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Diagnostic Reliability of Paediatric Appendicitis Score & Ultrasound Scan in Children with Suspected Acute Appendicitis

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Author`s Contribution	ABSTRACT
[1,2,5] *Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work. Study Design, data collection, manuscript writing,* [3,4]*Active participation in active methodology* *Funding Source: None* *Conflict of Interest: None* *Received: Sept 09, 2021* *Accepted: Jan 12, 2022* **Address of Correspondent** *Dr Muhammad Umer Qureshi Department of Neonatal and Paediatric Surgery, The Children Hospital, PIMS Islamabad* *umer_qureshi1@yahoo.com*	**Objective:** To evaluate the efficacy of Paediatric Appendicitis Score and ultrasound scan in the paediatric population. This study evaluates the best predictive measure for diagnosing acute appendicitis. **Methodology:** A prospective observational study on 120 children (02-13 years) in the department of Neonatal and Paediatric Surgery at The Children's Hospital PIMS, Islamabad, with suspected appendicitis. Each patient was evaluated based on their Paediatric Appendicitis Score and ultrasound findings. We performed open appendectomy under general anaesthesia in patients with Paediatric Appendicitis Score ≥06 or who presented with severe tenderness on cough, TLC more than 10,000/mm3, or positive ultrasound findings. **Results:** In our study, the sensitivity and specificity of the Paediatric Appendicitis Score were 92.6% and 72.0%, respectively. Its sensitivity and specificity were 84.09% and 85.71%, respectively, with cutoff ≥6 combined with ultrasound findings. The combined sensitivity and specificity of Paediatric Appendicitis Score <6 and ultrasound were 85.71% and 94.44%, respectively. **Conclusion:** Paediatric Appendicitis Score is a useful diagnostic tool for suspected appendicitis in pediatric population. Its efficacy is significantly increased when combined with ultrasound. Combined application of the Paediatric Appendicitis Score with ultrasonography helps to rule out negative appendectomies and reduces complications associated with delayed diagnosis. **Keywords:** Acute Appendicitis, Appendectomy, Paediatric Appendicitis Score (PAS), Ultrasound.

Introduction

Acute appendicitis is one of the paediatric surgical emergencies and a leading cause of morbidity in the paediatric population.[1] It requires prompt diagnosis and early intervention to prevent complications including perforation, abscess, or appendicular mass formation. Delayed intervention leads to dramatic complications, whereas early intervention is associated with a high negative appendectomy rate of as high as 15%–30%.[2]

In 1886, Fit *et al* first described perforating inflammation of the vermiform appendix.[1] McBurney explained the sign and symptoms of acute appendicitis.[1] He described McBurney's point, which still remains a key point in the diagnosis and management of acute appendicitis.[1]

It can be diagnosed through clinical examination, biochemical, and radiological investigations. The most common signs and symptoms of acute appendicitis are migratory abdominal pain, fever, nausea, anorexia, and vomiting. However, children are unable to express their pain. This, combined with an elusive history and anatomical variations such as an underdeveloped omentum, makes establishing a definite diagnosis difficult.[3]As a result, initial misdiagnosis rates in school-aged children ranged from 28% to 57%.[4]

Different scoring systems have been introduced based on history, clinical examination, and biochemical markers such as the ALVARADO, Modified ALVARADO, RIPASA scoring system, and Paediatric Appendicitis Score to rule out acute appendicitis. In 2002, Samuel introduced the Paediatric Appendicitis Scoring system

peculiarly for children aged 3-14 years.[5] PAS is 10 points scoring system that comprises eight clinical factors which stratify patients into low, medium, and high risk.[5] These clinical factors are nausea, anorexia, right lower quadrant migratory pain, fever, tenderness on coughing percussion or heel taping, leukocytosis, and neutrophilia.[5]

Nowadays, imaging modalities are essential for diagnosing acute appendicitis in paediatric population. These imaging techniques facilitate early diagnosis and differentiation of various stages of acute appendicitis. It significantly decreases the rate of negative appendectomies.[6] Pelvic–abdominal computed tomography (CT) is considered the gold standard diagnostic tool for appendicitis in children owing to its high sensitivity and specificity.[7] CT is unideal in the paediatric population because it falls short in certain aspects, such as being costly and having a high radiation dose.[6] Ultrasound, on the other hand, avoids ionizing radiation, allows for dynamic visualization of abdominal viscera, is easy to use, and is cost-effective.[6] A non-compressible, blind-ended tubular structure of >6 mm indicates acute appendicitis in ultrasonography.[6]

In the literature, the sensitivity and specificity of Paediatric Appendicitis Score are 86% and 80%, and ultrasonography is 90% and greater than 90%, respectively. Using paediatric appendicitis scoring and an ultrasound scan, this study determines the best predictive measure for diagnosing acute appendicitis.

