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**Research Article**

# A Prospective Clinical Study Evaluating the Diagnostic Accuracy of Ultrasonography and Contrast-Enhanced Computed Tomography in the Preoperative Assessment of Patients Presenting With Acute Appendicitis

**Dr. Greeshma S[1], Dr. Monish D U[2], c[*]**

[1]Assistant professor, Department of surgery, Kodagu institute of medical sciences, Madikeri.

[2]Senior resident, Department of Otorhinolaryngology, Kodagu institute of medical sciences, Madikeri.

[3*]Senior resident, Department of Community Medicine, Kodagu Institute of medical sciences, Madikeri.

**Corresponding Author:** Dr. Shreeshanand K

Senior resident, Department of Community Medicine, Kodagu Institute of medical sciences, Madikeri.

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**ABSTRACT**

**Background:** Acute appendicitis is a common surgical emergency in which early and accurate diagnosis is essential to prevent complications and unnecessary appendicectomy. Although ultrasonography (USG) is widely used as an initial imaging modality, contrast-enhanced computed tomography (CECT) may provide greater diagnostic accuracy. The present study was undertaken to compare the diagnostic accuracy of USG and CECT in patients with suspected acute appendicitis.

**Materials and Methods:** A prospective observational clinical study was conducted in the Department of Surgery at the Kodagu Institute of Medical Sciences, Madikeri, Karnataka, over 6 months. A total of 75 consecutive patients with clinically suspected acute appendicitis were included. All patients underwent clinical assessment and USG, while CECT was performed where clinically indicated and feasible. Operative findings and histopathological examination were used as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy were calculated for both imaging modalities.

**Results:** Among the 75 patients, 58 (77.3%) had histopathologically confirmed acute appendicitis. USG correctly identified 48 of these patients and demonstrated a sensitivity of 82.8%, specificity of 76.5%, PPV of 92.3%, NPV of 56.5% and diagnostic accuracy of 81.3%. CECT correctly identified 55 patients with acute appendicitis and demonstrated a sensitivity of 94.8%, specificity of 94.1%, PPV of 98.2%, NPV of 84.2% and diagnostic accuracy of 94.7%. Thus, CECT demonstrated superior diagnostic performance compared with USG.

**Conclusion:** CECT demonstrated higher diagnostic accuracy than USG in the preoperative diagnosis of acute appendicitis. USG remains a useful initial radiation-free investigation, while CECT may be considered in patients with equivocal ultrasound findings, persistent clinical suspicion or suspected complications.

**Keywords:** Acute Appendicitis, Ultrasonography, CECT, Diagnostic Accuracy, Sensitivity, Specificity, Histopathology.

## INTRODUCTION

Acute appendicitis is one of the most common causes of acute abdominal pain requiring emergency surgical evaluation and remains one of the leading indications for emergency abdominal surgery. It can occur at any age, although it is particularly common among adolescents and young adults. Early and accurate diagnosis is essential because delayed treatment may result in perforation, periappendiceal abscess, generalized peritonitis and other complications, whereas an incorrect diagnosis may result in unnecessary appendicectomy. Therefore, accurate preoperative diagnosis is important for appropriate patient management. [1,2]

The diagnosis of acute appendicitis is primarily based on clinical assessment supported by laboratory investigations and imaging. Classical clinical manifestations include abdominal pain that may migrate from the periumbilical region to the right iliac fossa, anorexia, nausea, vomiting, fever and localized tenderness. However, the clinical presentation

may vary considerably among patients. Atypical presentations are particularly encountered in patients with unusual anatomical positions of the appendix, elderly individuals and women of reproductive age. Laboratory abnormalities such as leukocytosis and neutrophilia may support the diagnosis but are not sufficiently specific to establish acute appendicitis independently. [2,3]

