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Risk Prediction of Appendicitis Perforation in Children Based on Leukocyte ond Neutrophil Count: A Logistic Regression Analysis

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ABSTRACT

Appendicitis in children is an emergency condition with a high risk of perforation, so it requires correct diagnosis and immediate treatment to prevent complications. Although leukocyte and neutrophil values are often used as initial indicators in diagnosing appendicitis, there is no clear consensus regarding the correct prediction of the risk of perforation in appendicitis. This study aims to predict the risk of perforation based on leukocyte and neutrophil values through logistic regression analysis. This retrospective study used secondary data from 195 pediatric patients diagnosed with appendicitis who were treated at the PKU Muhammadiyah Gamping Hospital. The results of logistic regression analysis showed that neutrophils significantly increased the risk of perforated appendicitis (OR = 1.040; 95% CI: 1.011-1.070; p = 0.006), while leukocyte values did not show a significant effect (OR = 1.031; 95% CI: 0.987 – 1.078; p = 0.172) with moderate model predictive ability (Nagelkerke R2 = 0.108). This study concluded that neutrophils are a more sensitive laboratory indicator than leukocyte values for predicting the risk of perforated appendicitis in children.

INTRODUCTION

Acute appendicitis in children is one of the most common emergency cases (Huerta, 2022). Based on previous research, the prevalence of pediatric appendicitis between the ages of 5 and 11 years was recorded at 66.7% (Anharuddin et al., 2024) Although many studies have discussed appendicitis, accurate diagnosis in children is still often difficult to make. The clinical diagnosis of appendicitis is established from anamnesis, physical examination, and supporting examinations such as laboratory and radiology. However, difficulties persist because the symptoms of appendicitis in children can vary.

The most common symptom is periumbilical pain that then moves to the lower right region of the abdomen, followed by anorexia, nausea, and vomiting (Jumah & Wester, 2022). To strengthen the diagnosis, laboratory tests such as counting the number of leukocytes and neutrophils are very important. This examination is very helpful in supporting the diagnosis of acute appendicitis because it can be done at the health center at an affordable price and easy to do.

However, in addition to the diagnosis of acute appendicitis, the doctor must be able to distinguish between acute appendicitis and perforation, as these two conditions require different treatment and have different prognosis. An incorrect diagnosis can be a high risk. Therefore, a prompt and precise diagnosis is essential in dealing with these cases. A study in Indonesia found an increase in leukocytes of around 79.6% in pediatric appendicitis cases,

with the majority of patients showing significantly new symptoms within the first 24 hours (Kheru et al., 2022; Rusfandi et al., 2024).

Recent research suggests that examination of leukocyte and neutrophil counts plays an important role in predicting perforation in acute appendicitis. Kaya, et al (2024) found that in children with perforated appendicitis, the values of leukocytes and neutrophils were significantly higher compared to non-perforated cases of appendicitis. The average number of leukocytes in the perforated group reached 17.123 ± 4.491 cells/μL, suggesting that an increase in leukocytes and neutrophils may be an early warning for perforation.6 In addition, Chen J et al (2024) also argued that neutrophil percentages provide better predictive value in distinguishing between acute appendicitis and perforation, which makes neutrophils a useful diagnostic tool in determining appropriate treatment.

Festy and Nur (2019) found that high leukocyte values were found in perforated appendicitis in both groups (p value <0.05). Research by Givari (2022) reported that the value of leukocytes for perforation prediction was ≥14,025 cells/mm³ with a sensitivity of 33% and a specificity of 31%. Amalia (2023) in her study found that neutrophil values (AUC 0.937 or 93.7%) can be used to predict acute appendicitis or perforation with an accuracy of 93.7% in 100 patients [20]. Shalaby (2025) proved that an increase in the number of neutrophils above 7,800 cells/μL ($p < 0.001$) is a strong indicator for detecting the incidence of perforation in pediatric appendicitis. Marjanović et al. (2024) also showed that the percentage of neutrophils is able to be a predictive indicator for detecting symptoms that have lasted >48 hours with a sensitivity of 75.0% and a specificity of 62.8%.

Although the diagnosis of acute appendicitis in children can be established through clinical and supportive examinations, distinguishing between acute appendicitis and perforation remains a challenge. An increase in the number of leukocytes and neutrophils can help differentiate between the two conditions, so that basic hematology examinations can be optimized to determine the appropriate treatment. The interest in predicting perforations in acute appendicitis prompted researchers to improve diagnostic accuracy in patient care.

The novelty of this research lies in several aspects. First, this study specifically used binary logistic regression analysis to quantify the magnitude of the influence of each parameter (leukocytes and neutrophils) on the risk of appendicitis perforation in children, which is expressed in the form of odds ratio (OR) along with its 95% confidence interval. This is different from previous studies that used more differential tests or correlation analysis. Second, this study directly compares the predictive values of leukocytes and neutrophils in the same analysis model in the child population in Indonesia, so as to determine which parameters are more sensitive and statistically significant. Third, this study presents clinical findings that every 1% increase in neutrophil values increases the risk of perforation by 1.04 times or 4% (95% CI: 1.011–1.070), which is a new contribution to the medical literature in Indonesia in the context of predicting the risk of appendicitis perforation in children.

