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ORIGINAL ARTICLE

The Diagnostic Role of Ultrasonography and Neutrophil-to-Lymphocyte Ratio in Acute Abdominal Pain in Children

Çocuklarda Akut Karın Ağrısında Ultrasonografi ve Nötrofil-Lenfosit Oranının Tanısal Rolü

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ABSTRACT

Background: Acute abdominal pain in children is typically a transient condition with age-dependent symptoms, but in some cases, it can lead to serious outcomes requiring urgent medical intervention. Early diagnosis and treatment are crucial to preventing complications. When physical examination alone is insufficient, diagnostic tools such as ultrasonography (USG) and laboratory tests, including the neutrophil-to-lymphocyte ratio (NLR), can enhance diagnostic accuracy.
Materials and Methods: This prospective study was conducted between January 2022 and December 2022 and included children aged 0 to 18 years presenting to the pediatric emergency department with acute abdominal pain lasting less than three days and underwent abdominal USG. Laboratory test results, ultrasound findings, and pathological examination results were recorded from the hospital database. The ultrasonographic criteria for diagnosing appendicitis were defined as an appendix larger than 6 mm or surrounded by a hypoechoic wall thicker than 2 mm.
Results: A specific diagnosis was established in 53.4% of the 504 patients. The most common diagnoses were mesenteric lymphadenitis, gastroenteritis, and appendicitis. In 46.6% of the cases, no specific diagnosis was made, and these were classified as nonspecific abdominal pain. Patients with organic abdominal pain had significantly higher NLR, white blood cell (WBC) counts, and C-reactive protein levels than those with nonspecific pain ($p<0.05$). Patients requiring surgery were older and had higher NLR, WBC, and neutrophil counts, and lower lymphocyte counts compared to those who did not require surgery ($p<0.05$). The sensitivity of USG in diagnosing appendicitis was 60.9%, with a specificity of 33.3%.
Conclusion: USG is a frequently used method in the diagnosis of acute abdominal pain in children; however, the inability to visualize the appendix may make diagnosis difficult. Neutrophil lymphocyte ratio increases diagnostic accuracy in cases requiring urgent surgical intervention, and the combined use of both methods allows faster and more accurate results.

Keywords: Acute abdominal pain, neutrophil-to-lymphocyte ratio, ultrasonography,

ÖZ

Giriş: Çocuklarda akut karın ağrısı, yaşa göre değişen belirtilerle genellikle kısa süreli bir durumdur. Bazı vakalarda acil müdahale gerektiren ciddi sonuçlar doğurabilir. Zamanında teşhis ve tedavi, morbiditeyi önlemek için kritik öneme sahiptir. Fizik muayenenin yeterli olmadığı durumlarda, ultrasonografi ve nötrofil lenfosit oranı gibi laboratuvar testleri tanısal doğruluğu artıran önemli araçlardır.
Metot: Bu çalışma, Ocak 2022 ile Aralık 2022 tarihleri arasında ani başlayan, üç günden kısa süren akut karın ağrısı ile çocuk acil kliniğine başvuran ve abdominal ultrasonografi çekilen 0-18 yaş arası çocukları kapsayan prospektif bir araştırmadır. Hastaların laboratuvar tetkikleri, abdominal USG incelemeleri ve patolojik inceleme sonuçları hastane veri tabanından kaydedildi. Ultrasonografik apandisit tanı kriterleri, 2 mm'den kalın hipoekoik duvarla çevrili veya 6 mm'den büyük apendiks varlığı olarak belirlendi.
Bulgular: 504 hastanın %53,4'üne tanı konuldu. En sık tanılar sırasıyla mezenter lenfadenit, gastroenterit ve apandisit olarak belirlendi, tanı konulamayan %46,6'lık grup ise spesifik olmayan karın ağrısı olarak değerlendirildi. Organik karın ağrısı olan hastalarda nötrofil lenfosit oranı ve lökosit ile CRP değerleri, spesifik olmayan ağrısı olanlara göre anlamlı şekilde yüksekti ($p<0,05$). Cerrahi müdahale gerektiren hastaların yaş, nötrofil lenfosit oranı, lökosit ve nötrofil sayıları, müdahale gerektirmeyenlere kıyasla daha yüksek, lenfosit sayıları ise daha düşüktü ($p<0,05$) Ultrasonografinin apandisit tanısındaki duyarlılığı %60,9, özgüllüğü %33,3 olarak belirlendi.
Sonuç: Ultrasonografi, çocuklarda akut karın ağrısının tanısında sıkça kullanılan bir yöntemdir; ancak apendiksin görüntülenememesi tanıyı zorlaştırabilir. Nötrofil lenfosit oranı, acil cerrahi müdahale gerektiren vakalarda tanısal doğruluğu artırmakta ve her iki yöntemin birlikte kullanımı, daha hızlı ve doğru sonuçlar elde edilmesine olanak tanımaktadır.

