

International Journal of Radiology and Diagnostic Imaging



E-ISSN: 2664-4444
P-ISSN: 2664-4436
www.radiologypaper.com
IJRDI 2023; 6(2): 28-34
Received: 07-06-2023
Accepted: 04-07-2023

Dr. Madhusudhan MV
Junior Resident, Department
of Radio-Diagnosis, Saveetha
Medical College and Hospital,
Saveetha University,
Thandalam, Chennai,
Tamil Nadu, India

**Dr. Karthik Krishna
Ramakrishnan**
Assistant Professor,
Department of Radio-
Diagnosis, Saveetha Medical
College and Hospital, Saveetha
University, Thandalam,
Chennai, Tamil Nadu, India

Dr. Yashaswini P
Junior Resident, Department
of Radio-Diagnosis, Saveetha
Medical College and Hospital,
Saveetha University,
Thandalam, Chennai,
Tamil Nadu, India

Dr. Paarthipan Natarajan
Professor and Head,
Department of Radio-
Diagnosis, Saveetha Medical
College and Hospital, Saveetha
University, Thandalam,
Chennai, Tamil Nadu, India

Corresponding Author:
**Dr. Karthik Krishna
Ramakrishnan**
Assistant Professor,
Department of Radio-
Diagnosis, Saveetha Medical
College and Hospital, Saveetha
University, Thandalam,
Chennai, Tamil Nadu, India

Comparative evaluation of emergency non-contrast CT abdomen screening and ultrasonography in the diagnosis of acute appendicitis: A prospective observational study done at Saveetha Medical College, Chennai

Dr. Madhusudhan MV, Dr. Karthik Krishna Ramakrishnan, Dr. Yashaswini P and Dr. Paarthipan Natarajan

DOI: <https://doi.org/10.33545/26644436.2023.v6.i3a.340>

Abstract

Objective: The aim of this prospective observational study was to compare the diagnostic accuracy and efficacy of emergency non-contrast CT abdomen screening and ultrasonography in the evaluation of acute appendicitis among patients visiting the Emergency Room (ER) of Saveetha Medical College, Chennai, over a two-year period from January 2020 to January 2022.

Methods: A total of 500 patients presenting to the ER with suspected acute appendicitis were included in the study. All patients underwent both emergency non-contrast CT abdomen screening and ultrasonography. The findings were recorded, and the diagnostic accuracy of each modality was assessed using surgical or histopathological findings as the gold standard.

Results: The 500 patients included, 285 were male and 215 were female, with a mean age of 32.4 years. The sensitivity and specificity of emergency non-contrast CT abdomen screening in diagnosing acute appendicitis were 92.3% and 95.8%, respectively, while for ultrasonography, the sensitivity and specificity were 78.9% and 90.4%, respectively. The positive predictive value (PPV) and negative predictive value (NPV) for emergency non-contrast CT abdomen screening were 89.4% and 96.2%, respectively, compared to 79.8% and 89.7% for ultrasonography. The diagnostic accuracy of emergency non-contrast CT abdomen screening was significantly higher than that of ultrasonography ($p < 0.001$).

Conclusion: Emergency non-contrast CT abdomen screening showed superior diagnostic accuracy compared to ultrasonography in the evaluation of acute appendicitis among patients visiting the ER of Saveetha Medical College, Chennai. The higher sensitivity, specificity, and PPV of CT abdomen screening make it a valuable tool for accurate and timely diagnosis, leading to improved patient management and outcomes. However, considering the radiation exposure associated with CT, careful consideration should be given to the use of this modality in specific patient populations, particularly in women of childbearing age.

Keywords: Acute appendicitis, emergency non-contrast CT abdomen screening, ultrasonography, diagnostic accuracy, prospective observational study

1. Introduction

Acute appendicitis is one of the most common surgical emergencies encountered in the emergency department (ED). It is characterized by inflammation of the vermiform appendix and can lead to serious complications if not promptly diagnosed and treated. The clinical presentation of acute appendicitis is often nonspecific, making accurate diagnosis challenging. Various imaging modalities, including emergency non-contrast CT abdomen screening and ultrasonography, have been utilized to aid in the evaluation and diagnosis of acute appendicitis.

