patients with generalized peritonitis or hemodynamic instability requiring immediate surgical intervention without imaging
- Patients with known inflammatory bowel disease (e.g., Crohn's disease, ulcerative colitis)
- Patients with other intra-abdominal pathologies confirmed on ultrasound or clinical workup (e.g., ruptured ovarian cyst, ectopic pregnancy)

#### **DATA COLLECTION PROCEDURE:**

After approval from institutional ethical review committee and CPSP, total 193 cases referred to Department of Surgery, Sheikh Khalifa Bin Zahid Al Niyah Hospital/CMH, Rawalakot, AJK, fulfilling inclusion criteria will be selected. An informed consent will be taken from patients. Age, gender, duration of symptoms and place of living will be noted. After this ultrasonography will be done in each patient by a linear transducer (5-7 MHz) or a curvilinear transducer (3.5 MHz), and an appendicitis assessment will be conducted using a graded compression technique. USG will be done by a consultant sonologist (at least 5 years of postfellowship experience) in the presence of researcher and presence or absence of acute appendicitis will be noted as mentioned in operational definition. All patients will then undergo for appendectomy and specimen will be sent to pathology laboratory for histopathology. All this data noted on a specially designed proforma (annexure I).

#### **STATISTICAL ANALYSIS:**

The collected information will be analyzed by using SPSS version 25.0. Shapiro wilk test will be used to check the normality of data. Age, Weight (kg), height (cm), BMI (kg/m<sup>2</sup>) and duration of symptoms will be presented as mean and SD or median (IQR). Frequency and percentage will be calculated for gender, place of living, acute appendicitis on ultrasonography and histopathology (present/absent) will be presented as frequency and percentage. 2x2 contingency table will be used to calculate the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of ultrasonography in diagnosing acute appendicitis, taking histopathology as gold standard. ROC curve and likelihood ratio will be calculated. Stratification will be done for age, gender, BMI, duration of symptoms and place of living and post-stratification diagnostic accuracy will be

calculated. Chi square test will be applied and p-value  $\leq 0.05$  will be taken as significant.

| Acute appendicitis on<br>ultrasonography | Acute appendicitis on<br>histopathology |                                 |
|------------------------------------------|-----------------------------------------|---------------------------------|
|                                          | Present                                 | Absent                          |
|                                          | Present<br>True positive<br>(a)         | Absent<br>False positive<br>(b) |
|                                          | Absent<br>False<br>negative<br>(c)      | True Negative<br>(d)            |

**Sensitivity:**  $a / a+c \times 100$

**Specificity:**  $d / b+d \times 100$

**Positive predictive value:**  $a / a+b \times 100$

**Negative predictive value:**  $d / c+d \times 100$

**Diagnostic accuracy:**  $a+d / a+b+c+d \times 100$

## Discussion

The present study evaluated the diagnostic accuracy of ultrasonography (USG) for acute appendicitis using histopathological examination as the reference standard. In the study population, ultrasonography demonstrated a **sensitivity of 88.9%, specificity of 66.7%, positive predictive value of 93.3%, negative predictive value of 53.3%, and overall diagnostic accuracy of 85.3%**. These findings indicate that ultrasonography was particularly effective in identifying patients who truly had acute appendicitis, although its ability to exclude the disease when the ultrasound result was negative was comparatively limited.

The relatively high sensitivity observed in this study is clinically important because delayed diagnosis of acute appendicitis may increase the risk of perforation, gangrene, and other complications. Previous research has demonstrated considerable variation in the sensitivity of ultrasonography. Giljaca et al., in a

systematic review and meta-analysis using histopathology as the reference standard, reported pooled sensitivity and specificity of 69% and 81%, respectively [1]. In another meta-analysis, Fu et al. reported an overall sensitivity of 77.2% and specificity of 60%, demonstrating that ultrasound performance can vary substantially between clinical settings [1112]. ([Wiley Online Library](#))

