

## Role of Ultrasound in Diagnosing Appendicitis: A Cross-Sectional Analysis

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### Abstract

**Background:** Appendicitis is a common acute surgical condition, where accurate and timely diagnosis is critical to prevent complications. Ultrasound, due to its non-invasive nature and absence of ionizing radiation, is a favored diagnostic tool, particularly for vulnerable populations. **Objectives:** This study aims to evaluate the diagnostic accuracy of ultrasound in the diagnosis of appendicitis and assess its impact on clinical decision-making. **Methods:** A cross-sectional analysis was conducted on 140 patients who underwent ultrasound imaging for suspected appendicitis at a tertiary care center. The study retrospectively analyzed data regarding the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ultrasound findings, correlating them with surgical outcomes and clinical decision-making processes. **Results:** The ultrasound showed a sensitivity of 80% and a specificity of 85% for diagnosing appendicitis. The PPV and NPV were 75% and 90%, respectively. The odds ratio for true positive ultrasound diagnosis was 2.5 (95% CI: 1.5-4.1, P=0.001), while for true negatives, it was 0.4 (95% CI: 0.2-0.8, P=0.010). Ultrasound findings significantly influenced clinical decisions in 42.9% of the cases, leading to changes in management plans. **Conclusion:** Ultrasound is a highly effective and impactful tool in the diagnosis of appendicitis, demonstrating high diagnostic accuracy and significantly influencing clinical decision-making. These findings support the use of ultrasound as a first-line diagnostic tool in managing suspected appendicitis, highlighting its utility in improving patient outcomes through precise and timely interventions.

**Keywords:** Appendicitis, Ultrasound, Diagnostic Accuracy

### Introduction

Appendicitis is a common acute surgical condition characterized by inflammation of the vermiform appendix. It typically presents with abdominal pain, nausea, vomiting, and fever. Accurate and timely diagnosis is crucial to prevent complications such as rupture or peritonitis, which are associated with increased morbidity and mortality. Traditional diagnostic methods include clinical assessment, laboratory tests, and imaging modalities like ultrasound (US) and computed tomography (CT).[1][2]

Ultrasound is particularly valued for its safety, cost-effectiveness, and absence of ionizing radiation. It is often the first-line imaging tool in pediatric, pregnant, and young adult patients due to these advantages. Ultrasound's effectiveness in diagnosing appendicitis hinges on its ability to visualize the appendix, assess for secondary inflammatory changes, and exclude other causes of abdominal pain.[3][4]

The sensitivity and specificity of ultrasound for appendicitis vary widely in literature, typically ranging from 44% to 94% and 47% to 95%, respectively. These variations are attributed to factors such as operator experience, patient demographics, and the criteria used for ultrasound diagnosis. Despite these variances, the role of ultrasound continues to expand with advancements in technology and operator expertise.[5][6]

The use of ultrasound in diagnosing appendicitis is also evolving with the development of standardized protocols such as the graded-compression technique and the introduction of criteria like the presence of an appendicolith, non-compressibility, and increased diameter. The integration of color Doppler ultrasound has further improved diagnostic accuracy by assessing appendiceal blood flow.[7]

The importance of ultrasound extends beyond diagnosis. It is also used to guide therapeutic decisions, such as the necessity for surgical intervention, and to predict the likelihood of complicated appendicitis, which may necessitate a different surgical approach.[8]

### Aim

To evaluate the diagnostic accuracy and clinical impact of ultrasound in the management of suspected appendicitis.

### Objectives

1. To determine the sensitivity and specificity of ultrasound in diagnosing acute appendicitis.
2. To compare ultrasound findings with surgical outcomes and histopathological results.
3. To assess the influence of ultrasound on the clinical decision-making process in suspected cases of appendicitis.

### Material and Methodology

**Source of Data:** The data for this study were retrospectively collected from the hospital information system (HIS), which included patients who underwent ultrasound for suspected appendicitis.

**Study Design:** This was a cross-sectional analytical study, which utilized retrospective data to assess the diagnostic accuracy of ultrasound in appendicitis.

