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TITLE PAGE

Title: Demographic Profile and Diagnostic Accuracy of the Pediatric Appendicitis Score in Children: A Retrospective Observational Study in a Tertiary Pediatric Intensive Care Unit

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Demographic Profile and Diagnostic Accuracy of the Pediatric Appendicitis Score in

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

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Abstract

Background/Objective: Pediatric appendicitis is a common surgical emergency in children, but diagnosis remains challenging, particularly in younger patients due to atypical presentations. This study aimed to describe the demographic characteristics of pediatric appendicitis, evaluate the diagnostic performance of the Pediatric Appendicitis Score (PAS), and assess postoperative length of stay in the pediatric intensive care unit (PICU)..

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: Nine patients (60%) were histopathologically confirmed to have appendicitis. These patients were significantly older than those without appendicitis (120 ± 59 vs. 42 ± 52 months). A PAS cutoff ≥ 6 showed a sensitivity of 55.6%, specificity of 83.3%, positive predictive value of 83.3%, negative predictive value of 55.6%, and diagnostic accuracy of 66.7%. ROC analysis yielded an AUC of 0.704 ($p = 0.195$), indicating moderate discriminative ability. PICU LOS was shorter in confirmed appendicitis cases (3.7 vs. 6.8 days), although not statistically significant.

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. Further studies with larger samples are needed to validate these findings.

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

Abstrak

Latar Belakang: Apendisitis pada anak merupakan kegawatdaruratan bedah yang sering dijumpai, namun diagnosis nya masih menantang, terutama pada usia lebih muda akibat manifestasi klinis yang tidak khas. Penelitian ini bertujuan menggambarkan karakteristik demografis apendisitis pediatrik, mengevaluasi nilai diagnostik *Pediatric Appendicitis Score* (PAS), serta menilai lama rawat pascaoperasi di *Pediatric Intensive Care Unit* (PICU)..

Metode: Penelitian observasional retrospektif potong lintang ini melibatkan 15 pasien anak dengan abdomen akut yang menjalani laparotomi eksploratif. PAS digunakan sebagai alat diagnostik dengan histopatologi sebagai standar baku. Seluruh pasien dirawat di PICU pascaoperasi. Data yang dikumpulkan meliputi karakteristik demografis, skor PAS, hasil histopatologi, dan lama rawat PICU. Nilai diagnostik PAS dianalisis menggunakan sensitivitas, spesifisitas, nilai prediktif, akurasi diagnostik, dan *area under the receiver operating characteristic curve* (AUC).

Hasil: Sebanyak 9 pasien (60%) terkonfirmasi apendisitis secara histopatologis. Pasien dengan apendisitis berusia lebih tua dibandingkan kelompok tanpa apendisitis (120 ± 59 vs. 42 ± 52 bulan). Nilai ambang PAS ≥ 6 menunjukkan sensitivitas 55,6%, spesifisitas 83,3%, nilai prediktif positif 83,3%, nilai prediktif negatif 55,6%, dan akurasi diagnostik 66,7%. Analisis ROC menunjukkan AUC 0,704 ($p = 0,195$), menandakan kemampuan diskriminatif sedang. Lama rawat PICU lebih singkat pada kasus apendisitis terkonfirmasi (3,7 vs. 6,8 hari), meskipun 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. Penelitian dengan sampel lebih besar diperlukan untuk validasi lebih lanjut.

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

INTRODUCTION

Appendicitis is a common cause of abdominal pain in children 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 The incidence of appendicitis is increasing in the pediatric population. In 2021, children accounted for 12.93% of all new appendicitis cases globally, with an estimated incidence rate of 109 per 100,000. The rate has increased by 0.3% annually since 1990, and incidence varies widely by region, correlating with sociodemographic factors.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 unnecessary surgeries, several appendicitis scoring systems have been developed. One of the commonly used tools is the Pediatric Appendicitis Score (PAS), which is simple and easy to apply. However, despite its practicality, PAS is not yet widely used in routine pediatric practice, and its diagnostic accuracy remains a subject of debate.^{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 study aimed to describe the demographic characteristics of pediatric appendicitis cases in our center, evaluate the diagnostic performance of PAS, and assess postoperative length of stay (LOS) in the pediatric intensive care unit (PICU).

