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Original Article

# Diagnostic Accuracy of Low Radiation Dose Contrast Enhanced Abdominal CT in Acute Appendicitis

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## Abstract

**Background:** Acute appendicitis is one of the commonest causes of acute abdomen in emergency departments, of them most patients require surgery. However, at times the clinical diagnosis of appendicitis becomes challenging. Imaging modalities like ultrasound have been widely used for evaluating patients with suspicion of acute appendicitis, however ultrasound has many limitations. In the past decade there has been an increasing use of computed tomography (CT) for diagnosing acute appendicitis especially in adults. CT abdomen examination is of particular concern due to exposure to ionizing radiation. Studies have shown that low radiation dose CT (LDCT) examination also has high accuracy in diagnosing acute appendicitis.
**Objective:** The rationale of the present study is to determine the diagnostic accuracy of low radiation dose contrast enhanced abdominal CT in diagnosis of acute appendicitis taking histopathology as gold standard.
**Study design, settings and duration:** This cross sectional study was conducted at Accident & Emergency Department and Radiology Department of Combined Military Hospital, Rawalpindi from December 2015 to June 2016.
**Methodology:** Using Non-probability consecutive sampling, 185 patients fulfilling inclusion criteria were enrolled. An informed consent was taken from patients or attendants. Intravenous contrast-enhanced images were obtained with the use of multi-detector CT scanner. All patients were followed for their histopathology report and its results were compared with LDCT. Data was analyzed using SPSS version 20.
**Results:** The mean age of patients was 33.36±10.35 years with age range of 18-60 years. There were 101 (54.6%) male and 84 (45.4%) female patients. There were 106 true positive, 68 true negative, 5 false positive and 6 false negative patients. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy was 94.64%, 93.15%, 95.5%, 91.89% and 94.05% respectively. The patients aged 18-40 years, male had higher diagnostic accuracy.
**Conclusion:** This study shows that LDCT has high diagnostic accuracy. Thus in future we can alter our practice by adopting LDCT for diagnosis of acute appendicitis to avoid patients from excessive radiations exposure and no doubt it can also reduce hospital cost. This can be further justified with large scale studies.
**Key words:** Appendicitis, Low radiation dose CT (LDCT), diagnostic accuracy.

## Introduction

Acute appendicitis is one of the commonest causes in patients presenting with acute abdomen in accident and emergency departments of hospitals, and most patients require surgery.[1] However, at times the clinical diagnosis of appendicitis becomes challenging.[2] Most commonly it occurs in younger population with only 5-10% of cases affecting elderly.[3,4] It is most commonly seen in children aged 10-14 years. It has a lifetime incidence rate of 9.0% and lifetime prevalence of 7-8%.[5,6] However, till now, acute appendicitis continues to pose a diagnostic challenge for the physicians.[2,7]

Alvarado score is the most commonly employed scoring tool for evaluating patients with acute appendicitis. It has a total score of 10 and comprises of; migratory RIF (right iliac fossa) pain, anorexia, nausea/vomiting, rebound tenderness, fever, having one score each and two scores each for RIF tenderness and leukocytosis.[8] Previously

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RA, RR & SA conceptualized the project. Data collection, literature search, statistical analysis, drafting, revision & writing of manuscript was also done by RA, RR & SA.

acute appendicitis was always clinically diagnosed taking into account patient's history of abdominal pain, examination findings and laboratory investigations. It was believed that an active approach should be employed in patients with clinical suspicion of acute appendicitis keeping a low threshold of surgical exploration. This approach however resulted in high negative appendectomies rate (20%), but was justified, based on the fact that delay in surgical intervention can lead to perforation resulting in high morbidity and even mortality.[9]

Imaging modalities like ultrasound have been widely used for evaluating patients with suspicion of acute appendicitis. It has many advantages, being cost effective, lack of exposure to ionizing radiation and can also diagnose conditions mimicking acute appendicitis.[8] However; ultrasound has limitations due to overlying intestinal gas shadows, pain and tenderness, atypical location of appendix and obesity. Moreover it is operator dependent reliant on the skills of the sonologist.[8]