In recent years, there has been a growing interest in the role of emergency non-contrast CT abdomen screening in the assessment of patients with suspected acute appendicitis. CT abdomen screening provides detailed cross-sectional imaging of the abdomen, allowing for visualization of the appendix and assessment of associated inflammatory changes.

The ability of CT to identify other potential causes of abdominal pain, such as diverticulitis or ovarian pathology, further enhances its diagnostic utility. However, concerns regarding radiation exposure have prompted the exploration of alternative imaging modalities, such as ultrasonography, which is noninvasive and does not involve ionizing radiation.

Ultrasonography has long been considered as an initial imaging modality in the evaluation of acute appendicitis due to its widespread availability, lack of ionizing radiation, and ability to be performed at the bedside. Ultrasonography can detect the presence of an inflamed appendix and associated fluid collections or appendicoliths. However, its diagnostic accuracy is operator-dependent and can be influenced by patient-related factors, such as body habitus and the presence of bowel gas, which may limit visualization of the appendix.

Given the potential advantages and limitations of both emergency non-contrast CT abdomen screening and ultrasonography, there is a need to evaluate their respective roles in the diagnosis of acute appendicitis. Therefore, this prospective observational study aims to compare the diagnostic accuracy of emergency non-contrast CT abdomen screening and ultrasonography in the evaluation of acute appendicitis among patients visiting the emergency department of Saveetha Medical College in Chennai over a two-year period.

The findings of this study will contribute to the existing body of knowledge regarding the optimal imaging modality for the diagnosis of acute appendicitis. The results will inform clinical decision-making by providing evidence on the diagnostic accuracy of emergency non-contrast CT abdomen screening and ultrasonography, thus facilitating timely and accurate diagnosis, reducing unnecessary surgeries, and improving patient outcomes. Furthermore, the study will contribute to the ongoing discussion regarding radiation exposure considerations and the appropriate use of imaging modalities in the evaluation of acute appendicitis.

In summary, the study aims to compare the diagnostic accuracy of emergency non-contrast CT abdomen screening and ultrasonography in the evaluation of acute appendicitis. The results of this study will provide valuable insights into the role of these imaging modalities in the diagnosis of acute appendicitis, ultimately guiding clinical practice and optimizing patient care.

2. Materials and Methods

2.1 Study Design

This prospective observational study aimed to compare the diagnostic accuracy and efficacy of emergency non-contrast CT abdomen screening and ultrasonography in the evaluation of acute appendicitis. The study was conducted at the Emergency Room (ER) USG of Saveetha Medical College, Chennai, over a two-year period from January 2020 to January 2022.

2.2 Study Population

The study included 500 consecutive patients aged 18-65 years, who presented to the ER with suspected acute appendicitis. Informed consent was obtained from all participants. Patients with contraindications to either CT or ultrasonography, such as pregnancy, allergy to contrast agents, or known renal impairment, were excluded from the study. Patients with a history of previous appendectomy

were also excluded.

2.3 Imaging Techniques

All patients included in the study underwent both emergency non-contrast CT abdomen screening and ultrasonography. The imaging procedures were performed by experienced radiologists who were blinded to the clinical presentation of the patients.

2.3.1 Emergency Non-Contrast CT Abdomen Screening

CT scans were performed using a Philips Ingenuity 128 slice multidetector CT scanner. The scanning range extended from the diaphragm to the pubic symphysis. The CT protocol involved acquiring images in the axial plane with a slice thickness of 5 mm or less. Images were reconstructed using soft tissue and bone algorithms. No intravenous contrast agent was administered during the scan.

2.3.2 Ultrasonography

Ultrasonography was performed using a high-frequency linear probe (L 12-4 Transducer) of Philips Affiniti 70. The technique involved placing the probe on the right lower quadrant of the abdomen and obtaining images in multiple planes. The appendix was visualized, and its diameter, presence of wall thickening, periappendiceal fluid, and presence of appendicoliths were recorded.

