# Usefulness of cell ratios and the derived neutrophil-to-lymphocyte ratio in the diagnosis of pediatric acute appendicitis

J.C. Moreno-Alfonso, A. Molina Caballero, A. Pérez Martínez

*Pediatric Surgery Department. Hospital Universitario de Navarra. Pamplona (Spain).*

**ABSTRACT**

**Objective.** To analyze the accuracy of cell ratios in the diagnosis of pediatric acute appendicitis while introducing a new one –the derived neutrophil-to-lymphocyte ratio (dNLR).

**Materials and methods.** An observational, retrospective study of patients aged 0-15 years old diagnosed with acute appendicitis (AA) and with non-surgical abdominal pain (AP) treated in our institution from 2021 to 2022 was carried out. The neutrophil-to-lymphocyte ratio (NLR), monocyte-to-lymphocyte ratio (MLR), platelet-to-lymphocyte ratio (PLR), and dNLR were compared between groups.

**Results.** 98 AA patients (30% of whom were female; age: 10 ± 3.3 years) and 97 AP patients (53% of whom were male; age: 9.3 ± 3.7 years) were included. NLR, MLR, PLR, and dNLR values were higher in AA patients than in AP patients: 9.6 IQR (interquartile range) 9.5 vs. 3.3 IQR 5.3: p < 0.0001; 0.7 IQR 0.6 vs. 0.46 IQR 0.7: p < 0.023; 199.8 IQR 163.9 vs. 134.0 IQR 129.2: p < 0.0001; and 5.29 IQR 3.9 vs. 2.39 IQR 2.7; p < 0.0001, respectively. Sensitivity, specificity, positive-negative predictive value, area under the ROC curve, and dNLR cut-off point for AA diagnosis were 70%, 78%, 77-72%, 0.811, and 3.98, respectively.

**Conclusions.** Cell ratios are useful and cost-effective inflammatory parameters in the diagnosis of pediatric acute appendicitis. The results of this study suggest dNLR has the greatest clinical accuracy.

**KEY WORDS:** Appendicitis; Biomarkers; Pediatrics.

**UTILIDAD DE LOS ÍNDICES CELULARES Y EL ÍNDICE NEUTRÓFILO/LINFOCITO DERIVADO EN EL DIAGNÓSTICO DE LA APENDICITIS AGUDA PEDIÁTRICA**

**RESUMEN**

**Objetivo.** Analizar la precisión de los índices celulares en el diagnóstico de la apendicitis aguda pediátrica, introduciendo uno nuevo, el índice neutrófilo/linfocito derivado (INLd).

**Material y métodos.** Estudio retrospectivo observacional de los pacientes de 0-15 años diagnosticados de apendicitis aguda (AA) y con dolor abdominal no quirúrgico (DA) tratados en nuestro centro entre 2021-2022. Se comparó el índice neutrófilo/linfocito (INL), índice monocito/linfocito (IML), índice plaqueta/linfocito (IPL) y el INLd entre los grupos.

**Resultados.** Se incluyeron 98 casos con AA (30% mujeres, edad 10 ± 3,3 años) y 97 pacientes con DA (53% hombres, edad 9,3 ± 3,7 años). Los valores de INL, IML, IPL e INLd fueron mayores en pacientes con AA respecto a niños con DA: 9,6 rango intercuartil (RIC) 9,5 *vs.* 3,3 RIC 5,3: *p* = < 0,0001; 0,7 RIC 0,6 *vs.* 0,46 RIC 0,7: *p* = < 0,023; 199,8 RIC 163,9 *vs.* 134,0 RIC 129,2: *p* = < 0,0001; y 5,29 RIC 3,9 *vs.* 2,39 RIC 2,7: *p* = < 0,0001; respectivamente. La sensibilidad, especificidad, valor predictivo positivo-negativo, área bajo la curva *ROC* y el punto de corte del INLd para el diagnóstico de AA fue de 70%, 78%, 77-72%, 0,811 y 3,98; respectivamente.

**Conclusiones.** Los índices celulares son parámetros inflamatorios útiles y coste-efectivos que pueden contribuir al diagnóstico de la apendicitis aguda pediátrica. Los resultados de este estudio sugieren que el INLd es el de mayor precisión clínica.

