

Survey of efficacy of pediatric appendicitis score in Iranian patients less than 18 years old referred to the emergency department

Hojjat Derakhshanfar¹, Elham Pournakhtyaran¹, Samane Rahimi¹,
Samira Sayyah¹, Fereshteh Karbasian¹, Zahra Soltantooyeh², Shahrzad Fallah¹

¹Department of Pediatric Emergency Medicine, Mofid Children Hospital, Shahid Beheshti University of Medical Sciences, Tehran, ²Pediatrician, Mofid Children Hospital, Tehran, Iran

ABSTRACT

Introduction: Abdominal pain, in particular appendicitis, is a common cause of emergency department visits in children. Therefore, early diagnosis is very important. There are different scoring systems for the diagnosis of appendicitis. This study is the first study to evaluate the performance and accuracy of pediatric appendicitis score (PAS) in Iranian children with abdominal pain in emergency departments. **Methods:** This is a cross-sectional study of children under 18 years with suspected appendicitis who were referred to the emergency medicine department of hospitals affiliated to SBMU during 2015. Acute appendicitis was determined according to pathological findings, and final PAS scores were calculated for all children. With statistical analysis, comparison between two groups was calculated and the diagnostic accuracy of PAS score was estimated. **Results:** 88 children with mean age of 10.5 ± 3 were studied. According to clinical examination 58 of the children were suspected to have acute appendicitis and 30 others were healthy. In current study, the diagnostic accuracy and precision of PAS at cutoff of 5.5 in patients younger than 18 years admitted to the emergency department with suspected acute appendicitis was 91% and 92%, respectively. Sensitivity, specificity, positive predictive value, and negative predictive value were 93.88%, 86.21% and 92%, 89.29%, respectively. **Conclusions:** The results of current study showed that PAS has high diagnostic predictive value for the diagnosis of acute appendicitis in children under 18 years and due to the advantages listed for this score, its use is recommended for children in emergencies.

Keywords: Diagnostic accuracy, emergency, pediatric, pediatric appendicitis score (PAS)

Introduction

Acute appendicitis is a common cause of abdominal pain in pediatrics referred to emergency department (ED). The incidence rate of acute appendicitis gradually increases after birth to a maximum level before age 20 years old. The trend

of acute appendicitis is faster in children and the chance of perforation and peritonitis is much higher in children than adults. Morbidity associated with delayed diagnosis and treatment of acute appendicitis leads to an increase in wound infection, pelvic abscess, length of hospital stay, delay in return to daily activities, and risk of bowel obstruction. On the other hand, unnecessary surgery imposes the exorbitant costs of treatment and care.^[1]

The prevalence of acute appendicitis in Western countries is 7%, and about 200,000 appendectomies are performed annually in the United States due to acute appendicitis.^[2]

Address for correspondence: Dr. Samane Rahimi,
Department of Pediatric Emergency Medicine, Mofid Children
Hospital, Shahid Beheshti University of Medical Sciences, Tehran,
Iran.

E-mail: samane_rahimi10@yahoo.com

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Appendicitis is caused by the early obstruction of the appendix lumen, then the appendix lumen fills with mucus and intraluminal and intramural pressure increases, causing thrombosis. Occlusion of small vessels and lymphatic stasis is followed by ischemia and necrosis of the appendix.^[3] The main cause of acute appendicitis is obstruction caused by fecalith, parasites, tumors, and so forth. The most common bacteria found in normal appendix, acute appendicitis, and perforated appendicitis is similar and include *Escherichia coli* and *Bacteroides fragilis*.^[3]

A variety of symptoms accompany appendicitis; distension of the inflamed appendix will stimulate the abdominal sympathetic nerves in the spinal cord associated with T8-11 levels. This stimulation causes vague and diffuse pain in the area around the navel, mid-abdomen, or epigastric. On the other hand, sudden distension of the appendix, stimulated peristalsis, and crampy pain also occur. When inflamed appendix touches the parietal peritoneum, the pain is transmitted through the somatic fibers in the form of sharp and focused pain, which is felt in the right-lower-quadrant (usually after a period of 1–12 hours).^[4] In most cases, the pain is associated with anorexia, nausea, and vomiting. The appendix may have different positions and anatomy so the pattern of pain may also be different. For example, in inflamed retrocecal appendix, pain in the side and back is more severe than the anterior abdominal. The inflamed pelvic appendix might also cause suprapubic pain, or inflamed retroileal appendix can cause pain in the testicle. On the other hand, if inflamed appendix is near the fallopian tubes, pelvic pain will be created.^[5] Other symptoms include obstipation which is sometimes before the onset of abdominal pain in patients and alleviated with defecation. Diarrhea is another symptom, especially in children.^[5]