Based on the background description, the purpose of this study is to analyze the effect of leukocyte and neutrophil values on the risk of appendicitis perforation in children using logistic regression analysis, compare the predictive values between leukocytes and neutrophils in predicting the incidence of appendicitis perforation, and quantify the risk of perforation in the form of odds ratio based on the increase in the value of leukocytes and neutrophils in the pediatric population in Indonesia. The benefits of this research include three aspects.

Theoretically, this study enriches the scientific literature in the field of pediatric surgery and clinical laboratories regarding the role of basic hematological parameters in predicting appendicitis complications, as well as providing empirical evidence on the superiority of neutrophils over leukocytes in the context of predicting perforation risk. Clinically and practically, the results of this study can be used by doctors in primary health facilities (puskesmas) and secondary (hospitals) as a guide in interpreting the results of leukocyte and neutrophil examinations in pediatric patients with suspected appendicitis, so as to determine more appropriate and faster referrals and treatments, as well as reduce the morbidity rate due to perforation. Methodologically, this study demonstrates the application of binary logistic regression analysis for the prediction of appendicitis perforation risk, which can be replicated in subsequent studies with different populations or laboratory parameters.

METHOD

This research was a retrospective study that uses secondary data from medical records of pediatric patients treated at the PKU Muhammadiyah Gamping Hospital, Yogyakarta. The data used includes information on the number of leukocytes, neutrophils, as well as the diagnosis of acute appendicitis or perforated appendicitis in pediatric patients during the period 2020 to 2023. All of this data has received ethical approval with ethical approval number 0914/PI.24.2/V/2023.

The data used in this study were selected based on the following criteria: (1) Pediatric patients diagnosed with acute appendicitis or perforation, based on complete medical records (Anharuddin et al., 2024). Data that includes information regarding the number of leukocytes and neutrophils during the 2020-2023 period.

The research analysis method uses SPSS with the Kolmogorov-Smirnov normality test, this test is to fulfill normality assumptions before further analysis is carried out. The test compares the differences between acute and perforated appendicitis patients using the nonparametric Mann-Whitney U test which is suitable for data that is not normally distributed, analysis of the relationship between variables using Spearman correlation, then to assess the prediction of peritonitis using logistic regression analysis, this test makes it possible to identify variables that are significantly associated with the possibility of peritonitis.

RESULTS AND DISCUSSION

The gender distribution of respondents in this study showed that 46.2% (91 people) were men, while 52.8% (104 people) were women. Descriptive analysis showed that the ages of respondents ranged from 2 to 17 years, with a mean of 12.07 years (SD = 3.63). A fairly large standard deviation indicates significant age variation among respondents. Based on the results of the normality test using Kolmogorov-Smirnov, it was discovered that most of the data distribution was not normal, so the test for differences in leukocyte and neutrophil values between the acute appendicitis and perforation groups was carried out using the Mann-Whitney test.

Table 1. Kolmogorv-Smirnov normality test and Mann-Whitney test

Final Diagnosis	n	Median Leukocytes (IQR)	Median Neutrophils (IQR)	Mann–Whitney p-value
Simple Appendicitis	149	12.3 (10.5–14.8)	74 (68–80)	
Perforated Appendicitis	46	16.8 (14.2–18.9)	86 (80–90)	<0.001

Source: Secondary data from the medical records of pediatric patients at PKU Muhammadiyah Gamping Hospital, Yogyakarta (period 2020-2023), processed using SPSS

Median leukocytes and neutrophils in the perforated appendicitis group were higher than in simple appendicitis (p<0.001), indicating that an increase in these two parameters correlated with the severity of appendicitis in children.

Table 2. Correlation of Leukocyte and Neutrophil Values with Simple and Perforated Appendicitis

Correlations				
			Hasil_AL	Neutrofil
Spearman's rho	Hasil_AL	Correlation Coefficient	1.000	.693**
		Sig. (2-tailed)	.	.000
		N	195	195
	Neutrofil	Correlation Coefficient	.693**	1.000
		Sig. (2-tailed)	.000	.
		N	195	195

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Secondary data from the medical records of pediatric patients at PKU Muhammadiyah Gamping Hospital, Yogyakarta (period 2020-2023), processed using SPSS

Spearman correlation analysis between leukocytes and neutrophils was strong and significant positive, meaning that the increase in leukocytes tended to be followed by an increase in neutrophils, in accordance with the pathophysiology of acute inflammation.

Binary logistic regression analysis was statistically significant for neutrophils (OR = 1.040; 95% CI: 1.011-1.070; p = 0.006), while leukocyte values did not show a significant effect (OR = 1.031; 95% CI: 0.987 – 1.078; p = 0.172) with moderate model predictive ability (Nagelkerke R2 = 0.108). Clinically, every 1% increase in neutrophil levels increases the chance of perforated appendicitis by 1.04 times or 4% (CI 95%; 1.011 – 1.070), so neutrophils can be used as an additional indicator to assess the risk of severity of appendicitis.

