

Accuracy Evaluation of Pediatric Appendicitis Scoring (PAS) Method in Differentiating Nonspecific Abdominal Pain from Appendicitis

Abstract

Background: This study aimed at evaluating the accuracy of the pediatric appendicitis scoring method in differentiating nonspecific abdominal pain (NSAP) from appendicitis. **Methods:** This cross-sectional study was conducted on 391 children who were hospitalized in the emergency ward due to acute abdominal pain suspected of appendicitis. Pediatric Appendicitis Score (PAS), C-reactive protein (CRP), and appendicitis pathology results of patients undergoing surgery were recorded. **Results:** The results showed that the no significant difference was found among patients in the three experimental groups (appendicitis, specific abdominal pain except appendicitis, and NSAP) with respect to temperature ($p = 0.212$), but the other variables were significantly different. Findings showed that high CRP frequency, pain migration to right lower quadrant (RLQ), tenderness in right iliac fossa (RIF), anorexia, leukocytosis, high neutrophil, and mean tenderness in RLQ in the appendicitis group were higher than those in the other two groups ($p = 0.001$). The PAS questionnaire can also be used as a reliable questionnaire with appropriate sensitivity (0.929) and specificity (0.993), and this questionnaire along with detailed clinical examinations could reduce the rate of negative appendectomy to less than 1%. **Conclusions:** This study showed high accuracy of PAS in diagnosing children with appendicitis and differentiating appendicitis from cases of NSAP and specific abdominal pain other than appendicitis. The PAS system could also significantly reduce cases of negative appendicitis. Although high CRP had an excellent ability to diagnose appendicitis, its accuracy was lower than PAS.

Keywords: Abdominal pain, appendicitis, nonspecific, pediatrics, scoring

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Introduction

Acute appendicitis often emerges with subtle symptoms and may be confused with other diseases. However, acute appendicitis is one of the most common causes of acute abdominal pain.^[1,2] The highest incidence of appendicitis is in the second decade of life with a rate of 86 per 100,000 cases per year.^[3-5]

Despite the application of new techniques and routine imaging tests, such as ultrasound and CT scan, 5% to 10% of appendectomies are still negative.^[6-9] The rate of negative appendectomy and complicated appendectomy in children is higher than that in adults. Based on the research literature, negative appendectomy in children is 8.4%, and in those under 6 years old is 56.7%. The appendicitis perforation rate in children under 6 years old is over 50%. This is likely related to the thinness of the appendix in these

children and the associated diagnostic problems.^[10,11]

Appendicitis symptoms overlap with other diagnoses of acute abdomen, cases where there are no typical symptoms, and complications associated with the delayed diagnosis. Consequently, this has led to the persistence of the challenges associated with diagnosis of appendicitis.^[12]

The term “nonspecific abdominal pain” (NSAP) refers to abdominal pain that, despite thorough clinical and Para-clinical examinations by a specialist, does not lead to a clear and accurate diagnosis.^[13] NSAP is one of the most common diagnoses following hospitalization of children due to abdominal pain.^[14] There are numerous diagnostic criteria for early and accurate diagnosis of appendicitis and reducing negative appendectomy due to specific abdominal pain except for appendicitis, and NSAP.

They also can reduce frequent visits to emergencies. These criteria include scoring

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systems, the help of inflammatory factors, imaging, and/or combination of such techniques. These criteria often include clinical evidence (signs and symptoms), laboratory markers, and imaging.^[15-17]

Significant progress has been made recently in the assessment of children with suspected appendicitis. For instance, using ultrasound as front-line imaging without much error in diagnoses or the negative results of appendectomy in acute abdominal pain has reduced CT scan application in the diagnosis of appendicitis. However, the perforated appendicitis rate has remained unchanged, and changes in care are still needed.^[18]

In meta-analysis studies, the usefulness of standard scoring systems in children was assessed according to the history of the disease, laboratory criteria, and criteria in pediatric emergencies. As a result, three scoring systems, including AIR, Alvarado, and Pediatric Appendicitis Score (PAS), were evaluated and compared. The results showed that the use of scoring systems as a tool could help in the subsequent decision-making of patients and physicians. Among them, PAS was the most helpful in differentiating cases of appendicitis.^[19] Some studies show that the PAS minimizes the risks of radiation and the use of ultrasound.^[20,21]