In the past decade there has been an increasing use of computed tomography for diagnosing acute appendicitis especially in adults.[10] It is found that CT has 100% accuracy in diagnosing acute appendicitis.[7] CT abdomen examination in pediatric population is of particular concern since it exposes them to ionizing radiation. Low radiation dose CT (LDCT) examination also has high accuracy in diagnosing acute appendicitis. [11]A study reported sensitivity of Low radiation dose CT of 95% and specificity of 96%.[9] Another study reported sensitivity and specificity of LDCT to be 94.5% and 93.3% respectively.[12] Moreover, another study found that gender, age, and body mass index do not affect appendix visualization in LDCT.[13]

Rationale of present study was to confirm diagnostic accuracy of low dose CT in patients suspected with acute appendicitis. To the best of our knowledge, limited data is available on the diagnostic accuracy of LDCT. In our routine practice we perform CT with standard dose of 7-8 mSv exposing human body with that extra radiation. This study helped us to generate evidence from our local population regarding role of LDCT in patients aged 18-60 years of age. This in future will help us alter our practice by adopting LDCT, avoiding patients from excessive radiations. Moreover it will also reduce hospital cost.

## Methodology

The objective of the study was to determine the diagnostic accuracy of low radiation-dose contrast-enhanced abdominal CT in acute appendicitis taking histopathology as gold standard. This cross sectional study was conducted at Accident & Emergency Department and Radiology Department of Combined Military Hospital, Rawalpindi from December 2015 to June 2016.

A total of 185 patients with clinical suspicion of acute appendicitis were taken in this study. The sample size was calculated using expected sensitivity of Low dose CT as 94.5% and specificity as 93.3% considering expected percentage of acute appendicitis i.e. 31% at 95% confidence level and 5% margin of error.[12]

Non-probability consecutive sampling technique was used. Adult patients between age of 18-60 years of either gender having any BMI presented with right iliac fossa pain and Alvarado score >7 were included in the study. Female patients with any adnexal pathology on previous ultrasound, pregnant patients (in order to avoid radiation induced teratogenicity) and patients with history of appendectomy were excluded.

One hundred eighty-five (185) patients fulfilling inclusion criteria from accident and emergency department of radiology CMH Rawalpindi were taken. An informed consent was obtained from study patients or their attendants. Demographic information of study patients like name, age, sex and address was obtained. Post Intravenous contrast images were obtained. An effective radiation dose of 2 mSv was obtained by empirically setting the reference mAs i.e. tube current–time product. The dose–length product provided the actual radiation dose which in turn was adjusted automatically depending on the size of the patient. All LDCT were conducted under the supervision of a senior radiologist having more than 5 years of experience after their post-graduation. The reporting of LDCT was done by same consultant to avoid bias. All patients were followed for their histopathology report and its results were compared with LDCT.

Data analysis was done using SPSS version 20. mean ± standard deviation was determined for quantitative variables like age. Frequency (%) was calculated for qualitative data like gender, diagnosis of acute appendicitis on LDCT and histopathology. A 2 x 2 table was made to calculate sensitivity and specificity, PPV and NPV of LDCT taking histopathology as gold standard. Data was cross tabulated for age, gender and BMI. Chi-square test was applied considering *p*-value ≤0.05 as significant.

Ethical approval was obtained from Institutional review board of Combined Military Hospital, Rawalpindi.

## Results

The mean age of study patients was 33.36 ± 10.35 with range of 18-60 years. A total of 146 (78.9%) patients were 18-40 years old and 39

(21.1%) were 41-60 years of age. There were 101 (54.6%) male and 84 (45.4%) female patients. The mean height, weight and BMI were 1.54±0.35 meters, 55.90±11.06 kg and 23.32±4.57, respectively. According to BMI stratification 40 (21.6%) patients had <18.5 and 145 (78.4%) patients had BMI ≥18.5.

