ORIGINAL ARTICLE

Assessment to Predict of Diagnostic Accuracy of Low-Dose CT Scan in Acute Appendicitis

FARAH KALSOOM[1], SADIA ANJUM[2], ADEEL MUSHTAQ[3]

[1,2]Assistant Professor, Radiology, Nishtar Medical University and Hospital, Multan
[3]MBBS, FCPS, Assistant Professor, Surgical Unit 3, General Hospital, Lahore
Correspondence to: Farah Kalsoom, Email: lammrssaqib@gmail.com

ABSTRACT

Background: Low-dose computed tomography has been introduced as an alternative option for the diagnosis of diseases in adults, however, limited studies have been conducted in children

Objective: To assess the diagnostic accuracy of low-dose CT for diagnosis of acute appendicitis in children as compared to ultrasound and CT scan.

Methodology: A retrospective study was conducted in the Radiology Department of Nishtar Hospital Multan from January 2022 to January 2023. A total of 250 pediatric patients younger than 10 years admitted to the hospital with signs of acute appendicitis were selected for the study.All patients underwent low-dose CT, abdominal ultrasound, or standard-dose CT.

Results : The methods did not differ significantly with respect to sensitivity for appendicitis diagnosis (96.9%, 95.9%, and 94.8%, p=0.789) and visualization of the perforated appendix (100%, 86.2%, and 100%).There was no significant difference between the diagnostic sensitivity of methods in early childhood (100%, 100%, and 94.8%, p=0.292) and late childhood (94%, 93.1%, and 94.8%, p=0.831). However, specificity (94%, 77.9%, and 98%, p=0.370) and PPV (97%, 90.3%, and 99%, p=0.011) in middle childhood were significantly difference between groups.

Conclusion: Low-dose CT has comparable effectiveness and accuracy for diagnosis of pediatric appendicitis as compared to ultrasound and standard-dose CT.

Keywords: Appendicitis, Computed Tomography, Ultrasonography, Ultrasound

INTRODUCTION

Acute appendicitis is a common surgical condition in children characterized by infection and inflammation in the appendix. About 250,000 cases of appendicitis are reported in children every year with every 1-2 children from ages 0-4 per 10,000 children and every 25 children from ages 10-17 per 10,000 children affected[1] Delayed diagnosis and treatment can lead to complications like abscess, peritonitis, and perforation of the appendix so timely appendectomy is essential[2]

Unnecessary appendectomies are avoided by radiological examination through ultrasound or CT scan which reduces the chance of negative procedure[3] Ultrasound is a safe and non-invasive modality of diagnosis in children; however, it has varied accuracy and is not suitable for obese patients. On the other hand, CT has a higher accuracy than the US hence it is the preferred method but exposes the patient to radiation. MRI is also an accurate and radiation-free method but it is expensive.Arruzza et al compared the accuracy of diagnostic methods for pediatric appendicitis to report no influence of age or BMI on the choice of modality[4]

Since there is no consensus on existing diagnostic methods, low-dose CT has been introduced that is appropriate for any age group and disease. However, its accuracy has not been tested by any study in children <10 years for diagnosis of acute appendicitis[5] This study was conducted to evaluate the diagnostic accuracy of low-dose CT for diagnosis of acute appendicitis in children as compared to ultrasound and CT scans.

METHODOLOGY

A retrospective study was conducted in the Radiology Department of Nishtar Hospital Multan from January 2022 to January 2023. A total of 250 pediatric patients younger than 10 years admitted to the hospital with signs of acute appendicitis were selected for the study. Patients who did not undergo radiological examination, those with a history of appendectomy, a gastrointestinal anomaly that could interrupt radiation, and patients with abdominal cancer or intussusceptions were excluded. The guardians of all patients provided their informed consent. The ethical board of the hospital approved the study.

Patients' data including clinical presentation, laboratory and radiological results, and pathological findings were recorded. All patients underwent abdominal ultrasound, standard-dose CT,or low-dose CT. For CT examination, only intravenous contrast media was used and the dose was set according to the age and BMI of the patient. Size-based technique was used for the CT scan with z-axis automatic tube current modulation from scout scans. Images were reformatted with 3-mm slice thickness each on the axial and coronal plane. Appendicitis was primarily diagnosed when the appendix was visualized as larger than 6 mm in diameter, the wall thicker than 2mm, and a non-opacified lumen. Secondary criteria were an indication of adjacent mesenteric fatty stranding, appendicolith, periinestinal fluid, extraluminal air, mesenteric lymph nodes, and an abscess or phlegmon. Perforation was visualized by the presence of the last four characteristics. Visualization of a normal appendix or absence of secondary criterion meant a negative scan for appendicitis and an alternative diagnosis was noted.

All data was analyzed by SPSS version 18. Differences between radiological groups, age groups, and BMI groups were evaluated by t-test, ANOVA, and Pearson's chi-squared test. A p-value less than 0.05 was considered significant.

RESULTS

Among 250 patients included in the study, 200 (80%) were diagnosed with acute appendicitis. The mean age and BMI were highest in the standard CT group (7.88 ± 1.85 years and 19.25 ± 3.24) as compared to other groups (p=0.001 and p=0.0, respectively). The groups differed significantly with respect to laboratory parameters; WBCs (p=0.031), ANC (p=0.034), and hsCRP (p=0.028). The clinical and laboratory characteristics of patient groups are shown in Table I.

The diagnostic accuracy of imaging methods for acute appendicitis is illustrated in Table II. The methods did not differ significantly with respect to sensitivity for appendicitis diagnosis (96.9%, 95.9%, and 94.8%, p=0.789) and visualization of perforated appendix (100%, 86.2%, and 100%). However, specificity (94%, 80.6%, and 99%, p=0.005) and PPV (97%, 93.1%, and 98%, p=0.023) were significantly different between the groups. NPV did not differ significantly between modalities (p=0.887).

