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Demographic Profile and Diagnostic Accuracy of the Pediatric Appendicitis Score in

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Children: A Retrospective Observational Study in a Tertiary Pediatric Intensive Care Unit

Abstract

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Background/Objective: Acute appendicitis remains a frequent cause of emergency surgery in children, yet diagnosis can be challenging due to nonspecific clinical presentations, particularly in younger age groups. This investigation was conducted to describe the demographic characteristics of pediatric patients with suspected appendicitis, evaluate the diagnostic utility of the Pediatric Appendicitis Score, as well as the duration of postoperative care in the pediatric intensive care unit.

Methods: This retrospective cross-sectional observational study included 15 pediatric patients with acute abdomen who underwent exploratory laparotomy. PAS was applied, with histopathology as the reference standard. Postoperative PICU admission was performed for all patients. Collected variables included demographic data, PAS, histopathology results, and PICU length of stay. Diagnostic performance was evaluated using sensitivity, specificity, predictive values, diagnostic accuracy, and area under the ROC curve.

Results: Of the included patients, histopathological confirmation of appendicitis was more commonly observed among older children. Higher Pediatric Appendicitis Score values were associated with confirmed appendicitis and demonstrated moderate diagnostic performance, with relatively high specificity but limited sensitivity. Receiver operating characteristic analysis indicated modest discriminative ability (AUC 0.704). Postoperative length of stay in the pediatric intensive care unit tended to be shorter in patients with confirmed appendicitis, although no statistically significant difference was observed.

Conclusion: Pediatric appendicitis in this tertiary center predominantly affected older children. The PAS demonstrated moderate diagnostic accuracy, with good specificity but limited sensitivity. Confirmed cases also tended to have shorter PICU stays. Additional studies involving larger patient populations are warranted to confirm and strengthen these findings.

Keywords: Appendicitis, Child, Diagnostic Accuracy, Pediatric Appendicitis Score, Pediatric Intensive Care Unit

Abstrak

Latar Belakang: Apendisitis akut masih merupakan penyebab tersering tindakan pembedahan darurat pada anak. Namun, penegakan diagnosis sering kali sulit, terutama pada kelompok usia yang lebih muda, akibat gambaran klinis yang tidak khas. Penelitian ini bertujuan untuk menggambarkan karakteristik demografis pasien anak dengan kecurigaan apendisitis, menilai kinerja diagnostik *Pediatric Appendicitis Score*, serta mengevaluasi durasi perawatan pascaoperasi di unit perawatan intensif anak.

Metode: Penelitian observasional retrospektif potong lintang ini melibatkan 15 pasien anak dengan abdomen akut yang menjalani laparotomi eksploratif. PAS diterapkan dengan pemeriksaan histopatologi sebagai standar baku. Seluruh pasien menjalani perawatan di PICU pascaoperasi. Variabel yang dikumpulkan meliputi data demografis, skor PAS, hasil histopatologi, dan lama rawat PICU. Kinerja diagnostik PAS dievaluasi menggunakan sensitivitas, spesifisitas, nilai prediktif positif dan negatif, akurasi diagnostik, serta area under the receiver operating characteristic curve (AUC).

Hasil: Apendisitis yang terkonfirmasi secara histopatologis lebih sering ditemukan pada anak usia lebih tua. Nilai PAS yang lebih tinggi berkaitan dengan diagnosis apendisitis dan menunjukkan kemampuan diagnostik tingkat sedang, dengan spesifisitas relatif baik namun sensitivitas yang terbatas. Analisis kurva ROC menunjukkan daya diskriminasi yang sedang (AUC 0,704). Lama rawat pascaoperasi di unit perawatan intensif cenderung lebih singkat pada pasien dengan apendisitis terkonfirmasi, meskipun perbedaannya tidak bermakna secara statistik.

Kesimpulan: Apendisitis pediatrik di pusat rujukan tersier ini lebih sering terjadi pada anak usia lebih besar. PAS menunjukkan akurasi diagnostik sedang dengan spesifisitas baik namun sensitivitas terbatas. Kasus terkonfirmasi cenderung memiliki lama rawat PICU lebih singkat. Diperlukan penelitian selanjutnya dengan jumlah subjek yang lebih besar untuk memvalidasi dan memperkuat temuan ini.