Clinical scoring systems may improve diagnostic assessment, but imaging is frequently required when the clinical diagnosis remains uncertain. Ultrasonography (USG) is commonly used as an initial imaging modality because it is non-invasive, relatively inexpensive, widely available and does not involve ionizing radiation. Graded-compression ultrasonography can demonstrate a non-compressible blind-ending tubular structure, increased appendiceal diameter, wall thickening, appendicolith and periappendiceal inflammatory changes. However, its diagnostic performance is influenced by operator experience, patient body habitus, bowel gas, appendix position and the ability to visualize the appendix. [4,5]

Contrast-enhanced computed tomography (CECT) provides detailed cross-sectional evaluation of the appendix and surrounding structures. Typical CT findings of acute appendicitis include appendiceal enlargement, wall thickening and enhancement, periappendiceal fat stranding, appendicolith, periappendiceal fluid collection and extraluminal air in cases of perforation. CT can also identify alternative causes of right lower quadrant pain and is particularly useful when ultrasonography is inconclusive or when complicated appendicitis is suspected. [6]

Evidence from diagnostic studies and meta-analyses has demonstrated that CT generally has higher sensitivity and specificity than conventional ultrasonography in adults with suspected acute appendicitis. Doria et al. reported pooled sensitivity and specificity of approximately 83% and 93%, respectively, for USG and approximately 94% and 94% for CT in adults. [7] Further evidence has demonstrated that CT and MRI provide high diagnostic accuracy when used as second-line imaging modalities following an initial ultrasound examination. [8] In addition, studies evaluating imaging strategies in younger populations have demonstrated that USG can be an appropriate initial investigation, with CT or MRI reserved for patients with equivocal or non-diagnostic ultrasound findings. [9]

Although CECT provides excellent diagnostic accuracy, its use is associated with exposure to ionizing radiation and, in appropriate patients, intravenous administration of iodinated contrast. Therefore, the selection of imaging modality should take into consideration age, pregnancy status, clinical probability, availability, operator expertise and the risk of complications. CT may also have an important role in reducing diagnostic uncertainty and identifying alternative diagnoses in patients presenting with right lower quadrant pain. [6,10]

Thus, USG and CECT have complementary roles in the evaluation of suspected acute appendicitis. USG may be used as an initial radiation-free investigation, while CECT may provide additional diagnostic information when the ultrasound examination is inconclusive or when complicated disease is suspected.

The present study was therefore undertaken to prospectively evaluate and compare the diagnostic accuracy of USG and CECT in patients presenting with clinically suspected acute appendicitis. Operative findings and histopathological examination were used as the reference standard. The study assessed sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy of both imaging modalities.

## MATERIALS AND METHODS

### Study Design and Setting

A prospective clinical observational study was conducted in the Department of Surgery, Kodagu Institute of Medical Sciences, Madikeri, Karnataka, over a period of 6 months. The study was designed to evaluate and compare the diagnostic accuracy of ultrasonography (USG) and contrast-enhanced computed tomography (CECT) in the preoperative assessment of patients presenting with suspected acute appendicitis.

### Study Population

The study included patients presenting to the surgical outpatient department or emergency department with clinical features suggestive of acute appendicitis and who were planned for surgical management.

### Sample Size

A total of 75 consecutive patients fulfilling the eligibility criteria were enrolled during the study period.

### Inclusion Criteria

Patients were included if they:

1. Presented with clinical features suggestive of acute appendicitis.
2. Were clinically assessed by the surgical team and considered for operative management.
3. Underwent USG abdomen/pelvis as part of the preoperative evaluation.
4. Underwent CECT abdomen and pelvis where clinically indicated and feasible.
5. Subsequently underwent appendicectomy, providing a definitive reference diagnosis.

**Exclusion Criteria**

Patients were excluded if they:

1. Had a previous history of appendicectomy.
2. Had known appendicular malignancy or other established causes of right iliac fossa pathology.
3. Were pregnant or had contraindications to ionizing radiation or iodinated contrast.
4. Had a history of significant contrast allergy or severe renal impairment precluding CECT.
5. Did not undergo either of the imaging investigations or definitive surgical/histopathological assessment.

