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The Association Between the Neutrophil-to-Lymphocyte Ratio (NLR) and Alvarado Score with Intraoperative Macroscopic Appendiceal Findings at Payangan General Hospital

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ABSTRACT

Acute appendicitis remains one of the most common surgical emergencies worldwide and represents a substantial healthcare burden in Indonesia. The Alvarado score and neutrophil-to-lymphocyte ratio (NLR) are readily accessible tools for preoperative assessment; however, their associations with intraoperative macroscopic appendiceal findings remain insufficiently investigated, particularly in regional Indonesian hospitals. This study aimed to examine the associations of the NLR and Alvarado score with intraoperative macroscopic appendiceal findings at Payangan General Hospital. An analytical observational study with a cross-sectional design was conducted from February to June 2026. A total of 40 patients diagnosed with acute appendicitis who underwent appendectomy were enrolled using consecutive sampling. Preoperative NLR values and Alvarado scores were recorded, and intraoperative macroscopic findings were classified as catarrhal, suppurative, or perforated appendicitis. Associations were analyzed using the chi-square test. Most patients were male (67.5%). Intraoperative findings revealed catarrhal appendicitis in 27 patients (67.5%), suppurative appendicitis in 10 (25.0%), and perforated appendicitis in 3 (7.5%). Among patients with an NLR greater than 3, 25 had catarrhal appendicitis, 10 had suppurative appendicitis, and 3 had perforated appendicitis. Higher Alvarado scores (≥7) were observed among patients with suppurative (20.0% of the total sample) and perforated appendicitis (7.5% of the total sample). Chi-square analysis indicated statistically significant associations between NLR and intraoperative macroscopic findings ($p < 0.05$) and between the Alvarado score and intraoperative macroscopic findings ($p < 0.05$). These findings suggested that both the NLR and Alvarado score were associated with the macroscopic severity of appendiceal inflammation and could potentially support preoperative risk stratification in resource-limited healthcare settings. However, further studies with larger samples and appropriate validation are needed to establish their predictive performance.

INTRODUCTION

Acute appendicitis remains one of the most common surgical emergencies worldwide and represents a substantial healthcare burden. The Global Burden of Disease Study 2021 estimated approximately 17 million new cases of appendicitis worldwide in 2021, corresponding to an age-standardized incidence rate of 214 per 100,000 population (GBD 2021 Appendicitis Collaborator Group, 2024; Yang et al., 2023). In Southeast Asia, Indonesia has been reported to experience a considerable burden of acute appendicitis, with estimates of approximately 10 million cases annually and a morbidity rate of 95 cases per 1,000 population per year. Appendicitis has also been described as a major contributor to the national disease burden (Han et al., 2024). However, these epidemiological estimates require verification against authoritative surveillance data because the reported incidence and annual case numbers appear unusually high and may reflect differences in case definitions, reporting periods, or statistical interpretation.

Acute appendicitis affects both males and females, with an estimated lifetime risk of approximately 7%–8% and a relatively high incidence among adolescents and young adults, particularly those aged 20–30 years (Wijaya et al., 2020). Older adults, especially individuals aged 60 years and above, may have an increased risk of perforated appendicitis, partly because of atypical clinical presentations and delayed diagnosis (Kheru et al., 2022). Appendiceal luminal obstruction is an important mechanism in the pathogenesis of appendicitis and may result from lymphoid hyperplasia, fecaliths, or other obstructive processes. Although dietary patterns and constipation have been discussed as potential contributing factors, their direct causal relationships with acute appendicitis remain insufficiently established.

The diagnosis of acute appendicitis is based on clinical history, physical examination, laboratory investigations, and imaging when indicated. The Alvarado score is commonly used to support clinical risk stratification, while ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI) provide complementary diagnostic information. However, the availability and suitability of these imaging modalities vary according to healthcare resources, patient characteristics, and clinical circumstances. CT involves exposure to ionizing radiation, whereas ultrasonography is operator-dependent and may have reduced diagnostic sensitivity in certain patients. MRI avoids ionizing radiation but may be limited by cost, examination time, and availability. Consequently, accessible laboratory parameters, including the neutrophil-to-lymphocyte ratio (NLR), have attracted attention as potential adjuncts to clinical assessment (Heriyanto et al., 2024; Putra et al., 2021). NLR reflects the relative distribution of circulating neutrophils and lymphocytes and has been investigated as a nonspecific inflammatory marker in infectious diseases, cardiovascular conditions, and malignancies (Buonacera et al., 2022; Raharjo et al., 2021).