METHODS

Study Design and Setting

This was a retrospective cross-sectional observational study conducted in PICU of Murni Teguh Memorial Hospital, a tertiary care center in Medan, Indonesia. The study period was from January 2024 to February 2025. Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara (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 data were anonymized and handled confidentially in accordance with ethical research standards.

Study Population

All pediatric patients admitted to the PICU during the study period for postoperative care following exploratory laparotomy due to acute abdomen were included in this study. Patients were eligible if they were aged between 1 month and 18 years, had undergone preoperative assessment using PAS, and 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 size was determined by the total number of eligible pediatric patients with acute abdomen who underwent exploratory laparotomy and postoperative PICU admission during the study period. All consecutive cases meeting the inclusion criteria were included, resulting in a sample of 15 patients. No formal sample size calculation was performed due to the retrospective and exploratory nature of the study.

Data Collection

Demographic and clinical data were retrospectively extracted from electronic medical records, including age, sex, nutritional status, preoperative Pediatric Appendicitis Score (PAS), histopathological findings, and postoperative length of stay (LOS) in the pediatric intensive care unit (PICU). The PAS was recorded prior to surgery as part of the routine diagnostic evaluation. Histopathological examination of the appendix was used to confirm or exclude the diagnosis of appendicitis. All included patients underwent exploratory laparotomy and were admitted to the PICU for postoperative monitoring.

Because of the retrospective nature of the study, 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 reduce diagnostic misclassification, only clearly documented clinical findings and objective laboratory parameters were included in the analysis, and histopathological examination served as the reference 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

The primary outcome measures included patient demographic and clinical characteristics, such as age, sex, nutritional status, preoperative Pediatric Appendicitis Score (PAS), and postoperative length of stay (LOS) in the pediatric intensive care unit (PICU). The diagnostic performance of PAS was evaluated using histopathological findings as the reference standard.

The Pediatric Appendicitis Score is a clinical scoring system based on eight variables: migration of pain, anorexia, nausea or vomiting, fever $>38^{\circ}\text{C}$, right lower quadrant tenderness, cough/percussion/hopping tenderness, leukocytosis ($>10,000$ cells/ mm^3), and polymorphonuclear neutrophilia ($>7,500$ cells/ mm^3). Each variable is assigned a score of 1 or 2, resulting in a total score ranging from 0 to 10.

Diagnostic accuracy metrics included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and the area under the receiver operating characteristic (ROC) curve (AUC).

Statistical Analysis

All statistical analyses were performed using IBM SPSS version 24 (IBM Corp., Armonk, NY, USA). Data normality was assessed using the Shapiro–Wilk test due to the small sample size. Continuous variables were summarized as mean $\pm$ standard deviation or median with interquartile range, as appropriate, and categorical variables were presented as frequencies and percentages. Between-group comparisons were conducted using the independent t-test or Mann–Whitney U test for continuous variables and the chi-square or Fisher’s exact test for categorical variables.

The diagnostic performance of the Pediatric Appendicitis Score (PAS) was evaluated using histopathological findings as the reference standard. Receiver operating characteristic (ROC) curve analysis was performed to determine the area under the curve (AUC), and sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using a PAS cutoff value of ≥ 6 .

No analytical adjustments for sampling strategy were required, as all eligible patients during the study period were included using consecutive sampling. Predefined subgroup, interaction, or sensitivity analyses were not performed due to the exploratory nature of the study and the limited sample size. A p-value < 0.05 was considered statistically significant.

