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Comparison of Appendicitis Scoring Systems in Childhood Appendicitis

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What is already known on this topic?

- *Appendicitis is a common disease in childhood, but prompt diagnosis which is crucial for preventing complications and unnecessary appendectomies may sometimes be difficult. Appendicitis scoring systems have been developed as a diagnostic tool to improve the decision-making process in patients with suspected appendicitis.*

What this study adds on this topic?

- *We found that scoring systems may assist in making the diagnosis of appendicitis and reducing negative appendectomy rates. The Lintula scoring system has the lowest negative appendectomy rate due to its higher specificity compared to Alvarado, Pediatric Appendicitis Score, modified Pediatric Appendicitis Score, and Tzanakis scoring systems. The Tzanakis scoring system has the highest accuracy rate in the diagnosis of appendicitis, and thus we believe that it may be used as an alternative scoring system for children.*

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ABSTRACT

Objective: Appendicitis scoring systems have been developed as a diagnostic tool to improve the decision-making process in patients with suspected appendicitis.The aim of the study was to compare the results of the Alvarado, The Pediatric Appendicitis Score, modified Pediatric Appendicitis Score, Lintula, and Tzanakis scoring systems in childhood appendicitis. We also aimed to see whether our rates of correct diagnosis and negative appendectomy could change, if we had made decisions using the scoring systems.

Materials and Methods: The patients who underwent appendectomy because of suspected appendicitis between June 2019 and June 2020 were evaluated prospectively. The patients were divided into appendicitis and non-appendicitis groups according to histopathological findings. The obtained data were used to calculate the scores for the scoring systems and statistical analyses.

Results: In the study, 141 patients were included. The negative appendectomy rate was 14.8%. The lowest negative appendectomy rate (6.38%) was obtained with the Lintula scoring system. Tzanakis scoring system had the highest accuracy rate (85.1%) compared to the other scoring systems.

Conclusion: The present scoring systems may assist in establishing the diagnosis of appendicitis and reducing negative appendectomy rates. The Lintula scoring system has the lowest negative appendectomy rate due to its higher specificity compared to Alvarado, Pediatric Appendicitis Score, modified Pediatric Appendicitis Score, and Tzanakis scoring systems. Tzanakis scoring system has the highest accuracy rate in the diagnosis of appendicitis, and thus we believe that it may be used as an alternative scoring system for children.

Keywords: Appendicitis, child, diagnosis, sensitivity and specificitiy, ROC curve

INTRODUCTION

Appendicitis is a common pathology in childhood.[1,2] Although surgical therapy is a well-established treatment modality, perforation due to delayed diagnosis and negative appendectomy rates are still at a high level despite the advances in laboratory tests and imaging techniques.[3-5] Thus, appendicitis scoring systems have been developed.[2,3]

Although these scoring systems are easy to apply, they still have not become a part of the routine pediatric practice. Some studies have shown that the scoring systems might reduce the negative appendectomy rate by 50%, but some reported that the diagnostic accuracy was troublesome.[5,6] Therefore, there is still no consensus on the diagnostic adequacy of scoring systems in childhood appendicitis.[6]

The aim of this study was to show whether the Alvarado, the Pediatric Appendicitis Score (PAS), modified PAS (MPAS), Lintula, and Tzanakis scoring systems were useful in the

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diagnosis of childhood appendicitis by comparing these scoring systems with each other. We also aimed to see whether our rates of correct diagnosis and negative appendectomy could change if we had made decisions using the scoring systems. To our knowledge, these 5 commonly used scoring systems have not been compared in a single study so far.

MATERIALS AND METHODS

A total of 141 patients who underwent appendectomy because of suspected appendicitis between June 2019 and June 2020 were evaluated. The study was carried out as a prospective trial and approved by the institutional ethics committee (number 2019/43). The parents of the patients were informed about the study and their written consent was obtained. All patients who underwent appendectomy in the age group of 3-18 years were enrolled in the study. Patients older than 18 years, with a history of previous abdominal surgery, chronic diseases, and inadequate laboratory parameters for all scoring systems, and the patients who refused surgery were excluded from the study. In total, 102 patients (72%) were seen in the emergency department and referred to a surgeon, and 39 patients (28%) were examined by a surgeon in the outpatient clinic. All patients were evaluated by a pediatric surgeon. The scoring systems were not used for the decision of surgery, and indication for appendectomy was set by clinical and laboratory findings.