Despite awareness of the symptoms of acute appendicitis and diagnostic tools such as ultrasound and laboratory findings, often it is difficult to achieve an accurate diagnosis. There are not always the classic signs and symptoms of appendicitis and different symptoms make it difficult to diagnose acute appendicitis. Delay in diagnosis of acute appendicitis is associated with increased morbidity and mortality.^[6,7]

The incorrect diagnosis of appendicitis in addition to imposing unnecessary surgery to patients, leading to no improvement of major problem after surgery, then patients declare displeasure of care systems and hospital.^[5-9] In order to facilitate the diagnosis of appendicitis, several scoring systems have been suggested that decrease the rate of negative appendectomy. Among these scoring systems, the pediatric appendicitis score (PAS) was created and proposed in 2002 by Samuel.^[10] In Samuel study on 1170 English children (from 4 to 15 years) over a period of 5 years, sensitivity, specificity, positive and negative predictive values of PAS were 100%, 92%, 96% and 99%, respectively. The score (PAS) in children equal or more than 6 points is associated with appendicitis.

Given the PAS is a simple, fast, reliable, and noninvasive diagnostic method carried out based on history, physical

examination, and laboratory tests and on the other hand has been provided exclusively for children^[10] as well as in various studies in other countries has introduced reliable, timely, and accurate diagnosis of appendicitis in children. We decided to study for the first time in Iranian pediatric population to assess the efficiency and accuracy diagnostic of PAS in diagnosis of acute appendicitis.

Patients and Methods

This is a cross-sectional descriptive study conducted in children under 18 years with suspected appendicitis admitted to ED of hospitals affiliated to Shahid Beheshti University of Medical Sciences, Tehran, Iran during 2015.

All children with abdominal pain for less than seven days who were referred to the ED and the emergency physician considered them with suspected appendicitis, after obtaining written informed consent from their parents, were studied.

In current study, children with appendicitis diagnosed in the ED by ultrasound or CT, children who had abdominal pain for more than seven days, children had a history of appendectomy or abdominal surgery, as well as children who had inflammatory bowel disease were excluded.

The following information about the history of the underlying disease, chronic disease, as well as the findings of the physical examination and medical history including age, gender, onset of symptoms, time of visit, the type of pain (migrant, non-migrant), nausea, vomiting, anorexia, diarrhea, constipation, presence or history of respiratory tract infection, gastroenteritis, rebound tenderness, leukocytosis, RLQ urinary tract infection, fever were recorded in the questionnaire. Information on laboratory findings (CBC and urinalysis) were also collected. For Children who had appendectomy, surgery report and early complications after surgery and pathological findings (normal, purulent, gangrenous, and perforated) were also recorded.

After 5–7 days, patients were contacted by telephone and final diagnoses were recorded after discharge from the ED. All children were categorized based on pathological findings in two groups with and without appendicitis as well as the PAS scores were calculated for them. At the end, comparing variables between the two groups and diagnostic accuracy of PAS score was calculated by using statistical methods.

Statistical analysis

All analyses were performed using a statistical program (SPSS for Windows 16.0, SPSS, Chicago, IL, USA). To make a comparison of qualitative variables between the two groups, a Chi-square test was performed. Considering the normal distribution of all quantitative parameters based on the Kolmogorov-Smirnov test, independent *t*-test was applied to compare continuous parameters among the two groups. The obtained results are represented as either mean \pm standard deviation (SD) or range (max–min). The amounts of *P* value less than 0.05 were assumed to be statistically

considerable. The PAS was calculated as detailed by Samuel for all patients. ROC curve was used to calculate the specificity, sensitivity, and PAS optimal cut points for identified appendicitis.

Ethical consideration

In the present study, the principles of Helsinki declaration were compiled which is confirmed by Medical Ethics Review Board of Shahid Beheshti University of Medical Sciences. After explaining the purpose of the study and assuring the confidentiality and anonymity of data gathered, a written informed consent was acquired from the children’s parents.