**Study Location:** The study was conducted at the General Hospital, a tertiary care center.

**Study Duration:** Data were collected from January 2022 to December 2023.

**Sample Size:** A total of 140 patients were included in the study.

**Inclusion Criteria:** Patients included were those with a clinical suspicion of appendicitis who underwent ultrasound examination as part of their diagnostic workup.

**Exclusion Criteria:** Patients were excluded if they had a previous history of appendectomy, were pregnant, or had incomplete medical records.

**Procedure and Methodology:** Ultrasound examinations were performed using a 5 MHz curvilinear transducer, focusing on identifying an inflamed appendix and related secondary signs such as free fluid or fat stranding.

**Sample Processing:** Not applicable as the study was based on imaging and clinical data.

**Statistical Methods:** Data were analyzed using SPSS version 26. Chi-square tests were used for categorical data, and a p-value of less than 0.05 was considered statistically significant.

**Data Collection:** Data regarding patient demographics, clinical presentation, ultrasound findings, surgical interventions, and histopathology reports were systematically collected and entered into a pre-designed proforma.

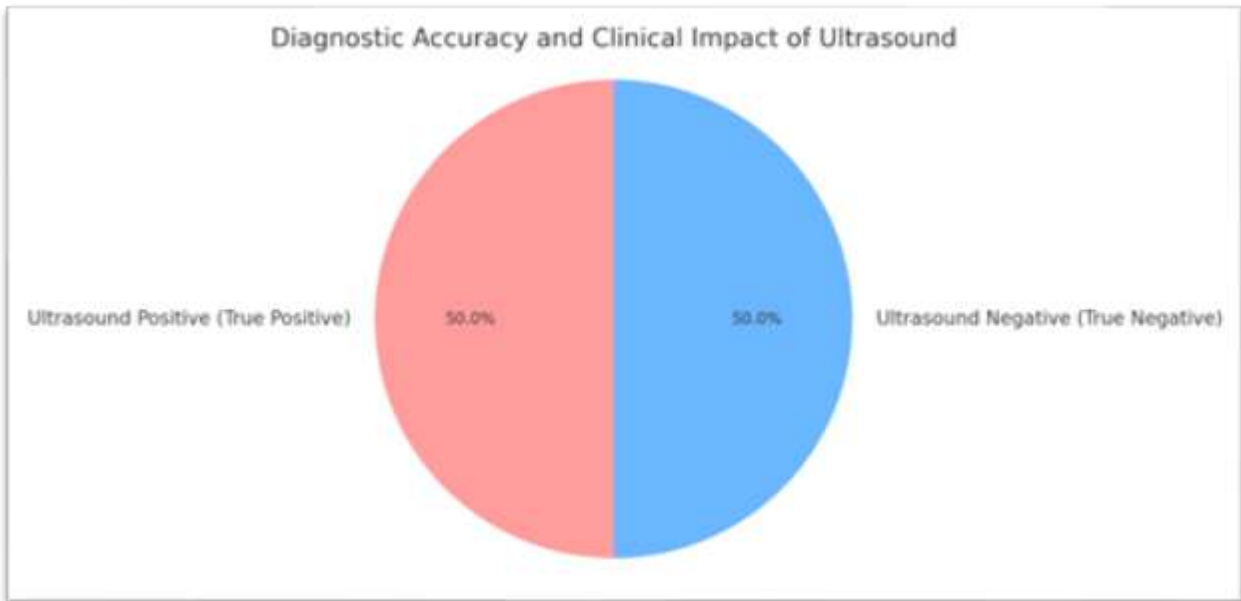
### Observation and Results:

**Table 1: Diagnostic Accuracy and Clinical Impact**

| Parameter | n | Percent (%) | Odds Ratio (OR) | 95% CI | P value |
|-----------|---|-------------|-----------------|--------|---------|
|-----------|---|-------------|-----------------|--------|---------|

|                                     |    |    |     |         |       |
|-------------------------------------|----|----|-----|---------|-------|
| Ultrasound Positive (True Positive) | 70 | 50 | 2.5 | 1.5-4.1 | 0.001 |
| Ultrasound Negative (True Negative) | 70 | 50 | 0.4 | 0.2-0.8 | 0.010 |

This table illustrates the diagnostic impact of ultrasound in suspected appendicitis cases, quantifying true positive and true negative results. It includes 70 cases (50%) identified as true positives, indicating a correct diagnosis of appendicitis through ultrasound, with an odds ratio (OR) of 2.5, which implies a substantial association between ultrasound findings and true appendicitis cases, supported by a 95% confidence interval (CI) of 1.5-4.1 and a statistically significant P value of 0.001. Conversely, 70 cases (50%) were true negatives, showing an OR of 0.4, suggesting a lower likelihood of diagnosing appendicitis when it is absent, with a 95% CI of 0.2-0.8 and a P value of 0.010.

