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Comparison of Alvarado score and pediatric appendicitis score for clinical diagnosis of acute appendicitis in children—a prospective study

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Abstract

Background: Acute appendicitis is the most common surgical condition of children. Differential diagnosis of an acutely inflamed appendix in children includes a vast variety of diseases which can present with the same symptoms and signs as acute appendicitis. It is an important factor for delay in diagnosis. Many scoring systems are being used to reach a diagnosis within time and to reduce the rate of negative appendectomies.

The purpose of this study was to compare both scoring systems (Alvarado and pediatric appendicitis scoring system) and to know which one is better to establish an early correct diagnosis of acute appendicitis in pediatrics, thus decreasing the morbidity and burden on hospital resources. Although many studies had been completed at the international level for comparing both of these scoring systems, the pediatric population in our region was still awaiting such an effort.

So a prospective cohort study was designed. A total of 180 patients were recruited with 95% confidence level and 5% margin of error. Every enrolled patient was awarded clinical scores according to both the Alvarado scoring system and the pediatric appendicitis scoring system. Patients having a score of 7 or more by both scoring systems were considered “seven or more than seven group” and their appendectomies were performed and histopathology reports were reviewed. Patients having a score of 7 in one system and less than 7 in the other/both were considered “less than seven group” and were admitted in the ward for further clinical evaluation and observation.

Results: At cutoff 7, the Alvarado score showed a sensitivity of 85.5%, specificity of 70%, PPV of 96.5%, NPV of 33.3%, and diagnostic accuracy of 84.11% while the pediatric appendicitis score showed a sensitivity of 93.8%, specificity of 70%, PPV of 96.8%, NPV of 53.8, and diagnostic accuracy of 91.59%.

Conclusion: The pediatric appendicitis score (PAS) is superior in diagnosing acute appendicitis in the pediatric population than the Alvarado score as indicated by the values of diagnostic accuracy. So it can be a good diagnostic tool for pediatric patients presenting with clinical symptoms and signs of appendicitis.

Keywords: Pediatric appendicitis, Alvarado score, Pediatric appendicitis score, Negative appendectomy, Diagnosing pediatric appendicitis, Right iliac fossa pain

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Backgrounds

Acute appendicitis is the most common surgical condition of children [1]. About 1 to 10% of children presenting in surgical emergencies with acute abdomen fall within the domain of acute appendicitis [2]. In few of these cases, clinical signs and symptoms at presentation are such that acute appendicitis is a clear diagnosis [3] while more often it is challenging for a surgeon to make a clinical diagnosis of acute appendicitis [4]. In these circumstances, explorations reveal negative appendectomies and an organ with potential functions can be lost [5]. While for neglected cases there is an unnecessary delay for making a diagnosis of acute appendicitis which can lead to gross complications including perforation [6], these complications can increase morbidity, mortality, and hospital stay which are an economic and social burden to the community. Moreover, differential diagnosis of an acutely inflamed appendix in children includes a vast variety of diseases. These diseases present with the same symptoms and signs as acute appendicitis and it is an important factor for delay in diagnosis [7]. Many investigations including ultrasonography, CT scan, diagnostic laparoscopy, and MRI are being used these days to make a definitive diagnosis of the acutely inflamed appendix [8].

Apart from the above mentioned investigations, many scoring systems are being used to reach a diagnosis within time and to reduce the rate of negative appendectomies [9]. These scoring systems rely on the presence/absence of few symptoms and signs along with elevated leukocyte count [10]. The Alvarado score is the commonest scoring system being used these days to establish a diagnosis of the acutely inflamed appendix. It was mostly used for the adult population in the past, but recently, few studies have validated its importance in the pediatric population as well [11]. Samuel in 2002 made a new scoring system for the children, the pediatric appendicitis score (PAS). In these scoring systems, there is a reference score above which surgery is recommended while only observation is warranted below the specific score [12].

The main purpose of this study was to compare both of these scoring systems (Alvarado and PAS) and to understand which is better for making a diagnosis of the acutely inflamed appendix in pediatric patients. Most of the points of evaluation in these scoring systems are the same except rebound tenderness and leukocytosis. Alvarado score gives more points for leukocytosis as compared to rebound tenderness while in the PAS rebound tenderness carries more points than leukocytosis. Although many international studies, e.g., Pogorelic et al., have been completed for validation of both of these scoring systems [13], the pediatric population in our region was still awaiting such an effort.