**Clinical Assessment**

All enrolled patients underwent detailed clinical evaluation, including history and physical examination. Clinical findings such as right iliac fossa pain and tenderness, fever, nausea/vomiting, anorexia, rebound tenderness and duration of symptoms were recorded. Relevant laboratory investigations, including complete blood count and total leukocyte count, were documented.

**Ultrasonography**

USG of the abdomen and pelvis was performed using a suitable high-frequency linear transducer with graded compression technique. The appendix was assessed for non-compressibility, increased outer diameter, wall thickening, periappendiceal inflammation, appendicolith, periappendiceal fluid collection and other associated findings. The USG examination was interpreted as positive, negative or equivocal for acute appendicitis based on the imaging findings.

**Contrast-Enhanced Computed Tomography**

CECT of the abdomen and pelvis was performed using a multidetector CT scanner following intravenous administration of iodinated contrast, after assessment of relevant contraindications. CT images were evaluated for appendiceal enlargement, wall enhancement and thickening, periappendiceal fat stranding, appendicolith, periappendiceal collection, extraluminal air and other complications. The CT examination was classified as positive or negative for acute appendicitis based on the overall radiological findings.

**Reference Standard**

The final diagnosis was established using operative findings and histopathological examination of the resected appendix. Histopathological evidence of acute appendicitis was considered the definitive reference standard wherever an appendix specimen was available.

**Outcome Measures**

The primary outcome was the diagnostic accuracy of USG and CECT in detecting acute appendicitis. The following parameters were calculated for both imaging modalities:

- Sensitivity
- Specificity
- Positive predictive value (PPV)
- Negative predictive value (NPV)
- Diagnostic accuracy

The ability of each modality to identify complicated appendicitis, including perforation and periappendiceal abscess/collection, was also assessed where applicable.

**Statistical Analysis**

Data were entered into Microsoft Excel and analysed using SPSS software. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, as appropriate, while categorical variables were presented as frequencies and percentages. Diagnostic performance of USG and CECT was assessed by constructing 2 × 2 contingency tables against the reference standard. Sensitivity, specificity, PPV, NPV and overall diagnostic accuracy were calculated with corresponding 95% confidence intervals. The diagnostic performance of USG and CECT was compared using an appropriate paired categorical-data test, such as McNemar's test, wherever applicable. A p-value $<0.05$ was considered statistically significant.

**Ethical Considerations**

The study was conducted after obtaining approval from the Institutional Ethics Committee of Kodagu Institute of Medical

Sciences, Madikeri. Written informed consent was obtained from all participants before enrollment. Patient confidentiality was maintained throughout the study, and the collected data were used solely for research purposes.

## RESULTS AND OBSERVATIONS

A total of 75 patients with clinically suspected acute appendicitis who fulfilled the eligibility criteria were included in the present study. All patients underwent clinical assessment and ultrasonography (USG), while contrast-enhanced computed tomography (CECT) was performed where clinically indicated and feasible. The final diagnosis was established by operative findings and histopathological examination.

Table 1. Age Distribution of Study Participants

| Age Group (Years) | Number Of Patients | Percentage |
|---|---|---|
| ≤20 | 14 | 18.7 |
| 21–30 | 25 | 33.3 |
| 31–40 | 18 | 24.0 |
| 41–50 | 11 | 14.7 |
| >50 | 7 | 9.3 |
| **Total** | **75** | **100.0** |

The majority of patients belonged to the 21–30 years age group (33.3%), followed by the 31–40 years group (24.0%).

Table 2. Sex Distribution of Study Participants

| Sex | Number of patients | Percentage |
|---|---|---|
| Male | 45 | 60.0 |
| Female | 30 | 40.0 |
| **Total** | **75** | **100.0** |

There was a male predominance, with males accounting for 60.0% of the study population.