Kata kunci: Akurasi Diagnostik, Anak, Apendisitis, *Pediatric Appendicitis Score*, *Pediatric Intensive Care Unit*

INTRODUCTION

Appendicitis represents a frequently encountered source of abdominal complaints among pediatric patients and often requires prompt surgical intervention.¹ Despite being a well-established condition, challenges remain in early diagnosis, contributing to high rates of perforation and negative appendectomy, even with advancements in imaging and laboratory test.² Appendicitis has shown a rising trend among children worldwide. In 2021, pediatric cases contributed to approximately 12.93% of newly diagnosed appendicitis cases globally, with an estimated incidence of 109 per 100,000 children. Since 1990, the incidence has increased at an average rate of 0.3% per year, with substantial regional variation influenced by sociodemographic characteristics.³ Although rare in infants, the incidence rises after birth and peaks in adolescence, with variation across sex, race, and socioeconomic status. To improve diagnostic accuracy and reduce the incidence of unwarranted surgical exploration in patients with suspected appendicitis, multiple clinical scoring tools have been developed. The Pediatric Appendicitis Score remains one of the most widely adopted instruments, primarily due to its practicality and straightforward clinical implementation. Nevertheless, despite these advantages, PAS has not been universally adopted in routine pediatric care, and its diagnostic reliability continues to be debated.^{2,4,5}

Management of appendicitis has evolved over time. Laparoscopic appendectomy has now become the standard approach, replacing the open technique due to better recovery and fewer complications. In complicated cases, surgery is often combined with postoperative antibiotics, and immediate surgery is no longer always necessary.⁶ Although nonoperative treatment with antibiotics has been considered, especially for uncomplicated cases, it is not routinely used in children due to higher failure rates and longer hospital stays. Thus, surgical removal, remains the preferred treatment in pediatric patients. Postoperative outcomes following uncomplicated appendectomy in children are generally favorable, with a short average hospital stay.⁷ Nonetheless, postoperative complications, although variable in incidence, still pose a significant clinical concern, particularly in complex cases.⁶ In this context, evaluating both the accuracy of diagnostic tools such as PAS and postoperative outcomes is essential to improving care quality and resource efficiency. This investigation was designed to characterize the demographic features of children affected by appendicitis at our institution, to determine the diagnostic performance of PAS, and to analyze postoperative length of stay within the pediatric intensive care unit (PICU).

METHODS

Study Design and Setting

A retrospective observational study with a cross-sectional design was carried out in the pediatric intensive care unit of Murni Teguh Memorial Hospital, a tertiary referral hospital located in Medan, Indonesia. Data collection covered the period from January 2024 through February 2025. Ethical clearance was granted by the institutional ethics review board of the Faculty of Medicine, Universitas Sumatera Utara (Reference No. 1165/KEPK/USU/2024). This study represents a sub-analysis of a larger ethically approved research protocol titled "Studi Epidemiologi dan Hasil Perawatan Intensif Pediatrik," within

which the pediatric appendicitis cases were included. All patient information was anonymized and managed confidentially in compliance with established ethical principles for clinical research.

Study Population

All children who required admission to the pediatric intensive care unit throughout the study timeframe for postoperative monitoring following exploratory laparotomy performed for acute abdominal pathology were included in the analysis. Eligibility criteria comprised patients aged from 1 month to 18 years who had undergone preoperative evaluation using the Pediatric Appendicitis Score and subsequently received exploratory laparotomy based on clinical suspicion of appendicitis. Histopathological examination of the surgical specimen was used to confirm or rule out the diagnosis of appendicitis. Both patients with histopathologically confirmed appendicitis and those with alternative diagnoses were included in the analysis to allow evaluation of PAS diagnostic accuracy. Patients with incomplete clinical data, missing PAS score, or unavailable histopathology results were excluded.

The study sample consisted of the entire cohort of eligible pediatric patients presenting with acute abdominal conditions who underwent exploratory laparotomy and required postoperative admission to the pediatric intensive care unit over the predetermined observation interval. All consecutive patients fulfilling the inclusion criteria were enrolled, yielding a total of 15 cases. No formal sample size estimation was performed, as the study employed a retrospective design and was intended primarily for exploratory analysis.