Results

In current study, 125 children suffering from abdominal pain (during one week) who were referred to the emergency medicine department and the emergency physician considered them with suspected appendicitis were studied, and according to inclusion and exclusion criteria for the study, 88 children were present in the final analysis. The mean age of 88 children was 10.5 ± 3 years, of which 52 were girls. Clinical examination showed that 58 children with the average age of 10.5 ± 3 years were with suspected appendicitis and 30 patients with an average age of 4.9 ± 3 years were healthy ($P = 0.12$).

It was found that symptoms such as anorexia, nausea, vomiting, migrant pain and infection in children with suspected appendicitis was more than other healthy children, although the difference was not significant [Table 1]. Comparing clinical examination data among the two groups showed that cough/percussion/hopping tenderness and right-lower-quadrant tenderness was notably higher among children who inflammation of the appendix suspected [Table 1]. The findings also showed that the percentage of PMN and leukocytosis was significantly higher in children with suspected appendicitis [Table 1].

Postoperative pathological findings in three children with suspected appendicitis was normal, but the number was eight in healthy children [Table 2].

4 children from 58 children with suspected acute appendicitis were discharged, but from 30 children 19 children were discharged [Table 3]. In this study, postoperation complication were present only in 2 children, both with acute appendicitis.

In this study, 11 operations were carried out in healthy children, while 4 children with suspected appendicitis were not operated on [Table 4].

In cutoff 5.5, the specificity and sensitivity of the PAS score in patients younger than 18 years old admitted to the ED were 86.21% (95% CI: 68.34%, 96.11%) and 93.88% (95% CI: 83.13%, 98.72%), respectively. Also the negative and positive PAS score predictive values among children were 89.29% (95% CI: 71.77%, 97.73%) and 92% (95% CI: 80.77%, 97.78%) respectively.

In general, the diagnostic accuracy and precision of the PAS score in children admitted to the emergency were 91% and 92%, respectively [Figure 1].

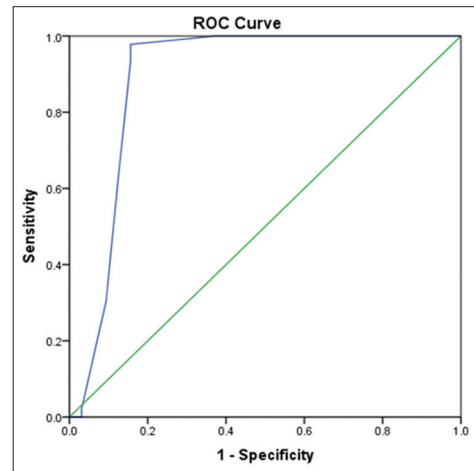


Figure 1: ROC curve for PAS score

Table 1: Comparison of history, physical examination and laboratory findings in both groups

| Parameters | | Children with suspected appendicitis (n=58) | Healthy (n=30) | P |
|--|-------------------|---|----------------|-------|
| Migration of pain | Migration of pain | 49 | 12 | 0.173 |
| | Non-migrant | 9 | 18 | |
| Anorexia | | 48 | 25 | 0.052 |
| Nausea/vomiting | | 43 | 22 | 0.542 |
| Constipation | | 5 | 1 | 0.704 |
| Diarrhea | | 0 | 0 | - |
| Presence or history of respiratory tract infection | | 4 | 0 | 0.114 |
| Gastroenteritis | | 16 | 22 | 0.281 |
| Onset of symptoms (hours ago) | | 7.1 ± 3.2 | 21.6 ± 4.9 | 0.001 |
| Cough/percussion/hopping tenderness | | 51 | 6 | 0.001 |
| Right-lower-quadrant tenderness | | 48 | 5 | 0.001 |
| Fever | | 37.2 ± 0.6 | 37.5 ± 0.7 | 0.32 |
| Leukocytosis | | 11200 | 6000 | 0.001 |
| PMN | | 76.5 ± 14 | 61 ± 18 | 0.001 |

Table 2: Comparison of postoperative pathology findings in both groups

| | | Children with suspected appendicitis (n=58) | Healthy (n=30) | P |
|-----------|------------|---|----------------|-------|
| Pathology | Normal | 3 | 8 | 0.015 |
| | Purulent | 42 | 2 | |
| | Gangrenous | 8 | 1 | |
| | Perforated | 1 | 0 | |

Table 3: Comparison of final outcome and PAS score in both groups

| | | Children with suspected appendicitis (n=58) | Healthy (n=30) | P |
|---------------|------------|---|----------------|-------|
| Final outcome | Operated | 54 | 11 | 0.001 |
| | Discharged | 4 | 19 | |
| PAS score | | 4.2±1.9 | 7.6±1.5 | 0.001 |