Using observational methods with aid of PAS, is highly useful in children and adolescents.^[22] PAS is based on clinical examination (anorexia, nausea, and vomiting, tenderness in the lower right abdomen, pain migration, tenderness during percussion or coughing, fever) and laboratory findings (neutrophils above 7,500 and leukocytosis above 10,000).^[23,24]

One of the important consequences of NSAP is the frequent visits to pediatric emergencies and the high prevalence of negative appendectomy in children with NSAP, which imposes costs on the health system. This leads to severe concern in families. Therefore, this study was aimed at evaluating the accuracy of pediatric appendicitis scoring method in differentiating NSAP from appendicitis.

Materials and Methods

A cross-sectional study was conducted on children aged 5–15 years who, were admitted to the emergency ward of Besat Medical Center of Hamadan, Iran, due to acute abdominal pain suspected of appendicitis during 2019–2021. The participants were selected based on total sampling and inclusion criteria (5- to 15-year-old children with acute abdominal pain suspected of appendicitis, and no underlying disease). According to the sample size, 391 patients were selected. Patients who met the following criteria were excluded from the study: a duration of abdominal pain more than 72 h (differentiation of appendicitis from NSAP is rarely required in these cases, and usually another diagnosis is required), having pain less than 6 h (diagnostic tests are not usually performed at this

time), a history of blood disorders, malignancy, liver disease or inflammatory diseases (currently either diagnosed within one month before the onset of symptoms), antibiotic or anti-inflammatory therapy within one month after diagnosis and patients who did not wish to continue to participate in the study due to any reason.

After explaining the process and objectives of the study and ensuring that records of individuals are preserved, all patients' parents were asked to sign the informed consent form. Next, with the cooperation of the patient, their demographic information and history (age, sex, length of hospital stay, the time interval from onset of pain to hospitalization, the time of the test, etc.) were recorded by the treating physician or pediatric resident. The second part of the questionnaire related to the PAS variables (pain in the right iliac fossa by RIF touching pain, tenderness in RIF with cough or percussion, pain migration to RIF, anorexia, nausea and vomiting, body temperature, leukocyte number, and neutrophil rate) with clinical examination and CRP results,

The results of pathology and abdominal ultrasonography were recorded by reviewing the patients' files and Para-clinical results.

Diagnosis of NSAP has been considered if a specific cause such as appendicitis, mesenteric adenitis, gastroenteritis, urinary tract infection, etc. Is not considered as the cause of abdominal pain with nonspecific findings on ultrasound and no antibiotic treatment in a month after discharge (to prevent cases of appendicitis or undiagnosed infectious disease). Diagnosis of appendicitis was also based on confirmation of postoperative pathology.

All patients with nonspecific pain up to one month after discharge were followed up by telephone to check for exclusion criteria. No antibiotic treatment within one month of discharge to prevent appendicitis cases of undiagnosed infectious disease.

Categorization in evaluating patients with suspected appendicitis:

- A. Low risk (PAS <4): Low risk of acute appendicitis with no imaging required. A score with a higher negative predictive value (95%) in the absence of right lower quadrant (RLQ) pain is considered other causes of acute abdominal pain if the pain intensifies with walking, jumping, or coughing.
- B. Moderate probability (PAS = 6–4): Imaging can be helpful in this subset of patients, preferably ultrasound. Surgical advice is essential for patients with double scores and imaging in which appendicitis cannot be visualized.
- C. High risk (6 PAS >): Surgical advice is essential for these patients. Patients should have an ultrasound before having surgical counseling.

All tests and imaging were performed at Besat Hospital, and no intervention was performed in the routine procedure

for acute abdomen based on the Alvarado system. CBC/UA tests and ultrasound were routinely performed for all patients with acute abdominal pain referred to the emergency ward and needed surgery counseling. Quantitative CRP was measured separately for patients, the results were recorded in a checklist, and the researcher performed all examinations and completed the information of the questionnaire. The decision to transfer to the operating room or discharge from the emergency room was coordinated with the pediatrician and surgeon. Finally, the results of each PAS scoring criteria were evaluated according to the final diagnosis, ultrasound, and pathology results in differentiating appendicitis from NSAP.

