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Diagnostic value of monocyte-based ratios for pediatric acute appendicitis

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Acute appendicitis (AA) is the most common surgical emergency in children.[1] Early diagnosis remains challenging, particularly in younger patients who often present with atypical symptoms and have limited ability to articulate their complaints, leading to higher rates of perforation.[2,3] Although clinical assessment remains fundamental, adjunctive laboratory and imaging modalities are frequently required to improve diagnostic accuracy and reduce unnecessary surgical interventions.

Ultrasound is recommended as the initial imaging modality in children; however, its diagnostic performance is operator-dependent and may be limited in certain clinical settings. Computed tomography (CT) provides higher diagnostic accuracy but raises concerns regarding radiation exposure.[4] Magnetic resonance imaging has also been proposed, yet accessibility and logistical limitations restrict its routine use.[4-6] Consequently, laboratory parameters derived from complete blood count continue to play an important role in daily clinical practice.

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Abstract

Objectives: The aim of this study was to evaluate the diagnostic performance of monocyte-based biomarkers in pediatric acute appendicitis (AA) and to investigate their potential role in the differential diagnosis of nonspecific abdominal pain (NAP).

Patients and Methods: This retrospective observational study included consecutive pediatric patients who presented to the emergency department with abdominal pain between June 2021 and December 2024. Patients were categorized into two groups: histopathologically confirmed AA and NAP with a normal appendix on abdominal computed tomography. Demographic characteristics and laboratory parameters, including white blood cell count (WBC), neutrophil percentage (NP), neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), monocyte (MO) count, monocyte-to-lymphocyte ratio (MLR), lymphocyte-to-monocyte ratio (LMR), and monocyte-to-MPV ratio (MMR), were analyzed. Diagnostic performance was evaluated using receiver operating characteristic (ROC) curve analysis.

Results: A total of 550 patients were included in the study, consisting of 200 patients in the AA group (121 male, 79 female; mean age: 11.9 ± 3.5 years; range, 3.5 to 18 years) and 350 in the NAP group (180 male, 170 female; mean age: 11.3 ± 3.8 years; range, 4 to 18 years). Patients with AA had significantly higher levels of WBC, NP, NLR, PLR, MO count, and MLR, whereas lymphocyte count, LMR, and MMR were significantly lower ($p < 0.05$). The ROC analysis demonstrated the highest diagnostic accuracy for LMR (area under the curve, AUC = 0.848) and MLR (AUC = 0.848), followed by NLR (AUC = 0.824). In multivariate analysis, LMR remained independently associated with AA. An LMR cut-off value of 2.98 yielded 75% sensitivity and 75.2% specificity. Higher LMR values were particularly useful for ruling out appendicitis.

Conclusion: Monocyte-based ratios, particularly LMR and MLR, demonstrated good diagnostic performance in differentiating pediatric AA from NAP in a clinically relevant cohort. Although not disease-specific, these inexpensive and readily available biomarkers may provide useful adjunctive information in children with equivocal presentations. In particular, LMR may support ruling out appendicitis and aid clinical decision-making, pending prospective validation.

Keywords: Acute appendicitis, lymphocyte-to-monocyte ratio, monocyte-based biomarkers, nonspecific abdominal pain, pediatric appendicitis.

Laboratory tests are relatively simple and easily accessible. Conventional inflammatory markers such as white blood cell count (WBC), absolute neutrophil count (ANC), neutrophil percentage (NP), and C-reactive protein (CRP) are widely used but lack sufficient specificity.[2] In recent years, several ratio-based indices, including neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), mean platelet volume (MPV), platelet (PLT) indices, and related parameters, have been investigated to enhance diagnostic performance.[7-12] In the literature, the blood tests and ratios mentioned above have been investigated in detail in pediatric patients. However, their reported accuracy varies, and many studies have compared appendicitis with healthy controls rather than clinically relevant differential diagnoses.

Despite their central role in innate immunity and host defense, monocytes (MOs) have been relatively underexplored in the differential diagnosis of pediatric AA. There are a few studies investigating the role of monocyte-to-lymphocyte (MLR) and lymphocyte-to-monocyte (LMR) ratios in the differential diagnosis of AA in pediatric patients.[13-17] To the best of our knowledge, there is no study fully focusing on the role of MOs in the differential diagnosis of appendicitis. Therefore, the aim of this study was to evaluate the diagnostic performance of monocyte-based biomarkers, including absolute MO count and derived ratios in distinguishing AA from nonspecific abdominal pain (NAP) in a clinically relevant pediatric population.