Methodology

A prospective cross-sectional study was conducted at "The Department of Neonatal and Paediatric Surgery, The Children's Hospital PIMS Islamabad" from July 2020 to December 2020. Ethical approval was obtained from Hospital Ethical Committee and informed written consent was taken from parents. Sample size was 120 calculated using online calculator for sensitivity and specificity by following assumptions, sensitivity 56%, specificity 85%, prevalence of 34%, precision of 15% and confidence level of 95%.[8] Sampling technique was consecutive sampling.

The inclusion criteria comprised participants of both genders, aged 2 to 13 years old, who presented with signs and symptoms of acute appendicitis. Exclusion criteria included participants with previous abdominal surgery, chronic medical conditions, immunodeficiency, sickle cell disease, cystic fibrosis, or other conditions that would influence the presentation of appendicitis.

The study included basic demographics, hemoglobin (Hb) level, total leucocyte count (TLC), neutrophil count, Paediatric Appendicitis Score, ultrasound findings, and perioperative findings. The Paediatric Appendicitis Score comprised eight components, including nausea, anorexia, migratory pain in the right lower quadrant, low-grade fever (more than 38°C), tenderness in the right lower quadrant, tenderness in the right lower quadrant on cough, percussion or heel taping, and leukocytosis more than 10,000/mm³. All components of the Paediatric Appendicitis Score have scored 01 points, except right quadrant tenderness and cough/percussion/heel tapping tenderness, which scored 2 points. The Paediatric Appendicitis Score is classified into three risk categories: 4 as mild risk, 4 to 7 as medium risk, and 8 to 10 as high risk. Participants were categorized into two main groups with a cutoff point of ≥6.

Diagnostic criteria were Paediatric Appendicitis score ≥ 6 or less than 06 with severe tenderness in right iliac fossa on cough, TLC more than 10,000/mm³, or positive ultrasound findings. Criteria for diagnosis on ultrasound were presence of probe tenderness, non-compressible tubular structure of size ≥07 mm, fat infiltrate surrounding appendix and fecolith presence.

After history-taking and clinical examination, we advised a complete blood count to evaluate the biochemical markers, including total leukocyte count and neutrophils, followed by an ultrasound of the abdomen and pelvis. After diagnosing acute appendicitis as per diagnostic criteria, we performed an open appendectomy under general anaesthesia. Perioperative findings of an acutely inflamed appendix, phlegmonous, perforated and gangrenous appendix were considered positive. We compared perioperative findings with preoperative Paediatric Appendicitis Score and ultrasonography.

Data was analyzed using SPSS version 25.0. Frequencies were calculated for categorical variables like gender, risk of acute appendicitis based on Paediatric Appendicitis Score and cutoff point of PAS. Mean and standard deviation were calculated for continuous variables like age, hemoglobin level, total leukocyte count, neutrophil level and Paediatric Appendicitis Score. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for evaluating the predictive value of PAS and ultrasound in the diagnosis of acute appendicitis in pediatric population. Chi square test was applied to qualitative variables for comparison, while the independent sample t-test was applied to all

quantitative variables. The p value of ≤0.05 was considered significant.

Results

A total of 120 patients included 37 (30.8%) females and 83 (69.2%) males treated. Mean age of patients was 8.68 ± 2.60 years (range 2 to 13 years).All patients included in this study underwent open appendectomy. Of these 120 patients, 95 (79.2%) had positive findings and 25 (20.8%) patients had a negative appendectomy. Demographic and clinical characteristic of patients as shown in table I.

Table I: Demographic and clinical characteristic of patients.

	Inflamed Appendix	Normal Appendix	P value
Age	8.54±2.59	9.24±2.65	0.236
Male	65	18	0.730
Female	30	7	0.730
PAS	6.82±1.09	4.56±1.04	<0.001
Leukocyte count	16.02±4.44	8.90±4.61	<0.001
Neutrophil	80.15±13.29	69.48±13.16	0.001
Hemoglobin	11.71±1.64	11.29±1.70	0.258
Ultrasound findings	82 (68.33%)	38 (31.66%)	<0.001

The mean Paediatric Appendicitis Score was 6.35±1.41. Patients were categorized as mild, moderate, or high risk for acute appendicitis based on PAS. Mild risk was found in 24 (20%) patients, moderate risk in 80 (66.7%) patients, and high risk in 16 (13.3%) patients. We observed a score ≥6 in 95 (79.1%) patients, and the remaining 25 (20.9%) had a Paediatric Appendicitis Score of less than 6. Out of 120 patients included, 82 (68.3%) had positive findings on ultrasonography. Sensitivity, specificity, positive predictive value, negative predictive value of Paediatric Appendicitis Score and ultrasound were calculated by the 2x2 table as shown in Table II.

