Journal of Paediatric Surgeons of Bangladesh (2022) Vol. 13 (1 & 2)
Official Journal of the Association of Paediatric Surgeons of Bangladesh

DOI: https://doi.org/10.3329/jpsb.v.13i1.87414

Journal of Paediatric Surgeons of Bangladesh

Original Article

Assessment Of the Complicated Appendicitis in Children by Using Paediatric Appendicitis Score and Neutrophil to Lymphocyte Ratio

Ali F[1], Chowdhury ASMLH[2], Muhmmod S[3], Alam MJ[4], Masud SA[5]

Abstract

Background: Background: Acute appendicitis is one of the most common causes of acute abdomen, which occurs in almost all age groups and especially in childhood. In many cases, the symptoms are atypical or equivocal and require laboratory investigations or imaging modalities to support or rule out the diagnosis.

Objective: This study was conducted with an objective to assess the accuracy of neutrophil-lymphocyte ratio (NLR) and Paediatric Appendicitis Score (PAS) for discriminating simple and complicated appendicitis in children.

Methods: This Cross-sectional analytic type study was conducted in Paediatric Surgery Department, Mymensingh Medical College Hospital from January, 2021 to June, 2023. Patients with appendicitis who admitted in the Paediatric surgery Department, Mymensingh Medical College Hospital were included according to inclusion criteria. After taking proper history, relevant investigations were done and peri-operative findings were observed and the resected appendix sent for histopathology. Recorded data were processed by computer and were presented by tables, diagrams and graphs based on data nature. The significance of this study was tested statistical ly by using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV). Ethical permission was taken IRB from Mymensingh Medical College.

Result: A total of 100 patients were enrolled in this study, most of the patients were in age group 6 to 10 years. Males (58%) were predominant than females (42%). PAS score was significantly higher in complicated appendicitis patients (7.31 ± 1.55) than simple appendicitis patients (5.24 ± 1.60) ($p < 0.001$). NLR was also higher in complicated appendicitis patients (5.12 ± 2.41) than simple appendicitis patients (4.24 ± 3.09), but the difference was not statistically significant ($p = 0.112$). The optimum cut-off levels for PAS is 5.5 with sensitivity of 86.3%, specificity of 65.3%, PPV of 72.1% and NPV of 82.1%. The area under the ROC curve was 0.822. The optimum cut-off levels for NLR is 3.87 with sensitivity of 76.5%, specificity of 71.4%, PPV of 73.6% and NPV of 74.5%. The area under the ROC curve was 0.728.

Conclusion: According to the findings of the study, both PAS and NLR can be used to identify complicated appendicitis. PAS was more sensitive, while NLR was more specific.

Key word: Acute appendicitis, neutrophil to lymphocyte ratio, Paediatric Appendicitis Score.

1. Dr. Farzana Ali
Indoor Medical Officer (Paediatric Surgery), Dhaka Medical College Hospital, Dhaka, Bangladesh
2. Dr. A.S.M Lokman Hossain Chowdhury
Professor, Department of Paediatric Surgery, Community Based Medical College Hospital, Mymensingh, Bangladesh
3. Dr. Shakil Muhmmod
Registrar (Paediatric Surgery), Dinajpur Medical College Hospital, Dinajpur, Bangladesh
4. Dr.Md. Jahangir Alam
Assistant Professor, Department of Paediatric Surgery, Gonoshasthaya Samaj Vittik Medical College, Dhaka, Bangladesh
5. Dr. Sadruddin Al Masud
Associate Professor, Department of Paediatric Surgery, Dhaka Medical College Hospital, Dhaka, Bangladesh

Correspondence to: Dr. Farzana Ali
Indoor Medical Officer (Paediatric Surgery)
Dhaka Medical College Hospital, Dhaka, Bangladesh
E-mail: dr.farzana1992@gmail.com

Introduction:

Acute appendicitis (AA) is a common surgical condition that can affect individuals of any age, with children being particularly susceptible. It is one of the most frequent causes of acute abdomen, with a lifetime incidence of approximately 7% and a perforation rate of up to 20% [1]. Despite classical symptoms and clinical findings, early diagnosis can be challenging. Diagnosis relies on clinical assessment, laboratory tests, imaging, and scoring systems, yet early identification remains difficult. Computed tomography (CT) is highly accurate but is costly, less available, and exposes patients to radiation [2]. No fully reliable method exists for early-stage appendicitis diagnosis. Clinical scoring systems, such as the Alvarado score and Paediatric Appendicitis Score (PAS), aim to improve diagnostic accuracy. However, these scores may be limited in

children, especially when patients are too young to communicate symptoms effectively, and they cannot reliably distinguish between simple and complicated appendicitis [3,4]. The PAS, developed specifically for children, has demonstrated good performance in predicting appendicitis. Scores ≤2 can rule out the disease, while scores ≥7 predict its presence; scores between 3 and 6 often require further imaging [5]. Laboratory parameters such as white blood cell count (WBC) and absolute neutrophil count (ANC) are commonly used but show variable sensitivity and specificity. Leukocytosis may be absent in up to 20% of children with confirmed appendicitis, and reported sensitivity and specificity range from 70–80% and 60–68% for WBC, and 59–97% and 51–90% for ANC [4]. These variations often reflect differences in pre-test probability and the clinical setting. Appendicitis severity classification varies by region; Western countries often use focal, suppurative, or gangrenous categories, whereas Japan uses catarrhal, phlegmonous, or gangrenous types, which may better correlate with inflammatory markers such as neutrophil-to-lymphocyte ratio (NLR), platelet count, and WBC count. NLR has been suggested as a sensitive marker for inflammation, often outperforming WBC counts, with a value >3.5 indicating potential appendicitis in children [6]. Neutrophilia combined with lymphopenia, especially in gangrenous appendicitis, contributes to elevated NLR [7]. Accurate and timely diagnosis reduces perforation risk and negative appendectomy rates. While NLR has been studied in adults as a diagnostic tool, its relevance in children remains under investigation due to differences in immunological and anatomical responses [8]. This study aimed to evaluate the diagnostic value of the Paediatric Appendicitis Score and neutrophil-lymphocyte ratio in identifying complicated appendicitis in children.

Materials and Methods

Study Design: This was a cross-sectional analytic study.

Place and Period of Study: The study was conducted in the Department of Paediatric Surgery, Mymensingh Medical College Hospital, Mymensingh, over two years and six months, from January 2021 to June 2023.

Study Population: Patients under 18 years of age with appendicitis admitted to the Paediatric Surgery Department were included.

Sample Size Determination: The sample size was calculated using the formula: n=(Z^2 pq)/d^2, where Z = 1.96 (95% confidence level), p = 0.07 (estimated prevalence of appendicitis), q = 1-p, and d = 0.05 (acceptable error). Approximately 100 patients were included.

Sampling Technique: Patients were selected purposively based on inclusion and exclusion criteria.

Selection Criteria:

Inclusion: Patients under 18 years with appendicitis admitted to the Paediatric Surgery Department.

Exclusion: Patients with hematological diseases, chronic inflammatory or autoimmune disorders, and recurrent appendicitis.

Study Procedure:

Eligible patients were identified, and demographic data, hospitalization time, neutrophil and lymphocyte counts were recorded. Histopathology was considered the gold standard for diagnosis. Patients were classified as having simple appendicitis (transmural inflammation, ulceration, with/without extramural pus) or complicated appendicitis (transmural inflammation with necrosis or perforation). The neutrophil-to-lymphocyte ratio (NLR) was calculated by dividing neutrophil count by lymphocyte count.

Data Collection:

Data were recorded using a predesigned questionnaire, including socio-demographic and clinical information.

Statistical Analysis:

Data were compiled and analyzed using SPSS 23. Qualitative data were expressed as frequency and percentage, and quantitative data as mean ± SD. Student's t-test was used for quantitative variables, and Chi-square test for qualitative variables. Receiver operating characteristic (ROC) curve analysis assessed diagnostic utility. A p-value <0.05 was considered significant. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and Youden index were calculated using standard formulas, considering histopathology as the gold standard:

Sensitivity= (True positive)/(True positive + False negative) × 100

Specificity= (True negative)/(True negative + False positive) × 100

PPV= (True positive)/(True positive + False positive) × 100

NPV= (True negative)/(True negative + False negative) ×100

Youden Index = Sensitivity + Specificity − 1

Results

This cross-sectional analytic type study was conducted on 100 patients under 18 years old with appendicitis who were admitted at the Department of Paediatric Surgery, Mymensingh Medical College Hospital, Mymensingh to assess the complicated appendicitis in children by using paediatric appendicitis score and neutrophil to lymphocyte ratio. The results were as follows:

Table 1: Age-wise distribution of the study subjects (n=100)

Age in years	Frequency	Percentage
≤5	14	14.0
6 - 10	64	64.0
11 - 16	22	22.0

Table 1 showed age-wise distribution of the study subjects. Most of the patients were in age group 6 to 10 years.

