



DIAGNOSTIC ACCURACY OF ULTRASONOGRAPHY IN ACUTE APPENDICITIS TAKING HISTOPATHOLOGY AS GOLD STANDARD

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ABSTRACT

Objective: To determine the diagnostic accuracy of ultrasonography in patients with suspected acute appendicitis, taking histopathological examination as the gold standard.

Study Design: Cross-sectional Validation Study.

Place & Duration of Study: Department of Radiology, Bolan Medical Complex, Quetta for a period of six months w.e.f. 04-08-2022 to 03-02-2023.

Methodology: Two hundred patients meeting inclusion criteria were enrolled at Bolan Medical Complex Quetta. Written consent and clinical history were obtained. All patients underwent abdominal ultrasonography followed by appendectomy, and specimens were sent for histopathology as the gold standard. A single radiologist and histopathologist evaluated all findings, and data were recorded in a proforma.

Results: A total of 200 patients with suspected acute appendicitis were included. Mean age was 36.88 ± 13.00 years, with 68% aged 18–49 years; 56% were males. Ultrasonography identified appendicitis in 83%, while histopathology confirmed 83.5%. USG showed sensitivity 95.21%, specificity 78.79%, and accuracy 92.50%. Diagnostic performance remained consistently high across age and gender subgroups.

Conclusion: Ultrasonography showed high diagnostic accuracy with excellent sensitivity and acceptable specificity in diagnosing acute appendicitis, using histopathology as the gold standard. It is a reliable, safe, and cost-effective first-line imaging tool, supporting its routine use for timely diagnosis and reduction of negative appendectomies.

Key Words: Acute Appendicitis, Ultrasonography, Histopathology, Diagnostic Accuracy, Sensitivity, Specificity.

INTRODUCTION

The term appendicitis is derived from Latin roots referring to inflammation of the appendix. The word “appendix” first appeared in the 1540s, describing a slender extension of an internal organ. Early medical literature did not immediately recognize the appendix as the source of abdominal

disease.¹ In 1759, Metievery provided one of the earliest descriptions of the condition; however, it was misinterpreted and attributed to nearby structures, leading to terms such as perityphlitis, typhlitis, paratyphlitis, and right iliac fossa abscess¹⁻³

Acute appendicitis is a frequent surgical emergency and contributes to a significant proportion of acute abdominal pain presentations, accounting for approximately 7-10% of emergency department visits.⁴ Although classical symptoms begin with central abdominal pain shifting to the right lower quadrant, this pattern is present in only about half of cases.⁵

Diagnosis remains challenging due to symptom overlap with other conditions such as urinary tract infections, gallbladder disease, Crohn's disease, gastritis, and gynecological disorders. Clinical evaluation is supported by laboratory tests, urine analysis, rectal examination, and imaging modalities including ultrasound and CT scanning.^{6,7} Despite advances, definitive diagnosis is confirmed through histopathological examination of the excised appendix, which remains the gold standard.⁸ While open surgery traditionally involved removal of even normal-appearing appendices, laparoscopic practice now avoids unnecessary removal when confident diagnosis is achieved.⁹ Imaging plays a key role in reducing diagnostic errors and negative appendectomy rates.¹⁰ Ultrasonography has been widely studied for diagnostic accuracy in appendicitis. Evidence suggests it is a valuable, non-invasive tool when used alongside clinical assessment.¹¹

Hasan et al. reported a sensitivity of 93.1%, specificity of 88.23%, and overall diagnostic accuracy of 91.3%.¹² Similarly, Farooq et al. found sensitivity of 80%, specificity of 60%, and accuracy of 77.5% when compared with histopathological findings.¹³

Existing literature shows considerable variation in the reported diagnostic performance of ultrasound for acute appendicitis. Sensitivity ranges from moderate to high, while specificity and overall accuracy differ across studies due to operator experience, patient factors, and imaging protocols. These inconsistencies highlighted the need for further evaluation in different clinical settings.

METHODOLOGY

The study design was a cross-sectional survey conducted in the Department of Radiology, Bolan Medical Complex, Quetta. The study was completed over a period of six months after approval of the synopsis. A total of 200 cases were included, and the sample size was calculated using a 95% confidence interval with an expected sensitivity of 93.1%, specificity of 88.23%, and a 10% margin of error, while the prevalence of disease was taken as 63.04%.¹² Non-probability consecutive sampling technique was used for patient selection.

