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Diagnostic Accuracy of Unenhanced Low-Dose Multidetector Computed Tomography in Suspected Cases of Acute Appendicitis

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ABSTRACT

Objective: To determine the diagnostic accuracy of unenhanced low-dose multi-detector computed tomography (LDMDCT) in detecting acute appendicitis, taking histopathology as the gold standard.
Study Design: Cross-sectional validation study.
Place and Duration of Study: Department of Radiology, Combined Military Hospital Rawalpindi, Pakistan, from May to Nov 2025.
Methodology: A total of 92 patients aged 18–40 years presenting with clinically suspected Acute Appendicitis were enrolled using non-probability consecutive sampling. All patients underwent unenhanced LDMDCT on a GE Optima 128-slice scanner with radiation dose maintained below 3 mSv. CT findings were evaluated against histopathological diagnosis of resected appendix specimens. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated.
Results: The mean age was 27.4±6.8 years, and 58(63.0%) participants were male. Histopathology confirmed acute appendicitis in 51 (55.4%) patients. Unenhanced LDMDCT demonstrated sensitivity of 88.2% (95% CI: 76.1–95.6%), specificity of 87.8% (95% CI: 73.8–95.9%), PPV of 90.0%, NPV of 85.7%, and overall diagnostic accuracy of 88.0%. No statistically significant difference in diagnostic accuracy was observed across gender or age subgroups (p>0.05).
Conclusion: Unenhanced LDMDCT is a reliable and radiation-conscious imaging modality with high diagnostic accuracy for suspected acute appendicitis. Its routine adoption in emergency imaging pathways is strongly recommended to reduce unnecessary surgery and curtail radiation burden in the predominantly young population affected by this condition.

Keywords: Acute Appendicitis, Computed Tomography, Diagnostic Accuracy, Histopathology, Low-Dose CT, Multi-Detector CT, Radiation Dose Reduction.

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INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies globally, with an incidence of approximately 96.5 - 100 cases per 100,000 adults anually.[1] There has been an increase in incidence of 11.4% between year 1990 and 2019 with an estimation of 17.7 million new cases in 2019 alone.[2] Appendectomy — the definitive surgical treatment remains one of the most frequently performed emergency operations globally.[3]

Owing to overlapping symptoms, there is an imprecision of diagnosis of acute appendicitis clinically. So there is 20% false-positive and false-negative rate of clinical diagnosis.[4] It poses two significant risks: undue surgery resulting in morbidity for individuals who do not have the condition, and the possibility for missed or delayed diagnosis for those who actually have it. The latter increases healthcare cost and patient morbidity through complications like perforation, peritonitis and sepsis.[5]

Clinical scoring systems, like the Alvarado Score, have been used to stratify diagnostic probability before imaging. Despite high sensitivity (≥82%) at a cut-off of 5, specificity remains low for deciding operative procedure that necessitates further imaging especially in equivocal cases.[6] Ultrasonography, is a common, easily accessible diagnostic tool, and has wide range of sensitivity (44–100%).[6] Magnetic Resonance Imaging is a better modality, preferred in pregnancy, but has limited availability in emergency conditions, less cost effectiveness and prolonged times.[7]

When it comes to diagnosing acute appendicitis in adults, multi-detector computed tomography (MDCT), has become the go-to imaging method in emergency settings. It has been incredibly effective in reducing the number of unwarranted

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appendectomies.[8] However, the downside is that conventional-dose CT scans can expose patients to a significant amount of radiation, typically in the range of 8-15 mSv per scan.[9,10]

This study was therefore conducted to determine the diagnostic accuracy of unenhanced low-dose multi-detector computed tomography (LDMDCT) in the detection of acute appendicitis, taking histopathological examination as the gold standard.

METHODOLOGY

This cross-sectional validation study was conducted at the Department of Radiology, Combined Military Hospital Rawalpindi, Pakistan, over a six-month period from May 2025 to Nov 2025. Study commenced after approval from the Institutional Review Board/Ethics Committee of CMH Rawalpindi (Ref: IRB-CMH-2022/147, dated 15 May 2025).