RESULTS

Patient Characteristics

During the study period, 15 pediatric patients who underwent exploratory laparotomy for suspected appendicitis and were admitted to the PICU were identified and all met the eligibility criteria; therefore, all were included in the analysis. 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%). Nutritional status did not differ significantly between groups. The mean PAS was higher in the appendicitis group compared with the non-appendicitis group (6.1 ± 1.7 vs. 4.5 ± 1.9), although this difference did not reach 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 the difference was not statistically significant ($p = 0.475$). Baseline demographic and clinical characteristics of the study population are summarized in Table 1.

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

Demographic Characteristics	All patient (n=15)	Appendicitis (n=9)	Non-Appendicitis (n=6)	P value
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Age (Months, Mean ± SD)	89 ± 67	120 ± 59	42 ± 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 ± SD)	5,2 ± 1,8	6,1 ± 1,7	4,5 ± 1,9	0,187
PAS ≥ 6 (n, %)	5 (33,3)	4 (44,4)	1 (16,7)	0,580
Length of stay (day, Mean ± SD)	5 ± 3,9	3,7 ± 1,92	6,8 ± 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.

Diagnostic Performance of the Pediatric Appendicitis Score (PAS)

The association between PAS categories and histopathological findings is shown in Table 2. Out of a total of 15 patients, 9 had positive histopathological findings and 6 had negative results. A PAS score ≥ 6 yielded a sensitivity of 55.6% and a specificity of 83.3%. The PPV was 83.3%, while NPV was 55.6%. Overall, the accuracy of the PAS score in predicting appendicitis in this population was 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.

The diagnostic performance of the Pediatric Appendicitis Score was further evaluated using ROC analysis, as presented in Table 3 and Figure 1. AUC was 0.704 (standard error 0.152), with a 95% confidence interval of 0.405–1.000 and a p-value of 0.195. This indicates that the discriminatory ability of the PAS score for predicting histopathological appendicitis is in the moderate category, although it is not statistically significant.

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.

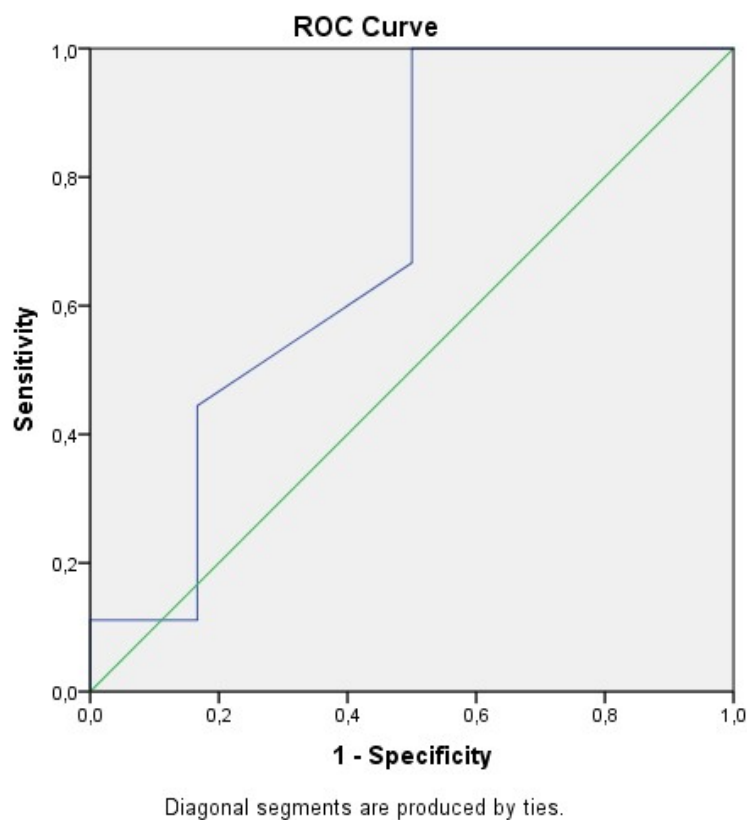


Figure 1. ROC Curve of PAS for Diagnosing Appendicitis.