Previous studies have suggested that elevated NLR values may be associated with complicated appendicitis, including perforation, and with systemic inflammatory responses in other infectious conditions, such as typhoid fever (Buonacera et al., 2022; Halaseh et al., 2022; Rajalingam et al., 2022; Verma et al., 2023). However, because NLR is not specific to appendiceal inflammation, its interpretation requires consideration of the patient's clinical presentation and other potential causes of inflammation. Similarly, although the Alvarado score is widely recognized as a practical clinical assessment tool, its diagnostic performance may

vary across populations and healthcare settings. Differences in clinical presentation, prior antibiotic exposure, and healthcare-seeking behavior may influence its performance, although the specific contributions of dietary practices and ethnicity-related pain perception require further empirical validation (Fanany et al., 2026; Gupta et al., 2023).

In Indonesia, acute appendicitis remains an important cause of emergency surgical admissions. National health reports have described appendicitis as a substantial healthcare concern, with more than 64,000 patients reported annually. Nevertheless, the completeness and comparability of national epidemiological estimates remain uncertain. Regional evidence suggests that delayed presentation, differences in access to diagnostic services, and variations in hospital resources may complicate timely diagnosis and treatment. These challenges are particularly relevant to regional general hospitals, where advanced imaging may be less accessible and clinicians frequently rely on clinical examination, standardized scoring systems, and routine laboratory investigations to guide diagnostic and surgical decisions.

The Alvarado score has been widely used to estimate the likelihood of acute appendicitis based on clinical symptoms, physical findings, and laboratory parameters. Nevertheless, its diagnostic performance varies across study populations (Favara et al., 2022; Pifeleti et al., 2022). A prospective study conducted in Croatia reported lower sensitivity and specificity for the Alvarado score than for experienced surgeons' clinical judgment, with values of 84% and 87.3%, respectively, compared with 96% and 92.06%. Similarly, a cross-sectional study conducted in Pakistan reported a sensitivity of 93% but a specificity of only 31%. These findings suggest that the Alvarado score may support initial risk stratification but should not be used independently to confirm appendicitis or determine the need for appendectomy. Its clinical utility depends on appropriate interpretation alongside physical examination, laboratory findings, and imaging when available (Pattiiha et al., 2022).

The NLR has also emerged as a potentially useful inflammatory biomarker in the evaluation of acute appendicitis. A systematic review and meta-analysis involving 19 studies and 5,974 pediatric patients reported a pooled sensitivity of 0.82, specificity of 0.76, and area under the summary receiver operating characteristic curve of 0.86 for diagnosing acute appendicitis (Eun et al., 2021). Beyond diagnostic assessment, NLR has been investigated for its ability to distinguish uncomplicated from complicated appendicitis. Hamid et al. (2025) reported a sensitivity of 76.9%, specificity of 93.3%, and negative predictive value of 94.2% for differentiating complicated from uncomplicated cases. Although these findings suggest potential clinical utility, differences in patient populations, NLR thresholds, disease definitions, and reference standards limit the direct generalizability of these estimates (Fawkner-Corbett et al., 2022; Moshtaghi et al., 2026).

Despite growing evidence regarding the individual diagnostic utility of the Alvarado score and NLR, their associations with specific intraoperative macroscopic appendiceal findings remain insufficiently characterized. Previous investigations have frequently emphasized histopathological confirmation or comparisons between uncomplicated and complicated appendicitis. Although histopathological examination provides important diagnostic information, intraoperative macroscopic assessment represents a distinct clinical outcome based on the surgeon's direct observations. Macroscopic findings may be categorized as catarrhal, suppurative, or perforated appendicitis, reflecting different observed patterns of appendiceal inflammation. However, these categories do not necessarily correspond perfectly

with histopathological severity, and their interpretation may vary among surgeons. Investigating their relationships with preoperative NLR values and Alvarado scores may therefore provide additional information regarding the clinical relevance of these accessible assessment tools.