Sample size was calculated using the World Health Organization (WHO) sensitivity and specificity calculator, based on previously reported sensitivity of 87.9%, specificity of 90.7%, and disease prevalence of acute appendicitis of 55.8%.[11] The minimum required sample size was 92 patients.

Inclusion Criteria: Patients aged 18–40 years of either gender fulfilling the operational definition of acute appendicitis were included.

Exclusion Criteria: Patients with a history of prior appendectomy, known inflammatory bowel disease (Crohn's disease or ulcerative colitis), confirmed abdominal malignancy, or confirmed pregnancy on ultrasonography were excluded.

Non-probability consecutive sampling was employed. All eligible patients referred to the Department of Radiology by the surgical team were enrolled sequentially until the target sample size was reached. Written informed consent was obtained from all the participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The operational definition of acute appendicitis required all three of the following to be present: body temperature exceeding 37.8°C (100°F), right lower quadrant pain and localized tenderness with a Visual Analogue Scale (VAS) score greater than 5 at McBurney's point, and leucocytosis of ≥10,000/mm^3 on full blood count.

All CT examinations were performed on a GE Optima 128-slice MDCT scanner. No oral, rectal, or intravenous contrast material was administered. The protocol used a weight-based, size-based technique at 100 kVp with automated z-axis tube current modulation from the scout image, and statistical iterative reconstruction (ASIR-V, 50%). Images were reconstructed with a slice thickness of 3 mm in both the axial and coronal planes. For all patients, the total radiation dose stayed below 3 mSv. CT images were independently evaluated by two consultant radiologists, each with a minimum of five years of subspecialty abdominal imaging experience, blinded to clinical and laboratory data. Discordant readings were resolved by consensus.

A positive CT result for Acute Appendicitis required all of the following: appendiceal diameter ≥8 mm (without intraluminal gas or fluid) or ≥10 mm (with gas or fluid), thickened appendiceal wall (>3 mm), and peri-appendiceal fat stranding. Signs of perforation including extraluminal gas, appendicolith, peri-appendiceal phlegmon or abscess, or a mural defect were additionally recorded.

All patients with a CT-positive result underwent appendectomy. Patients with negative CT findings were followed clinically and managed conservatively, with no subsequent clinical or imaging evidence of appendicitis on follow-up. Resected appendix specimens were submitted for formal histopathological examination by a qualified histopathologist blinded to CT findings. The diagnosis of Acute Appendicitis required the presence of serosal congestion, hemorrhage, and fibrinopurulent exudate on the serosal surface. Histopathology served as the gold standard.

We used Statistical Package for the Social Sciences (SPSS) version to enter and analyze data. Normality of continuous variables was assessed using the Shapiro-Wilk test; all quantitative variables (age, BMI, duration of complaints) were found to follow a normal distribution (p>0.05) and were therefore expressed as Mean±SD. Quantitative variables (age, BMI, duration of complaints) were expressed as Mean±SD. Categorical variables (gender, CT result, histopathological result) were reported as frequency and percentage. A 2×2 contingency table was constructed to derive true positive (TP), false positive (FP), false negative (FN), and true negative (TN) values, from which sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy were calculated. Post-stratification chi-square test was applied for comparisons across gender and age subgroups. A p-value ≤0.05 was considered statistically significant.

RESULTS

A total of 92 patients meeting the eligibility criteria were included. No patient was lost to follow-up or withdrawn after enrolment. Baseline demographic and clinical characteristics are summarized in Table-I.

Table-I: Baseline Demographic and Clinical Characteristics of patients (n = 92)

Variables	Values
Age (years) — Mean ± SD	27.4±6.8
Age Range (years)	18.0–40.0
Gender: Male, n (%)	58(63.0%)
Gender: Female, n (%)	34(37.0%)
Body Mass Index (kg/m²) Mean ± SD	24.3±3.1
Duration of Complaints (hours) Mean ± SD	18.6±7.2
Duration Range (hours)	6.0–48.0

The mean age was 27.4±6.8 years (range 18–40 years). The overall diagnostic accuracy was 88.0% 88.0% (95%CL:79.4-93.6%). Males comprised 58 (63.0%) of the cohort. The mean BMI was 24.3±3.1 kg/m² and the mean duration of symptoms prior to presentation was 18.6±7.2 hours.