Table 4: Appendectomy in both groups

| | | Children with suspected appendicitis (n=58) | Healthy (n=30) | P |
|--------------|--|---|----------------|-------|
| Appendectomy | | 54 | 11 | 0.001 |
| NO | | 4 | 19 | 0.001 |

Discussion

The findings of current study showed that PAS score has high diagnostic value for the acute appendicitis diagnosis in children under 18 years admitted to the ED. With the cutoff equal to 5.5, the diagnostic accuracy and precision are 91% and 92%, respectively. PAS score increases confidence coefficient of physical examination in the diagnosis of acute appendicitis.

A limited number of clinical research groups have tried to develop a clinical scoring in the pediatric population with suspected appendicitis. In 2002 Samuel developed a simple score of appendicitis for children.^[10] Over a period of 5 years, more than 1,100 children with the age between 4 and 15 years suffering from acute abdominal pain who their appendicitis were suspicious, were retrospectively evaluated in two hospitals in London. When children with appendicitis (734 children) were compared with children without appendicitis (436 children), it was found that 8 variables were significantly different between the two groups, which include: cough/percussion/hopping and right-lower-quadrant tenderness (with the index of 0.96), tenderness over the right iliac fossa (0.84), fever (0.87), polymorph nuclear neutrophilia (0.80), anorexia (0.88), nausea or vomiting (0.86), leukocytosis (0.81), and pain migration (0.80).

When this score was verified in a study cohort, 100% sensitivity and 92% specificity were recorded, and positive and negative predictive values were 96% and 99%. The score equal or more than 6 was higher likelihood of appendicitis, although the

evaluation of this score has not been carried out in a distinct group of children prospectively.

Though PAS was essentially developed for children with the age between 4 and 15 years, in current study we have evaluated in the ED for all Iranian children under 18 years. Although it was difficult to get an accurate answer in some questions from children for example migration of abdominal pain or when the child had nausea was not able to communicate verbally with us, however, we tried to study in all age groups of children in large-scale population in emergency departments of hospital.

In this study, the sensitivity and specificity of PAS score in 88 patients younger than 18 years was 93.88% and 86.21% and the positive and negative predictive value in the patients was 92% and 89.29%, respectively. These results are close to the findings of Samuel and colleagues, although all the values found in this study were lower.

However, the findings recorded in our study were higher than Schneider *et al.*^[11] and Bhatt *et al.*^[12] In Schneider *et al.* in 2006 in Boston, 588 children under 10 years, the sensitivity and specificity PAS score in the diagnosis of appendicitis with Cutoff 6 was 77% and 65%, respectively. The diagnostic accuracy, positive, and negative predictive value were 68%, 45%, and 88% respectively.^[11]

In another similar study, Bhatt *et al.* reported the sensitivity and specificity of PAS score in the diagnosis of appendicitis, 92.8% and 69.3%.^[12] In contrast, Goldman *et al.* demonstrated the sensitivity and specificity of PAS score in the diagnosis of appendicitis with the cut-off 7, 94% and 98%, respectively, claimed that if patients with this cutoff transferred to operation room, only 4% will not have appendicitis (96% will have appendicitis).^[13]

The differences observed in this study with other studies may be related to the studied population. In the present study and the Schneider *et al.* study^[11] and Bhatt *et al.* study,^[12] only patients suspected of having acute appendicitis were enrolled while Goldman *et al.* studied children who had been admitted with abdominal pain.^[13]

PAS score can be useful through several ways. First, in hospitals without the ultrasound and CT operators for children or where a pediatric surgeon is not available. This score is based on simple laboratory and clinical measures, simply trainable and can be utilized by both the trainees and expert personnel. It can be easily calculated without any specific, tedious or invasive tests. Healthcare providers can use PAS as a strong communication tool and as a guide for transfer of children between centers when pediatric surgical consultation is required.

The second approach of PAS score is proper selection of patients for imaging. In Samuel *et al.* study, it was suggested that PAS score equal or more than (\geq) 7 means that the patients have acute appendicitis with high probability and must be ready

for operation room, without doing imaging produce for them. This score was 5.5 in current study. Using the PAS score in these cases reduces the waiting time before surgery and also potentially reduces the perforation and the pain associated with an ultrasound scan, also reduced exposure to ray of CT and finally the costs are also reduced.