The sensitivity of 88.9% in the present study was therefore higher than that reported in several pooled analyses. This difference may be related to differences in operator experience, patient selection, disease prevalence, ultrasound equipment, examination technique, and criteria used to define a positive examination. The diagnostic performance of USG is particularly dependent on visualization of the appendix and recognition of characteristic findings such as a non-compressible blind-ending tubular structure, increased appendiceal diameter, wall thickening, periappendiceal inflammatory changes, and periappendiceal fluid. Meta-analytic evidence has also demonstrated that ultrasonographer experience and patient characteristics contribute to heterogeneity in ultrasound performance [13]. ([PubMed Central \(PMC\)](#))

The **specificity of 66.7%** in this study suggests that some patients without histopathologically confirmed appendicitis may nevertheless demonstrate sonographic abnormalities suggestive of inflammation. False-positive examinations can occur because several other conditions may produce right lower quadrant inflammatory changes or mimic appendicitis. Consequently, ultrasound findings should not always be interpreted in isolation. Clinical history, physical examination, inflammatory markers, and appropriate

clinical scoring systems can improve diagnostic decision-making.

The high **positive predictive value of 93.3%** observed in the present study is noteworthy. This indicates that most patients with a positive ultrasound examination were subsequently confirmed to have appendicitis on histopathology. A positive ultrasound in a patient with a compatible clinical presentation can therefore provide strong support for proceeding toward definitive surgical management. Current WSES recommendations emphasize combining clinical assessment with ultrasonography to improve diagnostic sensitivity and specificity and reduce unnecessary CT examinations [14]. ([PubMed Central \(PMC\)](#))

In contrast, the **negative predictive value of 53.3%** indicates that a negative ultrasound cannot reliably exclude acute appendicitis in patients with persistent clinical suspicion. This is consistent with previous evidence showing that ultrasound has a substantially lower ability to rule out appendicitis than to support the diagnosis in selected patients. Giljaca et al. reported that a negative ultrasound substantially reduced but did not eliminate the probability of appendicitis [1]. ([PubMed](#)) Therefore, patients with inconclusive or negative ultrasound findings but persistent clinical suspicion should undergo further clinical observation, repeat ultrasonography, or another appropriate imaging modality.

The use of ultrasonography as an initial investigation has several practical advantages. It is non-invasive, widely available, relatively inexpensive, and does not expose patients to ionizing radiation. These characteristics make it particularly attractive for children, young adults, and pregnant patients. The WSES guidelines recommend point-of-care

ultrasonography as an appropriate first-line investigation when imaging is indicated, particularly when performed by an experienced operator [15]. ([PubMed Central \(PMC\)](#)) The ACR has similarly recognized ultrasound-based diagnostic pathways as useful for reducing radiation exposure, with CT remaining an important option when ultrasound is inconclusive [16]. ([PubMed](#))

Histopathological examination remains an important reference standard in studies evaluating diagnostic accuracy because it provides microscopic confirmation of inflammatory changes in the appendix. In the present study, histopathology confirmed appendicitis in 126 of 150 patients, while 24 specimens were histologically normal. The presence of histologically normal appendices highlights the importance of improving preoperative diagnostic accuracy because unnecessary appendectomy exposes patients to operative risks without therapeutic benefit. Contemporary guidelines emphasize risk stratification and the integration of clinical findings with imaging to reduce negative appendectomy while maintaining timely treatment of true appendicitis [17]. ([PubMed Central \(PMC\)](#))

Overall, the findings support ultrasonography as a useful **first-line diagnostic modality** for suspected acute appendicitis, particularly when performed by experienced personnel and interpreted alongside clinical findings. However, its moderate specificity and relatively low negative predictive value demonstrate that a negative or equivocal examination should not independently exclude appendicitis. A conditional imaging strategy, in which CT or another appropriate modality is considered after an inconclusive ultrasound, can improve diagnostic certainty while

limiting unnecessary radiation exposure [18]. ([PubMed Central \(PMC\)](#))

## Conclusion

Ultrasonography demonstrated good diagnostic accuracy for the evaluation of acute appendicitis when histopathological examination was used as the gold standard. Its high sensitivity and positive predictive value indicate that it can be an effective first-line

imaging modality in patients with suspected acute appendicitis. However, the relatively lower specificity and negative predictive value suggest that a negative or inconclusive ultrasound examination should not independently exclude the diagnosis. Integrating ultrasonographic findings with clinical assessment and, when necessary, additional imaging can improve diagnostic confidence and reduce unnecessary appendectomies.

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