**PALABRAS CLAVE:** Apendicitis; Biomarcadores; Pediatría.

## INTRODUCTION

Acute appendicitis (AA) is the most frequent surgical emergency in the pediatric population. It is the cause of abdominal pain in 8% of the patients presenting at the emergency department as a result of this symptom[1]. However, AA assessment can prove complex in children, especially in those under 5 years of age or intellectually disabled, with the resulting dilemma between omitting a

DOI: 10.54847/cp.2024.01.11

**Corresponding author:** Dr. Julio César Moreno Alfonso. Pediatric Surgery Department. Hospital Universitario de Navarra. Calle Irunlarrea, 3. 31008 Pamplona (Spain)
E-mail address: juliomoreno.md@gmail.com

*This work was presented at the 60th Congress of the Spanish Pediatric Surgery Society held in Valencia (Spain).*

*Date of submission:* April 2023 *Date of acceptance:* October 2023

surgical abdomen and indicating an unnecessary surgery that is not exempt from complications[2].

Apart from imaging studies, multiple inflammatory parameters have been used in clinical practice to diagnose acute appendicitis. Leukocyte, neutrophil, and acute phase reactant counts have traditionally been the most widely used ones. Nevertheless, given their diagnostic limitations, the usefulness of cell ratios achieved in routine studies such as blood tests –and namely the neutrophil-to-lymphocyte ratio (NLR) and the monocyte-to-lymphocyte ratio (MLR), among others[3]– has been recently analyzed. Similarly, the effectiveness of a new biomarker –the derived neutrophil-to-lymphocyte ratio (dNLR)– has been described in the diagnosis of inflammatory, infectious, and neoplastic conditions. However, to our knowledge, the role of dNLR in acute appendicitis has not been assessed yet[4].

Assuming that this new biomarker could stand as a useful tool in the diagnosis of acute appendicitis, this work analyzes the accuracy of dNLR in pediatric appendicitis and compares it with other cell ratios.

## MATERIALS AND METHODS

An observational, retrospective study of patients aged 0-15 years old undergoing surgery as a result of histologically confirmed acute appendicitis (AA) and of patients assessed due to non-surgical abdominal pain (AP) in a second-level pediatric hospital from December 2021 to July 2022 was carried out. Variables were collected from electronic medical records while analyzing age, sex, histological appendicitis type, weight in kilograms (kg), progression time in days (d), abdominal pain location (controls), final diagnosis (controls), and absolute leukocyte, lymphocyte, neutrophil, monocyte, and platelet counts, as well as neutrophil-to-lymphocyte, monocyte-to-lymphocyte, platelet-to-lymphocyte, and derived neutrophil-to-lymphocyte cell ratios. Cell counts were achieved using the Beckman Coulter hematology analyzer, and in all acute appendicitis cases, the pathologist was unaware of the results. Patients undergoing incidental appendectomy or with an incomplete medical history were excluded.

NLR, MLR, and platelet-to-lymphocyte ratio (PLR) were calculated by dividing the absolute neutrophil, monocyte, and platelet count, respectively, by the lymphocyte count. On the other hand, dNLR was achieved by dividing the neutrophil count by the difference between the leukocyte and the neutrophil count. The clinical diagnosis of acute appendicitis was based on medical history, physical exploration, and ultrasound and/or blood count findings, whereas the final diagnosis was achieved from the pathological analysis classified as congestive, phlegmonous, gangrenous, and perforated appendicitis, as well as peritonitis. The diagnosis of appendicular plastron was established during surgery whenever the cecal appendix was inflamed and covered by an inflammatory intestinal loop and/or omental mass. In addition, local peritonitis was defined as the purulent/fecaloid contamination of one or two quadrants of the abdominal cavity, and widespread peritonitis was defined as the presence of contamination in three or more quadrants. This classification was based on the World Society of Emergency Surgery's guidelines for diagnosis and treatment of acute appendicitis[5].

Qualitative variables were expressed as relative and absolute frequencies, whereas quantitative variables were featured as mean and standard deviation (SD) or median and interquartile range (IQR). The distribution of quantitative variables was determined using the Kolmogorov-Smirnov test to define the hypothesis testing method to be employed –Student's t-test for normal distribution variables and Mann-Whitney U test for non-normal distribution variables. Qualitative variables were analyzed using the chi-squared test. Statistical significance was established at $p < 0.05$. NLR, MLR, PLR, and dNLR were all assessed using the 2x2 contingency table to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likelihood ratios. Using the area under a receiver operating characteristic curve (AUC ROC), the optimal cut-off point for the diagnosis of acute appendicitis was achieved through Youden's index (sensitivity + specificity - 1). Considering that AUC ROC is a representation of diagnostic test performance, with values ranging from 0 to 1 –the closer to 1, the more performant–, test accuracy was classified as poor (0.5-0.6), fair (0.61-0.7), acceptable (0.71-0.8), good (0.81-0.9), and outstanding (>0.9).