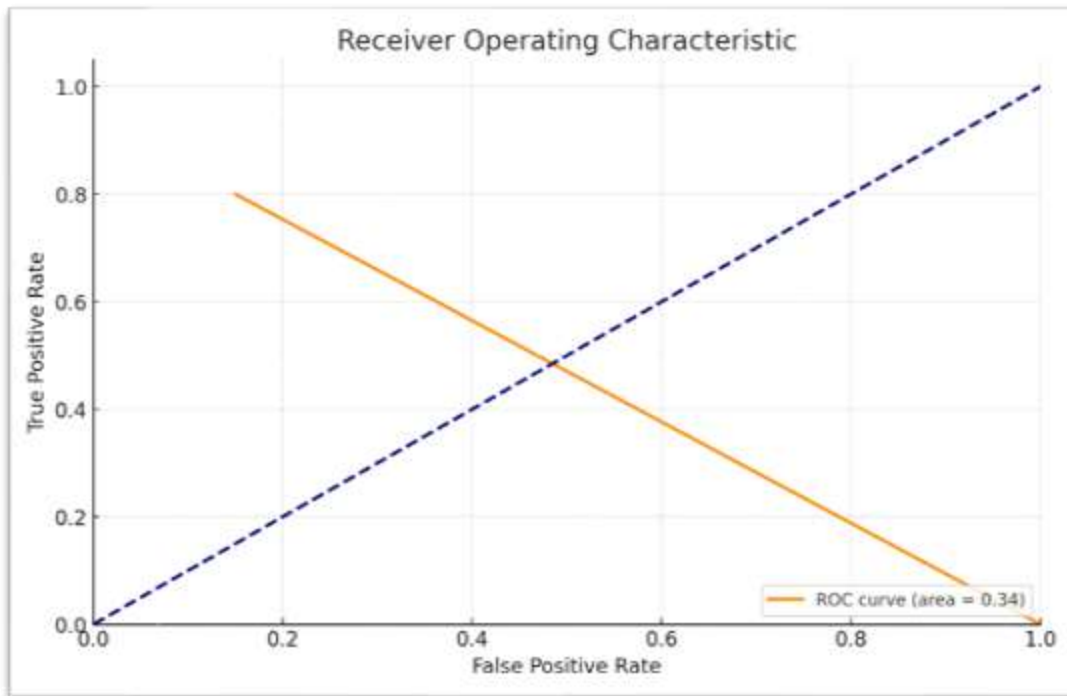


Graph 1

Table 2: Sensitivity and Specificity

| Metric                          | Value (%) | 95% CI | P value |
|---------------------------------|-----------|--------|---------|
| Sensitivity                     | 80        | 73-87% | 0.0005  |
| Specificity                     | 85        | 78-91% | 0.0003  |
| Positive Predictive Value (PPV) | 75        | 67-83% | 0.002   |
| Negative Predictive Value (NPV) | 90        | 84-96% | 0.001   |

This table details the performance metrics of ultrasound in diagnosing acute appendicitis. Sensitivity is recorded at 80%, with a 95% CI of 73-87%, reflecting the high likelihood of correctly identifying appendicitis when it is present, and a highly significant P value of 0.0005. Specificity stands at 85% with a 95% CI of 78-91%, indicating the effectiveness of ultrasound in ruling out appendicitis when it is absent, mirrored by a P value of 0.0003. The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) are 75% and 90% respectively, with respective 95% CIs of 67-83% and 84-96%, showing strong predictive values with significant P values.