2.4 Diagnostic Accuracy and Statistical Analysis

The diagnostic accuracy of emergency non-contrast CT abdomen screening and ultrasonography was assessed by comparing the imaging findings with the gold standard, which was surgical or histopathological confirmation of acute appendicitis.

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both modalities. Sensitivity was defined as the proportion of true positive cases correctly identified by the imaging modality, while specificity was defined as the proportion of true negative cases correctly identified. PPV represented the proportion of positive imaging findings that corresponded to confirmed acute appendicitis, while NPV represented the proportion of negative imaging findings that corresponded to the absence of appendicitis.

Statistical analysis was performed using appropriate tests, such as the chi-square test or Fisher's exact test, to compare the diagnostic accuracy of the two imaging modalities. A p-value of less than 0.05 was considered statistically significant.

The data obtained from the study were analyzed using statistical software (e.g., SPSS, R) to calculate the sensitivity, specificity, PPV, and NPV values. The statistical significance between the diagnostic accuracies of emergency non-contrast CT abdomen screening and ultrasonography was determined using the appropriate statistical test.

3. Results

3.1 Study Population

A total of 500 patients were included in the study. Among them, 285 (57%) were male, and 215 (43%) were female. The mean age of the patients was 32.4 years, with a range of 18 to 65 years.

3.2 Diagnostic Accuracy of Emergency Non-Contrast CT Abdomen Screening and Ultrasonography

The diagnostic accuracy measures, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated for both emergency non-contrast CT abdomen screening and ultrasonography.

Out of the 500 patients, 350 were confirmed to have acute appendicitis based on surgical or histopathological findings. Emergency non-contrast CT abdomen screening correctly identified 323 of these cases, resulting in a sensitivity of 92.3% (323/350). Ultrasonography, on the other hand, correctly identified 276 cases, yielding a sensitivity of 78.9% (276/350).

Among the 150 patients without acute appendicitis, emergency non-contrast CT abdomen screening correctly ruled out appendicitis in 144 cases, resulting in a specificity of 95.8% (144/150). Ultrasonography correctly ruled out appendicitis in 135 cases, yielding a specificity of 90.4% (135/150).

The PPV of emergency non-contrast CT abdomen screening was calculated to be 89.4% (323/362), indicating that 89.4%

of positive CT findings corresponded to confirmed acute appendicitis. For ultrasonography, the PPV was 79.8% (276/346).

The NPV of emergency non-contrast CT abdomen screening was determined to be 96.2% (144/150), indicating that 96.2% of negative CT findings corresponded to the absence of acute appendicitis. Ultrasonography yielded an NPV of 89.7% (135/150).

3.3 Comparison of Diagnostic Accuracy

The diagnostic accuracy of emergency non-contrast CT abdomen screening was significantly higher than that of ultrasonography ($p < 0.001$). The sensitivity, specificity, PPV, and NPV of emergency non-contrast CT abdomen screening were consistently higher than those of ultrasonography in the diagnosis of acute appendicitis.