Anonymized data was inserted into a Microsoft® Excel (version 16.66.1) table and analyzed using the SPSS® (IBM Corp., Armonk, NY, USA) and Epidat (version 3.1; Galician Department of Health, Spain) statistical software. This work was approved by the Clinical Research Ethics Committee (under registry number 2023/390894) and developed according to the Standards for Reporting Diagnostic Accuracy Studies[6].

## RESULTS

A total of 195 patients were included. 98 patients had acute appendicitis, and 97 patients had non-surgical abdominal pain (Fig. 1). 30.6% of AA cases were female vs. 45.4% in the AP group ($p = 0.034$), with a mean age of $10 \pm 3.3$ years vs. $9.3 \pm 3.7$ years; $p = 0.205$, respectively. Mean weight of AA patients was $39.4 \pm 17.1$ kg vs. $35.3 \pm 14.9$ kg in AP patients ($p = 0.077$). The primary histological findings in appendectomies were phlegmonous inflammation in 28.6% of the cases (n = 28/98), gangrene in 8.2% (n = 8/98), and perforation in 13.3% (n = 13/98), whereas the main surgical findings were appendicular plastron in 5% (n = 5/98), local peritonitis in 25% (n = 25/98), and widespread peritonitis in 19.4% (n = 19/98). 71.2%

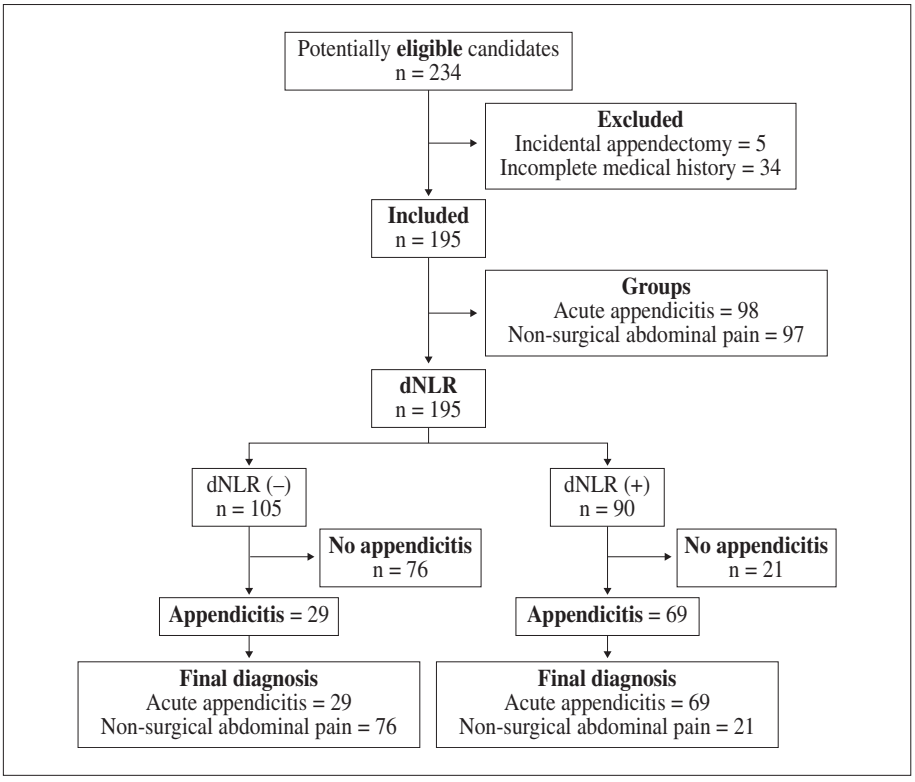


**Figure 1.** Flow diagram of the population analyzed. According to the cut-off point established for the derived neutrophil-to-lymphocyte ratio (dNLR), values ≥ 3.988 were considered positive (+), and the pathological report was used as a reference in the diagnosis of acute appendicitis.

of the surgeries were transumbilical and video-assisted, 6% were laparoscopic, 9.8% were Rocky-Davis laparotomies, and 13% required conversion to open surgery from a transumbilical access.