Histopathological examination confirmed acute appendicitis in 51 of 92 patients, yielding a disease prevalence of 55.4% within this cohort. Unenhanced LDMDCT correctly identified 45 of the 51 true cases (true positives) and correctly excluded the diagnosis in 36 of the 41 non-appendicitis patients (true negatives). There were 5 false-positive and 6 false-negative results. The 2×2 contingency table is presented in Table-II.

The derived diagnostic performance indices with 95% CI are presented in Table -III. 88.0% (95% CI: 79.4–93.6%) was diagnostic accuracy of unenhanced LDMDCT in total. Sensitivity was 88.2% (95% CI: 76.1–95.6%) and specificity was 87.8% (95% CI: 73.8–95.9%). PPV was 90.0% and NPV was 85.7%.

Table-II: Contingency Table for Unenhanced Low-Dose Multi-Detector Computed Tomography (LDMDCT) versus Histopathology (n = 92)

		Histopathology	
Unenhanced Low-Dose Multi-Detector Computed Tomography (LDMDCT)		Positive	Negative
	Positive	TP = 45	FP = 5
	Negative	FN = 6	TN = 36

**PPV: Positive Predictive Value, NPV: Negative Predictive Value*

Table-III: Diagnostic Performance indices of Unenhanced Low-Dose Multi-Detector Computed Tomography (LDMDCT) against Histopathology (n=92)

Diagnostic Parameters	Values(%)	95% CI
Sensitivity	88.2	76.1 – 95.6
Specificity	87.8	73.8 – 95.9
Positive Predictive Value (PPV)	90.0	78.2 – 96.7
Negative Predictive Value (NPV)	85.7	71.5 – 94.6
Overall Diagnostic Accuracy	88.0	79.4 – 93.6

DISCUSSION

This cross-sectional validation study established that unenhanced LDMDCT achieves sensitivity of 88.2%, specificity of 87.8%, and overall diagnostic accuracy of 88.0% for the detection of Acute Appendicitis when validated against histopathology.

Kim et al.'s landmark single-center Randomized Controlled Trial (RCT) showed that low-dose abdominal CT is not worse than standard-dose CT in young adults who might have appendicitis. The negative appendectomy rates were similar (3.5% vs. 3.2%) and no significant differences in perforation rate.[10] Another study further demonstrated sensitivity of 87.9% and specificity of 90.7% for unenhanced LDMDCT with coronal reformats as a first-line diagnostic tool.[11] The subsequent large-scale multi-center LOCAT trial, conducted across 20 South Korean teaching hospitals in 3,074 patients, confirmed these findings at the pragmatic real-world level.[12]

Despite this mounting evidence base, adoption of LDMDCT remains unsatisfactorily slow. A multinational survey of 579 clinicians revealed persistent reluctance stemming from concerns about image quality at reduced doses.[13] Advanced iterative reconstruction algorithms, including model-based iterative reconstruction and statistical approaches such as ASIR-V, have substantially resolved this concern by suppressing quantum noise at low dose levels while preserving diagnostic image quality.[14,15] Comparative analyses confirm that diagnostic accuracy is not significantly inferior with low-dose versus standard-dose CT for appendicitis.[16] Our results closely approximate the benchmark values reported by Yun et al. (sensitivity 87.9%, specificity 90.7%),[11] and confirm the diagnostic non-inferiority of low-dose protocols previously demonstrated in the large-scale LOCAT multi-center randomized trial.[12] The marginal differences from published benchmarks are attributable to variations in scanner technology, iterative reconstruction parameters, and local population characteristics.