PATIENTS AND METHODS

Study population

This retrospective cohort study was conducted by reviewing the medical records of all consecutive pediatric patients presenting to the Department of Pediatric Emergency at Erciş Şehit Rıdvan Çevik State Hospital between June 2021 and December 2024. The study included consecutive pediatric patients presenting out of hours to the emergency department during the study period with acute abdominal pain or clinical suspicion of appendicitis, whose medical charts were fully retrieved. According to preliminary data, the patients were divided into two groups: AA and NAP. Patients in the AA group comprised children who underwent surgical appendectomy with histopathologically confirmed appendicitis. The NAP group included patients who met all of the following criteria: *(i)* a Pediatric Appendicitis Score (PAS) ≥ 6, *(ii)* availability of an abdominal CT scan, and *(iii)* a clearly visualized, normal-appearing appendix on CT. This operational definition does not correspond to the conventional epidemiological definition of NAP but was specifically developed to identify children with an equivocal clinical presentation requiring differential diagnosis from AA. Patients were excluded from the NAP group if they met any of the following conditions: *(i)* mental retardation, *(ii)* presence of an underlying hematological disease, *(iii)* a PAS < 6, *(iv)* diagnosis of familial Mediterranean fever (FMF), *(v)* absence of an abdominal CT scan, or *(vii)* inability to visualize the appendix clearly on CT imaging. As this was a retrospective study based on the review of existing medical records, individual written informed consent was not obtained. The study protocol was approved by the Van Training and Research Hospital Non-Interventional Clinical Research Ethics Committee (Date: March 28, 2025, No: GOKAEK/28-03-03). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Independent variables and outcomes of interest

All clinical and laboratory features, including age, sex, WBC, ANC, NP, absolute lymphocyte count, NLR, PLT count, MPV, MPV-to-PLT ratio (MPR), platelet-to-MPV (PMR), PLR, absolute MO count, MLR, LMR, and monocyte-to-MPV ratio (MMR), were recorded. All CT images were routinely read by two readers (double-reading). The second reader in the double-reading workflow was completely blinded to the opinion of the first reader. In cases of discrepancy, the CT images were evaluated by a third reader to reach a consensus. All operations were performed by a single surgeon.

Management of abdominal pain in our hospital

Our hospital is a secondary care hospital that serves a population of approximately 550,000 during working hours and approximately 400,000 people outside of working hours. During working hours, ultrasound is used in the differential

diagnosis of abdominal pain, since a radiologist is available. However, since there is no radiologist and pediatrician on duty in our hospital outside of working hours, patients presenting with abdominal pain are evaluated by general practitioners, and CT is performed for patients who meet the criteria specified above. All imaging and blood tests are performed before the patient is referred to the pediatric surgery department.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 22.0 software (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was performed to assess normal distribution. The homogeneity of variance was determined by the Levene test. Parametric variables were analyzed by independent t-test and non-parametric variables by the Mann-Whitney U test. To compare qualitative variables the chi-square test with Fisher's exact test correction was used. Receiver operating characteristic (ROC) curves were created to assess the diagnostic performance of the identified risk factors. Optimal cut-off values were determined using the Youden index to maximize the combined sensitivity and specificity. C-index, that is, the area under the curve (AUC), was calculated for the risk model to assess the model's discriminatory power. Forward binary logistic regression (LR) was used for multivariate analysis, which included only variables that reached statistical significance in univariate analysis. Due to the reciprocal mathematical relationship between MLR and LMR, both parameters were not entered simultaneously into the regression model to avoid collinearity. The level of statistical significance for descriptive statistics was set at $p < 0.05$.

TABLE 1
Demographic characteristics and laboratory parameters of patients with acute appendicitis and nonspecific abdominal pain