Table 3. Presenting Clinical Features

| Clinical feature | Number of patients | Percentage |
|---|---|---|
| Right iliac fossa pain/tenderness | 71 | 94.7 |
| Nausea/vomiting | 53 | 70.7 |
| Anorexia | 48 | 64.0 |
| Fever | 39 | 52.0 |
| Rebound tenderness | 42 | 56.0 |
| Migration of pain | 36 | 48.0 |

Right iliac fossa pain and tenderness was the most frequent clinical finding, observed in 94.7% of patients, followed by nausea/vomiting (70.7%) and anorexia (64.0%).

Table 4. Laboratory Findings

| Laboratory parameter | Finding | Number (%) |
|---|---|---|
| Total leukocyte count | Elevated | 57 (76.0) |
| Total leukocyte count | Normal | 18 (24.0) |
| Neutrophilia | Present | 55 (73.3) |
| Neutrophilia | Absent | 20 (26.7) |

Leukocytosis was observed in 76.0% of patients, while neutrophilia was present in 73.3%.

Table 5. Ultrasonography Findings

| USG interpretation | Number of patients | Percentage |
|---|---|---|
| Positive for acute appendicitis | 52 | 69.3 |

| | | |
|---|---|---|
| Negative for acute appendicitis | 15 | 20.0 |
| Equivocal | 8 | 10.7 |
| **Total** | **75** | **100.0** |

USG was reported as positive for acute appendicitis in 69.3% of patients. The examination was equivocal in 10.7% of cases.

Table 6. Cect Findings

| CECT Interpretation | Number Of Patients | Percentage |
|---|---|---|
| Positive For Acute Appendicitis | 56 | 74.7 |
| Negative For Acute Appendicitis | 19 | 25.3 |
| **Total** | **75** | **100.0** |

CECT demonstrated findings suggestive of acute appendicitis in 74.7% of the study participants.

Table 7. Operative and Histopathological Findings

| Final diagnosis | Number of patients | Percentage |
|---|---|---|
| Acute appendicitis | 58 | 77.3 |
| No acute appendicitis | 17 | 22.7 |
| **Total** | **75** | **100.0** |

Histopathological examination confirmed acute appendicitis in 58 (77.3%) patients, while 17 (22.7%) patients had no histopathological evidence of acute appendicitis.

Table 8. Usg Diagnostic Performance against Histopathology

| USG result | Histopathology positive | Histopathology negative | Total |
|---|---|---|---|
| Positive | 48 | 4 | 52 |
| Negative | 10 | 13 | 23 |
| **Total** | **58** | **17** | **75** |

**Based On The Above Observations, USG Demonstrated:**

- Sensitivity: 82.8%
- Specificity: 76.5%
- Positive predictive value: 92.3%
- Negative predictive value: 56.5%
- Diagnostic accuracy: 81.3%

Table 9. Cect Diagnostic Performance against Histopathology

| CECT result | Histopathology positive | Histopathology negative | Total |
|---|---|---|---|
| Positive | 55 | 1 | 56 |
| Negative | 3 | 16 | 19 |
| **Total** | **58** | **17** | **75** |

**CECT Demonstrated:**

- Sensitivity: 94.8%
- Specificity: 94.1%
- Positive predictive value: 98.2%
- Negative predictive value: 84.2%
- Diagnostic accuracy: 94.7%

Table 10. Comparison of Diagnostic Performance of USG and CECT

| Diagnostic parameter | USG (%) | CECT (%) |
|---|---|---|
| Sensitivity | 82.8 | 94.8 |
| Specificity | 76.5 | 94.1 |
| PPV | 92.3 | 98.2 |
| NPV | 56.5 | 84.2 |
| Diagnostic accuracy | 81.3 | 94.7 |

CECT showed higher sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy compared with USG.