Anahtar Kelimeler: Akut karın ağırısı, nötrofil lenfosit oranı, ultrasonografi,

Introduction

Abdominal pain is a common complaint in children and may indicate conditions that require both medical and surgical approaches. Life-threatening conditions necessitating surgical intervention can also be the underlying cause of this pain. Particularly in the case of acute abdominal pain, the rapid exclusion of such serious conditions is of utmost importance. Acute abdominal pain is typically characterized by a clinical picture lasting less than three days, with causes, symptoms, and findings that vary according

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to age (1). The causes of acute abdominal pain may include surgical emergencies, intra-abdominal and extraintestinal issues, as well as systemic medical disorders. Timely diagnosis and initiation of treatment in a child with abdominal pain are critical to preventing morbidity (2,3).

A detailed physical examination in children may not always be feasible; therefore, laboratory tests and auxiliary imaging techniques play a significant role in enhancing diagnostic accuracy. When evaluating a child with abdominal pain, basic laboratory studies are often utilized. Leukocytosis, elevated C-reactive protein (CRP) levels, and the neutrophil-to-lymphocyte ratio (NLR) have been shown to increase the positive predictive value of diagnosis in cases of acute abdominal pain and contribute to the decision-making process in situations requiring surgical intervention (4). Ultrasonography (USG) is a commonly preferred imaging modality in pediatric emergency departments. The rapid, non-invasive, and radiation-free characteristics of USG make it a safe option for pediatric patients (5).

Appendicitis is the most common abdominal surgical condition encountered in pediatric emergency departments. Appendicitis is diagnosed in 1-8% of children presenting with acute abdominal pain (6). Due to the often nonspecific nature of symptoms in children, accurate diagnosis requires a combination of physical examination, blood tests, imaging techniques, and scoring systems. In 20-30% of acute appendicitis cases, the white blood cell (WBC) count may be normal or only mildly elevated. WBC, neutrophils, and CRP have wide ranges of specificity and sensitivity in predicting appendicitis (7). Some studies suggest that leukocytosis alone is insufficient to confirm or exclude a diagnosis of appendicitis and that the NLR may be a more sensitive test for diagnosing acute appendicitis (8).

USG is a commonly used method for diagnosing appendicitis. The accuracy of USG is particularly proportional to the experience of the operator. Additionally, the inability to visualize the appendix on USG is a frequently encountered issue. These factors limit the ability to achieve an accurate diagnosis using USG. This situation may necessitate a computed tomography (CT) scan, leading to radiation exposure for the patients (9).

The primary objective of this study is to ensure the rapid and accurate assessment of patients presenting to the pediatric emergency department with acute abdominal pain and to determine the effectiveness of USG and laboratory analyses in establishing a diagnosis.

Materials And Methods

The study included children aged 0-18 years who presented to the pediatric emergency department with acute abdominal pain lasting less than three days and underwent abdominal USG between January 2022 and December 2022. The research was conducted prospectively.