	AA group (n = 200)			NAP group (n = 350)			
	n	Mean ± SD	Range	n	Mean ± SD	Range	*p*
Age (year)		11.9 ± 3.5	3.5-18		11.3 ± 3.8	4-18	0.245*
Sex Male Female	 121 79			 180 170			0.169†
WBC		16.9 ± 4.61	5.79-37.88		13.8 ± 3.6	9.06-29.04	< 0.001‡
ANC		13.85 ± 4.6	3.41-36.41		9.9 ± 3.9	3.75-25.34	< 0.001*
NP		81.12 ± 9	37-96.4		69.8 ± 14.8	34.3-93.6	< 0.001‡
LY		1.93 ± 1	0.19-7.2		2.9 ± 1.6	0.41-9.11	< 0.001‡
NLR		9.4 ± 6.8	0.7-47.3		5.3 ± 5.1	0.62-24.9	< 0.001*
PLT		303 ± 67.5	170-538		306 ± 75.5	116-498	0.725*
PLR		202 ± 147.4	49.9-1652.6		145.5 ± 110	23.8-621.9	0.002*
MPV		9.5 ± 1	7-12		9.4 ± 1.1	7.1-12	0.573*
CRP		31.4 ± 41.6	0.5-151		16.4 ± 30.9	1-137	0.002‡
MPR		0.033 ± 0.01	0.015-0.066		0.033 ± 0.012	0.016-0.086	0.857*
MO		0.91 ± 0.38	0.22-2.32		0.74 ± 0.25	0.16-1.48	< 0.001‡
LMR		2.3 ± 1.3	0.37-9.84		4.4 ± 2.5	0.76-11.16	< 0.001‡
MLR		0.59 ± 0.36	0.1-2.69		0.34 ± 0.01	0.09-1.32	< 0.001‡
PMR		32.5 ± 8.5	15.2-64.1		33.2 ± 9.8	11.62-61.88	0.568*
MMR		12.5 ± 5.4	4.1-40		14.6 ± 6.7	4.93-51.88	0.011*

AA, Acute appendicitis; NAP, Nonspecific abdominal pain; SD, standard deviation; WBC: White blood cell count; NP: Neutrophil percentage; ANC: Absolute neutrophil count; LY: Lymphocyte; NLR: Neutrophil-to-lymphocyte ratio; PLT: Platelet; PLR: Platelet-to-lymphocyte ratio; MPV: Mean platelet volume; CRP, C-reactive protein; MPR: MPV-to-platelet ratio; MO: Monocyte; LMR: Lymphocyte-to-monocyte ratio; MLR: Monocyte-to-lymphocyte ratio; PMR: Platelet-to-MPV ratio; MMR: Monocyte-to-MPV ratio; *, T-test; †, chi-Square test; ‡ Mann-Whitney- U test.

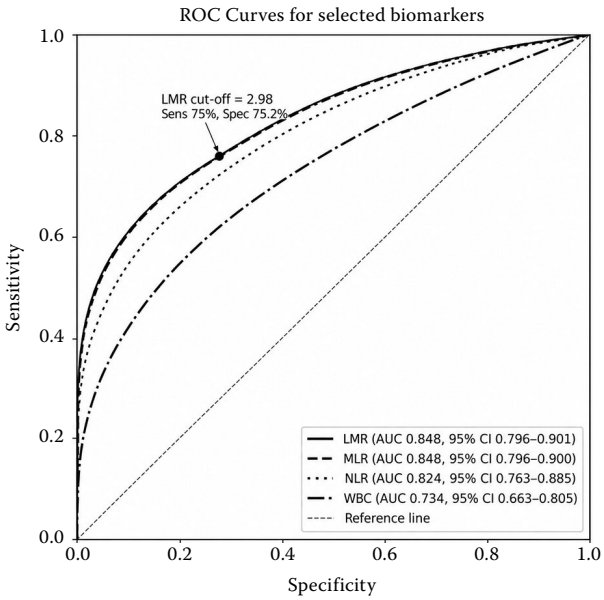


Figure 1. Receiver operating characteristic (ROC) curves of selected biomarkers for differentiating acute appendicitis from nonspecific abdominal pain. LMR and MLR demonstrated identical AUC values, and their ROC curves overlap because the two ratios are mathematically reciprocal. The marked point indicates the LMR cut-off value of 2.98, corresponding to 75% sensitivity and 75.2% specificity.

LMR, lymphocyte-to-monocyte ratio; MLR, monocyte-to-lymphocyte ratio.

RESULTS

A total of 550 patients were included in the study, consisting of 200 patients in the AA group (121 male, 79 female; mean age: 11.9 ± 3.5 years; range, 3.5 to 18 years) and 350 in the NAP group (180 male, 170 female; mean age: 11.3 ± 3.8 years; range, 4 to 18 years). Male predominance was observed in both groups, with a male-to-female ratio of 1.5:1 in the AA group and 1.05:1 in the NAP group. There was no statistically significant difference between the groups according to sex and age, as shown in Table 1.