Patients were selected according to predefined operational criteria. Suspected acute appendicitis was defined in patients presenting with right iliac fossa pain of less than 72 hours duration, localized tenderness with or without rebound tenderness, nausea or vomiting, fever greater than 37.5°C, leukocytosis with total leukocyte count more than 10,000/mm³, and those planned for appendectomy by the surgical team. These criteria were used to ensure uniform identification of clinically suspected cases.

Acute appendicitis on ultrasonography was defined as a non-compressible blind-ended tubular structure in the right iliac fossa with an appendiceal diameter greater than 6 mm, wall thickness more than 2 mm, or the presence of peri appendiceal fluid collection. Acute appendicitis on histopathology, which was taken as the gold standard, was confirmed when the removed appendix showed neutrophilic infiltration of the muscularis propria with mucosal ulceration, edema, congestion, or suppurative inflammation.

Diagnostic accuracy of ultrasonography was assessed in terms of sensitivity, specificity, positive predictive value, and negative predictive value. Sensitivity was defined as the ability of ultrasonography to correctly identify patients with acute appendicitis, while specificity was defined as its ability to correctly identify patients without the disease. Positive predictive value represented the probability that a positive ultrasound finding was confirmed on histopathology, and negative predictive value represented the probability that a negative ultrasound finding was confirmed as

negative on histopathology. True positive, true negative, false positive, and false negative results were categorized based on comparison between ultrasonography and histopathology findings. The formulas used included sensitivity as $TP/(TP+FN)$, specificity as $TN/(TN+FP)$, positive predictive value as $TP/(TP+FP)$, and negative predictive value as $TN/(TN+FN)$. Overall diagnostic accuracy was calculated as (True Positive + True Negative) divided by total cases, multiplied by 100. These parameters were used to evaluate the performance of ultrasonography against the gold standard.

For sample selection, patients aged above 18 years with clinical suspicion of acute appendicitis and planned appendectomy were included. Patients those not undergoing surgery, incidental appendectomy cases, appendicular mass managed conservatively, incomplete records, and pregnant patients were excluded from the study to avoid confounding factors and ensure data uniformity.

Data collection was carried out after obtaining informed consent and clinical history from all participants. A total of 200 patients meeting inclusion criteria were enrolled. Each patient underwent preoperative abdominal ultrasonography using a standardized protocol. All ultrasound examinations were performed and interpreted by a consultant radiologist with at least eight years of experience to minimize observer variation. After surgery, the resected appendix was sent for histopathological examination, which served as the gold standard for final diagnosis.

All collected data, including demographic details, ultrasound findings, and histopathology results, were recorded in a predesigned proforma by the principal investigator. Data were entered and analyzed using SPSS version 25. Numerical variables such as age were expressed as mean and standard deviation, while categorical variables were presented as frequency and percentage. A 2×2 contingency table was used to calculate diagnostic accuracy measures. Results were also stratified according to age and gender to assess their effect on diagnostic performance.

RESULTS

A total of 200 patients with suspected acute appendicitis planned for histopathological examination were included in the study. The mean age of the participants was 36.88 ± 13.00 years. Most patients, 136 (68.0%), were in the 18–49 years age group, while 64 (32.0%) were between 50–65 years. Regarding gender distribution, 112 (56.0%) patients were male and 88 (44.0%) were female. Data is given in Table I. A acute appendicitis on ultrasonography was identified in 166 (83.0%) cases, while 34 (17.0%) were reported as negative. On histopathological examination, which served as the gold standard, acute appendicitis was confirmed in 167 (83.5%) patients and was not present in 33 (16.5%) cases as shown in Table II. Histopathologically confirmed acute appendicitis was observed in 112 (82.4%) patients aged 18–40 years and 55 (85.9%) patients aged >40 years, with no significant difference between age groups ($p = 0.524$). By gender, 95 (84.8%) males had confirmed appendicitis compared to females, with no statistically significant association ($p = 0.570$) as given in Table III.

Out of 167 histopathology-positive cases, ultrasonography correctly identified 159 true positives and missed 8 cases (false negatives). Among 33 histopathology-negative cases, 26 were correctly identified as true negatives, while 7 were false positives. This yielded a sensitivity of 95.21%, specificity of 78.79%, and overall diagnostic accuracy of 92.50%. The positive and negative predictive values were 95.78% and 76.47%, respectively, with a disease prevalence of 83.50%. Data is given in Table IV.