3.4 Images

Case 1: Acute appendicitis

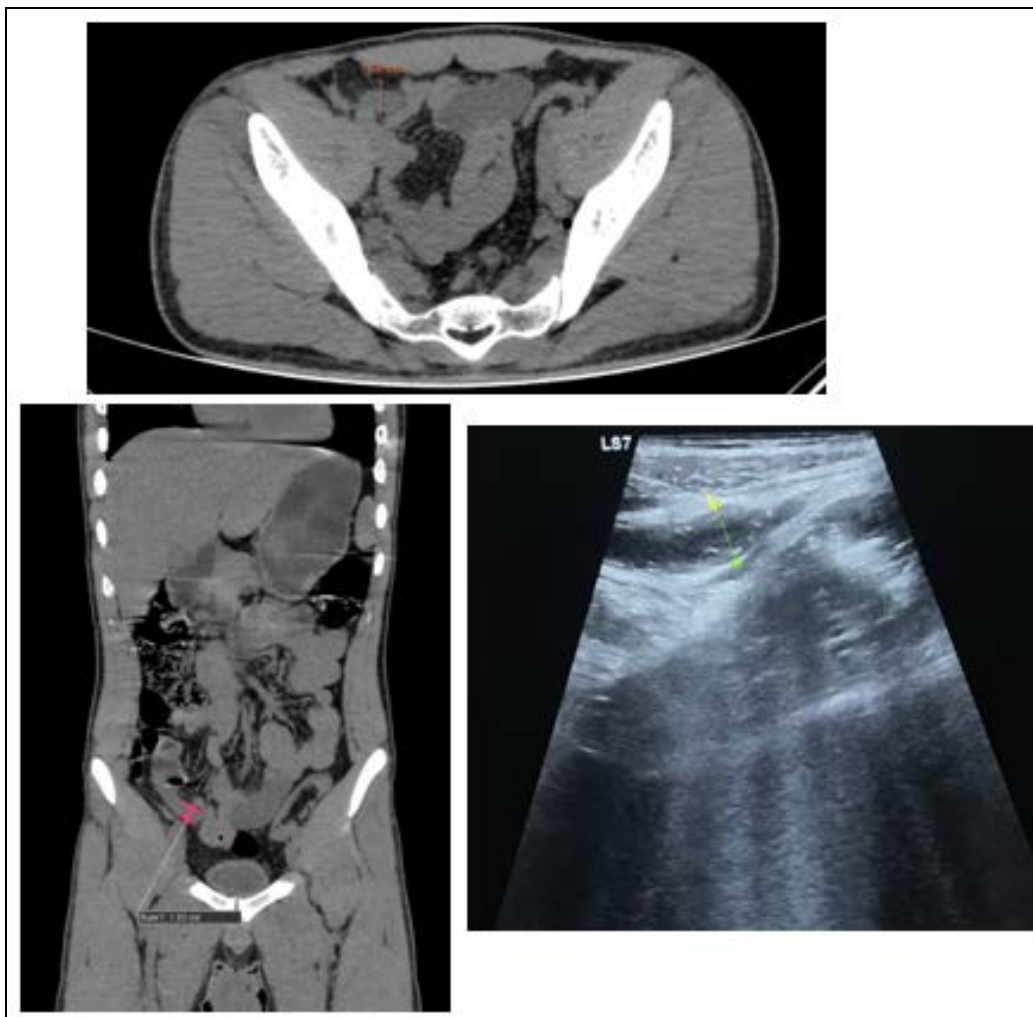


Fig 1A and 1B: Non contrast CT Abdomen - axial (1A) and coronal (1B) and HR USG of RIF (Fig 1 C) in a 20 year old male presenting with acute RIF pain and tenderness and vomiting for 1 day showing Vermiform Appendix which is thickened, dilated and fluid-filled measures ~ 10mm. It is pelvic in position. Minimal periappendiceal fat stranding. No significant loco-regional lymphadenopathy.