Among the variables evaluated in our study, a statistically significant difference was found between the groups according to WBC, NP, ANC, LY, NLR, PLR, CRP, MO, LMR, MLR, and MMR. Acute appendicitis was associated with elevated levels of WBC, NP, ANC, NLR, PLR, CRP, MO, MLR, and decreased levels of lymphocytes, LMR, and MMR. No differences were found in levels of PLT, MPV, MPR, and PMR (Table 1).

When a discrimination analysis of the significantly tested variables was performed by utilizing ROC curves, good diagnostic accuracy levels were obtained for LMR, MLR, NP, NLR, and moderate accuracy levels were obtained for lymphocyte, absolute neutrophil count, PLR, and WBC. Weak accuracy levels were obtained for CRP, MO, and MMR. The parameters with the largest AUC were LMR (AUC = 0.848), MLR (AUC = 0.848), and NP (AUC = 0.810), as shown in Figure 1 and Table 2.

TABLE 2
Diagnostic performance of laboratory biomarkers for differentiating acute appendicitis from nonspecific abdominal pain

	AUC	*p*	95% CI	Cut-off	Sensitivity%	Specificity%
LMR	0.848	< 0.001	0.796-0.901	2.98	75	75.2
MLR	0.848	< 0.001	0.796-0.900	0.34	75.2	75
NLR	0.824	< 0.001	0.763-0.885	5.25	71.5	71.9
NP	0.810	< 0.001	0.744-0.876	78.75	72.7	73.4
LY	0.798	< 0.001	0.732-0.863	2.28	68.8	68.5
ANC	0.796	< 0.001	0.731-0.861	11.36	72.7	73.4
PLR	0.767	< 0.001	0.697-0.837	128	68.5	68.8
WBC	0.734	< 0.001	0.663-0.805	14.3	69.1	68.8
CRP	0.693	< 0.001	0.617-0.768	4.5	66.1	68.8
MO	0.645	0.001	0.569-0.721	0.74	61.2	62.5
MMR	0.627	0.003	0.551-0.704	12.3	56.3	55.2

AUC, area under the curve; CI, confidence interval; LMR, lymphocyte-to-monocyte ratio; MLR, monocyte-to-lymphocyte ratio; NLR, neutrophil-to-lymphocyte ratio; NP, neutrophil percentage; LY, lymphocyte; ANC, absolute neutrophil count; PLR, platelet-to-lymphocyte ratio; WBC, white blood cell count; CRP, C-reactive protein; MO, monocyte; MMR, monocyte-to-MPV ratio.

Variables that reached statistical significance in univariate analysis were entered into a forward stepwise binary LR model. LMR was retained in the final model of independently associated variables with AA. The LMR, with a cut-off value of 2.98, was found to be an independent discriminatory factor for AA with 75% sensitivity and 75.2% specificity.

DISCUSSION

In the present study, we evaluated the diagnostic performance of monocyte-based biomarkers, including absolute MO count, in the differential diagnosis of AA in a well-defined NAP cohort, representing one of the first pediatric investigations to comprehensively address this topic to our knowledge.

Our study results showed that monocyte-based ratios, particularly LMR and MLR, provided the highest diagnostic discrimination between pediatric acute appendicitis and nonspecific abdominal pain, outperforming conventional inflammatory markers such as NLR, WBC, and CRP. An LMR cut-off value of 2.98 yielded a sensitivity of 75% and a specificity of 75.2%. Furthermore, LMR remained independently associated with acute appendicitis in multivariable analysis. These findings suggest that monocyte-based ratios may serve as inexpensive, readily available adjunctive biomarkers in the evaluation of children with suspected appendicitis, particularly when clinical findings are equivocal.

Diagnosis of pediatric appendicitis remains challenging due to atypical presentations and high perforation rates in younger children.[1-3] Consequently, there is a continuous search for reliable adjunctive biomarkers that may improve diagnostic discrimination in equivocal cases. Previous studies evaluating such biomarkers as NLR, PLR, and PLT indices have shown variable diagnostic performance.[7-12] Importantly, many of these investigations compared appendicitis with healthy controls rather than clinically relevant differential diagnoses.