Ultrasonography showed consistently high diagnostic performance across age groups as shown in Table V. In patients aged 18–40 years, sensitivity, specificity, accuracy, PPV, and NPV were 95.54%, 79.17%, 92.65%, 95.55%, and 79.11% with prevalence 82.40%. In those >40 years, values were 94.55%, 77.78%, 92.18%, 96.29%, and 70.07% with prevalence 85.90%. Across gender as shown in Table VI, males showed 96.68%, 94.12%, 93.75%, 98.95%, 71.48% with prevalence 85.60%, while females showed 97.22%, 62.50%, 90.59%, 91.65%, 84.16% with prevalence 80.90%.

Table I: Demographic Characteristics of Patients Suspected of Acute Appendicitis Planed for Histopathology

Characteristics	Participants (n=200)
Age (years)	36.88±13.00
• 18-49 years	136 (68.0%)
• 50-65 years	64 (32.0%)
Gender	
• Male	112 (56.0%)
• Female	88 (44.0%)

Table II: Frequency of Acute Appendicitis as per Ultrasonography and Histopathology

Modality	Acute Appendicitis (AP)	Frequency (n)	Percent (%)
Ultrasonography	Yes	166	83.0%
	No	34	17.0 %
	Total	200	100.0 %
Histopathology	Yes	167	83.5%
	No	33	16.5%
	Total	200	100.0 %

Table III: Comparison of Frequency of Acute Appendicitis upon Histopathology across Various Subgroups

Subgroups	n	Acute Appendicitis n (%)	P-value
Age (≥18 years)			0.524
• 18-40 years	136	112 (82.4%)	
• >40 years	64	55 (85.9%)	
Gender			0.570
• Male	112	95 (84.8%)	
• Female	88	17 (15.2%)	

Chi Square test taking p-value ≤0.05 as significant

Table IV: 2x2 Contingency Table to Determine Diagnostic Performance of Ultrasonography taking Histopathology Findings as Gold Standard

Histopathology	Histopathology		Total
	Acute Appendicitis	No	
Acute Appendicitis	159 ^a	7 ^c	166
No	8 ^b	26 ^d	34
Total	167	33	200

^aTrue Positive = 159, ^cFalse Positive =7, ^bFalse Negative = 8, ^dTrue Negative =26

Statistic	Formula	Value
Sensitivity	$\frac{a}{a+b}$	95.21%
Specificity	$\frac{d}{c+d}$	78.79%
Accuracy	$\frac{a+d}{a+b+c+d}$	92.50%
Disease prevalence	$\frac{a+b}{a+b+c+d}$	83.50%
Positive Predictive Value	$\frac{a}{a+c}$	95.78%
Negative Predictive Value	$\frac{d}{b+d}$	76.47%

Table V: 2x2 Contingency Table to Determine Diagnostic Performance Across Age

Age	USG	Histopathology		Total	Diagnostic Performance
		AP	No		
18-40 years (n=136)	AP	107	5	112	SN=95.54%, SP=79.17% PPV=95.55%, NPV=79.11% AC=92.65%, PR=82.40%
	No	5	19	24	
	Total	112	24	136	
> 40 years (n=64)	AP	52	2	54	SN=94.55%, SP=77.78% PPV=96.29%, NPV=70.07% AC=92.18%, PR=85.90%
	No	3	7	10	
	Total	55	9	64	

Table VI: 2x2 Contingency Table to Determine Diagnostic Performance Across Gender

Age	USG	Histopathology		Total	Diagnostic Performance
		AP	No		
Male (n=56)	AP	89	1	90	SN=96.68%, SP=94.12% PPV=98.95%, NPV=71.48% AC=93.75%, PR=85.60%
	No	6	16	22	
	Total	95	17	112	
Female (n=44)	AP	70	6	76	SN=97.22%, SP=62.50% PPV=91.65%, NPV=84.16% AC=90.59%, PR=80.9%
	No	2	10	12	
	Total	72	16	88	

DISCUSSION

Acute appendicitis is a common surgical emergency requiring prompt diagnosis to prevent complications.^{14,15} Histopathology remains the gold standard for confirming the diagnosis. Ultrasonography is widely used as a first-line imaging modality, especially in resource-limited settings, due to its availability, safety, and cost-effectiveness. However, its diagnostic accuracy varies across different studies and clinical settings, leading to inconsistent results in practice.^{12,13} This variability highlights the need to evaluate its performance against histopathology. Therefore, the present study was planned to assess the diagnostic accuracy of ultrasonography in patients with suspected acute appendicitis, taking histopathology as the reference standard.

In the present study, the mean age of patients was 36.88 ± 13.00 years, with the majority (68%) belonging to the 18-49 years age group. This finding is consistent with the well-established pattern that acute appendicitis is more common in young adults. Similar observations were reported by Hussain et al.¹² and Ahmed et al.¹⁶, where most patients were also in the younger age groups. Hasan et al.¹² further supported this trend by reporting a comparable mean age in the third decade of life, reinforcing that appendicitis predominantly affects younger populations across different clinical settings.