## DISCUSSION

Acute appendicitis is one of the most common surgical emergencies and requires timely and accurate diagnosis to prevent complications such as perforation, periappendiceal abscess and generalized peritonitis. Although clinical examination and laboratory investigations provide important diagnostic information, the clinical presentation may be variable and may overlap with other causes of right iliac fossa pain. Therefore, imaging plays an important role in confirming the diagnosis and guiding appropriate management. [1,2]

The present prospective clinical study included 75 patients with clinically suspected acute appendicitis. The majority of patients belonged to the younger age groups, with the highest proportion in the 21–30 years age group (33.3%), followed by the 31–40 years age group (24.0%). Males constituted 60.0% of the study population, whereas females constituted 40.0%. The predominance of young adults observed in the present study is consistent with the recognized epidemiological pattern of acute appendicitis. [2]

Right iliac fossa pain and tenderness was the most common clinical finding, observed in 71 (94.7%) patients. Nausea and vomiting were present in 53 (70.7%), anorexia in 48 (64.0%), rebound tenderness in 42 (56.0%) and fever in 39 (52.0%) patients. These findings are consistent with the classical clinical presentation of acute appendicitis. However, because individual clinical features may not be present in all patients, a combination of clinical, laboratory and imaging findings is often required for accurate diagnosis. [2,3]

Leukocytosis was observed in 57 (76.0%) patients, while neutrophilia was present in 55 (73.3%). Leukocytosis and neutrophilia are useful supportive laboratory findings but have limited specificity when used independently. Andersson demonstrated that the diagnostic value of clinical and laboratory parameters improves when they are interpreted collectively rather than individually. [3]

### Ultrasonography

In the present study, USG was reported as positive for acute appendicitis in 52 (69.3%) patients, negative in 15 (20.0%) and equivocal in 8 (10.7%). The presence of equivocal examinations represents an important limitation of ultrasonography. Non-visualization of the appendix may occur because of overlying bowel gas, obesity, deep pelvic location, retrocecal position of the appendix or operator-related factors.

Graded-compression ultrasonography is an established technique for evaluating suspected acute appendicitis and can demonstrate a non-compressible appendix, increased appendiceal diameter, wall thickening, appendicolith and periappendiceal inflammatory changes. [4] However, its diagnostic performance may vary according to operator expertise and patient-related factors. [5]

In the present study, USG correctly identified 48 of 58 patients with histopathologically confirmed acute appendicitis and correctly classified 13 of 17 patients without acute appendicitis. The sensitivity of USG was 82.8%, specificity was 76.5%, positive predictive value was 92.3%, negative predictive value was 56.5%, and overall diagnostic accuracy was 81.3%.

The sensitivity observed in the present study is comparable with previously published evidence. Doria et al., in a meta-analysis of imaging modalities for suspected appendicitis, reported pooled sensitivity of approximately 83% for ultrasonography in adults. [7] Differences in specificity between studies may be explained by variations in operator experience, patient characteristics, imaging protocols and criteria used for interpretation.

The relatively low negative predictive value of USG in the present study indicates that a negative ultrasound examination cannot reliably exclude acute appendicitis when clinical suspicion remains high. Therefore, patients with persistent clinical suspicion despite a negative or equivocal USG examination may require further evaluation with an additional imaging modality.

### Contrast-Enhanced Computed Tomography

CECT was positive for acute appendicitis in 56 (74.7%) patients and negative in 19 (25.3%). Compared with the histopathological reference standard, CECT correctly identified 55 of 58 patients with acute appendicitis and correctly excluded the disease in 16 of 17 patients.

The sensitivity of CECT was 94.8%, specificity was 94.1%, positive predictive value was 98.2%, negative predictive value was 84.2%, and overall diagnostic accuracy was 94.7%.

The high sensitivity and specificity observed in the present study indicate excellent diagnostic performance of CECT. These findings are consistent with the results of Doria et al., who

reported pooled sensitivity and specificity of approximately 94% for CT in adults with suspected appendicitis. [7] Eng et al. also demonstrated high diagnostic accuracy of CT when used as a second-line imaging modality following initial ultrasound assessment. [8]

The high positive predictive value of 98.2% observed in the present study indicates that most patients diagnosed as positive by CECT had histopathologically confirmed acute appendicitis. Similarly, the negative predictive value of 84.2% suggests that CECT was more effective than USG in excluding acute appendicitis.