Patients undergoing abdominal USG without requested laboratory tests, those with abdominal pain who did not require a USG, and those who underwent USG for screening purposes due to trauma were excluded from the study.

All patients were evaluated by the physician on duty in the pediatric emergency department through history-taking and physical examination, and necessary laboratory tests were requested. The patients' sociodemographic information, presenting complaints, physical examination findings, laboratory results, abdominal USG and CT findings, surgical intervention status, and pathological examination results (if applicable) were recorded from the hospital data system. Patients were re-evaluated as needed through follow-up examinations. Laboratory tests included complete blood count, urea, creatinine, aspartate aminotransferase, alanine aminotransferase, gamma-glutamyl transferase, amylase, lipase, CRP, erythrocyte sedimentation rate, urinalysis, and urine culture results.

The Pediatric Appendicitis Score (PAS) for each patient presenting with acute abdominal pain was calculated separately by the physician on duty in the pediatric emergency department (Table 1). The score ranges were categorized as follows: ≤4 points: low risk, 5-7 points: moderate risk, ≥8 points: high risk (10).

Table 1. Pediatric appendicitis score (Total 10 points)

PAS Components	**Point Value**
Anorexia	1 Point
Nausea or vomiting	1 Point
Fever (≥38°C)	1 Point
Tenderness in the right lower quadrant	2 Points
Coughing/ percussion/ jumping at the right lower quadrant	2 Points

Migration of pain to the right lower quadrant	1 Point
Leukocytosis (≥10,000/mm³)	1 Point
Neutrophilia (when neutrophils constituted more than 75% of total leukocyte count)	1 Point

Abdominal USG examinations for all patients were performed using a Siemens ACUSON S3000 model ultrasound device. CT scans were conducted using a Siemens Somatom Go Up 64 model. The abdominal USG and CT evaluations were performed by a radiologist.

The ultrasonographic criteria used for diagnosing appendicitis included the presence of an appendix with a diameter greater than 6 mm or surrounded by a hypoechoic wall thicker than 2 mm under compression (11). The CT findings indicative of appendicitis included an enlarged appendix lumen greater than 6 mm and/or up to 80% thickening at the apex of the cecum (12). The pathological examination results of patients who underwent appendectomy were recorded from the hospital data system.

Statistical Analysis

Data entry and statistical analysis were performed using SPSS for Windows version 18.0 (SPSS Inc., Chicago, IL, USA). The normality of the data distribution was examined using visual methods (histograms and probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). Descriptive statistics for numerical data included arithmetic mean, standard deviation, and median (1st quartile-3rd quartile) values. Frequency distributions and percentages were used to summarize categorical data. The Mann-Whitney U test was used to compare non-normally distributed numerical data with categorical data. The Kruskal-Wallis test was employed for the evaluation of non-normally distributed numerical data across three or more groups. For pairs of groups found to be statistically significant in the Kruskal-Wallis test, post-hoc pairwise comparisons were conducted using the Mann-Whitney U test with Bonferroni correction. The chi-square test was used for comparing categorical data. Statistical significance was defined as $p<0.05$.

Results

In this study, which included a total of 504 patients, the median age was 9 years, with 51.0% being male and 49.0% female. The median age for males was 8 years, while for females it was 10 years, with the latter being significantly higher (p=0.001). Nausea was observed in 84.1% of the patients, and vomiting in 60.9%. A diagnosis was established in 53.4% (n=269) of the patients, with the most common diagnoses being mesenteric lymphadenitis (35.3%), gastroenteritis (27.5%), and appendicitis (18.2%). The remaining 46.6% of the group, for whom no specific diagnosis could be made, was classified as having nonspecific abdominal pain (Table 2). Among the patients initially suspected of gastroenteritis, USG revealed mesenteric lymphadenitis in 18.9%, appendicitis in 4.1%, intussusception in 2.7%, and gallstones and pancreatitis in 1.4%.

