Original Article

Cukurova Anestezi ve Cerrahi Bilimler Dergisi

A Traditional Yet Powerful Tool: The Superiority of the Pediatric Appendicitis Score (PAS) Despite the Introduction of Novel Hematologic Markers

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Abstract

Objective: Acute appendicitis is one of the most common causes of emergency abdominal surgery in children, and early accurate diagnosis is essential. This study aimed to compare the diagnostic and severity-assessment performance of the Pediatric Appendicitis Score (PAS) with novel hematologic inflammatory markers in pediatric patients with suspected acute appendicitis. **Materials and Methods:** This retrospective single-center study included 209 pediatric patients evaluated for suspected acute appendicitis between January 2023 and January 2025. Patients were classified into three groups: non-appendicitis (n = 70), uncomplicated appendicitis (n = 69), and complicated appendicitis (n = 70). PAS, C-reactive protein (CRP), procalcitonin, neutrophil-to-lymphocyte ratio (NLR), systemic immune-inflammation index (SII), and aggregate index of systemic inflammation (AISI) were analyzed. Diagnostic performance was evaluated using ROC analysis. **Results:** PAS demonstrated the highest discriminative performance for the diagnosis of acute appendicitis (AUC = 0.92, $p < 0.001$). The AUC values were 0.84 for CRP and 0.81 for NLR. SII, AISI, and procalcitonin were also significant but showed lower performance. For distinguishing complicated from uncomplicated appendicitis, the AUC was 0.82 for PAS, 0.79 for CRP and procalcitonin, 0.75 for NLR, 0.74 for SII, and 0.70 for AISI. Multivariate analysis identified PAS as the strongest independent predictor of appendicitis (OR = 8.9, 95% CI: 4.2–18.4; $p < 0.001$). **Conclusion:** PAS remains the most reliable tool for diagnosing pediatric acute appendicitis and assessing disease severity. Novel hematologic markers may provide supportive value but do not outperform PAS when used alone.

Keywords: Acute appendicitis; Pediatric Appendicitis Score; Hematologic inflammatory markers; Child; Pediatric surgery

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1. Introduction

Acute appendicitis remains one of the most common causes of emergency abdominal surgery in the pediatric population. Early and accurate diagnosis is essential, as delays may lead to serious complications such as perforation, while overdiagnosis can result in unnecessary surgical procedures. To improve diagnostic accuracy, several scoring systems integrating clinical findings and laboratory parameters have been developed[1].

Among these, the Pediatric Appendicitis Score (PAS) is one of the most widely used and practical tools in clinical practice. Owing to its simplicity and reliance on readily obtainable clinical parameters, PAS has become a valuable aid in pediatric emergency departments[1,2]. Previous studies have demonstrated that PAS can reduce negative appendectomy rates and support clinical decision-making, particularly in distinguishing uncomplicated from complicated appendicitis[2,3].

In recent years, increasing attention has been directed toward hematologic inflammatory markers to further enhance diagnostic accuracy. Composite indices derived from routine blood parameters—such as neutrophils, lymphocytes, monocytes, and platelets—have been proposed to better reflect the systemic inflammatory response. However, most available evidence originates from adult populations, and data regarding their usefulness in pediatric appendicitis remain limited[4,5].

The neutrophil-to-lymphocyte ratio (NLR) is a widely studied inflammatory marker that reflects innate immune activation and has emerged as a practical and cost-effective biomarker in pediatric emergency settings, particularly for diagnosing and assessing the severity of acute appendicitis[6]. The Systemic Immune-Inflammation Index (SII), calculated using neutrophil, lymphocyte, and platelet counts, has been proposed as a promising indicator of systemic inflammation[7–9]. Similarly, the Aggregate Index of Systemic Inflammation (AISI), calculated by multiplying neutrophil, monocyte, and platelet counts and dividing by the lymphocyte count, has been investigated in disease severity evaluation; however, evidence supporting its diagnostic role in appendicitis remains limited[14,15].

The present study aims to compare PAS with emerging hematological inflammatory indices and to evaluate their diagnostic and severity-assessment performance in pediatric patients with suspected acute appendicitis.

2. Materials and Methods

2.1. Study Design and Ethical Considerations

This retrospective, single-center study was conducted in the Department of Pediatric Surgery, involving cases evaluated between January 2023 and January 2025. Ethical approval was obtained from the Institutional Review Board (Protocol No: 34), and the study was carried out in accordance with the principles of the Declaration of Helsinki.

2.2. Study Population

A total of 209 pediatric patients aged 3–17 years (mean age: 10.8 ± 3.2 years) presenting to the emergency department with abdominal pain and evaluated with a preliminary diagnosis of acute appendicitis were included. Of these, 139 underwent surgical intervention; 70 patients were observed clinically without antibiotic therapy and acute appendicitis was ruled out during follow-up. Patients were categorized into three diagnostic groups: non-appendicitis (n = 70, clinically/radiologically excluded), uncomplicated appendicitis (n = 69, histopathologically confirmed without perforation, abscess, or gangrene), and complicated appendicitis (n = 70, histopathologically confirmed with intraoperative evidence of perforation, abscess, or gangrenous appendicitis).