Table 2: Gender-wise distribution of the study subjects (n=100)

Gender	Frequency	Percentage
Male	58	58.0
Female	42	42.0

Table 2 showed gender-wise distribution of the study subjects. Males (58%) were predominant than females (42%).

Table 3: Paediatric appendicitis score of the study subjects (n=100)

Paediatric Appendicitis Score	Mean±SD
Elevated temperature >38°C	0.72 ± 0.45
Coughing, hopping, percussion, tenderness in right lower quadrant	0.48 ± 0.86
Right lower quadrant tenderness	1.96 ± 0.28
Nausea/Vomiting	0.94 ± 0.24
Anorexia	0.44 ± 0.50
Migration of pain	0.32 ± 0.47
Increased leukocyte count	0.58 ± 0.50
Neutrophilia	0.86 ± 0.35
Total	6.30 ± 1.88

Table 3 showed paediatric appendicitis score (PAS) of the study subjects. Mean PAS was 6.30 ± 1.88.

Table 4: Paediatric appendicitis score (PAS) and Neutrophil-Lymphocyte Ratio (NLR) in patients with complicated and simple appendicitis (n=100)

	Complicated appendicitis (Mean ± SD)	Simple appendicitis (Mean ± SD)	Total (Mean ± SD)	p-value
PAS	7.31 ± 1.55	5.24 ± 1.60	6.30 ± 1.88	<0.001
NLR	5.12 ± 2.41	4.24 ± 3.09	4.69 ± 2.79	0.112

Table 4 showed Paediatric appendicitis score (PAS) and Neutrophil-Lymphocyte Ratio (NLR) in patients with complicated and simple appendicitis. PAS score was higher in complicated appendicitis patients (7.31 ± 1.55) than simple appendicitis patients (5.24 ± 1.60) ($p < 0.001$) and statistically significant. NLR was also higher in complicated appendicitis patients (5.12 ± 2.41) than simple appendicitis patients (4.24 ± 3.09), but the difference was not statistically significant ($p = 0.112$).

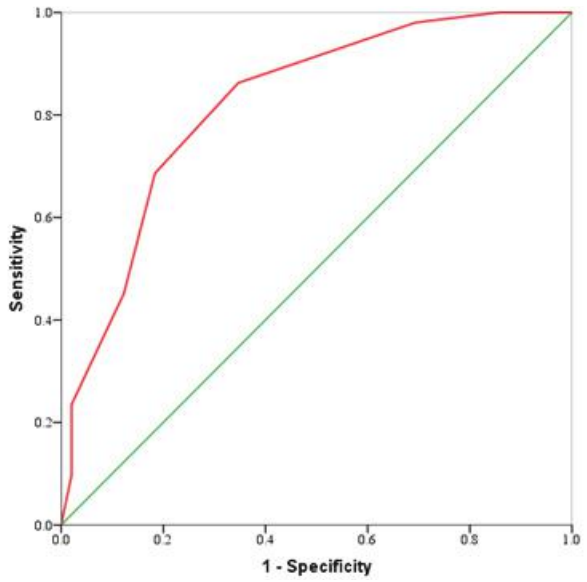

Figure 1: PAS receiver operating characteristic (ROC) curve for the differentiation of complicated appendicitis from simple appendicitis.

ROC plots of PAS is shown. The optimum cut-off level was determined by selecting points of test values that provided the greatest sum of sensitivity and specificity. The optimum cut-off levels for PAS is 5.5 with sensitivity of 86.3%, specificity of 65.3%, PPV of 72.1% and

NPV of 82.1%. The area under the ROC curve was 0.822 (95% CI 0.739 – 0.904).