Data Collection

Demographic profiles and clinical data were retrospectively retrieved retrospectively from institutional electronic health records, comprising patient age, biological sex, nutritional classification, preoperative Pediatric Appendicitis Score, histopathological findings, and duration of postoperative stay in the pediatric intensive care unit. The PAS was recorded prior to surgery as part of the routine diagnostic evaluation. Definitive confirmation or exclusion of appendicitis was established through histopathological evaluation of the resected appendix specimen. All included patients underwent exploratory laparotomy and were admitted to the PICU for postoperative monitoring.

Due to the retrospective study design, PAS components were derived from documented clinical and laboratory findings in the medical records; clinical features that were not explicitly recorded were considered absent. This approach may have introduced information bias related to incomplete documentation or variability in clinical assessment at presentation. To minimize the risk of diagnostic misclassification, the analysis was restricted to cases with clearly recorded clinical signs and objectively measurable laboratory findings, with histopathological examination designated as the diagnostic gold standard. No statistical imputation was performed. There were no missing data for the main study variables, including age, sex, PAS total score, histopathological results, and PICU length of stay.

Outcome Measures

Primary study outcomes encompassed patient demographic characteristics and relevant clinical variables, including age, sex, nutritional status, preoperative Pediatric Appendicitis Score, and length of postoperative admission in the pediatric intensive care unit. The diagnostic performance of PAS was evaluated using histopathological findings as the reference standard.

The Pediatric Appendicitis Score is a composite clinical scoring system consisting of eight components: migration of abdominal pain, anorexia, nausea and/or vomiting, fever exceeding 38 °C, right lower quadrant tenderness, pain provoked by coughing, percussion, or hopping, leukocytosis greater than 10,000 cells/mm³, and neutrophil predominance exceeding 7,500 cells/mm³. Each parameter is weighted with a score of either 1 or 2, producing a cumulative score ranging from 0 to 10.

Statistical Analysis

All statistical procedures were conducted with IBM SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). The distributional characteristics of continuous data were examined using the Shapiro-Wilk test in consideration of the limited sample size. Continuous variables were reported using either mean and standard deviation or median and interquartile range, depending on data distribution, while categorical variables were expressed as frequencies and proportion. Between-group comparisons were carried out using parametric or nonparametric tests for continuous data, as appropriate, and either the chi-square or Fisher's exact test for categorical variables.

The diagnostic capability of the Pediatric Appendicitis Score was evaluated by comparing score results with histopathological findings as the reference standard. Receiver operating characteristic analysis was employed to quantify overall discriminative performance, and diagnostic accuracy indices were calculated using a predefined cutoff value of 6 or higher. No adjustments for sampling design were necessary because all eligible patients within the study period were enrolled using a consecutive sampling approach. No subgroup analyses, interaction testing, or sensitivity assessments were planned or undertaken, as the study was exploratory in nature and involved a limited number of subjects. A threshold for statistical significance was defined using a two-sided p-value of less than 0.05.

RESULTS

Patient Characteristics

A total of 15 pediatric cases were included in the final analysis during the study period. All identified cases fulfilled the eligibility criteria and were therefore included in the final analysis. Histopathological evaluation confirmed appendicitis in 9 patients, whereas 6 patients showed non-appendicitis findings. Histopathological examination confirmed appendicitis in 9 patients, while 6 patients had non-appendicitis findings. Patients with appendicitis were significantly older than those without appendicitis (120 ± 59 vs. 42 ± 52 months, $p = 0.045$). Female patients slightly predominated in the overall cohort (53.3%). No statistically meaningful differences were observed in nutritional status across the

comparison groups. The mean PAS was numerically greater among patients with confirmed appendicitis than among the non-appendicitis group (6.1 ± 1.7 vs. 4.5 ± 1.9), although the observed difference failed to meet criteria for statistical significance ($p = 0.187$). The mean length of stay tended to be longer in the non-appendicitis group (6.8 ± 5.5 vs. 3.7 ± 1.9 days), but this variation did not demonstrate statistical significance ($p = 0.475$). An overview of the baseline demographic profiles and clinical features of the enrolled patients is provided in Table 1.