The importance of this investigation is particularly evident in regional hospitals with limited access to advanced diagnostic imaging. In such settings, identifying associations between readily available preoperative indicators and intraoperative disease characteristics may improve clinical risk assessment and support surgical planning. Elevated NLR values or Alvarado scores may indicate a greater likelihood of advanced appendiceal inflammation, although such associations alone cannot establish whether earlier surgical intervention would reduce perforation rates or other complications. Conversely, understanding the limitations of these indicators may help prevent their inappropriate use as standalone criteria for surgery. Rashid et al. (2024) reported a positive predictive value of 98.4% for NLR at a cutoff of ≥2.5; however, positive predictive values are influenced by disease prevalence and patient selection and should not be generalized without considering the study population and diagnostic context.

The principal contribution of this study was its examination of the associations between two accessible preoperative indicators, NLR and the Alvarado score, and intraoperative macroscopic appendiceal findings within the same patient population. Unlike investigations relying exclusively on histopathological outcomes, this study focused on the surgeon's direct observations of appendiceal inflammation, categorized as catarrhal, suppurative, or perforated appendicitis. This approach provided an opportunity to assess whether preoperative clinical and inflammatory indicators differed across macroscopic categories. The study was conducted at Payangan General Hospital in Bali, Indonesia, thereby contributing hospital-specific evidence from a regional healthcare setting. Nevertheless, macroscopic classifications should be interpreted cautiously because they may not independently determine the necessity of specific intraoperative procedures, such as peritoneal irrigation or drain placement, which require consideration of the overall surgical findings and current clinical guidelines.

The primary objective of this study was to determine the associations of the neutrophil-to-lymphocyte ratio and Alvarado score with intraoperative macroscopic appendiceal findings among patients undergoing appendectomy for acute appendicitis at Payangan General Hospital. Specifically, the study examined whether preoperative NLR values and Alvarado scores were associated with the observed categories of catarrhal, suppurative, and perforated appendicitis. By evaluating these relationships, the research sought to provide preliminary evidence regarding the potential relevance of routine clinical and laboratory parameters for assessing appendiceal inflammation in a regional hospital setting.

The findings were expected to contribute to clinical practice, hospital management, and future research. For clinicians, identifying associations between preoperative indicators and intraoperative findings could support more informed clinical assessments when used alongside established diagnostic procedures. For hospital administrators, the findings could provide preliminary information relevant to the use of accessible laboratory investigations and clinical assessment tools. For researchers, the study offered regional data that could inform larger comparative investigations and future evidence syntheses. However, establishing the predictive accuracy of NLR and the Alvarado score would require additional analyses, including diagnostic performance measures, validated thresholds, and sufficiently large samples.

Accordingly, the study primarily sought to characterize associations rather than establish definitive diagnostic or prognostic performance.

METHOD

This study employed an analytical observational design with a cross-sectional approach and was conducted at Payangan General Hospital (Rumah Sakit Umum Payangan, RSU Payangan) from February to June 2026.

The study population comprised patients diagnosed with acute appendicitis who were admitted to Payangan General Hospital during the study period. Eligible participants were patients with a preoperative clinical diagnosis of acute appendicitis who underwent a complete blood count examination and appendectomy. Patients with concurrent infections were excluded. Consecutive sampling was used to recruit eligible patients until the required sample size was reached. The minimum sample size was estimated using a formula for comparing two independent proportions, with assumed proportions of 0.40 and 0.60, a significance level of 5%, and a statistical power of 80%. A total of 40 patients were included in the study.