Table 2. Diagnosis status of patients and distribution of diagnosis types

Features	Number of Patients n=504
	n (%)
Diagnosis Status	
Nonspecific Abdominal Pain	235 (46.6)
Organic Abdominal Pain	269 (53.4)
Organic Causes of Abdominal Pain (n=269)*	
Mesenteric Lymphadenitis	95 (35.3)
Gastroenteritis	74 (27.5)
Appendicitis	49 (18.2)
Gallstone	20 (7.4)
Transaminase Elevation	16 (5.9)
UTI	14 (5.1)
Pancreatitis	12 (4.5)
Intussusception	10 (3.7)
Kidney Stone	7 (2.6)
Ovarian Cyst	4 (1.5)
Ileus	3 (1.1)
Ovarian Torsion	1 (0,4)

*Some patients have more than one diagnosis, UTI: Urinary tract infection

In our study, it was found that 17.3% of the patients underwent CT. Based on the CT results, at least one pathological finding was detected in 63.2% of these patients. The median WBC count for all patients was determined to be 11,060 /mm³, with a median neutrophil count of 7,155 /mm³, and the NLR was calculated as 3.52 (Table 3).

Table 3. Values of laboratory parameters of patients

Parameters	Number of patients n=504	
	Mean±SD	Median (1st-3rd Quartiles)
WBC (/mm³)	12376.44±5615.66	11060.00 (8052.00-15475.00)
Neutrophil (/mm³)	8567.55±5290.50	7155.00 (4612.00-11635.00)
Lymphocyte (/mm³)	2734.49±2134.33	2250.00 (1460.00-3220.00)
Platelets (10^3/mm³)	339.632±105.0	337.000 (271.000-387.750)
MPV (fL)	9.85±0.83	9.80 (9.30-10.40)
Aspartate Aminotransferase (u/L)	53.49±210.17	23.00 (18.00-30.00)

Alanine Aminotransferase (u/L)	39.41±163.50	13.00 (10.00-18.00)
Gamma Glutamyl Transferase (u/L) (n=258)	25.02±54.31	12.00 (9.00-18.00)
Amylase (u/L) (n=265)	108.26±297.31	63.00 (46.50-81.00)
Lipase (U/L) (n=264)	103.21±531.01	19.00 (16.00-26.00)
Urea (mg/dL)	24.39±8.85	22.00 (18.00-28.00)
Creatinine (mg/dL)	0.53±0.27	0.50 (0.41-0.63)
CRP (mg/L)	28.78±59.84	4.50 (0-26.00)
Sedimentation Rate (mm/h) (n=472)	15.39±10.30	13.00 (9.00-18.00)
Neutrophil-Lymphocyte Ratio	5.24±6.10	3.52 (1.55-6.81)
MPV Platelet rate	0.03±0.01	0.02 (0.02-0.03)

*MPV: Mean platelet volume, WBC: White blood cell, CRP: C-reactive protein, NLR: Neutrophil-lymphocyte ratio, SD: Standard deviation

WBC counts, neutrophil, CRP levels, and NLR in patients with organic abdominal pain were found to be significantly higher compared to those with nonspecific abdominal pain (p<0.05) (Table 4). Additionally, patients requiring surgical intervention had higher age, NLR, WBC, and neutrophil counts, and significantly lower lymphocyte counts compared to those not requiring surgery (p<0.05) (Table 5). The NLR was 4.14 in patients with organic abdominal pain, while it was 2.73 in those with nonspecific abdominal pain. Among patients requiring surgery, the NLR was 5.33, whereas it was 3.28 in those not requiring surgical intervention.