The pediatric surgeon completed a data sheet that included the patient's name, age, gender, laboratory analysis [white blood cell count (WBC), absolute neutrophil count], ultrasound (USG) findings, signs, and symptoms of all patients for the evaluation of the scoring systems. Alvarado, PAS, MPAS, Lintula, and Tzanakis scores were calculated for each patient. Original cut-off values defined in previous studies were used in the calculation of sensitivity and specificity of the scoring systems for receiver operating characteristic (ROC) curves. Appendectomy has been strongly recommended for the patients having indicated Alvarado (≥7), PAS (≥6), MPAS (≥4), Lintula (≥21), and a Tzanakis (≥8) scores.[3,5,6] Appendectomy was performed by 4 pediatric surgeons.

Following appendectomy, all the obtained specimens were evaluated by histopathological examination. Depending on the histopathological findings, patients were divided into appendicitis and non-appendicitis groups.

Statistical Analysis

Descriptive statistics for categorical data were expressed as numbers and percentages, while mean ± standard deviation was used to express continuous data with normal distribution and median (minimum-maximum) with non-normal distribution. The data were analyzed by using Statistical Package for Social Sciences version 18.0 (SPSS Inc.; Chicago, Ill, USA). A comparison of the quantitative data between the groups was performed by using Student's *t*-test for the normally distributed variables and Mann–Whitney *U*-test for the non-normally distributed variables. The chi-square test or Fisher's exact test was used for the statistical analysis of the categorical sizes. The screening performance of the scoring systems was evaluated. The ROC curve was used to evaluate the predictive value of scores. $P < .05$ was considered statistically significant.

Sensitivity was defined as how often a scoring system correctly generated a positive result for the children who truly had appendicitis. Specificity measured the ability of the scoring systems to correctly generate a negative result for the children who did not have appendicitis. Positive predictive value (PPV) was the proportion of the children with a positive score who actually had appendicitis. The negative predictive value (NPV) was the proportion of those with a negative result who did not have appendicitis. The area under the ROC curve (AUC) was an effective and combined measure of sensitivity and specificity that described the inherent validity of diagnostic tests. An AUC of 0.5 suggested no discrimination, while AUC values of 0.7-0.8, 0.8-0.9, and ≥0.9 were considered acceptable, excellent, and outstanding, respectively.[7]

Table 1. The Scoring Systems Used in the Study

Predictor	**Alvarado**	**PAS**	**MPAS**	**Lintula**	**Tzanakis**
Migration of pain to right iliac fossa	+ (1)	+(1)	+ (1)	+ (4)	
Anorexia	+ (1)	+(1)	+ (1)		
Nausea/vomiting	+ (1)	+(1)	+ (1)	+ (2)	
Tenderness in right lower quadrant	+ (2)	+(2)	+ (2)	+ (4)	+ (4)
Rebound pain	+ (1)				
Elevated temperature	+ (1)	+(1)	+ (1)	+ (3)	
Leukocytosis	+ (2)	+(1)			+ (2)
Shift of white blood cell count to the left	+ (1)	+(1)			
Cough/hopping/percussion tenderness in right lower quadrant		+(2)	+ (2)		
Rebound tenderness				+ (7)	+ (3)
Positive USG findings of appendicitis					+ (6)
Male gender				+ (2)	
Intensity of pain = severe				+ (2)	
Guarding				+ (4)	
Decreased bowel sound				+ (4)	
Total score	10	10	8	32	15
Cut-off level (≥)	7	6	4	21	8

USG, ultrasound; PAS, Pediatric Appendicitis Score; MPAS, modified Pediatric Appendicitis Score.

RESULTS

Totally 141 patients who had undergone appendectomy and had complete required data for Alvarado, PAS, MPAS, Lintula, and Tzanakis scoring systems were evaluated. The scoring systems used in the study are shown in Table 1. The mean age of the patients was 11.7 ± 3.2 (range, 3-17) years, and 93 patients (66%) were male and 48 (34%) patients were female.

Alvarado, PAS, MPAS, Lintula, and Tzanakis scores were calculated. Statistical analyses showed that Alvarado, PAS, Lintula, and Tzanakis scores were significantly higher in patients with positive appendectomy (P = .001, P = .003, P = .004, and P = .003, respectively), but there was no significant difference for MPAS (P = .11). Demographic features of the patients, clinical and laboratory findings, and all scores for the current scoring systems are shown in Table 2.

The cut-off values for Alvarado, PAS, MPAS, Lintula, and Tzanakis scoring systems regarding histopathology are shown in Table 3.

Results of the intergroup analyses of the scoring systems in terms of sensitivity, specificity, PPV, NPV, and accuracy rates are shown in Table 4.