Binary logistic regression analysis table

Table 3. Binary Logistic Regression Analysis

Variable	B	S.E.	Wald	df	Sig.	Exp(B) / OR	95% CI for Exp(B)
Leukocytes (AL_Result)	0.031	0.022	1.865	1	0.172	1.031	0.987–1.078
Neutrophils	0.039	0.014	7.457	1	0.006	1.040	1.011–1.070
Constant	-4.556	1.090	17.486	1	<0.001	0.011	—

Source: Secondary data from the medical records of pediatric patients at PKU Muhammadiyah Gamping Hospital, Yogyakarta (period 2020-2023), processed using SPSS

Acute appendicitis is a surgical emergency in children that requires immediate treatment.8 Data in the United States (2001-2015) found an increase in the perforation rate from 317.5 to 457.7 per 1000 cases of pediatric appendicitis, which means around 25,000 cases of perforation in children each year, this reinforces the importance of timely diagnosis and treatment. In this study, the distribution of pediatric appendicitis patients is greater, namely 52.8% (104 people), while men were 46.2% (91 people). These results are different from epidemiological studies, which usually show a slightly higher incidence of acute appendicitis in men. 10 However, the results of this study are in line with several previous studies, Wibawa et al (2024) stated that the most cases of acute appendicitis were in women with the number of cases being 73.3%, Irawan (2019) obtained similar data, namely 57.6% in women and 42.4% in men. Research by Hori T, et al (2021) stated that the incidence of acute appendicitis in women may increase due to the influence of an imbalance in the hormone's oestrogen and progesterone.

The perception of most doctors in primary care is that a high leukocyte count parameter in appendicitis patients will support the diagnosis, but this value can be increased in other inflammatory processes that resemble acute appendicitis (Demir et al., 2023; Nandan et al., 2023). Therefore, the diagnostic value of leukocyte count values in cases of acute appendicitis is still uncertain. But an increase in these two parameters correlated with the severity of childhood appendicitis ($p<0.001$). Based on binary logistic regression analysis, it is statistically significant for neutrophils (OR = 1.040; 95% CI: 1.011-1.070; p = 0.006, clinically, every 1% increase in neutrophil levels increases the chance of perforated appendicitis by 1.04 times or 4% (95% CI; 1.011 - 1.070), so neutrophils can be used as an indicator additionally to assess the risk of severity of appendicitis.

Research by Festy and Nur (2019) found that high leukocyte values were found in perforated appendicitis in both groups (p value <0.05) (Lee et al., 2025). Leukocytosis with a shift to the left can indicate early inflammation, but is less specific. perforation is ≥14,025 cells/mm3 with a sensitivity of 33% and a specificity of 31% (Zeppieri, 2025). An increased leukocyte count can also be found in other diseases such as gastroenteritis, mesenteric adenitis, and pelvic inflammatory disease, while a normal leukocyte count does not rule out appendicitis (Ainippully et al., 2018). Another opinion states that leukocytes can be used as an early indicator of the risk of complications, especially when combined with clinical signs and other laboratory parameters (Mathews et al., 2014).

Amalia, A (2023) in her research found that the neutrophil value (AUC 0.937 or 93.7%) could be used to predict acute appendicitis or perforation with an accuracy of 93.7% in 100 patients. In establishing a diagnosis, a study by Shalaby (2025) proved that an increase in the number of neutrophils above 7,800 cells/μ (P, 0.001) is a strong indicator for detecting an event. perforation in children's appendicitis. Supporting journals show that the percentage of neutrophils is capable of being a predictive indicator for detecting symptoms that have lasted >48 hours with a sensitivity of 75.0% and a specificity of 62.8% (Eun et al., 2021). The laboratory parameter value of neutrophils is more sensitive than leukocytes in predicting the risk of perforated appendicitis in children.

CONCLUSION

This study concludes that neutrophil count is a more sensitive and statistically significant laboratory indicator than leukocyte count for predicting the risk of perforated appendicitis in children. Based on binary logistic regression analysis of 195 pediatric patients, neutrophils significantly increased the risk of perforation (OR = 1.040; 95% CI: 1.011-1.070; p = 0.006), meaning that every 1% increase in neutrophil levels raises the chance of perforation by 4%. In contrast, leukocyte values did not show a significant effect (OR = 1.031; p = 0.172), although both parameters were significantly higher in the perforated appendicitis group ($p < 0.001$). The moderate predictive ability of the model (Nagelkerke $R^2 = 0.108$) suggests that neutrophils should be used as an adjunctive tool combined with clinical signs, not in isolation. Clinically, these findings enable doctors in primary and secondary healthcare facilities to use routine neutrophil counts as an early warning indicator for perforation risk, facilitating faster referral and appropriate surgical management. However, this study has limitations including its retrospective design, single-center setting, and the fact that leukocyte and neutrophil counts explain only 10.8% of perforation risk variance. Future prospective multicenter studies should develop composite prediction models incorporating additional parameters such as CRP, symptom duration, and clinical scoring systems to improve predictive accuracy for pediatric appendicitis perforation.

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