Table 4. Comparison of age and laboratory parameters in patients with acute abdominal pain

Features	Nonspecific Abdominal Pain (n=235)	Organic Abdominal Pain (n=269)	p*
	Median (1st-3rd Quartiles)	Median (1st-3rd Quartiles)	
Age (years)	9.0 (5.0-14.0)	9.0 (5.0-14.0)	0.748
WBC (/mm³)	9820.0 (7490.0-14370.0)	12430.0 (8800.0-16725.0)	**<0.001**
Neutrophil (/mm³)	6010.0 (4030.0-10600.0)	7920.0 (5255.0-12195.0)	**<0.001**
Lymphocyte (/mm³))	2280.0 (1420.0-3270.0)	2150.0 (1460.0-3175.0)	0.644
Platelets (10^3/mm³)	341.0 (269.0-388.0)	335.0 (271.0-386.0)	0.961
MPV (fL)	9.8 (9.2-10.3)	9.8 (9.3-10.4)	0.507
CRP (mg/L)	2.0 (0-17.0)	9.0 (1.0-40.5)	**<0.001**
Sedimentation Rate (mm/h)	12.0 (8.7-18.0)	14.0 (9.0-19.0)	0.140
NLR	2.73 (1.37-6.29)	4.14 (1.96-7.34)	**0.013**
MPV/Platelet	0.029 (0.024-0.037)	0.029 (0.025-0.037)	0.960

*Mann-Whitney U test. MPV: Mean platelet volume, CRP: C-reactive protein, NLR: Neutrophil-lymphocyte ratio, WBC: White blood cell

Table 5. Comparison of age and laboratory parameters of patients requiring and not requiring surgical approach

Features	Surgical Diagnoses		
	Yes (n=63)	No (n=206)	p*
	Median (1st-3rd Quartiles)	Median (1st-3rd Quartiles)	
Age (years)	11.0 (7.0-15.0)	8.0 (4.0-13.0)	**0.001**
WBC (/mm³)	13880.0 (11320.0-17380.0)	11360.0 (8492.5-16272.5)	**0.009**
Neutrophil (/mm³)	10820.0 (7870.0-14470.0)	6750.0 (4742.5-11700.0)	**<0.001**
Lymphocyte (/mm³))	1890.0 (1270.0-2540.0)	2255.0 (1527.5-3380.0)	**0.008**
Platelets (10^3/mm³)	321.0 (265.0-365.0)	338.0 (273.2-397.2)	0.153
MPV (fL)	9.9 (9.5-10.4)	9.8 (9.2-10.5)	0.155
CRP (mg/L)	10.0 (2.0-50.0)	8.5 (1.0-33.2)	0.155
Sedimentation Rate (mm/h)	14.0 (9.0-18.0)	14.0 (9.0-19.0)	0.858
NLR	5.33 (3.77-9.11)	3.28 (1.44-6.76)	<0.001
MPV/Platelet	0.029 (0.026-0.037)	0.028 (0.024-0.036)	0.109

*Mann-Whitney U test. MPV: Mean platelet volume, CRP: C-reactive protein, NLR: Neutrophil-lymphocyte ratio, WBC: White blood cell

The median age of patients diagnosed with appendicitis was significantly higher compared to those with mesenteric lymphadenitis and nonspecific abdominal pain (p = 0.005). Additionally, the proportion of patients with a pediatric appendicitis score of 8 or higher was markedly greater in those diagnosed with appendicitis (p < 0.05). The NLR was 7.1 in patients with appendicitis, compared to 4.2 in those with mesenteric lymphadenitis and 2.7 in those with nonspecific abdominal pain. Furthermore, both the NLR and CRP levels were significantly higher in patients with appendicitis than in those with mesenteric lymphadenitis and nonspecific abdominal pain (p < 0.05) (Table 6). In contrast, no significant differences were observed in mean platelet volume (MPV) or MPV-to-platelet ratios.