In the AP group, progression time was 1.6 days (IQR: 2), and the primary locations were the right iliac fossa (38%, n=37/97), periumbilical location (15.5%, n=15/97), diffuse location (12.4%, n=12/97), migration to the right iliac fossa from another location (12.4%, n=12/97), and widespread location (7.2%, n=7/97), with the remaining patients having pain in other areas. Regarding the final diagnosis of AP, 64.9% of the patients were diagnosed with unspecific abdominal pain (n=63/97), 6.2% with gastroenteritis, 5.2% with cecal ileitis, 4.1% with mesenteric adenitis, and 3.2% with ultrasound incipient appendicitis. The remaining individuals had abdominal pain associated with respiratory (COVID-19, upper airway viral infections, pneumonia, streptococcal pharyngitis), biliary, and ovarian conditions, as well as inflammatory bowel disease.

Leukocyte and neutrophil counts were significantly higher in AA patients than in AP patients ($p<0.0001$), whereas the absolute lymphocyte count was higher in the second group, without statistical differences in terms of monocyte and platelet counts ($p>0.05$). In spite of this, all cell ratios were higher in AA patients than in AP patients (Table 1).

dNLR was the cell index with a better AUC ROC for the diagnosis of acute appendicitis, with a sensitivity of 70% (95% confidence interval [95%CI]: 61-79%), a specificity of 78% (95%CI: 70-87%), a PPV of 77% (95%CI: 68-85%), a NPV of 72% (95%CI: 64-81%), a positive likelihood ratio (PLIKR) of 3.25 (95%CI: 2.18-4.85), a negative likelihood ratio (NLIKR) of 0.38 (95%CI: 0.27-0.52), a 76% (95%CI: 69-83%) post-test probability of a positive result, and a 27% (95%CI: 21-34%) post-test probability of a negative result (Table 2). However, there were no statistical differences between dNLR's and NLR's diagnostic performance ($p=0.809$).

## DISCUSSION

Acute appendicitis is the most frequent surgical emergency in the pediatric population. It typically occurs with hyporexia, periumbilical pain with migration to the right iliac fossa, and painful decompression of McBurney's point (Blumberg's sign)[7]. Leukocytosis and slightly increased C-reactive protein levels are also frequent. Nevertheless, in certain situations, diagnosis may prove uneasy, and even with the use of validated scores, false positive rate has been reported to be as high as 35%[8,9]. Indeed, in our study, nearly 13% of the patients with non-surgical abdominal pain had periumbilical pain with migration to the right iliac fossa, and up to 3.2% were diagnosed with ultrasound incipient appendicitis. As a result of this, and also due to the high risk (17-33%) of appendicular perforation and

**Table 1. Blood cell count and cell ratio values in the population analyzed.**

| | *Appendicitis* | *Abdominal pain* | *p value* |
|---|---|---|---|
| Leukocytes | 16,468/mm³ ± 5,224 | 11,251/mm³ ± 4,207 | <0.0001 |
| Lymphocytes | 1,574/mm³ ± 859 | 2,254/mm³ ± 1,125 | <0.0001 |
| Neutrophils | 13,651/mm³ ± 4,997 | 7,771/mm³ ± 3,879 | <0.0001 |
| Monocytes | 987/mm³ ± 527 | 860/mm³ ± 395 | 0.060 |
| Platelets | 292,969/mm³ ± 73,016 | 298,123/mm³ ± 86,877 | 0.654 |
| NLR* | 9.6 ± 9.5 | 3.3 ± 5.3 | <0.0001 |
| MLR* | 0.7 ± 0.6 | 0.46 ± 0.7 | <0.023 |
| PLR* | 199.8 ± 163.9 | 134 ± 129.2 | <0.0001 |
| dNLR* | 5.2 ± 3.9 | 2.3 ± 2.7 | <0.0001 |

*mm³ = cubic millimeter. All values are expressed as mean and standard deviation, except for those with an asterisk (*), which are featured as median and interquartile range.*