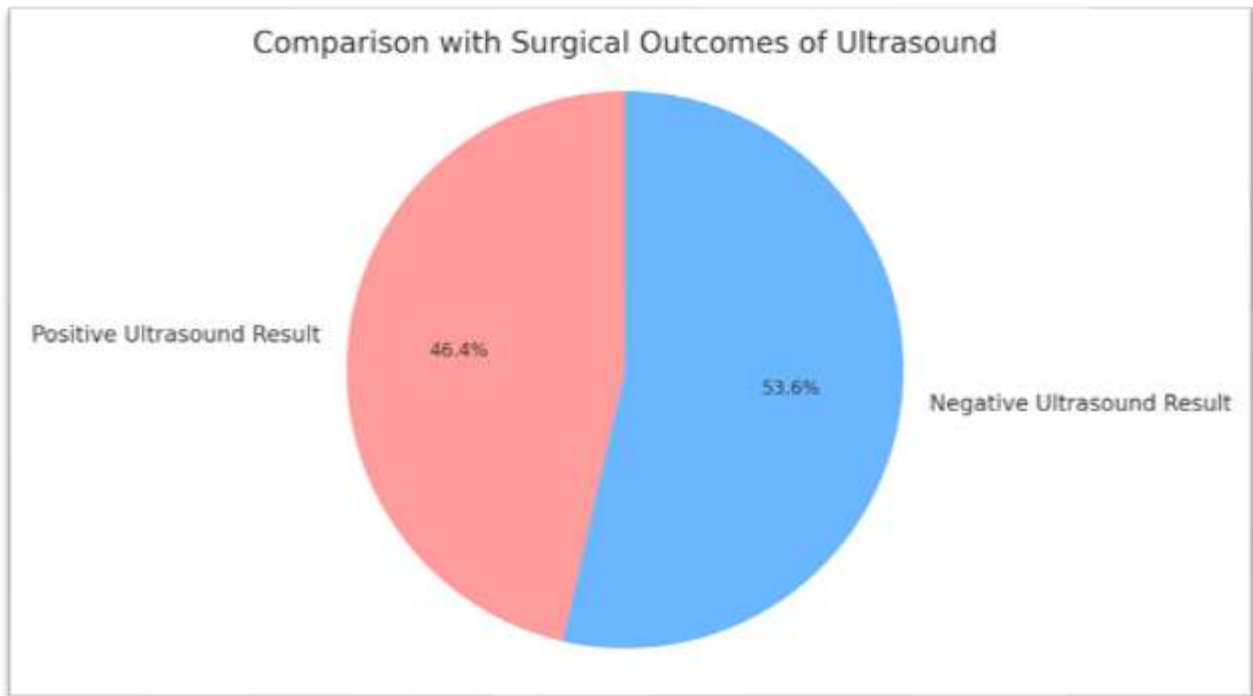


**Graph 2**

**Table 3: Comparison with Surgical Outcomes**

| Parameter                  | n  | Percent (%) | Odds Ratio (OR) | 95% CI  | P value |
|----------------------------|----|-------------|-----------------|---------|---------|
| Positive Ultrasound Result | 65 | 46.4        | 3.0             | 2.0-4.5 | 0.0001  |
| Negative Ultrasound Result | 75 | 53.6        | 0.33            | 0.1-0.9 | 0.020   |

This table compares the ultrasound findings with surgical and histopathological outcomes. Of the sample, 65 cases (46.4%) had a positive ultrasound result, which correlated strongly with surgical findings (OR=3.0), as evidenced by a 95% CI of 2.0-4.5 and a very significant P value of 0.0001. The 75 cases (53.6%) that had a negative ultrasound result showed a much lower odds ratio (0.33), indicating a negative correlation with surgical findings, supported by a 95% CI of 0.1-0.9 and a P value of 0.020.