Table 1. Demographic and Clinical Baseline Characteristics of the Study Cohort.

Demographic Characteristics	All patient (n=15)	Appendicitis (n=9)	Non-Appendicitis (n=6)	P value
Age (Months, Mean $\pm$ SD)	89 $\pm$ 67	120 $\pm$ 59	42 $\pm$ 52	*0,045
0 – 1	2(13,4)	0 (0)	2 (33,3)	0,083
1 – 5	5(33,3)	2 (22,2)	3 (50,0)	
5 – 12	5(33,3)	4 (44,4)	1 (16,7)	
12 – 18	3(20,0)	3 (33,4)	0 (0)	
Sex				0,608
Male	7(46,7)	5(55,6)	2(33,3)	
Female	8(53,3)	4(44,4)	4(66,7)	
Nutritional Status				0,582
Severe Malnutrition	3(20,0)	1 (11,1)	2 (33,3)	
Mild Malnutrition	1(6,7)	1 (11,1)	0 (0)	
Well-nourished	7(46,7)	4 (44,4)	3 (50,0)	
Over-nourished	4(26,7)	3 (33,4)	1 (16,7)	
Pediatric Appendicitis Score (Mean $\pm$ SD)	5,2 $\pm$ 1,8	6,1 $\pm$ 1,7	4,5 $\pm$ 1,9	0,187
PAS $\geq$ 6 (n, %)	5 (33,3)	4 (44,4)	1 (16,7)	0,580

Length of stay (day, Mean $\pm$ SD) $5 \pm 3,9$ $3,7 \pm 1,92$ $6,8 \pm 5,5$ 0,475

Note: *significant at $p < 0.05$ by Mann-whitney U test; SD = standard of deviation; p=probability; PAS = pediatric appendicitis score.

Predictive Performance of the Pediatric Appendicitis Score (PAS)

The association between PAS categories and histopathological findings is shown in Table 2. Using a cutoff value of 6 or higher, the Pediatric Appendicitis Score showed moderate sensitivity (55.6%) and higher specificity (83.3%) for histopathologically confirmed appendicitis. Taken together, the overall accuracy of the score for identifying appendicitis within this study population was calculated at 66.7%.

Table 2. Association Between PAS Categories and Histopathological Results.

	Histopathological (+)	Histopathological (-)	Total
PAS ≥ 6	5	1	6
PAS < 6	4	5	9
Total	9	6	15

Note: PAS = pediatric appendicitis score.

Additional assessment of the diagnostic capability of the Pediatric Appendicitis Score through receiver operating characteristic curve analysis is illustrated in Table 3 and Figure 1. The analysis demonstrated a moderate ability of the score to distinguish cases with versus those without histopathologically confirmed appendicitis; however, the observed discriminatory performance did not reach statistical significance.

Table 3. Diagnostic Performance of PAS Based on ROC Analysis.

AUC	Std. Error	P value	95% CI (Lower – Upper)
0,704	0,152	0,195	0,405 – 1,000

Note: AUC = area under the curve; CI = confidence interval.

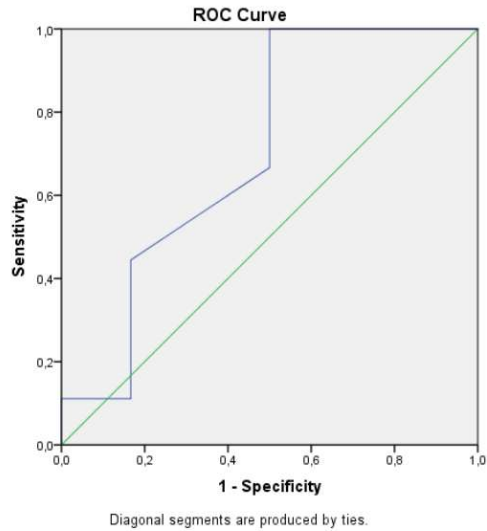


Figure 1. ROC Curve of PAS for Diagnosing Appendicitis.