**Table 2. AUC ROC and accuracy of every ratio assessed in the diagnosis of acute appendicitis.**

| | *AUC* | *Cut-off p.* | *Sensit.* | *Specif.* | *PPV* | *NPV* | *PLIKR* | *NLIKR* | *p value* |
|---|---|---|---|---|---|---|---|---|---|
| NLR | 0.801 | 5.65 | 79% | 68% | 71% | 76% | 2.46 | 0.31 | <0.0001 |
| MLR | 0.595 | 0.31 | 83% | 37% | 57% | 68% | 1.31 | 0.47 | <0.023 |
| PLR | 0.672 | 134.12 | 79% | 51% | 62% | 70% | 1.59 | 0.42 | <0.0001 |
| dNLR | 0.811 | 3.988 | 70% | 78% | 77% | 72% | 3.25 | 0.38 | <0.0001 |

a negative laparotomy rate of 3-54%, auxiliary diagnostic biomarkers such as cell ratios have been subject to research[10]. This work assessed the role of certain well-known parameters in the diagnosis of acute appendicitis, such as the neutrophil-to-lymphocyte, monocyte-to-lymphocyte, and platelet-to-lymphocyte ratios, while introducing a new one that had not been previously described in the pediatric population –the derived neutrophil-to-lymphocyte ratio. The latter was found to be more performant.

Neutrophils are polymorphonuclear leukocytes emerging from the common myeloid progenitor. Thanks to their diapedesis capacity, they play an important role in inflammation, macrophage recruitment, and immune system activation[11]. They respond to humoral stimuli such as cytokines, granulocyte colony stimulating factors, and bacterial and fungal antigenic components[12]. In the immunological reaction initiated following appendicular obstruction, the liberation of proinflammatory cytokines increases the neutrophil count in the peripheral blood and the site of the aggression, which can be easily quantified through a hemogram. Various studies have analyzed the usefulness of NLR in the diagnosis of acute appendicitis, positing that it could be more accurate than the isolated neutrophil count, given that it takes the lymphocytic dynamic into account[13,14]. Based on this physiopathological argumentation, and given that the myeloid-granulocyte line is the primary inflammatory response in appendicitis, we assumed dNLR could be an equally –or even more– precise marker than the aforementioned ones, since it is unrelated to the lymphocyte count, which can be altered in an unspecific fashion as a result of various stimuli.

Duman et al. studied the role of NLR in the diagnosis of appendicitis in children, with mean values of 11 in patients with non-complicated appendicitis, and up to 13.4 in patients with perforated appendicitis[15]. These values are higher than those found in our population with appendicitis (9.6). However, the cut-off point established by Duman et al. was 4.4 vs. 5.6 in our series. We believe our cut-off point was higher as a result of the great number of patients with advanced appendicitis (62.7%, n=62/98). In addition, a meta-analysis of 5,974 children with acute appendicitis demonstrated that the cut-off point of NLR is significantly variable, with values ranging between 2.5 and 6.1[16]. In that study, the overall sensitivity of NLR was 82%, with a specificity of 76%, slightly higher than in our study (79% and 68%, respectively), but with a similar AUC –0.86 vs. 0.80 in our series. These differences are most likely due to the variability of the lymphocyte and neutrophil counts in the various age groups, since these numbers are only stable after puberty. In order to establish benchmark values for cell ratios in the pediatric population, Mossman et al. analyzed more than 60,000 samples while calculating the

neutrophil-to-lymphocyte, the lymphocyte-to-monocyte, and the platelet-to-lymphocyte ratios. They found these ratios were significantly variable, in particular NLR in the first two years of life, with a progressive increase and a new fluctuation peak after puberty. This can be explained by the increase in the neutrophil count that occurs between the neonatal period and adolescence, and also by the progressive reduction in the lymphocyte count from birth to the age of 18 years old[5]. PLR results were similar, with a progressive increase with age in spite of the reduction in neonatal thrombocytosis, since lymphocytosis progressively decreased. Hence the hypothesis that dNLR may prove useful, since it is less variable as it is unrelated to lymphocytes[5].