Patients with known chronic inflammatory conditions, immunodeficiency, prior abdominal surgery, prior antibiotic or anti-inflammatory treatment before hospital admission, or incomplete records were excluded.

2.3. Data Collection and Hematologic Parameters

Collected data included demographic characteristics, PAS, complete blood count parameters, CRP, procalcitonin, and surgical/pathological outcomes. All laboratory parameters were obtained from the first blood samples at emergency department admission before any treatment. Hematological inflammatory indices were calculated as:

NLR = Neutrophil count / Lymphocyte count; SII = (Platelet count × Neutrophil count) / Lymphocyte count; AISI = (Platelet count × Neutrophil count × Monocyte count) / Lymphocyte count.

2.4. Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 27.0. Continuous variables were assessed for normality using the Shapiro–Wilk test and presented as mean ± SD or median (IQR). Group comparisons used ANOVA or Kruskal–Wallis test for continuous variables, and Chi-square test for categorical variables. Diagnostic utility was evaluated via ROC curve analysis. AUC, sensitivity, specificity, and optimal cut-off values were reported. $P < 0.05$ was statistically significant.

3. Results

3.1. Diagnostic Utility of Scoring Systems and Biomarkers

The overall mean age was 10.8 ± 3.2 years, with no statistically significant differences in age or sex distribution among the three groups. PAS demonstrated the highest diagnostic accuracy, with mean scores of 4.1 ± 1.6, 6.8 ± 1.3, and 7.9 ± 1.1 in the non-appendicitis, uncomplicated, and complicated appendicitis groups, respectively ($p < 0.001$). ROC analysis demonstrated the highest discriminative ability for PAS (AUC = 0.92)[1,2]. CRP levels increased from 6.3 ± 2.5 mg/L (non-appendicitis) to 18.5 ± 4.2 mg/L (uncomplicated) and 41.3 ± 5.7 mg/L (complicated) ($p < 0.001$). Median NLR values increased from 2.1 (1.4–2.8) to 4.6 (3.5–5.8) and 7.3 (5.5–9.5) across the three groups ($p < 0.001$). ROC analysis showed AUC values of 0.84 for CRP and 0.81 for NLR ($p < 0.001$).

Table 1. Comparison of scores and inflammatory markers among study groups

Parameter	Non-appendicitis (n=70)	Uncomplicated appendicitis (n=69)	Complicated appendicitis (n=70)	p-value
PAS	4.1 ± 1.6	6.8 ± 1.3	7.9 ± 1.1	<0.001
CRP (mg/L)	6.3 ± 2.5	18.5 ± 4.2	41.3 ± 5.7	<0.001
NLR	2.1 (1.4–2.8)	4.6 (3.5–5.8)	7.3 (5.5–9.5)	<0.001
SII ($\times 10^3/mm^3$)	482 (350–650)	963 (750–1200)	1450 (1100–1800)	<0.01
AISI	172 (120–250)	691 (500–900)	1132 (850–1500)	<0.01
Procalcitonin (ng/mL)	0.10 (0.05–0.20)	0.38 (0.20–0.60)	1.70 (0.90–3.00)	<0.05

PAS: Pediatric Appendicitis Score; CRP: C-reactive protein; NLR: neutrophil-to-lymphocyte ratio; SII: systemic immune-inflammation index; AISI: aggregate index of systemic inflammation. Values are mean ± SD or median (IQR). p-values represent overall comparisons among the three groups (non-appendicitis, uncomplicated appendicitis, and complicated appendicitis) using one-way ANOVA or the Kruskal–Wallis test, as appropriate. Data are presented as mean ± standard deviation (SD) or median (interquartile range, IQR) according to data distribution.

Table 2. ROC analysis for diagnosis of acute appendicitis

Marker	AUC	Cut-off	Sensitivity (%)	Specificity (%)
PAS	0.92	6.0	92	89
CRP (mg/L)	0.84	10	85	78
NLR	0.81	3.5	83	74
SII ($\times 10^3/mm^3$)	0.78	800	80	70
AISI	0.74	600	76	68
Procalcitonin (ng/mL)	0.71	0.3	72	65

ROC analysis was performed to evaluate the diagnostic performance of each parameter for distinguishing acute appendicitis from non-appendicitis. ROC analysis was performed to evaluate the diagnostic performance of each parameter for distinguishing acute appendicitis (uncomplicated + complicated) from non-appendicitis. Cut-off values, sensitivity, and specificity were determined based on ROC curve analysis.

Median SII values were 482, 963, and 1450 × 10^3/mm^3 and AISI values were 172, 691, and 1132 across the three groups, respectively (both $p < 0.01$). ROC analysis demonstrated AUC values of 0.78 for SII and 0.74 for AISI. Procalcitonin levels were 0.10, 0.38, and 1.70 ng/mL across the groups ($p < 0.05$), with an AUC of 0.71. All comparisons are summarized in Table 1 and ROC analysis results in Table 2.

3.2. Assessment of Appendicitis Severity

When uncomplicated and complicated appendicitis were compared, PAS (AUC = 0.82), CRP (AUC = 0.79), procalcitonin (AUC = 0.79), NLR (AUC = 0.75), SII (AUC = 0.74), and AISI (AUC = 0.70) all showed significant discrimination (Table 3).