Statistical analysis was performed using SPSS version 16. Descriptive statistics were used to achieve the objectives of the study. A *P* value less than 0.05 was considered statistically significant. Uniformity analysis of quantitative variables was performed through a *t*-test; qualitative variables were assessed using a multivariate logical regression of Chi-square test to identify variables most associated with appendicitis and NSAP. Finally, the area below the ROC curve and the cut-off point was determined for quantitative variables to differentiate appendicitis from NSAP.

Results

A total of 391 patients aged 5–15 years who were suspected of having acute appendicitis were included in the study. The mean age of these patients was 9.46 ± 2.62 years, and the age range of patients was between 5 and 15 years. Of the 391 included patients, 160 (40.9%) were male, and 231 (59.1%) were female. Table 1 shows frequency of final diagnosis results for patients.

Comparison of PAS variables frequency in the three groups of appendicitis, specific abdominal pain except for appendicitis, and NSAP is shown in Table 2.

Table 3 shows ROC curve information, cut-off point and sensitivity and specificity of PAS, CRP, and PAS+CRP variables.

ROC curve, PAS, CRP, and PAS+CRP variables are presented in Figure 1.

Taking the cut-off point (7.5 for PAS) into consideration, 92.9% of appendicitis patients were located above that point and, only 2.7% of patients with NSAP had a PAS score above 7.5. None of the patients with specific abdominal pain had a PAS score above 7.5 except for the appendicitis group. Comparison of patients with PAS score above 7.5, CRP above 25.5, and PAS+CRP above 7.5 showed a significant difference between the three groups ($p = 0.001$). With the use of the PAS questionnaire and through determining the cut-off point of 7.5, the rate of negative appendectomies was reduced from 9.1 to 0.38%. By setting a cut-off point equal to 25.5 for

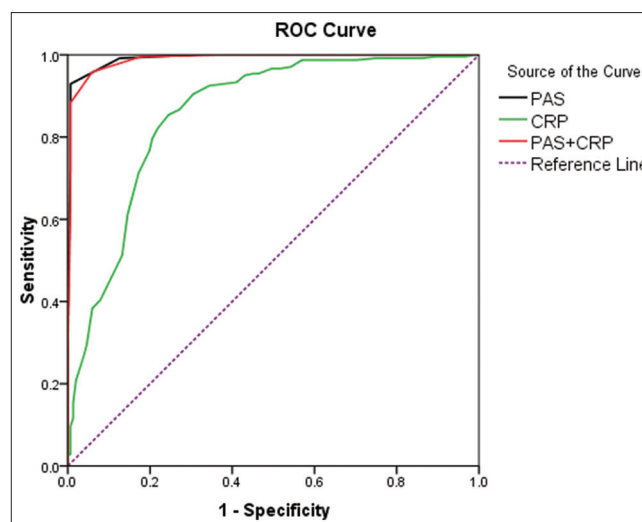


Figure 1: ROC curve, PAS, CRP, and PAS+CRP variables

CRP, the rate of negative appendectomies was reduced to 4.92%. Furthermore, using the 7.5 cut-off point for PAS+CRP, the rate of negative appendectomies was reduced to 3.41%.

If the cut-off point (CRP) of CRP is 25.5, 76.7% of appendicitis patients were located above the cut-off point, and 35.1% of patients had a CRP more than 25.5 for NSAP. However, only 14.9% of patients with the specific abdominal pain without appendicitis group had a CRP of more than 25.5.

If we consider patients with a CRP score greater than 25.5 or equivalent to one with other patients scoring zero and add these numbers to the PAS score, the cut-off point value of PAS+CRP is 7.5. 95.8% of appendicitis patients were located above the cut-off point. PAS+CRP score of 24.3% of patients with NSAP was above 7.5. However, PAS+CRP score of the patients with the specific abdominal pain without the appendicitis group was lower than 7.5.

One-month follow-up results showed that 7 patients (2.65%) who underwent an operation developed postoperative complications. In addition, among the patients in the specific abdominal pain without appendicitis group, 21 patients needed to take antibiotics for up to one month after discharge.