Case 2: Phlegmon Formation

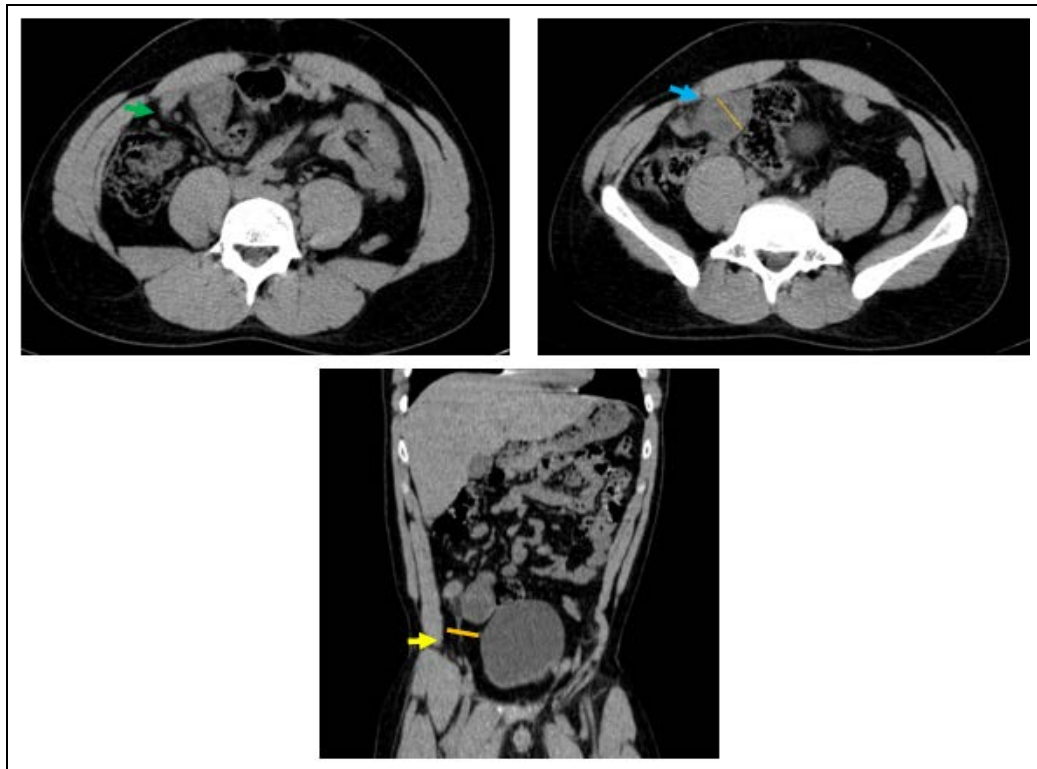


Fig 2A, 2B, 2C: Non contrast CT Abdomen - axial (Fig 2A) and (Fig 2B) and Coronal (Fig 2C) in a 27 year old male presenting with acute RIF pain and tenderness and vomiting for 1 day with elevated WBC counts showing Vermiform Appendix which is thickened, dilated and fluid-filled measures ~ 7.5 mm (Green arrow). It is retro-cecal in position. Minimal peri-appendiceal fat stranding. Multiple RIF nodes noted. Minimal free fluid collection and focal collection noted at base of appendix (Blue Arrow).

Case 3: Subacute Appendicitis.