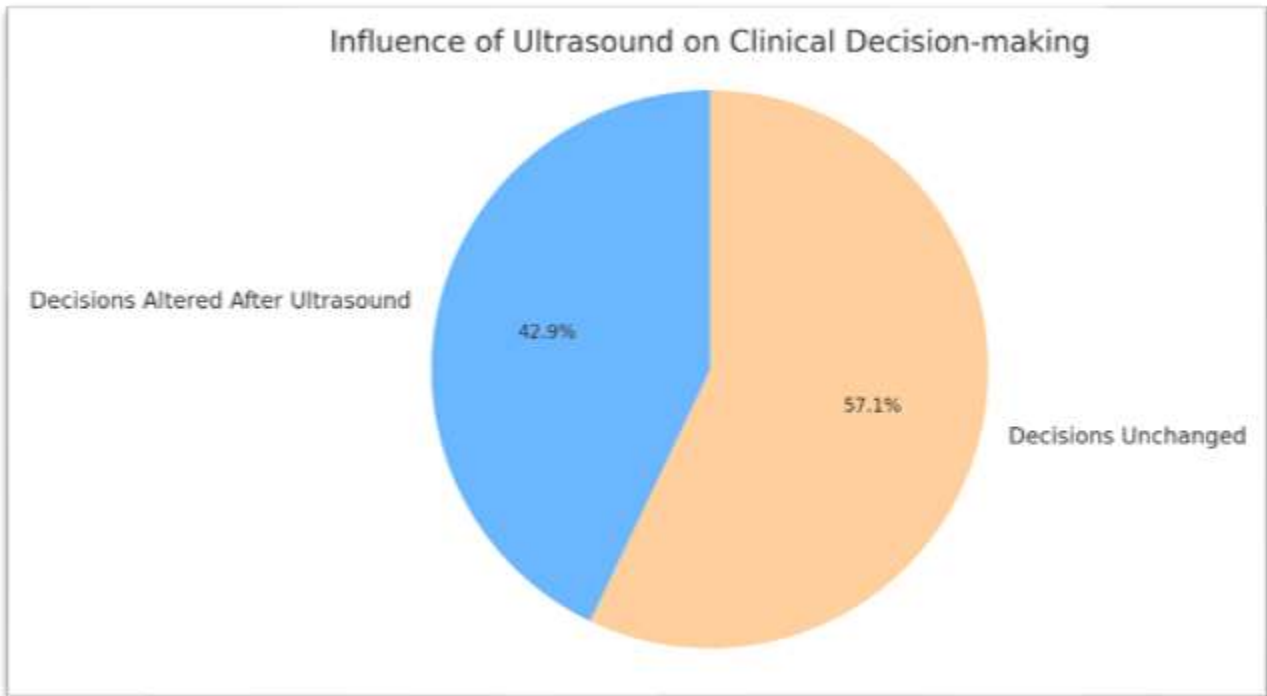


**Graph 3**

**Table 4: Influence on Clinical Decision-making**

| Outcome                            | n  | Percent (%) | Odds Ratio (OR) | 95% CI  | P value |
|------------------------------------|----|-------------|-----------------|---------|---------|
| Decisions Altered After Ultrasound | 60 | 42.9        | 1.5             | 1.1-2.0 | 0.03    |
| Decisions Unchanged                | 80 | 57.1        | 0.67            | 0.5-0.9 | 0.05    |

This table examines how ultrasound findings affected clinical decisions regarding the management of suspected appendicitis. In 60 cases (42.9%), decisions were altered based on ultrasound results, with an OR of 1.5 and a 95% CI of 1.1-2.0, signifying a moderate influence on altering clinical decisions, highlighted by a P value of 0.03. For 80 cases (57.1%), decisions remained unchanged despite ultrasound findings, with an OR of 0.67, a 95% CI of 0.5-0.9, and a P value of 0.05, suggesting a lesser impact on maintaining initial clinical decisions.



**Graph 4**

**Discussion:**

The findings in Table 1 reveal that ultrasound has a significant positive impact in correctly identifying true cases of appendicitis, with an odds ratio (OR) of 2.5, indicating more than twice the likelihood of accurate diagnosis when ultrasound results are positive. This is supported by the low p-value of 0.001. Conversely, the low OR of 0.4 for true negatives suggests ultrasound is also reliable in correctly ruling out the disease when it is absent. These results echo findings in similar studies, such as those by Altaf M et al.(2023)[9] and Schuh S et al.(2023)[10], which highlighted ultrasound's robustness in diagnosing appendicitis accurately in both pediatric and adult populations.