Another parameter assessed was MLR. Its diagnostic usefulness in appendicitis was compared with other biomarkers, including NLR. Accuracy demonstrated to be high, with an AUC ROC of 0.798, a sensitivity of 75%, and a specificity of 72%. However, our results were significantly different, and it is worth noting that, in our series, MLR was the inflammatory parameter with less diagnostic capacity –AUC ROC of 0.596, sensitivity of 83%, and specificity of 37%[15]. Apart from the influence of age differences among participants on these discrepancies, the authors of this work do not mention the method used to select the cut-off point, which has a serious impact on test performance and can be a cause of bias. These inconsistences among the various studies have generated interest in other markers. Considering that the inflammatory cascade sparks platelet activation, the diagnostic capacity of PLR in acute appendicitis was assessed, with an AUC of 0.660, a sensitivity of 64%, a specificity of 79%, and a cut-off point of 149.2[17]. These results are comparable with ours –AUC of 0.672, sensitivity of 79%, and specificity of 51%, but with a slightly lower cut-off point (134.1).

Finally, in our study, dNLR was the biomarker with a better AUC ROC for the diagnosis of acute appendicitis (Fig. 1), with a sensitivity of 70%, a specificity of 78%, and a positive predictive value of 77%. Unfortunately, these results cannot be contrasted, since there are currently no similar studies in the pediatric population. However, Asghar et al. studied the usefulness of dNLR as a predictor of severity and outcomes of COVID-19 in a 1,000-individual sample, and reported a correlation with ICU stay, death, and need for invasive ventilation ($p<0.05$)[18]. Surprisingly, in spite of the intense inflammatory response caused by COVID-19, the cut-off point turned out to be 2.63 –lower than that established for the diagnosis of appendicitis in our study (3.98). This could be explained by the viral etiology of COVID-19 and the fact its immune response is primarily lymphocytic, whereas in acute appendicitis, there is often a local infectious component involving the intestinal bacterial flora[19,20]. In this very study, NLR had a better AUC than dNLR, but the latter showed greater sensitivity and negative likelihood ratio. This is consistent with our findings and demonstrates the usefulness of dNLR in the decision-making process and the indication of additional studies. The usefulness of dNLR has also been proven in other acute and chronic inflammatory conditions, cardiovascular diseases, and as a prognostic factor in various types of cancer[21-23].

This work has the limitations inherent to a retrospective study and the variability of the sample in terms of social and demographic characteristics. Given that progression time of abdominal pain was not recorded in patients with appendicitis, correlation with dNLR values could not be established, but it is an interesting aspect to probe on in the future. To our knowledge, this is the first description of this biomarker in the diagnosis of pediatric acute appendicitis, which means prospective studies with a larger patient cohort are required to contrast our results.

In conclusion, cell ratios are useful and cost-effective inflammatory parameters in the diagnosis of acute appendicitis. The results of this study suggest the derived neutrophil-to-lymphocyte ratio is a novel biomarker with a good predictive capacity and little variability, which means it could stand as an auxiliary diagnostic tool to help the physician decide when to conduct an imaging test in situations with unclear symptoms or unspecific physical exploration.

## REFERENCES


1. Genzor SJ, Rodríguez JM, Giménez T, Vallejo C, Aguirre N, Miguelena JM. Ultrasonography and the Alvarado score in the diagnosis of acute appendicitis: impact on the negative appendectomy rate. Emergencias. 2016; 28: 396-9.
2. Lee SL, Stark R, Yaghoubian A, Shekherdimian S, Kaji A. Does age affect the outcomes and management of pediatric appendicitis? J Pediatr Surg. 2011; 46: 2342-5.
3. Yazici M, Ozkisacik S, Oztan MO, Gürsoy H. Neutrophil/lymphocyte ratio in the diagnosis of childhood appendicitis. Turk J Pediatr. 2010; 52: 400-3.
4. Song S, Li C, Li S, Gao H, Lan X, Xue Y. Derived neutrophil to lymphocyte ratio and monocyte to lymphocyte ratio may be better biomarkers for predicting overall survival of patients with advanced gastric cancer. Onco Targets Ther. 2017; 10: 3145-54.
5. Moosmann J, Krusemark A, Dittrich S, Ammer T, Rauh M, Woelfle J, et al. Age- and sex-specific pediatric reference intervals for neutrophil-to-lymphocyte ratio, lymphocyte-to-monocyte ratio, and platelet-to-lymphocyte ratio. Int J Lab Hematol. 2022; 44: 296-301.
6. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg. 2020; 15: 27.
7. Moreno-Alfonso JC, Ayuso L, Hernández S, Arredondo J, Ros R, Pérez A. Urachal remnant and acute abdomen: when it's not what it seems. An Sist Sanit Navar. 2022; 45: e1026.
8. Bansal S, Banever GT, Karrer FM, Partrick DA. Appendicitis in children less than 5 years old: influence of age on presentation and outcome. Am J Surg. 2012; 204: 1031-5.