In the literature, the blood tests and ratios mentioned above have been investigated in detail in pediatric patients. Despite their central role in innate immunity, MOs have received limited attention in this context. Monocytes play an essential role in the innate and adaptive immune system. They are crucial for an effective immune response against many pathogens.[18] During inflammation, the number of circulating MOs increases.[19] Monocytes are equipped with chemokine receptors and adhesion receptors that modulate migration from the blood to the site of infection. Therefore, it is not surprising that their amount increases in the lamina propria of the appendix during acute inflammation.[20]

Cases of neutrophilia indicating left shift are often related to lymphopenia, which is accompanied by monocytosis. In a recent study, higher values of MLR demonstrated greater possibilities for bacterial infection and low probabilities for viral infection.[21] Therefore, MO and monocyte-based ratios such as MLR and LMR may provide clinically useful adjunctive information despite their lack of disease specificity.[14]

In our cohort, absolute MO count was significantly higher in the AA group ($p < 0.001$); however, its discriminatory capacity was limited (AUC = 0.645). This finding suggests that although monocytosis accompanies AA, absolute MO count alone may not provide sufficient diagnostic precision in clinically relevant populations. Previous studies evaluating MOs in appendicitis are scarce and have yielded heterogeneous results. In an adult study comparing AA with healthy controls, MO levels demonstrated high diagnostic performance (AUC = 0.876).[22] However, comparisons with healthy individuals may overestimate diagnostic accuracy, as MO elevation reflects generalized inflammatory activation rather than appendicitis-specific pathology. Pediatric data remain limited, and available studies have not consistently demonstrated strong standalone discriminatory performance.[8,15] These observations underscore an important limitation of isolated MO measurement: while biologically plausible, monocytosis is not specific to appendiceal inflammation and may occur in a variety of bacterial or systemic inflammatory conditions. This limitation provides a rationale for evaluating ratio-based indices that integrate MO dynamics with complementary leukocyte subsets, potentially enhancing discriminatory precision.

The MLR has been utilized to identify patients at risk for malaria and might be useful in distinguishing bacterial from viral infections

in feverish patients.[14,21] In our study, MLR was statistically significantly higher in the AA group ($p < 0.001$). Moreover, the predictive value of MLR was quite high (AUC = 0.848). Previous pediatric studies have similarly reported moderate-to-good diagnostic accuracy for MLR in appendicitis.[15,17] However, its performance has not consistently exceeded that of conventional inflammatory markers,[15] and reported cut-off values vary across populations. These findings suggest that although MLR captures biologically relevant inflammatory shifts, its diagnostic contribution may depend on the clinical context and comparator group. Given that MLR primarily reflects monocytic predominance, its reciprocal counterpart, LMR, may offer an alternative interpretative framework.

The LMR has recently attracted attention as a potential biomarker in inflammatory diseases and has been investigated in the differential diagnosis of pediatric appendicitis. In our study, LMR below 2.98 was found to be an independent factor for the presence of AA (AUC = 0.848, sensitivity 75%, specificity 75.2%). The literature reports conflicting results regarding this parameter. In a retrospective study by Korkut et al.[23] on adults, LMR was found to be lower in AA patients. However, the predictive value of LMR for AA was low (AUC = 0.636). In the pediatric study comparing appendicitis with FMF and mesenteric lymphadenitis (ML), LMR was found to be statistically significantly higher in the FMF and ML groups. However, since the AUC was quite low (0.259), it was not considered a potent parameter for differential diagnosis.[24] In contrast, in another study on the differential diagnosis of AA and ML, LMR was found to be lower in the AA group. The AUC value of LMR was found to be very high, 0.981, in this study (cut-off: 8.95, sensitivity 89%, and specificity 97%). The authors commented that "even if the WBC is within standard limits, the LMR seems to be reliable for initial differential diagnosis between AA and ML".[13] Comparison of AA with only ML patients was the major limitation of the study. A possible explanation for the markedly elevated AUC of LMR reported in that study may be the substantially lower inflammatory burden in the control group compared with our cohort (mean WBC: 10.28 *vs.* 13.8; mean CRP: 10.21 *vs.* 16.4), which may have artificially amplified discriminatory separation. In our study, LMR demonstrated balanced sensitivity and specificity (~75%), suggesting that its clinical value may lie not only in identifying appendicitis when low but also in helping exclude the diagnosis when values remain above the threshold.