Data were collected from patients' clinical assessments, preoperative laboratory results, and intraoperative surgical findings. The independent variables were the neutrophil-to-lymphocyte ratio (NLR) and Alvarado score, while the dependent variable was intraoperative macroscopic appendiceal findings. The Alvarado score was calculated from preoperative clinical and laboratory assessments, while NLR was determined by dividing the absolute neutrophil count by the absolute lymphocyte count obtained from the preoperative complete blood count. Intraoperative macroscopic findings were classified as catarrhal, suppurative, or perforated appendicitis based on the surgeon's observations.

Data were organized and analyzed using IBM SPSS Statistics version 25. Descriptive statistics were used to summarize patient characteristics and study variables. Normally distributed continuous variables were presented as means and standard deviations, while nonnormally distributed variables were summarized using medians and interquartile ranges. Categorical variables were expressed as frequencies and percentages.

Bivariate analyses were conducted to examine the associations of NLR and Alvarado score categories with intraoperative macroscopic appendiceal findings. Associations were assessed using Pearson's chi-square test, with Fisher's exact test considered when expected cell frequencies did not satisfy the assumptions of the chi-square test. Statistical significance was established at $p < 0.05$.

Methodological clarification: The stated sample size of 40 patients should be verified against the original calculation because the specified assumptions for comparing two independent proportions (0.40 versus 0.60, 5% significance, and 80% power) do not ordinarily yield a total sample of 40. Additionally, given the small number of perforated cases, the appropriateness of the chi-square test should be checked using expected cell frequencies.

Table 1. Example of a chi-square test table for the association between the Alvarado Score and intraoperative appendicitis findings

	Catarrhal	Suppurative	Perforated	Total
Alvarado score 1–4	a	d	g	a+d+g
Alvarado score 5–6	b	e	h	b+e+h
Alvarado score ≥7	c	f	i	c+f+i
Total	**a+b+c**	**d+e+f**	**g+h+i**	

Table 2. Example of a chi-square test table for the association between the Neutrophil-to-Lymphocyte Ratio (NLR) and intraoperative appendicitis findings

	Catarrhal	Suppurative	Perforated	Total
NLR < 2	a	c	e	a+c+e
NLR ≥ 3	b	d	f	b+d+f
Total	**a+b**	**c+d**	**e+f**	

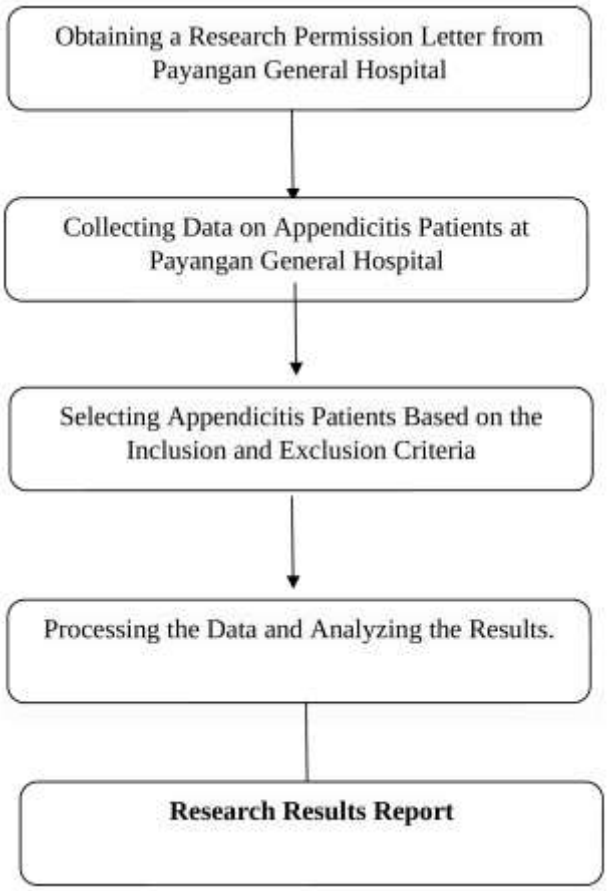


Figure 1. Research flowchart

RESULTS AND DISCUSSION

General Overview of the Study

This study was conducted to determine the correlation between the Neutrophil-to-Lymphocyte Ratio (NLR) and the Alvarado Score with macroscopic appendiceal findings