Methods

Patients presented in surgical emergency with right lower abdominal pain having sign and symptoms of acute appendicitis were enrolled after obtaining informed written consent from parents/guardian by considering inclusion criteria such as age 4 to 12 years and history of symptoms less than 72 h and exclusion criteria such as associated co-morbidity, complicated appendicitis, and an appearance of appendicular mass on the clinical exam/initial ultrasonography on presentation. The sample size was calculated by considering Pogorelic et al. as a reference study. Each enrolled patient was awarded clinical scores according to both the Alvarado scoring system and the pediatric appendicitis scoring system. Two groups were made with a cutoff value of 7 for both scoring systems. Patients having a score of 7 or more in both scores were considered “seven or more than seven group.” Their appendectomies were performed and histopathology reports were reviewed. Patients having a score of 7 in one system and less than 7 in the other/both were considered “less than seven group.” These patients were admitted in the ward for further evaluation and observation. They were allowed only clear liquids orally without prescribing any antibiotics. In these patients, we relied upon only the scoring system without any further radiological investigation.

Data was collected regarding the history of migration of pain, anorexia, and nausea. Tenderness, rebound tenderness, and temperature were checked during the examination. Laboratory samples were sent to calculate leukocytosis and shift to left. Ultrasonography was performed by a radiologist in the emergency room on each patient to rule out appendicular mass and complicated appendicitis.

From operated cases, the appendix was collected as the sample for histopathology examination and reports were reviewed from the Pathology department without prior information to the pathologist for such sampling for the research project.

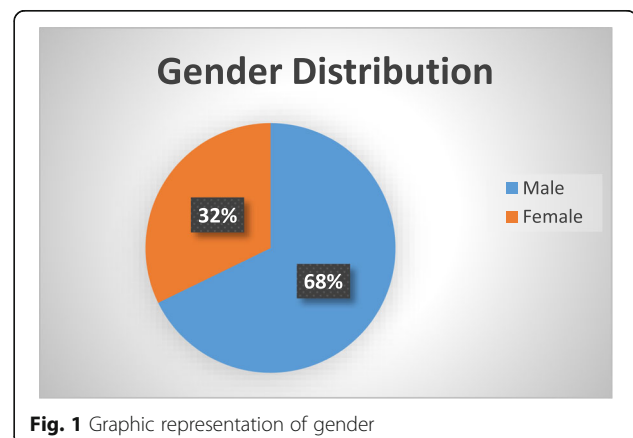


Fig. 1 Graphic representation of gender

Table 1 Stratification of total enrolled patients with regard to groups

Group	Management plan	No. of cases	Total
Less than seven	Treated conservatively and discharged after complete regression of symptoms	73	98
	Initially treated conservatively and had to proceed with surgery	25	
Seven or more than seven	Surgery decided at arrival	82	82
Total enrolled patients			180

The patients from “less than seven group” were admitted in the ward and the clinical course of the disease was observed. Their scoring systems were reviewed at 6, 12, 24, 36, and 72 h during admission by us. The patients from this group who settled during observation were discharged from the hospital. The patients who got an increase in their scoring system during the observation phase were operated upon and their appendix was sent for histopathology.

To calculate sensitivity, specificity, PPV, and NPV, histopathology report was considered as the gold standard, so total operative cases ($n = 107$) were considered as shown in Tables 4, 5, and 6. So these statistical values were calculated for both scoring systems at cutoff score 7 as well as for leukocytosis and rebound tenderness as these were the only differentiating points in both scoring systems.

A comparison of both scoring systems, the Alvarado scoring system and the pediatric appendicitis scoring system, was made by using values of diagnostic accuracy calculated by data of each scoring system.