Acute bacterial inflammation is typically characterized by relative monocytosis accompanied by lymphopenia, making monocyte-lymphocyte-based indices biologically plausible markers. Since MLR increases in response to bacterial inflammatory shifts, it may reflect systemic bacterial activation rather than appendicitis-specific pathology. Therefore, elevated MLR values are not unique to appendicitis and may be observed in a variety of infectious conditions presenting with abdominal pain. In contrast, LMR represents the reciprocal expression of the same inflammatory axis (LMR = 1/MLR) and therefore inherently shares identical discriminatory capacity at the univariate level, as reflected by equivalent ROC performance. However, its clinical interpretability differs fundamentally. Rather than merely indicating relative lymphocytosis, elevated LMR primarily reflects attenuation of monocytic expansion, which constitutes a central component of acute bacterial inflammatory activation. In this framework, LMR may more directly capture the absence of a monocyte-driven inflammatory phenotype, thereby functioning as a biologically coherent negative discriminator in diagnostically equivocal cases. From a practical standpoint, this characteristic may be particularly advantageous, as the primary clinical challenge often lies not in identifying overt appendicitis but in safely excluding the diagnosis in patients with indeterminate presentations. In this context, the identified threshold provides clinically meaningful information: LMR values above 2.98 may help rule out AA, reflecting the absence of a pronounced monocyte-driven inflammatory response. Therefore, rather than functioning solely as a marker of disease presence when low, LMR may be particularly valuable as a rule-out biomarker, assisting clinicians in identifying patients with a lower likelihood of appendicitis in equivocal clinical scenarios.

The principal strength of our study lies in the selection of the comparison group. The objective was not to determine whether monocyte-based biomarkers distinguish appendicitis from every inflammatory or infectious disease, since no single

laboratory marker can achieve such specificity. Rather, we aimed to evaluate their performance in one of the most common real-world clinical scenarios faced by pediatric surgeons: a child with persistent suspicion of appendicitis despite inconclusive clinical assessment. These are patients in whom history, physical examination, routine inflammatory markers, and even ultrasonography fail to provide a confident diagnosis, while the PAS suggests an intermediate probability rather than a clear indication for surgery. In many secondary-care hospitals, particularly during out-of-hours practice where pediatric surgeons may work without immediate specialist support and ultrasonography may be nondiagnostic, the decision to admit, observe, obtain further imaging, or proceed with surgery remains challenging. In this specific setting, LMR should not be viewed as an appendicitis-specific biomarker but rather as an inexpensive adjunct that may increase diagnostic confidence and assist clinicians in safely identifying children with a lower probability of appendicitis.

Nevertheless, these findings should be interpreted within the clinical context. Monocyte count, MLR, and LMR reflect systemic inflammatory activation rather than appendiceal inflammation itself and therefore are not specific for AA. Similar alterations may occur in other inflammatory or infectious conditions such as pyelonephritis, urinary tract infection, bacterial gastroenteritis, inflammatory bowel disease, intussusception, pneumonia, tonsillitis, and sepsis. Consequently, these biomarkers should not replace clinical judgment or imaging but should be considered complementary tools that may support decision-making in diagnostically equivocal patients. Future prospective studies comparing appendicitis directly with these conditions are warranted.

The most important limitation of our study is its retrospective nature. The single-center nature of the study limits the generalizability of our findings to other patient populations. Furthermore, the present study compared AA only with NAP. The diagnostic performance of monocyte-based biomarkers against other inflammatory or infectious diseases that may mimic appendicitis was not evaluated and warrants investigation in future prospective studies.

From a clinical perspective, one of the major challenges in pediatric appendicitis is the management of children with equivocal presentations in whom neither clinical assessment nor routine investigations provide sufficient diagnostic confidence. In this setting, LMR may serve as a practical, inexpensive adjunctive biomarker to support decision-making, particularly by helping identify patients with a lower probability of appendicitis. If validated prospectively, this approach may contribute to reducing unnecessary imaging and optimizing resource utilization in pediatric emergency settings.

In conclusion, monocyte-based ratios, particularly LMR, may represent useful adjunctive biomarkers in the evaluation of children with equivocal suspected appendicitis. Although they are not disease-specific and should not replace clinical assessment or imaging, their low cost, widespread availability, and favorable diagnostic performance suggest that they may improve diagnostic confidence in clinically challenging cases. In particular, higher LMR values may help identify children with a lower probability of appendicitis, potentially supporting safer patient triage and reducing unnecessary imaging. Prospective multicenter studies are needed to validate these findings before routine clinical application.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: M.H.: Idea/concept, design, writing the article; M.K.: Control/supervision, critical review.

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