observed intraoperatively at Payangan General Hospital (RSU Payangan). The study was carried out in the operating room of RSU Payangan from February to June 2026. Sampling was performed using the consecutive sampling method, in which all patients undergoing appendectomy at RSU Payangan who met the inclusion and exclusion criteria were consecutively recruited until the required sample size was achieved. A total of 40 samples were included in this study. The data collected in this study included patient sex, Neutrophil-to-Lymphocyte Ratio (NLR), Alvarado Score, and macroscopic appendiceal findings in patients who underwent appendectomy.

Sample Characteristics

The study sample consisted of 27 male patients and 13 female patients, as presented in Table 3.

Table 3. Distribution of patients by sex

No	Male/Female	Frequency	Percentage (%)
1	Male	27	67.5
2	Female	13	32.5
	Total	**40**	**100**

Among the study participants, 5 patients had an NLR of less than 2, while 35 patients had an NLR of greater than 3, as presented in Table 4.

Table 4. Distribution of patients by NLR

No	NLR	Frequency	Percentage (%)	P-value
1	< 2	5	12.5	
2	> 3	35	87.5	
	Total	**40**	**100**	**0.03**

Among the study participants, 27 patients had catarrhal appendicitis, 10 patients had suppurative appendicitis, and 3 patients had perforated appendicitis, as presented in Table 5.

Table 5. Distribution of macroscopic appendiceal findings

	Catarrhal	Suppurative	Perforated
Frequency	27	10	3
Percentage (%)	67.5	25	7.5

Bivariate Analysis

The analysis of the association between the Alvarado Score and macroscopic findings in patients with acute appendicitis who underwent appendectomy is presented in Table 6. The results of the Chi-square test revealed a statistically significant association, with a p-value of less than 0.05 ($p < 0.05$).

Table 6. Association between the Alvarado Score and macroscopic findings

	Catarrhal	Suppurative	Perforated	P-value
Alvarado score 1–4	0	0	0	
Alvarado score 5–6	25	2	0	
Alvarado score ≥7	2	8	3	0.00

An analysis of the association between the Neutrophil-to-Lymphocyte Ratio (NLR) and macroscopic appendiceal findings observed intraoperatively in patients with acute appendicitis undergoing appendectomy was conducted (Table 7). Among patients with an NLR of less than 2, only 2 samples showed catarrhal appendicitis. Meanwhile, among patients with an NLR of greater than 3, 25 patients presented with catarrhal appendicitis, 10 with suppurative appendicitis, and 3 with perforated appendicitis. The results of the Chi-square test demonstrated a statistically significant association, with a p-value of less than 0.05 ($p < 0.05$).

Table 7. Association between NLR and macroscopic findings

No	NLR	Catarrhal	Suppurative	Perforated
1	< 2	2	0	0
2	> 3	25	10	3

The sample characteristics showed that the study population consisted predominantly of male patients (67.5%) compared to female patients (32.5%). Similar findings have been reported in previous studies, which found that acute appendicitis was more prevalent among male patients. The scientific explanation for this difference has not been fully established. However, other studies have reported relatively equal proportions of male and female patients with appendicitis, while some have found a predominance of female patients.

Bivariate analysis was performed to investigate the association between the Alvarado Score and the Neutrophil-to-Lymphocyte Ratio (NLR) with macroscopic intraoperative findings in patients with acute appendicitis. Using the Chi-square test in SPSS Statistics, the analysis yielded a p-value of less than 0.05 ($p < 0.05$), indicating a statistically significant association. The NLR cut-off values used in this study were less than 2 and greater than 3. These values were based on the commonly reported normal NLR range in adults of 1–2, whereas values greater than 3 or less than 0.7 may indicate an inflammatory condition.