Table 5: Sensitivity, Specificity, PPV and NPV of PAS at different cut-off point in the differentiation of complicated appendicitis from simple appendicitis (n=100)

PAS	Sensitivity	Specificity	PPV	NPV	Youden Index
3.50	1.000	0.143	0.548	1.000	0.143
4.50	0.980	0.306	0.595	0.936	0.287
5.50	0.863	0.653	0.721	0.821	0.516
6.50	0.686	0.816	0.795	0.714	0.503
7.50	0.451	0.878	0.793	0.606	0.329
8.50	0.235	0.980	0.923	0.552	0.215

Table 6: True positive, false positive, false negative and true negative value of PAS in differentiating complicated appendicitis from simple appendicitis at a cut-off point >5.5

PAS	Complicated appendicitis	Simple appendicitis	p-value
≥5.5	44 (86.3) TP	17 (34.7) FP	<0.001
<5.5	7 (13.7) FN	32 (65.3) TN	

Among 51 complicated appendicitis patients 44 had PAS ≥ 5.5 and 7 had PAS < 5.5, they were true positive and false negative respectively. Among 49 simple appendicitis patients 17 had PAS ≥ 5.5 and 32 had PAS < 5.5, they were false positive and true negative respectively.

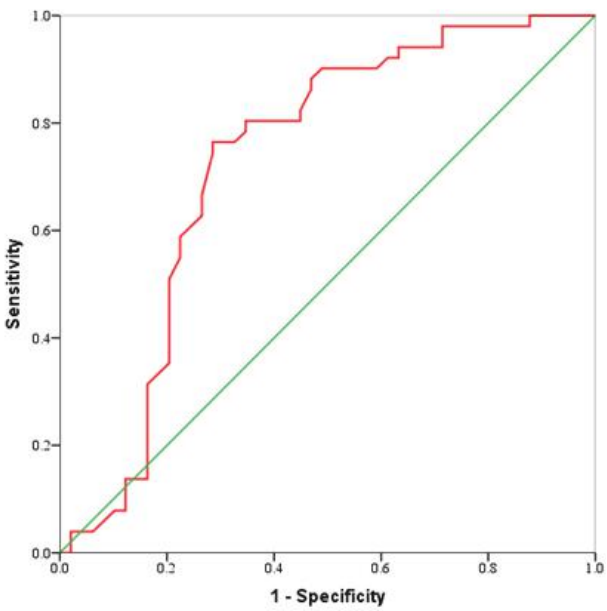

Figure 2: Neutrophil-Lymphocyte Ratio (NLR) receiver operating characteristic (ROC) curve for the differentiation of complicated appendicitis from simple appendicitis.

ROC plots of NLR is shown. The optimum cut-off level was determined by selecting points of test values that provided the greatest sum of sensitivity and specificity. The optimum cut-off levels for NLR is 3.87 with sensitivity of 76.5%, specificity of 71.4%, PPV of 73.6% and NPV of 74.5%. The area under the ROC curve was 0.728 (95% CI 0.623 – 0.833).

Table 7: Sensitivity, Specificity, PPV and NPV of NLR at different cut-off point in the differentiation of complicated appendicitis from simple appendicitis (n=100)

NLR	Sensitivity	Specificity	PPV	NPV	Youden Index
3.69	0.804	0.653	0.707	0.762	0.457
3.75	0.784	0.653	0.702	0.744	0.437
3.82	0.765	0.673	0.709	0.733	0.438
3.87	0.765	0.714	0.736	0.745	0.479
4.00	0.745	0.714	0.731	0.729	0.459
4.11	0.667	0.735	0.723	0.680	0.401

Table 8: True positive, false positive, false negative and true negative value of NLR in differentiating complicated appendicitis from simple appendicitis at a cut-off point >3.87

NLR	Complicated appendicitis	Simple appendicitis	p-value
≥3.87	39 (76.5) TP	14 (28.6) FP	<0.001
<3.87	12 (23.5) FN	35 (71.4) TN	

Among 51 complicated appendicitis patients 39 had NLR ≥ 3.87 and 12 had NLR < 3.87, they were true positive and false negative respectively. Among 49 simple appendicitis patients 14 had NLR ≥ 3.87 and 35 had NLR < 3.87, they were false positive and true negative respectively.