DISCUSSION

This study provides insight into the demographic profile, diagnostic performance of the Pediatric Appendicitis Score (PAS), and postoperative outcomes among pediatric patients with suspected appendicitis managed 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. Together, these findings highlight both the potential utility and the limitations of PAS when applied in a small, heterogeneous pediatric population requiring intensive postoperative care.

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 showing that the incidence of pediatric appendicitis increases with age and remains uncommon in infants and toddlers. Aneiros et al. (2019) 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. (2021), who observed median ages of 10 years in appendicitis cases and 4 years in non-appendicitis cases.⁹ Comparable mean ages among children with appendicitis were reported by Ray et al. (2023) and Simkhada et al. (2025), as well as by Trinidad et al. (2024) in a large multicenter cohort. Collectively, these findings reinforce that appendicitis predominantly affects older children and adolescents.^{10–12}

No statistically significant difference in sex distribution was observed between children with and without appendicitis in this study ($p = 0.608$). Although the overall cohort showed a relatively balanced sex distribution, previous studies have consistently reported a male predominance in pediatric appendicitis. Ray et al. (2023) and Simkhada et al. (2025) documented male proportions of 66% and 92%, respectively,^{10,11} while Aneiros et al. (2019) and Salö et al. (2015) similarly reported male predominance in large pediatric surgical cohorts.^{8,13} Aydoğdu et al. (2022) found a male-to-female ratio of 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. (2024) also reported male predominance in 60.3% of cases.¹² The absence of a significant sex difference in this study may be related to the limited sample size.

No significant association was identified between nutritional status and the presence of appendicitis ($p = 0.582$). 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. A PAS cutoff ≥ 6 yielded a sensitivity of 55.6%, specificity of 83.3%, and an AUC of 0.704, indicating modest

discriminative ability. These findings suggest that while PAS may be useful in supporting the diagnosis of appendicitis, it has limited reliability for excluding the disease, particularly in small or heterogeneous pediatric populations. Similar limitations have been reported previously. Salö et al. (2015) and Salö et al. (2014) described low sensitivity of PAS ≥ 6 , especially in younger children.^{13,15} Raeisi et al. (2023) 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. (2022) further showed that despite high PPV at higher PAS cutoffs, NPV remained low, limiting its utility for ruling out appendicitis.¹ Fujii et al. (2020) suggested that higher PAS values may be more useful for identifying disease severity rather than serving as a standalone diagnostic tool.¹⁷ Overall, these findings support the use of PAS as an adjunct rather than a definitive diagnostic instrument.

Children with histopathologically confirmed appendicitis had a shorter mean postoperative PICU length of stay compared with those without appendicitis, although this difference was not statistically significant. 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} Laparoscopic appendectomy has been associated with shorter hospital stays and fewer complications compared with open surgery.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 limitations should be acknowledged. The small sample size limits statistical power and generalisability. The single-center, retrospective design and inclusion of only postoperative PICU patients may not reflect the broader pediatric appendicitis population. Reliance on medical records introduces potential information bias, and surgical approach and postoperative complications were not analyzed. Future multicenter prospective studies with larger cohorts are needed to validate these findings and further clarify the diagnostic and prognostic role of PAS, as well as the potential influence of nutritional status and surgical technique.

Overall, the findings of this study should be interpreted with caution. Although the Pediatric Appendicitis Score demonstrated moderate diagnostic accuracy with relatively high specificity, its limited sensitivity suggests that PAS alone is insufficient to exclude appendicitis, particularly in a small and heterogeneous pediatric population. These results are consistent with previous studies reporting variable diagnostic performance of PAS across different age groups and clinical settings. Given the retrospective design, small sample size, and exploratory analyses performed, the conclusions should be viewed as hypothesis-generating rather than definitive.

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

No potential conflict of interest relevant to this article was reported.

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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. All authors approved the manuscript for submission.

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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.