In this study, four children with acute appendicitis with PAS score more than 5.5 were discharged. Examination time in the emergency medicine department was decreased, the number of ultrasound imaging examinations decreased, CT radiation exposure was reduced, but it would be better that these patients were followed and the morbidity associated with the discharge compared. The persistence of symptoms may return these discharged patients to the hospital.

According to the current findings, PAS score continues to be a fast and efficient diagnosis tool of true acute appendicitis other than differential diagnosis. But on the other hand, it seems necessary to revise the parameters and its valuation (weighting) of PAS score, although it already has acceptable efficacy. Since the leukocytosis, polymorphonuclear neutrophilia, cough/percussion/hopping, and right-lower-quadrant tenderness in the diagnosis of acute appendicitis were significant in our study, it is suggested that more weight and value placed on them.

Limitation

While the PAS score is simple and just a simple clinical examination allows accurate calculation of 6 clinical parameters of this score, the 2 other parameters is related to laboratory findings. Taking blood sample from some children is not possible and we excluded them. On the other hand, the study was conducted in several different hospital centers and collected data and PAS score were calculated by different persons, which may be consider as confounding factor. To overcome this confounding factor, the emergency physician, which were alert about the study was recruited for collecting data and calculating PAS score. The parents' satisfaction for the participation of their children was another limitation. By counseling and outlining the benefits of participating in a study we can satisfy some of them.

Conclusion

In current study the diagnostic accuracy and precision of the PAS score in children under 18 years old admitted to ED were 91% and 92%, respectively. With Cutoff 5.5, the sensitivity, specificity, positive and negative predictive value of the PAS score was 93.88% (95% CI: 83.13%, 98.72%), 86.21% (95% CI: 68.34%, 96.11%), 92% (95% CI: 80.77%, 97.78%) and 89.29% (95% CI: 71.77%, 97.73%), respectively. The results of this study showed that PAS score has high diagnostic accuracy in the diagnosis of acute appendicitis in children under 18 years and due to the advantages listed for this score, its use is recommended for children in emergency department.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflict of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

References

1. Sivit CJ, Siegel MJ, Applegate KE, Newman KD. When appendicitis is suspected in children. *Radiographics* 2001;21:247-88.
2. Kharbanda AB, Vazquez-Benitez G, Ballard DW, Vinson DR, Chettipally UK, Kene MV, *et al.* Development and validation of a novel pediatric appendicitis risk calculator (pARC). *Pediatrics* 2018;141:e20172699.
3. Balthazar EJ. Appendicitis: Prospective evaluation with high resolution CT. *Radiology* 1991;180:21-4.
4. Ohmann C, Yang Q, Franke C; The Abdominal Pain Study Group. Diagnostic scores for acute appendicitis. *Eur J Surg* 1995;161:273-81.
5. Fenyő G. Routine use of a scoring system for decision-making in suspected acute appendicitis in adults. *Acta Chir Scand* 1987;153:545-51.
6. Jaffe BM, Berger DH. The appendix. In: Brunicaudi FC, Anderson DK, editors. *Schwartz's principles of surgery*. 8th ed. New York: McGraw Hill Company; 2005. p. 1119-36.
7. Fenyő G, Lindberg G, Blind P, Enochsson L, Oberg A. Diagnostic decision support in suspected acute appendicitis: Validation of a simplified scoring system. *Eur J Surg* 1997;163:831-8.
8. McLean AD, Stonebridge PA, Bradbury AW, Rainey JB, Macleod DA. Time of presentation, time of operation and unnecessary appendectomy. *Br Med J* 1993;306:307.
9. Surana R, O'Donnell B, Puri P. Appendicitis diagnosed following active observation does not increase morbidity in children. *Pediatr Surg Int* 1995;10:76-8.
10. Samuel M. Pediatric appendicitis score. *J Pediatr Surg* 2002;37:877-81.
11. Schneider C, Kharbanda A, Bachur R. Evaluating appendicitis scoring systems using a prospective pediatric cohort. *Ann*

- Emerg Med 2007;49:778-84.
12. Bhatt M, Joseph L, Ducharme FM, Dougherty G, McGillivray D. Prospective validation of the pediatric appendicitis score in a Canadian pediatric emergency department. Acad Emerg Med 2009;16:591-6.
 13. Goldman RD, Carter S, Stephens D, Antoon R, Mounstephen W, Langer JC. Prospective validation of the pediatric appendicitis score. Pediatr 2008;153:278-82.