9. Kulik DM, Uleryk EM, Maguire JL. Does this child have appendicitis? A systematic review of clinical prediction rules for children with acute abdominal pain. J Clin Epidemiol. 2013; 66: 95-104.
10. Tseng Y-C, Lee M-S, Chang Y-J, Wu H-P. Acute abdomen in pediatric patients admitted to the pediatric emergency department. Pediatr Neonatol. 2008; 49: 126-34.
11. Selders GS, Fetz AE, Radic MZ, Bowlin GL. An overview of the role of neutrophils in innate immunity, inflammation and host-biomaterial integration. Regen Biomater. 2017; 4: 55-68.
12. Dale DC, Boxer L, Liles WC. The phagocytes: neutrophils and monocytes. Blood. 2008; 112: 935-45.
13. Kocaman OH, Yagmur I, Günendi T, Demir M, Tunçekin A, Boleken ME. Can neutrophil-lymphocyte ratio in complete blood count help in the differential diagnosis between acute appendicitis and right ureteral stones in pediatric age groups? Cureus. 2022; 14: e23866.
14. Yazar FM, Bakacak M, Emre A, Urfalıoglu A, Serin S, Cengiz E, et al. Predictive role of neutrophil-to-lymphocyte and platelet-to-lymphocyte ratios for diagnosis of acute appendicitis during pregnancy. Kaohsiung J Med Sci. 2015; 31: 591-6.
15. Duman L, Karaibrahimoglu A, Büyükyavuz BI, Savas MÇ. Diagnostic value of monocyte-to-lymphocyte ratio against other biomarkers in children with appendicitis. Pediatr Emerg Care. 2022; 38: e739-42.
16. Eun S, Ho IG, Bae GE, Kim H, Koo CM, Kim MK, et al. Neutrophil-to-lymphocyte ratio for the diagnosis of pediatric acute appendicitis: a systematic review and meta-analysis. Eur Rev Med Pharmacol Sci. 2021; 25: 7097-107.
17. Ayeni A, Mahmood F, Mustafa A, Mcleish B, Kulkarni V, Singhal S, et al. Predicting the severity of acute appendicitis in children using neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR). Cureus. 2022; 14: e28619.
18. Asghar MS, Akram M, Yasmin F, Najeeb H, Naeem U, Gaddam M, et al. Comparative analysis of neutrophil to lymphocyte ratio and derived neutrophil to lymphocyte ratio with respect to outcomes of in-hospital coronavirus disease 2019 patients: A retrospective study. Front Med (Lausanne). 2022; 9: 951556.
19. Abdul Jawad K, Qian S, Vasileiou G, Larentzakis A, Rattan R, Dodgion C, et al. Microbial epidemiology of acute and perforated appendicitis: A post-hoc analysis of an EAST Multicenter Study. J Surg Res. 2022; 269: 69-75.
20. Tamura R, Nakamura K, Hirotani T, Yasui Y, Okajima H. Differences in isolated bacteria between perforated and non-perforated appendicitis: an analysis of 680 consecutive appendicectomies in a single institution. Pediatr Surg Int. 2022; 38: 1887-93.
21. Szkandera J, Gerger A, Liegl-Atzwanger B, Stotz M, Samonigg H, Friesenbichler J, et al. The derived neutrophil/lymphocyte ratio predicts poor clinical outcome in soft tissue sarcoma patients. Am J Surg. 2015; 210: 111-6.
22. Tanacan E, Dinçer Rota D, Oktem R, Erdogan FG. The correlation of systemic immune-inflammation index, neutrophil-to-lymphocyte ratio, derived neutrophil-to-lymphocyte ratio, and platelet-to-lymphocyte ratio with disease severity in recurrent aphthous stomatitis. J Cosmet Dermatol. 2022; 21: 4858-63.
23. Liu G-Q, Zhang W-J, Shangguan J-H, Zhu X-D, Wang W, Guo Q-Q, et al. Association of derived neutrophil-to-lymphocyte ratio with prognosis of coronary heart disease after PCI. Front Cardiovasc Med. 2021; 8: 705862.