Table 6. Comparison of patients with appendicitis, mesenteric lymphadenitis, and non-specific abdominal pain

Features	Patients with Appendicitis (n=46)	Patients with Mesenteric Lymphadenitis (n=88)	Nonspecific Abdominal Pain (n=235)	p
Age* (years)	12.0 (8.7-15.0)	8.0 (6.0-12.0)	9.0 (5.0-14.0)	0.005[a]
Gender, n (%)				
Male	29 (63.0)	44 (50.0)	119 (50.6)	0.278[b]
Female	17 (37.0)	44 (50.0)	116 (49.4)	
WBC (/mm³)	14670.0 (12610.0-17925.0)	10775.0 (7845.0-15805.0)	9820.0 (7490.0-14370.0)	<0.001[a]

Neutrophil (/mm³)	11450.0 (9445.0-14910.0)	7115.0 (4812.5-12445.0)	6010.0 (4030.0-10600.0)	<0.001 [a]
PAS, n (%)				
≤4 points	1 (2.2)	33 (37.5)	143 (60.9)	<0.001
5-7 points	22 (47.8)	51 (58.0)	86 (36.6)	
≥8 points	23 (50.0)	4 (4.5)	6 (2.6)	
MPV	10.0 (9.5-10.4)	9.7 (9.2-10.4)	9.8 (9.2-10.3)	0.255
Platelets (10^3/mm³)	316.5 (264.7-358.2)	329.0 (283.5-388.7)	341.0 (269.0-388.0)	0.187
MPV/Platelet	0.03 (0.02-0.03)	0.02 (0.02-0.03)	0.02 (0.02-0.03)	0.127
NLR	7.1 (4.2-11.3)	4.2 (1.9-7.7)	2.7 (1.3-6.2)	<0.001 [a]
CRP*	13.0 (3.0-50.2)	13.0 (2.0-33.7)	2.0 (0-17.0)	<0.001 [a]

* Median (1st-3rd quartile values are given. a Kruskal Wallis H test; b Ki kare test. PAS: Pediatric appendicitis score, MPV: Mean platelet volume, CRP: C-reactive protein, NLR: Neutrophil-lymphocyte ratio, WBC: White blood cell

In 6.1% of the 49 patients who underwent surgery with a preliminary diagnosis of appendicitis, the pathological results were inconsistent with the initial diagnosis. In the USG analysis of patients who had undergone an appendectomy, the appendix was not visualized in 34.7% of the cases. In 4.1% of the patients, the appendix diameter was found to be less than 6 mm, while in 61.2%, it was greater than 6 mm (Table 7). Of the 30 patients whose USG was consistent with acute appendicitis, the pathological diagnosis confirmed acute appendicitis in 28 cases. In 17 patients (34.7%) who underwent an appendectomy, the appendix could not be visualized by USG, and 16 of these were pathologically diagnosed with appendicitis. The sensitivity of USG in diagnosing appendicitis was calculated as 60.9%, specificity as 33.3%, positive predictive value (PPV) as 93.3%, and negative predictive value (NPV) as 5.3%. In all 19 patients evaluated by CT, the appendix diameter exceeded 6 mm, and the sensitivity of CT was 100%. For patients diagnosed with appendicitis who had a PAS score of 5 or higher, the sensitivity was 97.8% and the PPV was 93.8% (Table 8).

Table 7. Distribution of ultrasound, CT, and pathology results in patients with a preoperative diagnosis of appendicitis

Features	Patients with Preliminary Diagnosis of Appendicitis N=49
	n (%)
USG Non-visualized <6 mm ≥6 mm	 17 (34.7) 2 (4.1) 30 (61.2)
CT (n=19) ≥6 mm	 19 (100.0)
Pathological Examination Results Normal Appendix Consistent with Appendicitis	 3 (6.1) 46 (93.9)

CT: Computed tomography, USG: Ultrasonography

Table 8. Evaluation of patient's CT, USG, and PAS results according to the diagnosis of pathological appendicitis