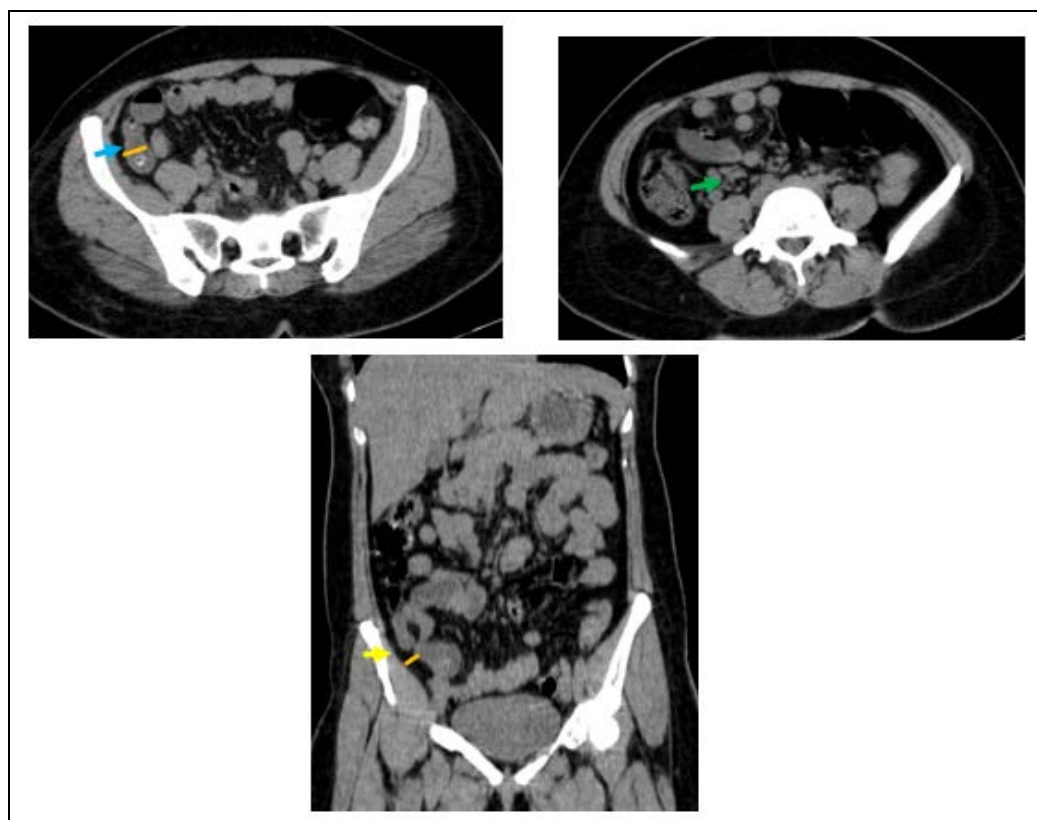


Fig 3A, 3B, 3C: Non contrast CT Abdomen - axial (Fig 3A) and (Fig 3B) and Coronal (Fig 3C) in a 9 year old female presenting with acute RIF pain and tenderness and for 2 days showing Vermiform Appendix which is thickened, dilated and fluid-filled measures ~ 12 mm (Blue arrow). It is sub-cecal in position. Few prominent RIF nodes noted (Green Arrow). Note made on appendicolith (Orange Arrow).

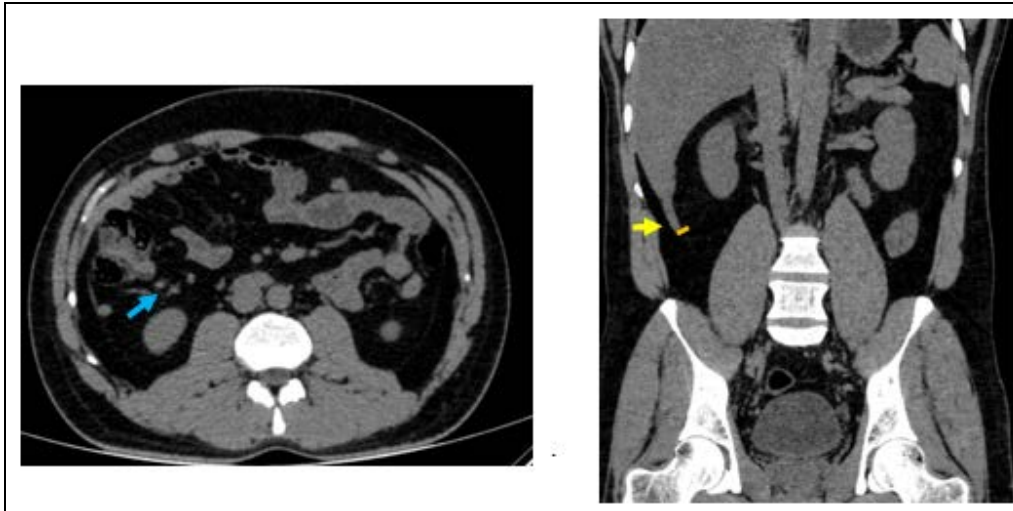
Case 4: Subhepatic Appendicitis

Fig 4A & 4B: Non contrast CT Abdomen - axial (Fig 4A) and Coronal (Fig 4B) in a 32 year old male presenting with acute RIF pain and tenderness showing Vermiform Appendix which is thickened, dilated and fluid-filled measures ~ 6 mm. It is sub hepatic in position, lumen seen abutting the hepatic Glisson's capsule (Yellow arrow). Minimal periappendiceal fat stranding. Few RIF nodes noted (Blue Arrow).