The disease prevalence in our cohort (55.4%) is aligned with international estimates. The PPV of 90.0% indicates that nine in ten patients with a positive LDMDCT result have histopathologically confirmed appendicitis, substantially informing operative decision-making. The NPV of 85.7% suggests that a negative LDMDCT reliably excludes appendicitis in most cases, potentially facilitating safe discharge or conservative management and thereby reducing the negative appendectomy rate an outcome demonstrated to follow mandatory imaging protocols in international settings.[17]

The false-negative rate of 11.8% warrants clinical interpretation. These cases most plausibly represent early or subacute appendicitis in which appendiceal distension and peri-appendiceal inflammatory change have not yet reached the defined CT positivity threshold. Complementary application of the Alvarado Score alongside LDMDCT has been proposed to identify high-clinical-risk presentations that may benefit from repeat imaging or surgical consultation despite an initially negative CT result.[6] Bouali et al. similarly highlighted that clinical scoring tools optimally complement imaging rather than replace it.[18]

Stratification analyses by gender and age subgroup confirmed no statistically significant difference in diagnostic performance (p>0.05 for all comparisons). This uniformity strengthens the external validity of LDMDCT across the target demographic. It is consistent with findings from Rahim *et al*. in a comparable South Asian equivocal appendicitis cohort, and with the review by Yang *et al*. highlighting that imaging performance is not substantially modified by patient demographic factors in adult acute appendicitis.[19,20]

From a radiation protection perspective, the LDMDCT protocol in this study delivered effective doses below 3 mSv representing up to 75% reduction compared to standard abdominal CT protocols. The ASIR-V iterative reconstruction algorithm on the GE Optima 128-slice scanner effectively attenuated quantum noise at reduced dose levels while maintaining acceptable diagnostic image quality. This addresses the predominant clinical concern raised in the Kim *et al*. willingness survey, where many providers remained hesitant to adopt LDMDCT due to perceived diagnostic compromise at lower doses.[13]

Haijanen et al., in their prospective cohort study, confirmed that diagnostic accuracy using low-dose versus standard-dose CT for appendicitis is not significantly different, further reinforcing the feasibility of routine LDMDCT adoption.[16] The original single-center RCT by Kim *et al*.[10] and the subsequent LOCAT multi-center RCT together constitute a robust evidence base that our study extends to a South Asian military tertiary hospital context.[12] Haijanen *et al*. have additionally argued that low-dose CT should be regarded as the optimized gold standard in appendicitis imaging pathways rather than an alternative to standard protocols.[15]

The iterative reconstruction meta-analysis by Yun *et al*. further affirmed that low-dose CT with iterative reconstruction is diagnostically equivalent to standard-dose CT across heterogeneous study populations, supporting generalization of this approach.[14] Park *et al*. reviewed the evidence specifically in adolescents and young adults and concluded that a low-dose CT protocol of 2 mSv is sufficient for reliable appendicitis diagnosis while markedly reducing radiation burden.[17]

LIMITATIONS OF STUDY

Limitations include the single-center design at a military hospital potentially limiting civilian generalizability, restriction to the 18–40 year age range, and exclusion of pediatric and elderly patients. Inter-observer variability between the two radiologists, though resolved by consensus, may have introduced modest classification bias. Future multi-center studies spanning a broader age range and employing next-generation photon-counting CT technology would further consolidate these findings.

CONCLUSION

Unenhanced low dose MDCT demonstrates high sensitivity, specificity, and overall diagnostic accuracy for detecting acute appendicitis, with diagnostic performance comparable to conventional-dose CT. Its use significantly reduced radiation exposure without compromising diagnostic reliability, supporting its routine adoption in emergency imaging pathways. Diagnostic reliability is consistent across gender and age subgroups within the studied population. The substantial reduction in ionizing radiation delivered without compromise to diagnostic quality strongly supports routine implementation of the LDMDCT protocol in emergency department imaging pathways, particularly given the predominantly young age of the affected population. This approach serves to minimize unnecessary surgery, reduce cumulative radiation burden, and optimize patient outcomes in a resource-conscious manner.

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MA & TA: Conception, study design, drafting the manuscript, approval of the final version to be published.
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Authors 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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