Table II: Paediatric Appendicitis Score and Ultrasound

Paediatric Appendicitis Score	Inflamed Appendix	Normal Appendix
≥6	88 (73.33%)	7 (5.83%)
<6	7 (5.83%)	18 (15.00%)
Ultrasound		
Positive	80 (66.66%)	2 (1.6%)
Negative	15 (12.5%)	23 (19.16%)

Paediatric Appendicitis Score yielded a sensitivity of 92.6%, specificity of 72.0%, positive predictive value of 92.6%, negative predictive value of 72%, and accuracy of 88.33%. Ultrasound showed sensitivity of 84.2%, specificity of 92.0%, positive predictive value of 97.56%,

negative predictive value of 60.53%, and accuracy of 85.83%.

In our study, mean of TLC was 14.54x103/mm3±5.32 and mode was 17.89x103/mm3. 91(75.8%) patients had a total leukocyte count of more than 10,000/mm3, and 29(24.2%) patients had less than 10,000/mm3. Sensitivity and specificity of TLC resulted in 91.6% and 84.0%, respectively. Mean of neutrophils was 77.93±13.91. 91(75.8%) had neutrophils level more than 75% and 29(24.2%) with neutrophils level of less than 75%. Neutrophil sensitivity and specificity were 84.2% and 56.0%, respectively.

Sensitivity and specificity of Paediatric Appendicitis Score with cutoff point 6 with ultrasound were calculated by 2x2 table as shown in Table III.

The sensitivity and specificity of the Paediatric Appendicitis Score with a cutoff of ≥6 were 84.09% and 85.71%, respectively, when combined with ultrasound findings. The sensitivity and specificity of the Paediatric Appendicitis Score <6 in combination with ultrasound were 85.71% and 94.44%, respectively.

Table III: Table for Paediatric Appendicitis Score with Ultrasound

PAS cutoff point	Ultrasound	Inflamed Appendix	Normal Appendix
≥6	Present	74	1
	Absent	14	6
<6	Present	6	1
	Absent	1	17

Discussion

Acute appendicitis is the most common cause of surgical emergency, with 72,000 patients discharged from hospital each year.[9] The diagnosis of acute appendicitis is based on patient's history, physical assessment, and, most importantly biochemical and imaging findings. Paediatric Appendicitis Score and Alvarado Score take these elements into account to identify the severity of acute appendicitis and highlight the importance of accurate history-taking, physical examination, and laboratory findings. It is difficult to diagnose in the paediatric population due to the inability to obtain a patient's history and the strain on clinical examination; however, prompt identification is required to avoid potentially fatal complications such as perforation and abscess.[3]

For patients with suspected acute appendicitis, different scoring systems have been introduced as a diagnostic tool to aid in decision making. A simple clinical assessment using Paediatric Appendicitis Score as a reference to

diagnose acute appendicitis is helpful. A policy of observation in the hospital is usually practiced in patients with an uncertain diagnosis of acute abdominal pain.[10] PAS can be used as a simple guide for repeated systematic clinical examinations to determine whether the patient requires observation or surgery.

For this study, we chose descriptive analysis to assess the efficacy of Paediatric Appendicitis Score and ultrasound for acute appendicitis. According to Paediatric Appendicitis Score, the patients were classified as mild (1-3), moderate (4-7), or high risk (8-10), and the score was set at a cutoff value of 6 to determine the sensitivity and specificity of PAS. According to Lourenco et al, patients with a PAS of 1 to 3 are more likely to be discharged from the hospital without further imaging evaluation, while those with a PAS of 4 to 6 require further imaging evaluation, and those with a PAS of 7 to 10 require surgical consultation without imaging.[11]

Samuel et al found that a score of 6 can be used to diagnose acute appendicitis with a sensitivity of 100% and a specificity of 92%.[5] Derakhshanfa et al observed that Paediatric Appendicitis Score with a cutoff point of 5.5 exhibited sensitivity of 93.88% and specificity of 86.21%.[12] In our study, sensitivity and specificity of Paediatric Appendicitis Score were 92.6% and 72%, respectively.