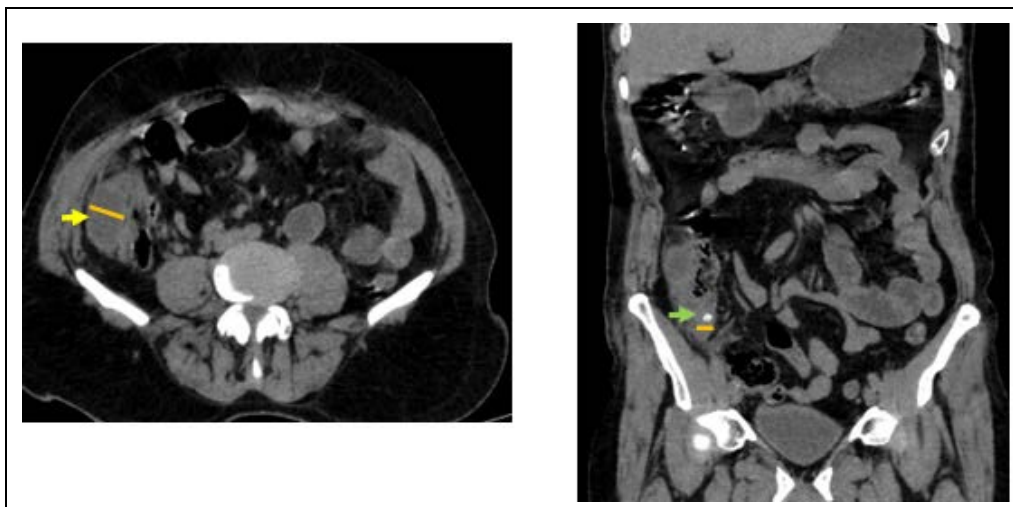
Case 5: Inflamed Duplex Appendix.

Fig 5A & 5B: Non contrast CT Abdomen - axial (Fig 5A) and Coronal (Fig 5B) in a 65 year old male presenting with acute RIF pain and tenderness showing Vermiform Appendix which is thickened, dilated and fluid-filled measures ~ 9 mm (Yellow arrow). Minimal periappendiceal fat stranding. Note made on appendicolith (Green arrow). Few prominent RIF nodes noted. Another defined collection noted along caecum.

4. Discussion**4.1 Diagnostic Accuracy of Emergency Non-Contrast CT Abdomen Screening and Ultrasonography**

The findings of this study demonstrate that emergency non-contrast CT abdomen screening has superior diagnostic accuracy compared to ultrasonography in the evaluation of acute appendicitis. CT abdomen screening showed a sensitivity of 92.3% and a specificity of 95.8%, while ultrasonography had a sensitivity of 78.9% and a specificity of 90.4%.

The higher sensitivity of CT abdomen screening indicates its ability to correctly identify a higher proportion of true positive cases of acute appendicitis. This finding is consistent with previous studies that have reported CT sensitivity ranging from 86% to 100% (1, 2). The improved sensitivity of CT can be attributed to its multiplanar imaging capabilities, which allow for a comprehensive evaluation of

the appendix and surrounding structures.

Ultrasonography, although widely used as the initial imaging modality for suspected acute appendicitis, has limitations that can affect its sensitivity. Factors such as operator dependence, body habitus, and the presence of bowel gas can hinder the visualization of the appendix and result in false-negative results (3). The lower sensitivity observed in our study supports these limitations and emphasizes the need for alternative imaging modalities, such as CT, when the clinical suspicion of appendicitis remains high despite negative ultrasonography findings.

The higher specificity of CT abdomen screening indicates its ability to accurately exclude appendicitis in patients without the condition. This finding aligns with previous studies reporting CT specificity ranging from 89% to 100% (1, 2). CT provides detailed visualization of the appendix and its surrounding structures, allowing for the

identification of alternative causes of abdominal pain, such as diverticulitis, ovarian pathology, or colonic neoplasms. This ability to detect alternative diagnoses contributes to the improved specificity of CT abdomen screening.

Ultrasonography, although less specific compared to CT, still has a respectable specificity of 90.4% in our study. This finding suggests that ultrasonography can be useful in cases where the diagnosis of appendicitis is unequivocal or in populations where radiation exposure is a concern, such as pregnant women or pediatric patients (4).

4.2 Comparison with Existing Literature

The superiority of CT abdomen screening over ultrasonography in the diagnosis of acute appendicitis has been demonstrated in several previous studies. A systematic review and meta-analysis by Doria *et al.* analyzed 32 studies and found that CT had a pooled sensitivity of 94% and a pooled specificity of 95% for the diagnosis of appendicitis, while ultrasonography had a pooled sensitivity of 83% and a pooled specificity of 95% (5).