In terms of gender distribution, the present study showed a male predominance (56% males and 44% females). This is in agreement with several published studies. Farooq et al.¹³ reported 58.5% male and 41.5% female patients, while Ahmed et al. demonstrated an even stronger male predominance with 74.7% males and 25.3% females. Khan et al.¹⁷ also observed higher male involvement in appendectomy cases. However, Manea et al.¹⁸ reported a relatively balanced distribution, with 52.09% males and 47.9% females, suggesting that gender distribution may vary across populations and study settings. Overall, the present findings align with most literature indicating a mild male predominance in acute appendicitis.

Regarding diagnostic performance, ultrasonography in the present study demonstrated high sensitivity (95.21%), specificity (78.79%), positive predictive value (95.78%), negative predictive value (76.47%), and overall diagnostic accuracy of 92.50%. These results indicate strong diagnostic reliability when compared with histopathology. Similar findings were reported by Hasan et al.¹², who documented sensitivity of 93.1%, specificity of 88.23%, PPV of 93.1%, and NPV of 88.23%, with overall diagnostic efficacy of 91.3%. This closely parallels the high sensitivity and accuracy observed in the present study.

Hussain et al.¹⁹ reported sensitivity of 88%, specificity of 92%, PPV of 94%, NPV of 86%, and accuracy of 90%, which again supports the overall diagnostic utility of ultrasonography, although their sensitivity was slightly lower than that observed in the current study. Shrestha et al.²⁰ found sensitivity of 87.7%, specificity of 88.2%, PPV of 96.4%, and NPV of 62.5%, showing relatively lower sensitivity and markedly reduced negative predictive value compared to the present study. This suggests variability in ruling out disease, possibly due to differences in operator experience or patient selection.

Manea et al.¹⁸ reported sensitivity of 86.5%, specificity of 86.6%, PPV of 99.8%, and a notably low NPV of 32.5%, despite good overall accuracy (86.5%). The extremely low NPV indicates limitations in excluding disease in their study population, whereas the present study demonstrated a comparatively higher NPV, reflecting better reliability in negative cases.

Ahmed et al.¹⁶ reported that 79% of ultrasound-positive cases were confirmed on histopathology, indicating lower concordance compared to the present study, where histopathological confirmation of ultrasound-positive cases was significantly higher. Additionally, they highlighted that ultrasound also identified alternative diagnoses in some patients, reinforcing its role as a useful screening tool rather than a definitive diagnostic modality alone.

Farooq et al.¹³ demonstrated comparatively lower diagnostic performance, with sensitivity of 80%, specificity of 60%, and overall accuracy of 77.5%. This is notably inferior to the present study findings. Their results suggest higher false-positive rates and lower specificity, which may be attributed to variability in operator skill, different diagnostic criteria, or patient-related factors.

Khan et al.¹⁷ reported that ultrasound was used as the sole imaging modality in pediatric appendectomies and resulted in a low negative appendectomy rate of 3.6%, supporting its clinical utility in reducing unnecessary surgeries. Although their study was pediatric-based, it still highlights the effectiveness of ultrasound in improving diagnostic confidence.

Overall, the present study demonstrates comparatively higher sensitivity and diagnostic accuracy than most previously reported studies, while maintaining acceptable specificity. The findings strongly support ultrasonography as a reliable first-line imaging modality in suspected acute appendicitis when correlated with histopathological confirmation.

This study has strong methodological design, use of histopathology as gold standard, and robust sample size enhancing reliability. Limitations include single-center setting and operator dependence

of ultrasonography. Future studies should include multicenter, larger populations with CT correlation and inter-observer analysis to improve generalizability and diagnostic standardization.

CONCLUSION

Ultrasonography showed high diagnostic accuracy with excellent sensitivity and acceptable specificity in diagnosing acute appendicitis, using histopathology as the gold standard. It is a reliable, safe, and cost-effective first-line imaging tool, supporting its routine use for timely diagnosis and reduction of negative appendectomies.

PATIENT'S CONSENT

Informed written consent was obtained from each study subject.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHORS CONTRIBUTION

Author 1

Substantial contributions to study design, acquisition of data

Analysis & Interpretation of Data, Manuscript writing

Has given final approval of the version to be published

Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Author 2

Contributions to concept, study design

Data Analysis, Manuscript writing, Critical Review

Has given final approval of the version to be published

Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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