Results

During the enrollment period (from 4 Jan. 2018 to 3 Jan. 2019), 180 patients who met the inclusion criteria (as mentioned in methodology) were enrolled. The mean age was 8.96 years for males and 9 years for females (range, 4–12 years). Of the enrolled patients, 122 (67.8%)

Table 2 Stratification of duration with frequency and percentage of patients (proceeded with surgery) from the observational group

Duration	No. of patients	Percentage
6 h	16	64
12 h	4	16
24 h	3	12
1–3 days	2	8
Total	25	100.0

Table 3 Distribution of operated cases ($n = 107$) according to groups

Group	Management type	No. of patients
Less than 7	Initially treated conservatively and have to proceed with surgery	25
7 or more than seven	Surgery decided at arrival	82
Total		107

were males and 58 (38.2%) were females as shown in Fig. 1.

Following the methodology, 82 (45.5%) patients were included in the operated group (seven or more than seven group) and 98 (54.5%) patients were included in the observational group (less than seven group). Out of those 98 patients classified as the observational group, 73(74.5%) patients got settled during observation without any complication while 25 (25.5%) had to be proceeded with surgery because of an increase in their score (PAS/Alvarado) values during their observational period (Table 1). Out of those 25 patients, 16 (64%) were operated upon during the first 6 h of admission, 04 (16%) within 12 h, 03 (12%) within 24 h, and 2 (8%) within 1–3 days (Table 2).

Out of total 180 patients, 107 got operated and according to histopathology report 97 were confirmed as acute appendicitis while 10 (9.34%) were declared as negative appendectomies. To check the individual performance of each scoring system, data was reviewed for operated cases ($n = 107$) (Table 3). According to the Alvarado scoring system, 86 patients were in the “seven or more than seven” group while 21 patients were in the “less than seven” group. According to histopathology at cutoff value 7, the Alvarado score resulted in 83 correct diagnoses of appendicitis and 3 innocent appendectomies. According to the pediatric appendicitis scoring system, 94 patients were in the “seven or more than seven” group while 13 patients were in the “less than seven” group.

Table 4 Distribution of operated patients according to groups by both scoring systems and type of histopathology

Scoring system	Groups	Histopathology		Total	Grand total
		Inflamed, $n = 97$	Normal, $n = 10$		
Pediatric appendicitis score	Seven and more than seven	91	03	94	107
	Less than seven	06	07	13	
Alvarado score	Seven and more than seven	83	03	86	107
	Less than seven	14	07	21	

Table 5 Individual performance of the pediatric appendicitis score (PAS) and Alvarado score at cutoff value 7

Cutoff score	"Pediatric appendicitis score"					"Alvarado score"				
	Sensitivity; %	Specificity; %	PPV; %	NPV; %	Accuracy; %	Sensitivity; %	Specificity; %	PPV; %	NPV; %	Accuracy; %
Seven	93.81	70.0	96.81	53.85	91.59	85.57	70.0	96.51	33.33	84.11

According to histopathology cutoff value 7, the pediatric appendicitis score resulted in 91 correct diagnoses of appendicitis and 3 innocent appendectomies (Table 4). So considering the data as shown in Table 4, sensitivity, specificity, PPV, NPV, and diagnostic accuracy are calculated for both scoring systems as shown in Table 5.

Sensitivity, specificity, PPV, and NPV for all study variables are calculated for operated cases by considering the histopathology report as a gold standard as shown in Table 6.

For comparing the two scoring systems, diagnostic accuracy values were calculated for both scoring systems and PAS showed a diagnostic accuracy of 91.59% and the Alvarado scoring system 84.11% as shown in Table 5.

Discussion

During this study, we enrolled 180 patients with right iliac fossa pain suspected of having appendicitis, while in our reference study, Pogorelic et al., a total of 311 pediatric patients were included and all those were proceeded with appendectomy [13]. We completed all variables and counts regarding the PAS and Alvarado scores for each patient included in the study, as done in our reference study. The mean age was 8.9 years (range, 4–12 years) in our study while in our reference study it was 11.7 years (range, 3–17 years).