In order to estimate the severity of the inflammation, biomarker tests and imaging investigations are recommended in paediatric patients with suspected acute appendicitis.[13] The Paediatric Appendicitis Score includes the total leukocyte count and neutrophil count, which are used to diagnose acute appendicitis. Di Saverio et al concluded leukocytosis of $16,000/mm^3$ is a predictive factors of appendicitis.[13] Sameul et al study reported that total leukocyte count showed 80% sensitivity and 90% specificity, as in our study.[5] One of the elements of PAS is neutrophilia. The sensitivity of neutrophils was reported to be 79.7% by Chung et al.[14] In our study, neutrophil sensitivity was 84.2%.

Ultrasonography has been proven to be a valuable diagnostic aid in the diagnosis of acute appendicitis and to improve clinical decision-making. According to Bachur et al, among children with suspected acute appendicitis, the use of ultrasound has significantly increased (from 24.0% in 2010 to 35.3% in 2013), whereas CT use has decreased (from 21.4% in 2010 to 11.6% in 2013).[15] Ultrasound has proven to be quite effective, especially in the paediatric population due to

the thinness of abdominal fat and the absence of ionizing radiation. The efficacy of ultrasound is operator-dependent, and it can be influenced by obesity and the presence of severe pain in the patient.[16] We used a high-frequency probe to scan in lower abdomen because ultrasound was our preferred modality. As shown in Figure 2, the appendix can be observed emerging from the caecum with a thickness of 7 mm. The normal appendix is around 6mm in diameter, with very thin walls of about 3mm; it flattens out when compressed and has no hypervascularity.[17]

Figure 2: Showing ultrasound imaging of Acute Appendicitis

Chang et al found ultrasound's overall sensitivity and specificity were 76% and 95%, respectively.[18] According to Matthew Field et al.'s meta-analysis, ultrasound has a sensitivity and specificity of 91% and 97 % in diagnosing acute appendicitis, respectively.[19] Positive and negative predictive values were 91% and 94%, respectively.[19] In our study, positive findings were found in 82 (68.3%). It showed sensitivity of 84.2%, specificity of 92%, and PPV of 97.56%. NPV of 60.53%.

A Paediatric Appendicitis Score of greater than 7 indicates a strong suspicion of acute appendicitis, whereas PAS levels of less than 4 indicate a rule-out. It is recommended to use an imaging test to strengthen the reliability of the diagnosis for intermediate PAS 4 to 7 scores.[16] In children with suspected appendicitis, an ultrasound should be used with a Paediatric Appendicitis Score to ascertain the next steps in management.[20] Prolonged observation or further imaging is advised if the clinical findings and radiology do not correlate.[20] Aydin et al reported that when the score cut-off was set at 6, the sensitivity and specificity of PAS were 86.7% and 63.1%, respectively. The diagnostic efficacy of ultrasound was

91.1% sensitivity and 71.1% specificity. PAS > 6 or positive ultrasound findings or both had 96.7% sensitivity and 59.9% specificity, respectively, and the negative appendectomy rate was 4.4%.[20] We found the sensitivity and specificity of ultrasonography with a Paediatric Appendicitis Score with a cutoff point of <6 as 85.71% and 94.44%, respectively. The Paediatric Appendicitis Score's sensitivity and specificity with ultrasound and a cutoff of ≥6 were 84.09% and 85.71%, respectively. PAS combined with ultrasonography can be used as a diagnostic tool for acute appendicitis in the paediatric population, which helps significantly reduce the number of negative appendectomies. It can also improve the management of acute appendicitis and reduce morbidity in children.

Our study has some limitations, such as the fact that it was conducted at a referral hospital where many of the patients examined had already received antibiotics, resulting in a low Paediatric Appendicitis Score. Another consideration was avoiding needless CT scan radiation exposure in the paediatric population, which led to our reliance on ultrasonography in our setup.

Conclusion

The Paediatric Appendicitis Score is an applicable diagnostic tool that can be used in paediatric appendicitis cases to help stratify the population into mild, moderate, and high-risk groups. There were no complications observed in patients who were discharged based on the Paediatric Appendicitis Score. When combined with ultrasound, its efficacy increased significantly, from 72% to 85.71% in PAS cutoff point ≥6 and up to 94% in cutoff <6. The incidence of negative appendectomies and morbidities related to delayed diagnosis were reduced when the Paediatric Appendicitis Score was used with ultrasonography. It proved invaluable not only in excluding but also in diagnosing acute appendicitis in our setting, which was lower middle socioeconomic status.

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