Discussion

Appendicitis is one of the most common surgical emergencies in paediatric surgical practices. Clinical symptoms, physical findings, and differential WBC are used to score the PAS. This score has been widely used as a tool for acute appendicitis in children due to its ease

of use. A score of 6 was reported to be consistent with appendicitis. However, no research has been published on how many PAS points are likely to indicate complicated appendicitis [1]. In this study, total 157 patients were admitted with features of appendicitis, but after taking history, clinical examination and laboratory evaluation, 36 patients were found as abdominal pain of non-appendicular origin. Then 21 patients were excluded according to selection criteria from remaining 121 patients. Finally, 100 patients were selected for the study sample. All study sample undergone operative procedure and resected specimen sent for histopathological examination. In this study, most of the patients were in age group 6 to 10 years. Males (58%) were predominant than females (42%). In the study of Chuluun et al [1] most acute appendicitis patients in their study were between the ages of 5 - 10 years old where 43.75% females and 56.05% males. Sensitivity, specificity, PPV and NPV and cut off point of PAS and NLR were found different during comparison of our study findings with others. In this study PAS score was significantly higher in complicated appendicitis patients (7.31 ± 1.55) than simple appendicitis patients (5.24 ± 1.60) ($p < 0.001$). NLR was also higher in complicated appendicitis patients (5.12 ± 2.41) than simple appendicitis patients (4.24 ± 3.09), but the difference was not statistically significant ($p = 0.112$). Chuluun et al [1] found that there was a statistically significant difference in the PAS between simple appendicitis and complicated appendicitis. Thus, the PAS may be correlated with histopathological progression. In this study optimum cut-off levels for PAS is 5.5 with sensitivity of 86.3%, specificity of 65.3%, Positive predictive value (PPV) of 72.1% and Negative predictive value (NPV) of 82.1%. The area under the ROC curve was 0.822 (95% CI 0.739 – 0.904). The sensitivity, specificity, positive predictive value, negative predictive value, and cutoff point of PAS for differentiating complicated and simple appendicitis were 56.7%, 79.1%, 82.9%, 52.3%, and 8 respectively [1]. The median PAS was significantly higher (7 versus 5, $p < 0.05$) in patients with complicated appendicitis than that with simple appendicitis. The AUC for PAS was 0.735 (95% CI 0.658–0.802). When the score was 7 (optimal cutoff point) PAS had the largest Youden index. In validation sample, patients with the score of 7 or greater were considered to be more likely to have complicated appendicitis. With the optimal cutoff point of 7, the discrimination values of PAS were 64.6% sensitivity, 70.3% specificity, 70.7% PPV and 64.2% NPV [9]. In this study optimum cut-off levels for NLR is 3.87 with sensitivity of 76.5%, specificity of 71.4%, positive predictive value of 73.6% and negative predictive value of 74.5%. The area under the ROC curve was 0.728 (95% CI 0.623 – 0.833). A study conducted by Yazici et al [10] showed that a NLR over 3.5 can be used in the prediction of appendicitis in a pediatric patient group. ROC curve analysis identified NLR of 8.8 as cut-off value for complicated appendicitis with sensitivity of 76.92% (95% CI 46.2%- 95.0%) and specificity 100% (95% CI 75.3%-100%). AUC was 0.91 (95% CI 0.73-0.99, $p < 0.0001$) [11]. The sensitivity, specificity, positive predictive value, negative predictive value, area under the ROC curve of NLR for differentiating complicated and simple appendicitis were 81.9%, 85.24%, 91.5%, 70.74%, and 0.899 [1]. ROC analysis of the ratio of neutrophils to lymphocytes between complicated and uncomplicated appendicitis had an area under the curve of 0.77 (95% CI 0.73 to 0.80) ($p < 0.0001$). The cut-off point with NLR > 8.39 has a sensitivity of 73.17% and a specificity of 70.11% [12]. Goodman et al [13] described neutrophil-lymphocyte ratio (NLR) as a diagnostic instrument for the first time, and when this ratio was higher than 3.5, they showed that it was significant in the diagnosis of acute appendicitis. In the following years, other authors demonstrated that NLR is a marker of inflammation and found it to play a preoperative diagnostic role in uncomplicated and complicated appendicitis [14]. As our results and previous studies show that Paediatric Appendicitis score (PAS) and Neutrophil-Lymphocyte ratio are evaluated for their utility in differentiating between simple and complicated appendicitis in paediatric patients. For simple appendicitis, antibiotic can be given as initial [15,16] but surgery remains the first choice for complicated appendicitis, particularly gangrenous appendicitis.

Conclusion

The results demonstrated that both PAS and NLR can serve as potential tools for identifying complicated appendicitis. PAS had higher sensitivity while NLR had higher specificity. The study provides valuable insights into the diagnostic potential of these parameters in guiding the management of appendicitis in children.

Limitations

- NLR (Neutrophil-Lymphocyte ratio) were observer dependent.
- Histopathology reports were observer dependent.