DISCUSSION

This study offers insight into the demographic characteristics, diagnostic performance of PAS, and postoperative outcomes of pediatric patients with suspected appendicitis treated in a tertiary PICU setting. The main findings indicate that histopathologically confirmed appendicitis predominantly occurred in older children, that PAS demonstrated moderate diagnostic accuracy with high specificity but limited sensitivity, and that confirmed appendicitis cases tended to have shorter postoperative PICU length of stay compared with non-appendicitis cases. Collectively, these results underscore both the potential usefulness and the inherent limitations of PAS when applied to a small and heterogeneous pediatric population requiring intensive postoperative management.

Patients with histopathologically confirmed appendicitis in this cohort were significantly older than those without appendicitis (120 ± 59 vs. 42 ± 52 months, $p = 0.045$). This finding is consistent with established epidemiological patterns demonstrating a progressive increase in appendicitis incidence with advancing pediatric age, while occurrence in infants and very young children remains uncommon. Aneiros et al. reported appendicitis rates of only 2.9% in infants and 13.4% in preschoolers, likely related to underdeveloped lymphoid tissue in early life.⁸ Similar age differences have been consistently reported, including by Dadeh et al., who observed median ages of 10 years in appendicitis cases and 4 years in non-appendicitis cases.⁹ Similar mean age distributions among pediatric patients diagnosed with appendicitis have been documented in prior

studies by Ray et al. and Simkhada et al., as well as in a large multicenter investigation conducted by Trinidad et al. Collectively, these findings reinforce that appendicitis predominantly affects older children and adolescents.^{10–12}

Within this cohort, no meaningful statistical difference in sex distribution was identified between children who were diagnosed with appendicitis and those in whom the diagnosis was excluded ($p = 0.608$). Although the overall cohort showed a relatively balanced sex distribution, previous studies have consistently reported a male predominance in pediatric appendicitis. Ray et al. and Simkhada et al. documented male proportions of 66% and 92%, respectively,^{10,11} while Aneiros et al. and Salö et al. similarly reported male predominance in large pediatric surgical cohorts.^{8,13} Aydoğdu et al. found a predominance of male patients, with a male-to-female ratio approximating 2.2:1 and noted higher negative appendectomy rates among females, potentially reflecting diagnostic challenges related to gynecological conditions in adolescent girls.¹⁴ Trinidad et al. also reported male predominance in 60.3% of cases.¹² The absence of a sex-related difference in the present analysis is likely influenced by the limited number of participants included in the study.

Nutritional status was not statistically associated with the occurrence of appendicitis in the analyzed population ($p = 0.582$). Children in both groups exhibited a wide range of nutritional statuses, with most confirmed appendicitis cases being well-nourished or over-nourished, while severe malnutrition was relatively more frequent in non-appendicitis cases. Although the role of nutritional status in pediatric appendicitis remains poorly defined, malnutrition may obscure inflammatory responses or delay presentation, whereas overnutrition could contribute to diagnostic challenges. To date, no published studies have specifically evaluated the impact of nutritional status on pediatric appendicitis risk or outcomes. Consequently, these findings provide preliminary observations and highlight the need for further research in this area.

The Pediatric Appendicitis Score demonstrated moderate diagnostic performance in this study, with relatively high specificity but limited sensitivity. When a Pediatric Appendicitis Score threshold of 6 or greater was applied, the tool yielded a sensitivity of 55.6% and a corresponding specificity of 83.3%, with an area under the receiver operating characteristic curve measuring 0.704, suggesting moderate discriminatory capacity. These results indicate that although PAS may assist in supporting the diagnosis of appendicitis, its ability to reliably exclude the disease is limited, especially in small and heterogeneous pediatric populations. Similar limitations have been reported previously. Salö et al. and Salö et al. described low sensitivity of PAS ≥ 6 , especially in younger children.^{13,15} Raeisi et al. reported variable diagnostic performance depending on patient characteristics and cutoff values.⁴ In contrast, larger validation studies have demonstrated higher sensitivity at the expense of lower specificity, highlighting an inherent trade-off between case detection and false-positive rates.^{2,16} Salahuddin et al. further showed that despite high PPV at higher PAS cutoffs, NPV remained low, limiting its utility for ruling out appendicitis.¹ Fujii et al. suggested that higher PAS values may be more useful for identifying disease severity rather than serving as a standalone diagnostic tool.¹⁷ Collectively, these results suggest that the Pediatric Appendicitis Score is more appropriately utilized as an adjunct to clinical judgment rather than as an independent determinant for establishing a definitive diagnosis.