The results of this study indicate that higher Alvarado Scores and NLR values are associated with more severe appendiceal inflammation. In this study, patients with an Alvarado Score of 5–6 showed a prevalence of catarrhal appendicitis of 62.5% and suppurative appendicitis of 5%. Meanwhile, patients with an Alvarado Score greater than 7 showed 20% suppurative appendicitis and 7.5% perforated appendicitis. Furthermore, among patients with an NLR greater than 3, 62.5% presented with catarrhal appendicitis, 25% with suppurative appendicitis, and 7.5% with perforated appendicitis. These findings are consistent with the view that an increased leukocyte count may help determine the severity of appendicitis.

The Neutrophil-to-Lymphocyte Ratio (NLR) can also be used to differentiate between uncomplicated and complicated acute appendicitis. An increased leukocyte count indicates a more severe inflammatory process and a wider area of inflammation. From a pathophysiological perspective, neutrophils represent the nonspecific immune system, which initiates the body's response to inflammation, whereas lymphocytes represent the protective component of the immune response against inflammation.

CONCLUSION

The findings of this study indicated statistically significant associations of both the neutrophil-to-lymphocyte ratio (NLR) and Alvarado score with intraoperative macroscopic appendiceal findings among patients with acute appendicitis at Payangan General Hospital.

Higher Alvarado scores (≥7) and elevated NLR values (>3) were associated with more advanced macroscopic inflammatory findings, including suppurative and perforated appendicitis, whereas lower values were more frequently observed in patients with catarrhal appendicitis. Pearson's chi-square analysis yielded p-values below 0.05 for both associations, suggesting that these preoperative parameters may provide useful supplementary information regarding the severity of appendiceal inflammation. However, statistical significance alone did not establish their diagnostic accuracy or predictive performance. Male patients accounted for 67.5% of the study population, while catarrhal appendicitis was the most common intraoperative finding (67.5%), followed by suppurative (25.0%) and perforated appendicitis (7.5%). These findings provided preliminary descriptive evidence regarding the clinical characteristics and macroscopic appendiceal findings of patients treated at the study hospital. Overall, the results suggested that NLR and the Alvarado score could serve as accessible, low-cost adjuncts to preoperative clinical assessment in resource-limited healthcare settings. Nevertheless, their clinical application should be supported by further validation and interpreted alongside patient history, physical examination, and other appropriate diagnostic investigations.

Future research should prioritize larger, multicenter studies involving more diverse patient populations to validate these associations and determine appropriate NLR cutoff values for differentiating macroscopic categories of appendicitis. Prospective investigations incorporating histopathological examination alongside intraoperative macroscopic assessment are also recommended to evaluate agreement between surgical observations and microscopic findings. Furthermore, the development and validation of combined predictive models incorporating NLR, the Alvarado score, and additional inflammatory biomarkers, such as C-reactive protein (CRP), may help determine whether integrating these parameters improves diagnostic discrimination compared with their individual use. Future studies should also examine variations in NLR according to symptom duration and the timing of preoperative blood sampling, as these factors may influence inflammatory marker levels. Finally, implementation research is needed to assess the feasibility and clinical effectiveness of incorporating these parameters into standardized preoperative assessment protocols in regional hospitals. Such investigations should evaluate their potential effects on surgical decision-making, time to intervention, negative appendectomy rates, and patient outcomes. These approaches would provide stronger evidence for translating the observed statistical associations into clinically meaningful improvements in acute appendicitis management.

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CONFLICT OF INTEREST

The authors declare that this research is free from conflicts of interest. The authors also have no business or financial relationships with any party that could influence the conduct of the research, the results of the analysis, or the way the findings are presented in this manuscript.

AUTHOR CONTRIBUTIONS

All authors had an equal role and contribution at every stage of the preparation of this work. Tasks were divided fairly, from conceiving the initial idea and conducting the

analysis to writing and refining the manuscript, so that no author played a greater role than the others.

GENERATIVE AI STATEMENT

In preparing this manuscript, the authors used artificial intelligence (AI) technology to a limited extent, solely to help improve grammar and ensure the accuracy of language use. All ideas, analyses, and contents of the manuscript originate entirely from the authors' own thinking, and the authors take full responsibility for them.

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