The appendix was diagnosed positive (appendicitis) in 111 (60%) patients on low dose CT and 112 (60.5%) were positive on histopathology (Table-1 & 2).

**Table 1: Frequency distribution of Findings of low dose CT (LDCT).**

| | | *Frequency* | *Percent* |
|---|---|---|---|
| Diagnosis on LDCT | Positive | 111 | 60.0 |
| | Negative | 74 | 40.0 |
| | Total | 185 | 100.0 |

**Table 2: Frequency distribution of findings of Histopathology.**

| | | *Frequency* | *Percent* |
|---|---|---|---|
| Histopathology | Positive | 112 | 60.5 |
| | Negative | 73 | 39.5 |
| | Total | 185 | 100.0 |

**Table 3: Comparison of diagnosis on low dose CT and histopathology.**

| | | *Histopathology findings* | | *Total* |
|---|---|---|---|---|
| | | *Positive* | *Negative* | |
| Low dose CT | Positive | 106 | 5 | 111 |
| | Negative | 6 | 68 | 74 |
| Total | | 112 | 73 | 185 |

Sensitivity = 94.64%
Specificity = 93.15%
PPV = 95.5%
NPV= 91.89%
Diagnostic Accuracy = 94.05%

**Table 4: Comparison of diagnosis on Low dose CT and histopathology when stratified for age groups.**

| | | | *Histopathology findings* | | *p-value* |
|---|---|---|---|---|---|
| | | | *+ve* | *-ve* | |
| 18-40 years | Low dose CT | Positive | 91 | 2 | <0.001 |
| | | Negative | 4 | 49 | |
| 41-60 Years | Low dose CT | Positive | 15 | 3 | |
| | | Negative | 2 | 19 | |

| *Age 18-40 years (%)* | | *Age 41-60 years (%)* | |
|---|---|---|---|
| Sensitivity | 95.79 | Sensitivity | 88.24 |
| Specificity | 96.08 | Specificity | 86.36 |
| Positive Predictive Value | 97.85 | Positive Predictive Value | 83.33 |
| Negative Predictive Value | 92.45 | Negative Predictive Value | 90.48 |
| Diagnostic Accuracy | 95.89 | Diagnostic Accuracy | 87.18 |

**Table 5: Comparison of diagnosis on low dose CT and histopathology when stratified for gender.**

| | | | *Histopathology Findings* | | *p-value* |
|---|---|---|---|---|---|
| | | | *+ve* | *-ve* | |
| Male | Low dose CT | Positive | 61 | 2 | <0.022 |
| | | Negative | 3 | 35 | |
| Female | Low dose CT | Positive | 45 | 3 | |
| | | Negative | 3 | 33 | |

| *Male (%)* | | *Female (%)* | |
|---|---|---|---|
| Sensitivity | 95.31 | Sensitivity | 93.75 |
| Specificity | 94.59 | Specificity | 91.67 |
| Positive Predictive Value | 96.83 | Positive Predictive Value | 93.75 |
| Negative Predictive Value | 92.11 | Negative Predictive Value | 91.67 |
| Diagnostic Accuracy | 95.05 | Diagnostic Accuracy | 92.86 |

**Table 6: Comparison of diagnosis on low dose CT and histopathology when stratified for BMI.**

| *Body Mass Index* | | | *Histopathology Findings* | | *p-value* |
|---|---|---|---|---|---|
| | | | *+ve* | *-ve* | |
| *<18.5* | *Low dose CT* | *Positive* | 37 | 0 | <0.051 |
| | | *Negative* | 0 | 3 | |
| *≥18.5* | *Low dose CT* | *Positive* | 69 | 5 | |
| | | *Negative* | 6 | 65 | |

| *BMI, <18.5 (%)* | | *BMI, ≥ 18.5 (%)* | |
|---|---|---|---|
| Sensitivity | 100 | Sensitivity | 92.00 |
| Specificity | 100 | Specificity | 92.86 |
| Positive Predictive Value | 100 | Positive Predictive Value | 93.24 |
| Negative Predictive Value | 100 | Negative Predictive Value | 91.55 |
| Diagnostic Accuracy | 100 | Diagnostic Accuracy | 92.41 |