Discussion

NSAP is defined as an acute abdominal pain process without a suspected organic cause, which is self-limiting and does not recur. In pediatric emergency departments, this is the most common discharge diagnosis in patients with acute abdominal pain and often requires a differential diagnosis with appendicitis in clinical practice.^[25,26]

Marcos Prada *et al.* (2018)^[27] examined the usefulness of PAS and CRP in differentiating appendicitis from NSAP. The results showed no difference in temperature and RLQ

Table 1: Frequency of final diagnosis results for patients

Variable	Frequency	Frequency percentage
Final diagnosis		
Transfer to surgical service	15	3.8
Transfer to surgical service and performing appendectomy	264	67.5
Discharge from the emergency room or ward without surgery	40	10.2
Diagnosis of pneumonia	1	0.3
Diagnosis of urinary tract infection	9	2.3
Diagnosis of gastroenteritis	32	8.2
Diagnosis of mesenteric adenitis	15	3.8
Pharyngitis	2	0.5
Discharge without a particular diagnosis	13	3.3
Total	391	100%
Outcomes of surgical appendicitis pathology		
Normal appendicitis	131	49.6
Gangrene appendicitis	86	32.6
Perforated appendicitis	23	8.7
Typical appendicitis (healthy)	24	9.1
Total	264	100%

Table 2: Comparison of PAS variables frequency in the three groups of appendicitis, specific abdominal pain except for appendicitis, and nonspecific abdominal pain

Variable	Status						P
	Appendicitis		specific abdominal pain except appendicitis		Nonspecific abdominal pain		
	No	%	No	%	No	%	
Fever	38	15.8	23	20.2	3	8.1	0.212
High CRP	784	76.7	17	14.9	13	35.1	0.001
Pain migration to RLQ	205	85.4	63	55.3	21	56.8	0.001
Tenderness in RIF	231	96.2	14	12.3	20	54.1	0.001
Anorexia	201	83.8	59	51.8	18	71.1	0.001
Leukocytosis more than 10,000	234	97.5	35	30.7	25	67.6	0.001
Neutrophils over 75%	237	98.8	27	23.7	23	62.2	0.001

Table 3: ROC curve information, cut-off point and sensitivity and specificity of PAS, CRP, and PAS + CRP variables.

Variable	The area under the curve (AUC)	Confidence interval (CI 95%)	Cut-off point	Sensitivity	Specificity	P
PAS	0.991	0.984-0.999	7.5	0.929	0.993	0.001
CRP	0.858	0.817-8980	25.5	0.767	0.801	0.001
PAS + CRP	0.989	0.980-0.998	7.5	0.958	0.940	0.001

tenderness between patients with appendicitis and patients with NSAP. While the pains exacerbated by coughing, jumping, or percussion in the RLQ of the abdomen, were variables more closely related to appendicitis. Leukocytosis, CRP, and neutrophils were significantly different. PAS correctly classified patients into low-risk and a high-risk group for appendicitis, and also the CRP was effective in increasing the diagnostic accuracy.^[27] Our results showed that no significant difference was found between patients with appendicitis and patients with NSAP with respect to temperature, but the tenderness in touching RLQ in the appendicitis group was higher than that in the NSAP groups. The difference between the two studies may be due to different perceptions of pain intensity in different cultures. In other parameters our study was consistent with previous studies.

Khaasteh *et al.* (2020)^[28] showed that WBC more than 11,000 and PMN more than 65% have a remarkable ability to diagnose appendicitis and its complications. Kharbanda *et al.* (2017)^[29] showed that the intensity of tenderness in RLQ and tenderness in RIF and coughing and percussion are among the main symptoms of appendicitis. Various studies have reported different numbers on the sensitivity and specificity of leukocyte and PMNs counts, ranging from 55% to 89% and from 43 to 66%, respectively.^[30-32] The elevation of these counts in many other manifestations with RIF pain causes their low specificity. Given that inflammatory and infectious processes are associated with the activation of neutrophils in the first 3–6 h of onset, they are more useful in the first 24 h of onset. In the present study, the cut-off points with the discriminatory power and

the sensitivity and specificity found were consistent with the previous studies.