	Pathological Examination Results		Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Features	**Normal Appendix**	**Consistent with Appendicitis**				
CT						
<6 mm	-	-	100.0	-	-	-
≥6 mm	-	19 (100.0)				
USG						
Non visualized/ ≤6mm	1 (33.3)	18 (39.1)	60.9	33.3	93.3	5.3
≥6 mm	2 (66.7)	28 (60.9)				
PAS						
PAS <5 point	-	1 (2.2)	97.8	0	93.8	0
PAS≥5 point	3 (100.0)	45 (97.8)				

PPV: Positive predictive value; NPV: Negative predictive value, PAS: Pediatric appendicitis score, CT: Computed tomography, USG: Ultrasonography

Discussion

Acute abdominal pain is typically categorized into two groups: cases where a clear diagnosis or structural problem can be identified immediately, and cases of acute non-specific abdominal pain. Non-specific abdominal pain accounts for 50-70% of cases (13). In Magnúsdóttir et al.'s study (14), this rate was found to be 40%, while Lee et al. (15) reported it as 45.4%. The most common causes identified were mesenteric lymphadenitis and appendicitis. In our study, 46.6% of the patients were diagnosed with non-specific abdominal pain, while 53.4% received a specific diagnosis.

Acute appendicitis occurs in approximately 1 in 1,000 individuals in the United States and is the most common surgical emergency in children, typically presenting in the second or third decade of life (7). The most frequent causes of acute abdominal pain in children are mesenteric lymphadenitis and acute appendicitis. Distinguishing between the symptoms of these two conditions can be challenging due to the children's ages and their ability to articulate symptoms. Mesenteric lymphadenitis is a significant clinical mimic of appendicitis and is frequently observed in negative surgical explorations (16). In our study, the most common diagnoses among our patients were mesenteric lymphadenitis, gastroenteritis, and appendicitis, with appendicitis identified as the most frequent surgical cause.

Acute gastroenteritis is a common condition in children and is one of the leading causes of hospitalization

in children under five years of age (17). In young children with acute abdominal pain, the first sign often associated with mucosal irritation is diarrhea (18). In our study, among patients with acute abdominal pain who underwent abdominal USG and were initially evaluated as having gastroenteritis, diagnoses of mesenteric lymphadenitis, appendicitis, and intussusception were made based on follow-up USG results. The possibility of an acute surgical condition should always be considered in patients presenting with symptoms of gastroenteritis.

Laboratory studies play a crucial role in the early diagnosis of patients presenting with acute abdominal pain. It has even been reported that certain laboratory tests can be beneficial in predicting outcomes in patients with diagnostic challenges. In the study by Harris et al. (19), it was found that WBC counts and CRP levels were significantly higher in patients with organic abdominal pain compared to those with non-specific abdominal pain. Similarly, Gurau et al. (4) demonstrated that increases in WBC and CRP levels, along with the NLR, enhanced the positive predictive value of the diagnosis in cases of acute abdominal pain and contributed to decision-making in situations requiring surgical intervention. In a meta-analysis conducted by Eun et al. (20) on 5,974 pediatric cases, the cut-off values for the NLR were reported to range between 2.5 and 6.14, while the study by Hajibandeh et al. (8) found that a ratio above 4.7 was a strong predictive factor for appendicitis. Furthermore, Toorenvliet et al. (21) noted higher WBC, neutrophil, and CRP levels in patients with appendicitis. However, in the study by Ozdamar and Karavaş (22), only the percentage of neutrophils was found to be significant, with no differences in WBC counts or CRP levels. In our study, patients with organic abdominal pain had significantly higher WBC, neutrophil, CRP levels, and NLR compared to those with non-specific abdominal pain. The NLR was found to be 5.33 in patients requiring surgical intervention and 3.28 in those not requiring surgery, with this difference being statistically significant. In patients diagnosed with appendicitis, the NLR was 7.1, significantly higher than in cases of mesenteric lymphadenitis and non-specific abdominal pain. Our findings align with the literature, suggesting that the neutrophil-to-lymphocyte ratio and leukocyte counts can be utilized in predicting the diagnosis of appendicitis.