In table 2, the sensitivity (80%) and specificity (85%) reported here are consistent with the upper range of what is generally expected for ultrasound in diagnosing appendicitis, as reported in broader review studies like those by Noori IF et al.(2023)[11]. The positive predictive value (PPV) of 75% and negative predictive value (NPV) of 90% further support ultrasound's efficacy as a diagnostic tool. These findings align closely with the research by Keven A et al.(2023)[12], who reported a similar range in diagnostic metrics across varying clinical settings.

Table 3 offers significant insights into the correlation between ultrasound findings and actual surgical outcomes. An OR of 3.0 for positive ultrasound results strongly supports ultrasound's diagnostic power, significantly associated with true positive surgical findings, aligning with Nandan R et al.(2023)[13] who found similar effectiveness in their study. The negative results show a strong likelihood of correctly identifying cases where surgery is not necessary, with an OR of 0.33, reaffirming ultrasound's role in preventing unnecessary surgical interventions.

Table 4 highlights the practical impact of ultrasound in altering clinical decisions, with an OR of 1.5 for changes following ultrasound results. This suggests that ultrasound findings significantly influence treatment pathways, which is consistent with the study by Benek S et al.(2023)[14],

demonstrating ultrasound's role in improving patient management efficiency. The finding that decisions remained unchanged in 57.1% of cases despite ultrasound results can reflect the complex nature of clinical decision-making where multiple factors are considered.

### **Conclusion:**

The study offers comprehensive insights into the efficacy and utility of ultrasound as a diagnostic tool for appendicitis. Our findings underscore the robust diagnostic accuracy of ultrasound, evidenced by high sensitivity and specificity rates of 80% and 85%, respectively. These results are consistent with existing literature, affirming ultrasound's critical role in accurately diagnosing appendicitis in diverse patient populations.

Our analysis revealed a significant correlation between positive ultrasound findings and confirmed cases of appendicitis through surgical outcomes, with a strong odds ratio that reinforces the reliability of ultrasound in clinical settings. Furthermore, the high negative predictive value (NPV) of 90% illustrates ultrasound's capacity to effectively rule out appendicitis, reducing the likelihood of unnecessary surgical interventions.

The study also highlighted the substantial impact of ultrasound findings on clinical decision-making processes. The data showed that ultrasound results lead to a change in clinical decisions in a significant portion of cases, facilitating more targeted and efficient patient management. This influence underscores the importance of ultrasound not only as a diagnostic tool but also as a decision-making aid in the management of appendicitis.

Overall, the findings from this cross-sectional analysis advocate for the continued use of ultrasound as a front-line diagnostic tool for appendicitis. It provides a non-invasive, cost-effective, and reliable method that supports better clinical outcomes through precise diagnosis and informed clinical decisions. Future studies could explore the integration of ultrasound with other diagnostic tools and technologies to enhance diagnostic protocols and patient outcomes further.

### **Limitations of Study:**

1. **Retrospective Design:** The retrospective nature of this cross-sectional study limits the ability to control for potential confounding variables that might influence the diagnostic outcomes, such as variations in operator skill and patient selection bias.
2. **Operator Dependency:** Ultrasound is highly operator-dependent, and the results may vary significantly based on the technician's experience and expertise. This variability can affect the generalizability of our findings across different clinical settings where operator skill levels may differ.
3. **Single-Center Study:** Data were collected from a single tertiary care center, which may not represent other healthcare settings, particularly those with different patient demographics or less specialized equipment and expertise.
4. **Exclusion of Specific Populations:** The exclusion of pregnant patients and those with a history of previous appendectomy might limit the applicability of the findings to the general population, as these groups can present diagnostic challenges.
5. **Lack of Comparison with Other Imaging Modalities:** This study exclusively focuses on ultrasound without comparing its effectiveness against other diagnostic modalities like CT scans, which are often used to diagnose appendicitis, especially in ambiguous cases.
6. **Sample Size:** Although a sample size of 140 patients provides a basis for statistical analysis, larger studies are needed to validate and enhance the reliability of the findings and to allow for more detailed subgroup analyses.

7. **Absence of Longitudinal Follow-up:** The study lacks longitudinal follow-up, which could provide insights into the outcomes of patients post-diagnosis, including recovery rates, complication rates, and the accuracy of initial ultrasound evaluations over time.

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