There were 106 patients who had positive findings on both LDCT and histopathology while 68 patients had negative findings on both LDCT and histopathology. There were 5 false positive and 6 false negative findings in this study. The sensitivity, specificity, PPV(positive predictive value), NPV (negative predictive value) and diagnostic accuracy

was 94.64%, 93.15%, 95.5%, 91.89% and 94.05% respectively (Table-3).

When data was stratified/ cross tabulated over age groups, gender and BMI comparing LDCT and Histopathology we found significant difference in findings of LDCT in different age groups, gender and BMI. The patients aged 18-40, male and having BMI <18.5 had higher diagnostic accuracy (Table-4, 5 & 6).

## Discussion

There are various imaging modalities to diagnose acute appendicitis including sonography, computed tomography and MRI. Abdominal ultrasound is believed to be the first line test for evaluating patients suspected of acute appendicitis. Although there is risk of radiation exposure associated with CT, it is considered superior to ultrasound. It is performed in patients with equivocal ultrasound findings and in cases where perforation is suspected. It is believed that low-dose unenhanced CT is equivalent to standard-dose contrast enhanced CT in diagnosing acute appendicitis.[14]

In the last two decades, there has been a considerable increase in the use of CT for diagnosis of acute appendicitis.[15] However it is associated with high radiation exposure with radiation dose of 7-10mSv.[16,17] Exposure to this high radiation increases the risk of carcinogenesis especially in children and young adult who are reported to be usually presenting with appendicitis. Therefore, it is now believed that radiation dose should be kept as low as achievable. With the advent of new advances in CT technology in past few years, a low-dose CT for appendicitis trial is now advocated to be better than previously used standard CT protocols.

Furthermore, it has been reported that low image quality of low dose CT scan can be compensated by image reconstruction and the use of multiplanar sliding slab averaging technique.[18,19] Many hospitals have these two techniques but their use is often overlooked by radiologists.[20]

It is found in many studies that even if the radiation dose of CT examination is decreased by 50% to 80%, the diagnosis of acute appendicitis can still be made, even though the image quality is lower.[21] Recently, a randomized controlled trial conducted in a single institution found that low dose CT which used only one fourth of radiation dose of standard dose CT had almost comparable negative appendectomies rate i.e. 3.5% vs 3.2%.[12]

In current study the sensitivity, specificity, positive predictive value(PPV), negative predictive value(NPV) and diagnostic accuracy was 94.64%, 93.15%, 95.5%, 91.89% and 94.05% respectively. The role of LDCT and standard CT with BMI > and <18.5 is controversial in different studies. In current study the sensitivity and specificity was 100% each in patients having BMI <18.5 and 92% and 92.86% in patients with BMI ≥18.5. Our results are comparable to some extent with a study conducted by Platon A et al, in which they compare LDCT with standard dose CT.[9] That study showed that LDCT and standard CT had same sensitivity (100%) and specificity (98%) for diagnosing appendicitis in patients BMI ≥18.5. However, in patients with BMI < 18.5, the sensitivity to diagnose was 50% for LDCT and 100% for standard CT. These findings are having some contradictions to our findings.

It is found that although the quality of image is compromised but Low-dose CT (LDCT) techniques reduce the radiation exposure and improves the diagnostic accuracy for appendicitis.[13]

This study shows high diagnostic accuracy of LDCT so in future we can alter our practice by adopting LDCT to avoid patients from excessive radiations and no doubt it will also reduce hospital cost for diagnosis of acute appendicitis. However, larger scale studies are recommended in our setup to compare between standard dose of CT and LDCT and to confirm the role of LDCT in diagnostic workup of BMI > or <18.5.

**Conflict of interest:** None declared.

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