Table 3. ROC analysis for differentiating complicated from uncomplicated appendicitis

Marker	AUC	Cut-off	Sensitivity (%)	Specificity (%)
PAS	0.82	7.5	79	77
CRP (mg/L)	0.79	28	76	72
Procalcitonin (ng/mL)	0.79	0.8	74	71
NLR	0.75	5.5	82	60
SII ($\times 10^3/mm^3$)	0.74	1150	71	68
AISI	0.70	900	68	65

Abbreviations: *PAS, Pediatric Appendicitis Score; CRP, C-reactive protein; NLR, neutrophil-to-lymphocyte ratio; SII, systemic immune-inflammation index; AISI, aggregate index of systemic inflammation. ROC analysis was performed to evaluate the diagnostic performance of each parameter for differentiating complicated from uncomplicated appendicitis.*

3.3. Multivariate Analysis

PAS, CRP, NLR, SII, AISI, and procalcitonin were included in a multivariate logistic regression model. PAS was identified as the strongest independent predictor of appendicitis (OR = 8.9; 95% CI: 4.2–18.4; $p < 0.001$). CRP and NLR were also independently associated with appendicitis.

4. Discussion

The PAS was first introduced by Samuel M. in 2002 and has since been widely adopted in the diagnosis of pediatric appendicitis. In the original study, PAS demonstrated a sensitivity of 100% and a specificity of 92%[16,17]. Attia M.W. reported that a PAS value ≥6 demonstrated sensitivity of 100% and specificity of 92%[18]. Goldman et al. reported that PAS values above 7 were associated with specificity of 96% and sensitivity of 61%[19]. However, Aydın et al. and Pogorelić et al. stated that PAS alone is insufficient for diagnosis[16,20]. In our study, PAS values ≥6 demonstrated sensitivity of 92% and specificity of 89%. These results are largely consistent with the majority of the existing literature.

CRP is a well-established inflammatory biomarker used in both the diagnosis and severity evaluation of acute appendicitis[22]. Narci et al. emphasized the diagnostic value of CRP in identifying appendicitis cases[23]. Zani et al. reported that CRP levels below 40 mg/dL were associated with an approximately 80% probability of non-complicated appendicitis[24], while Wu et al. demonstrated that CRP levels exceeding 50 mg/dL were significantly associated with complicated appendicitis[25]. In our study, CRP emerged as the second most valuable biomarker after PAS, with mean levels of 6.3, 18.5, and 41.3 mg/L across the three groups.

NLR has been reported as a significant biomarker for both the diagnosis and severity differentiation of acute appendicitis. Presetya et al. reported sensitivity of 83.5%, specificity of 57.7%, and AUC of 0.79 in pediatric patients[26]. Kapetanovic et al. identified NLR as a statistically significant diagnostic marker with sensitivity of 63% and specificity of 74%

(AUC = 0.69)[27]. In our study, NLR showed sensitivity of 85% and specificity of 74%, supporting its role as a valuable adjunctive marker, albeit with lower accuracy than PAS.

Regarding SII, Kart and Uğur demonstrated an AUC of 0.98 with sensitivity of 95% and specificity of 98% in 162 pediatric patients; however, SII was not effective in distinguishing complicated from uncomplicated appendicitis[22]. Cakcak et al. emphasized the utility of SII as a reliable predictor of appendicitis-related complications[4]. In our study, SII yielded an AUC of 0.78 for diagnosis, indicating moderate performance inferior to PAS.

AISI has emerged more recently as a composite biomarker of systemic inflammatory burden, particularly investigated during the COVID-19 pandemic[14]. Feier et al. in a study of 407 adult patients showed AISI was associated with histopathological differentiation of appendicitis subtypes[28]. In our study, AISI also showed statistically significant associations with both diagnosis and severity assessment but exhibited the lowest discriminative capacity among the studied markers.

This study has several limitations. First, its retrospective and single-center design may limit generalizability. Second, cut-off values were derived without external validation. Third, clinical decision-making processes may introduce potential selection bias. Future prospective multicenter studies are needed to validate these findings.

5. Conclusion

The Pediatric Appendicitis Score (PAS) remains the most reliable and effective method for both diagnosing acute appendicitis and stratifying its severity in the pediatric population. Although emerging hematologic markers such as NLR, SII, AISI, and procalcitonin provide meaningful supplementary information by reflecting systemic inflammatory changes, their diagnostic and prognostic performances do not yet surpass the accuracy and clinical consistency of PAS. Incorporating these biomarkers alongside PAS may support a more comprehensive evaluation, particularly in complex or ambiguous presentations. Future multicenter, prospective studies are warranted to determine whether combined diagnostic models can further enhance precision and reduce unnecessary surgical interventions.

Ethical Approval: Ethical approval was obtained from the Institutional Review Board (Protocol No: 34). The study was conducted in accordance with the principles of the Declaration of Helsinki. Informed consent was waived due to the retrospective design.

Conflict of Interest: The authors declare no conflict of interest.

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