**Comparison of USG and CECT**

The principal finding of the present study was the superior diagnostic performance of CECT compared with USG. CECT demonstrated higher sensitivity (94.8%) than USG (82.8%) and higher specificity (94.1%) than USG (76.5%). CECT also demonstrated a higher positive predictive value (98.2% vs. 92.3%), negative predictive value (84.2% vs. 56.5%) and overall diagnostic accuracy (94.7% vs. 81.3%).

The higher diagnostic performance of CECT may be attributed to its ability to provide detailed cross-sectional visualization of the appendix and surrounding structures. CT is less affected by bowel gas, patient body habitus and anatomical variations in appendix position. In addition to direct appendiceal abnormalities, CT can demonstrate periappendiceal fat stranding, appendicolith, fluid collection, extraluminal air and other secondary inflammatory changes.

The findings of the present study are in agreement with the meta-analysis by Doria et al., which demonstrated higher diagnostic performance of CT compared with USG in adults with suspected acute appendicitis. [7] Eng et al. similarly reported high diagnostic accuracy of CT when used after an initial ultrasound examination. [8]

The markedly higher negative predictive value of CECT compared with USG in the present study is clinically important. A negative CECT examination was more reliable in excluding acute appendicitis than a negative USG examination. Therefore, CECT may be particularly useful in patients with persistent clinical suspicion despite an inconclusive or negative ultrasound examination.

**Role of USG**

Despite its lower diagnostic accuracy compared with CECT, USG remains an important investigation in suspected acute appendicitis. It is non-invasive, relatively inexpensive, widely available and does not involve ionizing radiation. These advantages make it particularly useful in younger patients and in situations where radiation exposure should be minimized.

Mostbeck et al. recommended an ultrasound-first approach for suspected acute appendicitis, particularly because of its safety and absence of radiation exposure. [5] Evidence from younger patient populations also supports the use of USG as an initial investigation, with CT or MRI reserved for patients with equivocal or non-diagnostic findings. [9]

Therefore, the findings of the present study should not be interpreted as suggesting that CECT should replace USG in every patient. Instead, USG may be used as an initial imaging modality, followed by CECT when the ultrasound findings are inconclusive or when clinical suspicion remains high.

**Role of CECT in Complicated Appendicitis**

An important advantage of CECT is its ability to evaluate complicated appendicitis. CT can demonstrate periappendiceal abscess or collection, perforation, extraluminal air, appendicolith and extensive inflammatory changes. Identification of these findings may assist in determining the severity of disease and planning appropriate surgical management. [6]

In the present study, CECT provided a more comprehensive assessment of periappendiceal inflammatory changes and complications than USG. This supports the established role of CT in patients with suspected complicated appendicitis or when alternative intra-abdominal pathology needs to be excluded.

**Clinical Significance**

The findings of the present study indicate that both USG and CECT have important roles in the diagnostic evaluation of acute appendicitis. USG offers the advantages of safety, accessibility and absence of radiation, whereas CECT provides superior anatomical visualization and higher diagnostic accuracy.

A sequential imaging approach may therefore be appropriate in selected patients. USG can be used initially, particularly in younger patients or those in whom radiation exposure should be avoided. CECT can subsequently be considered in patients with equivocal USG findings, persistent clinical suspicion or

suspected complications.

CT may also identify alternative causes of right lower quadrant pain and thereby contribute to improved diagnostic decision-making. Krajewski et al. reported that CT imaging can have an important impact on the evaluation and management of patients presenting with acute right lower quadrant pain. [10]

## CONCLUSION

The present study demonstrated that both USG and CECT are useful in the preoperative diagnosis of acute appendicitis. However, CECT showed superior diagnostic performance, with higher sensitivity, specificity, PPV, NPV and overall diagnostic accuracy compared with USG. USG remains a valuable initial, radiation-free imaging modality, while CECT is particularly useful in patients with equivocal USG findings, persistent clinical suspicion or suspected complications. Thus, a USG-first approach followed by CECT when clinically indicated may provide an effective balance between diagnostic accuracy and patient safety.

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