Patients with histopathologically confirmed appendicitis exhibited a trend toward shorter postoperative stays in the pediatric intensive care unit compared with those

without confirmed appendicitis; however, this difference did not attain statistical significance. This trend may reflect more straightforward postoperative recovery in confirmed appendicitis cases, whereas patients without appendicitis may require prolonged observation due to diagnostic uncertainty or alternative intra-abdominal pathology. Previous studies have demonstrated that LOS is influenced by disease severity and surgical approach.^{6,7,18} Existing literature has demonstrated that laparoscopic appendectomy is associated with shorter hospitalization durations and lower postoperative complication rates when compared with conventional open surgical techniques.¹⁹ Patient-related factors such as obesity appear to have less impact on LOS than clinical and surgical variables.²⁰ These findings suggest that LOS reflects a combination of disease complexity, management strategy, and institutional practices.

Several methodological constraints should be acknowledged. Most notably, the limited sample size substantially restricts statistical power and reduces the extent to which the findings can be generalized. Furthermore, the retrospective design, single-center setting, and exclusive inclusion of postoperative pediatric intensive care unit admissions may not fully capture the broader clinical spectrum of pediatric appendicitis, thereby limiting external validity. Reliance on medical records introduces potential information bias, and surgical approach and postoperative complications were not analyzed. Future investigations employing larger-scale, multicenter prospective studies are necessary to corroborate the present findings and to better define the diagnostic and prognostic relevance of the Pediatric Appendicitis Score, including the potential influence of nutritional status and surgical mortality.

Accordingly, the results of this study should be interpreted with an appropriate degree of caution. While the Pediatric Appendicitis Score demonstrated moderate diagnostic accuracy with relatively high specificity, its limited sensitivity indicates that PAS alone is inadequate for excluding appendicitis, particularly in small and heterogeneous pediatric cohorts. The observed outcomes are consistent with previous reports indicating that the diagnostic accuracy of the Pediatric Appendicitis Score may vary across different pediatric age groups and clinical settings. Considering the retrospective nature of the study, the limited sample size, and the exploratory analyses undertaken, the conclusions should be regarded as hypothesis-generating rather than conclusive.

CONCLUSIONS

Results of this study highlight that pediatric appendicitis in a tertiary PICU setting predominantly affects older children and remains a diagnostic challenge in younger age groups. While PAS showed good specificity, its limited sensitivity underscores the need for complementary diagnostic tools. Furthermore, shorter postoperative stays among children with confirmed appendicitis suggest the benefit of early and accurate diagnosis. These findings support the continued refinement of clinical scoring systems like PAS and emphasize the importance of integrating demographic and perioperative data to improve diagnostic accuracy and postoperative outcomes in pediatric appendicitis.

CONFLICT OF INTEREST

The authors state that no competing interests associated with this work are present.

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AUTHOR CONTRIBUTION

A and RFM were responsible for conceptualization and methodology, while A and DM handled data curation and investigation. A performed the formal analysis with input and validation from RFM and DM. RFM oversaw project administration, supervision, and funding acquisition, while DM and RFM provided necessary resources. Visualization was carried out by A and RFM. A drafted the original manuscript, and all authors (RFM, DM, and A) contributed to reviewing and editing the final version. A was responsible for drafting the initial version of the manuscript. All authors (RFM, DM, and A) contributed to critical revision of the content and approved the final manuscript prior to submission.

DATA AVAILABILITY

The datasets underpinning the results derived from this investigation were restricted from open access in accordance with institutional policies and ethical obligations related to patient privacy. Access to the underlying dataset can be granted by the corresponding author upon submission of a justified request.

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FIGURE LEGENDS

Figure 1. Receiver operating characteristic curve of the Pediatric Appendicitis Score.

The curve illustrates the diagnostic performance of the Pediatric Appendicitis Score for histopathologically confirmed appendicitis.

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