Recommendations

- PAS and NLR can be used as a predictor to distinguish between simple and complicated appendicitis.
- Higher the level of PAS and NLR, higher the possibility of complicated appendicitis.

References

1. Chuluun, E., Ankhbayar, B., Ganzorig, G., Luuzan, G., Dambadarjaa, D., Dungerdorj, Z. and Chimedtseye, P., 2020. Usefulness of the pediatric appendicitis score and neutrophil to lymphocyte ratio for assessing the complicated appendicitis in children. Open Journal of Clinical Diagnostics, 10(4), pp.93-103.
2. Prasetya, D., 2019. Accuracy of neutrophil lymphocyte ratio for diagnosis of acute appendicitis in children: A diagnostic study. Annals of Medicine and Surgery, 48, pp.35-38.
3. Özsoy, Z. and Yenidoğan, E., 2017. Evaluation of the Alvarado scoring system in the management of acute appendicitis. Turkish journal of surgery, 33(3), p.200.
4. Glass, C.C. and Rangel, S.J., 2016, August. Overview and diagnosis of acute appendicitis in children. In Seminars in pediatric surgery (Vol. 25, No. 4, pp. 198-203). WB Saunders.
5. Goldman, R.D., Carter, S., Stephens, D., Antoon, R., Mounstephen, W. and Langer, J.C., 2008. Prospective validation of the pediatric appendicitis score. The Journal of pediatrics, 153(2), pp.278-282.
6. Ishizuka, M., Shimizu, T. and Kubota, K., 2013. Neutrophil-to-lymphocyte ratio has a close association with gangrenous appendicitis in patients undergoing appendectomy. International surgery, 97(4), pp.299-304.
7. Jahangiri, M. and Wyllie, J.H., 1990. Peripheral blood lymphopenia in gangrenous appendicitis. BMJ: British Medical Journal, 301(6745), p.215.
8. Kelly, M.E., Khan, A., Riaz, M., Bolger, J.C., Bennani, F., Khan, W., et al., 2015. The utility of neutrophil-to-lymphocyte ratio as a severity predictor of acute appendicitis, length of hospital stay and postoperative complication rates. Digestive surgery, 32(6), pp.459-463.
9. Feng, W., Zhao, X.F., Li, M.M. and Cui, H.L., 2020. A clinical prediction model for complicated appendicitis in children younger than five years of age. BMC pediatrics, 20(1), pp.1-9.
10. Yazici, M., Özkisacik, S., Öztan, M.O. and Gürsoy, H., 2010. Neutrophil/lymphocyte ratio in the diagnosis of childhood appendicitis. The Turkish journal of pediatrics, 52(4), p.400.
11. Hajibandeh, S., Hajibandeh, S., Hobbs, N. and Mansour, M., 2020. Neutrophil-to-lymphocyte ratio predicts acute appendicitis and distinguishes between complicated and uncomplicated appendicitis: A systematic review and meta-analysis. The American Journal of Surgery, 219(1), pp.154-163.
12. Balanescu, L., Băetu, A.E., Cardoneanu, A.M., Moga, A.A. and Bălănescu, R.N., 2022. Predictors of complicated appendicitis with evolution to appendicular peritonitis in pediatric patients. Medicina, 59(1), p.21.
13. Goodman, D.A., Goodman, C.B. and Monk, J.S., 1995. Use of the neutrophil: lymphocyte ratio in the diagnosis of appendicitis. The American surgeon, 61(3), pp.257-259.
14. Akyuz, M., Topal, U., Gök, M., Öz, B., İsaoğulları, Ş.Y. and Sözüer, E.M., 2020. Predictive Value of Neutrophil/Lymphocyte Ratios in the Diagnosis of Acute Appendicitis. Medical journal of bakirkoy, 16(1).
15. Huang, L., Yin, Y., Yang, L., Wang, C., Li, Y. and Zhou, Z., 2017. Comparison of antibiotic therapy and appendectomy for acute uncomplicated appendicitis in children: a meta-analysis. JAMA pediatrics, 171(5), pp.426-434.
16. Gorter, R.R., The, S.M.M., Gorter-Stam, M.A., Eker, H.H., Bakx, R., van der Lee, J.H. and Heij, H.A., 2017. Systematic review of nonoperative versus operative treatment of uncomplicated appendicitis. Journal of Pediatric Surgery, 52(8), pp.1219-1227.