There was no significant difference between the diagnostic sensitivity of methods in early childhood (100%, 100%, and 94.8%,

p=0.292) and late childhood (94%, 93.1%, and 94.8%, p=0.831). However, specificity (94%, 77.9%, and 98%, p=0.370) and PPV(97%, 90.3%, and 99%, p=0.011) in middle childhood were significantly difference between groups(Table III). A total of 188 patients (75.2%) had normal BMI, 25 (10%) were underweight and 37 (14.8%) were overweight.

There was no significant difference between the diagnostic accuracy of modalities with respect to BMI. The sensitivity in underweight (90.7%, 100%, 100%, p= 1.0) and overweight (100%, 100%, 92.9%, p= 0.2) was comparable.

Table 1: Clinical Features and Laboratory Parameters of Children with Appendicitis

	Low-dose CT (n=72)	Ultrasound (n=32)	Standard dose CT (n=96)	P
Mean age	7.28 ± 1.87	6.92 ± 2.12	7.88 ± 1.85	0.001*
Age groups				
Early childhood (2-5 years)	11 (15.3%)	11 (34.4%)	15 (15.7%)	0.019*
Middle childhood (6-10 years)	61 (84.7%)	21 (65.6%)	81 (84.3%)	
Male patients	48 (66.7%)	50 (16%)	65 (67.8%)	0.077
Mean BMI	17.30 ± 2.09	17.30 ± 2.27	19.25 ± 3.24	0.0*
Duration of hospital stay (days)	5.1 ± 2.0	5.1 ± 2.9	5.5 ± 2.3	0.146
Perforated appendicitis	21 (29.2%)	6 (18.8%)	29 (30.3%)	0.233
Laboratory parameters				
White blood cells	15545 ± 5022	13223 ± 4765	15338 ± 4845	0.031*
Absolute neutrophil count	12742 ± 4801	9486 ± 4624	12350 ± 4662	0.034*
Erythrocyte sedimentation	9.1 ± 16.3	7.2 ± 16.7	8.9 ± 16.5	0.655
Highly sensitive c-reactive protein	39.3 ± 58	14.5 ± 26.2	32.0 ± 53.3	0.028*

*Significant

Table 2: Comparison of Diagnostic Accuracy of Radiological Test for Appendicitis

	Ultrasound (n=38)	Standard dose CT (n=112)	Low-dose CT (n=100)	P-value
Sensitivity	95.9%	94.8%	96.9%	0.789
Specificity	80.6%	99%	94%	0.005*
Positive predictive value	93.1%	98%	97%	0.023*
Negative predictive value	86.2%	91.7%	94%	0.887

*Significant

Table 3: Diagnostic Accuracy of Methods According to Age Groups

	Ultrasound (n=38)	Standard dose CT (n=112)	Low-dose CT (n=100)	P-value
Early childhood				
Sensitivity	100%	94.8%	100%	0.292
Specificity	100%	100%	97%	0.370
Positive predictive value	100%	100%	94%	0.883
Negative predictive value	100%	96.9%	100%	0.354
Middle Childhood				
Sensitivity	93.1%	94.8%	94%	0.831
Specificity	77.9%	98%	94%	0.009*
Positive predictive value	90.3%	99%	97%	0.011*
Negative predictive value	84.8%	89.6%	90.7%	0.875

*Significant

DISCUSSION

This study was conducted the evaluate the efficacy of low-dose computed tomography in comparison to ultrasound and standard-dose tomography for diagnosis of pediatric appendicitis. The results showed a satisfactory and reliable diagnostic accuracy of low-dose CT in diagnosing appendicitis and perforation irrespective of age group and BMI. It accurately diagnosed the condition in early and middle childhood and underweight and overweight children. These findings are similar to previous studies conducted for other pediatric diseases and appendicitis in adults[6,7]

In overweight children, sensitivity, specificity, PPV, and NPV were 100% each for low-dose CT which was more effective than standard CT (94.8%, 100%, 100%, 84.9%). The effectiveness of low-dose CT also presents it as an alternative to ultrasound which often shows unclear imaging in obese patients[8]

The retrospective study design limited the determination of specific doses of CT, and it varied with age and BMI. The radiation dose in low-dose CT (2.11 ± 0.49) was 65% less than standard CT (5.80 ± 3.17), however, there was a significant difference between tube voltage and tube current (p=0.0). This is similar to chest CT doses where standard CT has 7mSv radiation and low-dose Ct has 1-2 mSv which is 70-85% less than the former[9] The two CT groups also did not differ significantly in age although the mean age was higher in the standard CT group (7.88 ± 1.85 vs 7.28 ± 1.87 years). There was no significant difference between the diagnostic

sensitivity of methods in early childhood (100%, 100%, and 94.8%, p=0.292) and late childhood (94%, 93.1%, and 94.8%, p=0.831). This is backed by previous literature that age was a predictor diagnostic accuracy of CT imaging[10,11]

Although the results show that low-dose CT is effective, the authors do not recommend its imprudent use as according to the BEIR VII report, low radiation doses increase the risk of cancer[12] Hence, ultrasound should be used as a gold standard for diagnosing appendicitis in children and adults[13] Alternatively, standard CT should be performed in case of unclear findings by ultrasound. If imaging is ambiguous with both modalities, lowCT should be performed.

Our study has some limitations. The sample size in the ultrasound group was significantly less than the low-dose CT group so the efficacy of these modalities could not be compared individually. Secondly, the retrospective study design did not allow for a predetermined CT dose.

CONCLUSION

Low-dose CT has comparable effectiveness and accuracy for the diagnosis of pediatric appendicitis as compared to ultrasound and standard-dose CT.

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