Samuel (2002) conducted a study to examine the pediatric appendicitis scale. The results showed that pain indicators in the RLQ of the abdomen were sensitive to cough and percussion, anorexia, nausea, RIF's tenderness, leukocytosis, PMN, and pain migration were sufficiently sensitive in the diagnosis of appendicitis. The pediatric appendicitis scale had a sensitivity of 1, specificity of 0.82, a positive predictive value of 0.96, and a negative predictive value of 0.99. Pediatric appendicitis score was a simple and relatively accurate diagnostic tool for diagnosing appendicitis in children.^[33] The negative appendectomy rate in the study was 9.1%, and there was no patient with undiagnosed appendicitis. The results of studies and published statistics related to the rate of appendectomy indicate a prevalence of 5% to 10% negative appendectomy,^[6-7] which is consistent with our study

Marcos Prada *et al.* (2018)^[27] showed that CRP was effective in increasing the diagnostic accuracy, which is not consistent with our study. According to their proposal, in addition to using PAS to differentiate NSAP from appendicitis, CRP can be used alongside PAS indicators for diagnosis. Also, Khaasteh *et al.* (2020)^[28] showed that if the CRP level is within the normal range, it will have a negative predictive value of about 100% for appendicitis. For diagnosis of appendicitis, especially in the early stages, the discriminatory power of CRP is not high because its value is in the range that is compatible with other processes. However, to differentiate between uncomplicated and complex appendicitis, CRP levels are helpful.

Given the results of most studies on the influential role of CRP and the inconsistency with our study, the accuracy of the laboratory used can be somewhat questioned, which requires further investigation

Although PAS+CRP have reduced the rate of negative appendectomies, this reduction has been less than that of PAS, making its use a little questionable.

Marcos Prada *et al.* (2018)^[27] demonstrated the ability of the PAS to correctly classify patients into low-risk and high-risk groups for appendicitis. Attia *et al.* (2009)^[34] demonstrated the usefulness of PAS scoring in differentiating appendicitis from other causes of abdominal pain. Thus, the score of six and above showed a high-rate probability of appendicitis with 100% sensitivity and 92% specificity. In another study, Bhatt *et al.* (2009)^[35] showed the usefulness of the PAS for diagnosing appendicitis in children; the use of PAS reduced 41% of unnecessary imaging, and the rate of negative appendectomy was less than 8%.

Recently, systematic studies of various appendicitis prediction rules used in children have demonstrated the high methodological quality of validation studies for PAS,

which offers superior diagnostic performance (sensitivity of 93% and negative predictive value of 10%)^[12]

Studies also show that it can help classify patients into low-risk and high-risk groups and that there is no need for further diagnostic tests^[35-39]

PAS can be very useful in guiding clinical decision-making and improving resources use. It can also be used as a valuable tool to predict the severity of appendicitis and the risk of complications and guide the decision to repeat a structured physical examination during the observation time.

Given that PAS classifies patients by risk of appendicitis; it may be helpful in the differential diagnosis of appendicitis and NSAP. The variable associated with appendicitis is Tenderness in the RIF on coughing, hopping, and percussion, which in the PAS justifies its greater weight

Conclusions

The results showed a high accuracy of PAS in early diagnosis of appendicitis, differentiation of appendicitis from nonspecific cases of abdominal pain, and specific abdominal pain without appendicitis. The PAS could also significantly reduce cases of negative appendicitis. Although CRP had an excellent ability to diagnose appendicitis, its accuracy was lower than PAS. CRP can be used as an alternative to PAS in the diagnosis of appendicitis.

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This study was approved in Hamadan University of Medical Sciences, as a research project.

Ethical considerations

The research followed the tents of the Declaration of Helsinki. The Ethics Committee of Hamadan University of Medical Sciences approved this study. The institutional ethical committee at Hamadan University of Medical Sciences approved all study protocols (IR.UMSHA.REC.1398.312). Accordingly, written informed consent taken from all participants before any intervention. This study was extracted from M.D thesis of Hamadan at this university (Thesis COD: 9904102233)

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors. The patient gave the consent to publish as a case report

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Conflicts of interest

There are no conflicts of interest.

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