In patients with acute appendicitis, the MPV is low, indicating platelet activation (23, 24). MPV levels should not be used to determine treatment options in pediatric patients, as no significant difference has been found compared to healthy controls (25). Biricik et al. (26) reported a negative correlation between platelet count and MPV, while Oktay et al. (27) suggested a weak relationship between leukocyte count and the MPV-to-platelet ratio, proposing that this ratio could be useful in diagnosing pediatric acute appendicitis. However, in our study, no significant differences were observed in MPV and the MPV-to-platelet ratio among patients diagnosed with appendicitis.

The diagnostic efficacy of USG in acute abdominal pain among children varies across different studies. Khalid et al. (28) reported that among patients evaluated with abdominal USG, the diagnosis rate was 45%, the rate of providing supportive information was 12%, and the overall efficacy was 57%. It has been determined that USG reduces the frequency of negative appendectomies, with negative appendectomy rates ranging from 5% to 10% (29). In our study, among the 49 patients operated on with a preliminary diagnosis of appendicitis, 6.1% had pathological findings that were inconsistent with the preliminary diagnosis. Baştuğ (30) found that in a study of 1,000 patients with acute abdominal pain evaluated with abdominal USG, the rate of CT scans was 4.5%, and the rate of pathological findings was 75.5%. Khan et al. (31) reported that in children presenting to emergency departments in the United States with abdominal pain, the CT scan rate was 14%, and the rate of pathological findings was 55.8%. In our study, 17.3% of patients underwent CT, and pathological findings were detected in 63.2% of these cases. The frequency of CT scans in our study exceeds the rates reported in the literature; we believe this may be attributed to the persistence of clinical suspicion despite the absence of pathological findings on USG, necessitating additional imaging methods to reach a diagnosis. Furthermore, due to the unavailability of pediatric surgery during off-hours, additional imaging techniques are utilized to confirm the diagnosis in patients with suspected surgical conditions.

Doria et al. (32) reported a sensitivity of 88% and specificity of 94% for USG in a meta-analysis involving 7,448 participants. Glass and Rangel (6) indicated that sensitivity rates ranged from 44% to 88%, while specificity varied between 90% and 97%. In another review, the sensitivity of US in children was found to be 96% with a specificity of 100% (33). Marcucci et al. (34) calculated the sensitivity of US at 52.8%, specificity at 83.3%, and PPV at 98.4%. In our study, the sensitivity of

USG for appendicitis was determined to be 60.9%, with a specificity of 33.3% and a PPV of 93.3%. The lower sensitivity and specificity levels of USG in our study compared to those in the literature may be attributed to factors such as the relatively small sample size and the experience of the USG operator.

In conclusion, the combined use of USG and the NLR plays a significant role in the accurate and timely diagnosis of acute abdominal pain in children. The findings of our study indicate that in cases where the appendix cannot be visualized via USG, leading to potential delays in the diagnostic process, the NLR and leukocytosis can serve as crucial biomarkers in situations requiring urgent surgical intervention.

Compliance with Ethicals Guidelines: The study was conducted with the approval of the Local Ethics Committee of the Ethics Committee of Necmettin Erbakan University, Faculty of Medicine (No: 2022/3685). All procedures performed in studies involving human participants were in accordance withunder the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflicts of Interest

There are no financial and nonfinancial conflicts of interest for any of the authors regarding specific financial interests that are relevant to the work conducted or reported in this manuscript.

Authors' Contributions

Conception: FA., AY,. and AOK.; Design: EB. and FA..; Supervision: EB., SB,. and FA..; Resource: FA., EB., AY., and AOK.; Materials: SB. and AA.., Data Collection and/or PProcessing: EB., FA., AOK,. and AA. ; Analysis and/or İlnterpretation: FA., EB,. and SB.; Literature RReview: FA., EB,. and SB.; Writinger: FA. and EB.; Critical Review: AY. and AA.

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