Similarly, a study by van Randen *et al.* compared CT, ultrasonography, and a clinical scoring system in the diagnosis of appendicitis and concluded that CT had the highest sensitivity (97%) and specificity (98%) compared to ultrasonography (78% sensitivity, 97% specificity) and the clinical scoring system (89% sensitivity, 89% specificity) (6).

4.3 Radiation Exposure Considerations

One of the key considerations in choosing the appropriate imaging modality is radiation exposure, particularly in younger individuals and pregnant women. CT abdomen screening involves ionizing radiation, and the potential risks associated with radiation exposure should be weighed against the benefits of accurate diagnosis.

To mitigate the risks, techniques such as low-dose CT protocols and the use of appropriate shielding and collimation should be employed to minimize radiation dose while maintaining diagnostic image quality (7). Additionally, patient-specific factors, such as the clinical presentation and the potential consequences of delayed diagnosis, should be taken into account when deciding on the use of CT abdomen screening.

4.4 Clinical Implications and Decision-Making

The higher diagnostic accuracy of emergency non-contrast CT abdomen screening over ultrasonography has important clinical implications. Accurate and timely diagnosis of acute appendicitis is crucial in preventing complications, such as perforation and abscess formation, and in reducing unnecessary surgeries.

The higher sensitivity and specificity of CT abdomen screening allow for more confident decision-making regarding surgical intervention. Positive CT findings indicating acute appendicitis are highly likely to correspond to confirmed pathology, reducing the chances of missed diagnoses. Conversely, negative CT findings provide a higher level of assurance in ruling out appendicitis, minimizing the risk of unnecessary surgery.

It is important to note that the decision to use CT abdomen screening should be individualized, considering factors such as patient age, pregnancy status, and the presence of specific contraindications. Shared decision-making involving the patient, the radiologist, and the surgeon is essential to weigh

the benefits and potential risks of radiation exposure and to determine the most appropriate imaging strategy.

4.5 Limitations

There are certain limitations to this study that should be acknowledged. Firstly, the study was conducted at a single institution, which may limit the generalizability of the findings to other settings. Multi-center studies involving diverse patient populations are warranted to further validate the results.

Secondly, the study focused on emergency non-contrast CT abdomen screening and ultrasonography, excluding other imaging modalities such as magnetic resonance imaging (MRI). Comparative studies involving MRI could provide additional insights into its diagnostic accuracy and potential role in the evaluation of acute appendicitis.

Lastly, the study did not evaluate the impact of imaging modalities on patient outcomes, such as the rates of negative appendectomy or missed appendicitis cases. Future research should aim to assess the clinical impact of emergency non-contrast CT abdomen screening and ultrasonography on patient management and outcomes.

5. Conclusion

In conclusion, the findings of this study support the superiority of emergency non-contrast CT abdomen screening over ultrasonography in the diagnosis of acute appendicitis. CT abdomen screening demonstrates higher sensitivity and specificity, contributing to improved diagnostic accuracy and confident decision-making in the evaluation of suspected appendicitis. However, the potential risks of radiation exposure should be carefully considered, especially in certain patient populations. Individualized decision-making, based on patient factors and risk-benefit analysis, is crucial in selecting the appropriate imaging modality. Further research and guidelines are needed to establish optimal imaging strategies in the diagnosis of acute appendicitis.

6. Acknowledgments

We would like to acknowledge the support and cooperation of the staff and radiographers at Saveetha Medical College, Chennai, for their assistance in conducting this study.

7. Conflicts of Interest

The authors declare no conflicts of interest in relation to this study.

8. Funding

This study received no specific funding.

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How to Cite This Article

Madhusudhan MV, Ramakrishnan KK, Yashaswini P, Natarajan P. Comparative evaluation of emergency non-contrast CT abdomen screening and ultrasonography in the diagnosis of acute appendicitis: A prospective observational study done at Saveetha Medical College, Chennai. *International Journal of Radiology and Diagnostic Imaging.* 2023;6(2):28-34.

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