Few studies in the literature are there for comparison of these scoring systems. A total of 206 patients younger than 10 years in a research project showed the results as follows: an Alvarado score greater than or equal to 7 revealed sensitivity = 73%, specificity = 80%, NPV 89%, and PPV 58%. A PAS greater than or equal to 6 revealed

a sensitivity of 77%, specificity 65%, NPV 88%, and PPV 45% [14]. Mandeville et al. in their research project enrolled 287 patients. In appendicitis patients, a PAS cutoff of 6 or greater would give 137 correct appendectomies, sensitivity = 88%, specificity = 50%, and PPV = 67%. An Alvarado cutoff of 7 or greater would give 118 correct appendectomies, sensitivity = 76%, specificity = 72%, and PPV = 76% [15]. In our research project for operated cases (n = 107), at cutoff value 7, Alvarado score gives a sensitivity value of 85.57%, a specificity value of 70.0%, a PPV of 96.51.7%, and an NPV of 33.3%, while in our reference study, these were as follows: a sensitivity value of 89%, a specificity value of 59%, a PPV of 93.1%, and an NPV of 46%; for PAS when cutoff value was 7, we obtained a sensitivity value of 93.81%, a specificity value of 70.0%, a PPV of 96.81.7%, and an NPV of 53.85%, while in our reference study, these values were as follows: a sensitivity value of 86%, a specificity value of 50%, a PPV of 90.1%, and an NPV of 38% [13]. In our research project, the negative appendectomy rate is 9.34%, while in the literature, it is 10–20% with aid radiological investigations and up to 30% without the aid of radiological investigations. The lower value in our research project is the result of methodology because we used cutoff value 7 by both scoring systems on each patient for screening.

According to our study results, PAS was more sensitive in diagnosing acute appendicitis in the pediatric age group than the Alvarado score at cutoff value 7. The difference of these results with respect to our study may be the reason that we included the patients up to 12 years of age and we used the cutoff score 7 for PAS while other studies used cutoff score 6 for the same purpose.

We compared the rebound tenderness and leukocytosis in our study population of operated cases as these were the main differentiating points between the two scoring systems. We found these results: for rebound tenderness, sensitivity was 86.6%, specificity was 80%, PPV was 97.6%, and NPV was 58.1%, and for leukocytosis, sensitivity was 80.4%, specificity was 60%, PPV was 95.1%, and NPV was 78.5%. These values indicate that rebound tenderness is more specific and sensitive for the diagnosis of appendicitis in the pediatric age group than leukocytosis.

For comparing the two scoring systems, the calculated diagnostic accuracy values were relied upon and PAS showed a better value than the Alvarado score which indicated that there was a statistical difference between

Table 6 Statistics of all study variables (for operated cases, n = 107)

Variable	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Migration of pain	64.95	50.0	92.65	12.82
Anorexia/vomiting	81.44	30.0	91.86	14.29
Nausea	86.60	10.0	90.32	7.14
Tenderness	98.97	20.0	92.31	66.67
Rebound tenderness	86.60	80.0	97.67	38.10
Temperature	61.86	70.0	95.24	15.91
Leukocytosis	80.41	60.0	95.12	78.50
Shift to left	55.67	90.0	98.18	17.31

the two scores. So PAS was found to be a more reliable tool than the Alvarado score for the diagnosis of the acutely inflamed appendix in children.

Conclusion

Statistically, the pediatric appendicitis score (PAS) is superior in the diagnosis of acute appendicitis in the pediatric population than the Alvarado score regarding the sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV), and diagnostic accuracy. As PAS is superior to the Alvarado score, so PAS can be used as a good tool for diagnosing cases of suspected appendicitis in the pediatric population.

Abbreviations

PPV: Positive predictive value; NPV: Negative predictive value; CT scan: Computerized tomography scan; MRI: Magnetic resonance imaging; PAS: Pediatric appendicitis score

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Authors' contributions

MAI: Designing the study and collecting data and final approval of the version. SHD: Review the written material and edited. UAR: Analysis and interpretation of data. MJB: Drafting the work. MS: Revising critically. UH: Organizing data and building research questionnaire. NS: Collection of data. All authors have read and approved the final manuscript.

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Availability of data and materials

The datasets (SPSS files) used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethical approval was obtained before starting this research project from the institute review board, Services Institute of Medical Sciences, Lahore, Pakistan, with reference number IRB/2017/341/SIMS dated 06 June 2017. Informed written consent for participation in the research project was obtained from parents/guardian of the child before enrolment.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests. This article is extracted from the research thesis completed by the first author and supervised by the second author as a requirement for Master of Surgery in Pediatric Surgery degree under the University of Health Sciences, Lahore, Pakistan.

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