Area under the ROC curve values were 0.723 (95% CI: 0.61-0.83) for Alvarado; 0.698 (95% CI: 0.59-0.80) for PAS; 0.602 (95% CI 0.49-0.71) for MPAS; 0.697 (95% CI: 0.59-0.80) for Lintula, and 0.682 (95% CI: 0.56-0.80) for Tzanakis scoring systems (Figure 1).

Table 2. Comparison of Demographic and Clinical Characteristics of the Patients

	Histopathological Examination		
Variables	**Appendicitis (+) (n = 120)**	**Appendicitis (−) (n = 21)**	***P***
Demographic data			
Age, year	11 ± 3.3 (3-17)	11.5 ± 2.9 (6-16)	.6
Sex (male/female), n	83/37	10/11	.055
Preoperative laboratory values			
WBC (/mm^3)	15.4±5.4	10±3.3	<.001
ANC (/mm^3), median (range)	12.2 (1.5-30.4)	6.2 (2.2-11.2)	<.001
Ultrasonography findings; n (%)			
Positive	108 (90)	18 (85.7)	.47
Negative	12 (10)	3 (14.3)	
Scoring Systems			
Alvarado score, mean ± SD	8±1.6	6.6±1.8	.001
PAS, mean ± SD	7.9±1.5	6.9±1.4	.003
MPAS, mean ± SD	6.5±1	6.2±0.7	.1
Lintula score, mean ± SD	21.6±5.4	18.4±4.5	.004
Tzanakis score, mean ± SD	13.8±2.1	12.1±3.1	.003

SD, standard deviation; PAS, Pediatric Appendicitis Score; MPAS, modified Pediatric Appendicitis Score; WBC, white blood cell; ANC, absolute neutrophil count.

Table 3. Cut-off Values of Alvarado, PAS, MPAS, Lintula, and Tzanakis Regarding Histopathology

	Histopathological Examination	
Scoring Systems/ Cut-off Value	**Appendicitis (+) (n = 120 (%))**	**Appendicitis (−) (n = 21 (%))**
Alvarado		
≥7	97 (80.8)	12 (57.1)
<7	23 (19.2)	9 (42.9)
PAS		
≥6	110 (91.7)	18 (85.7)
<6	10 (8.3)	3 (14.3)
MPAS		
≥4	119 (99.2)	21 (100)
<4	1 (0.8)	0
Lintula		
≥21	87 (72.5)	9 (42.9)
<21	33 (27.5)	12 (57.1)
Tzanakis		
≥8	117 (97.5)	18 (85.7)
<8	3 (2.5)	3 (14.3)

PAS, Pediatric Appendicitis Score; MPAS, modified Pediatric Appendicitis Score.

The histopathological analysis of the resected appendices revealed the presence of appendicitis in 120 patients (85.8%). The patients had acute (n = 81, 57.4%), gangrenous (n = 24, 17%), and perforated (n = 15, 10.6%) appendicitis. Appendicitis was not detected in 21 patients (14.8%) and 18 of these 21 patients had secondary findings in USG for appendicitis (increased diameter of appendix, distended appendiceal lumen with anechoic and hypoechoic material, appendicolith, etc.).

If we had used scoring systems in decision-making processes, our negative appendectomy rates would have been 8.51% (Alvarado), 12.7% (PAS), 14.8 (MPAS), 6.38% (Lintula), and 12.7% (Tzanakis) according to indicated respective scoring systems. The cut-off values and negative appendectomy rates of the scoring systems used are shown in Table 5.

DISCUSSION

Appendicitis is a common disease in childhood, but prompt diagnosis which is crucial for preventing complications and unnecessary appendectomies may sometimes be challenging.[8] Thus, different scoring systems have been developed.[9] Alvarado scoring system is the oldest and most commonly used one in adults.[3] Alvarado scoring system suggested that the patients with a score below 5 did not have appendicitis, but the patients with a score of 7 or higher would require surgery.[10]

Table 4. Diagnostic Performance Parameters

	Sensitivity (%)	**Specificity (%)**	**PPV (%)**	**NPV (%)**	**Accuracy (%)**
Alvarado	80.8	42.9	88.9	28.1	75.2
PAS	91.7	14.3	85.9	23.1	80.1
MPAS	99.2	0	85	0	84.4
Lintula	72.5	57.1	90.6	26.7	70.2
Tzanakis	97.5	14.3	86.7	50	85.1

PAS, Pediatric Appendicitis Score; MPAS, modified Pediatric Appendicitis Score; PPV, positive predictive value; NPV, negative predictive value.

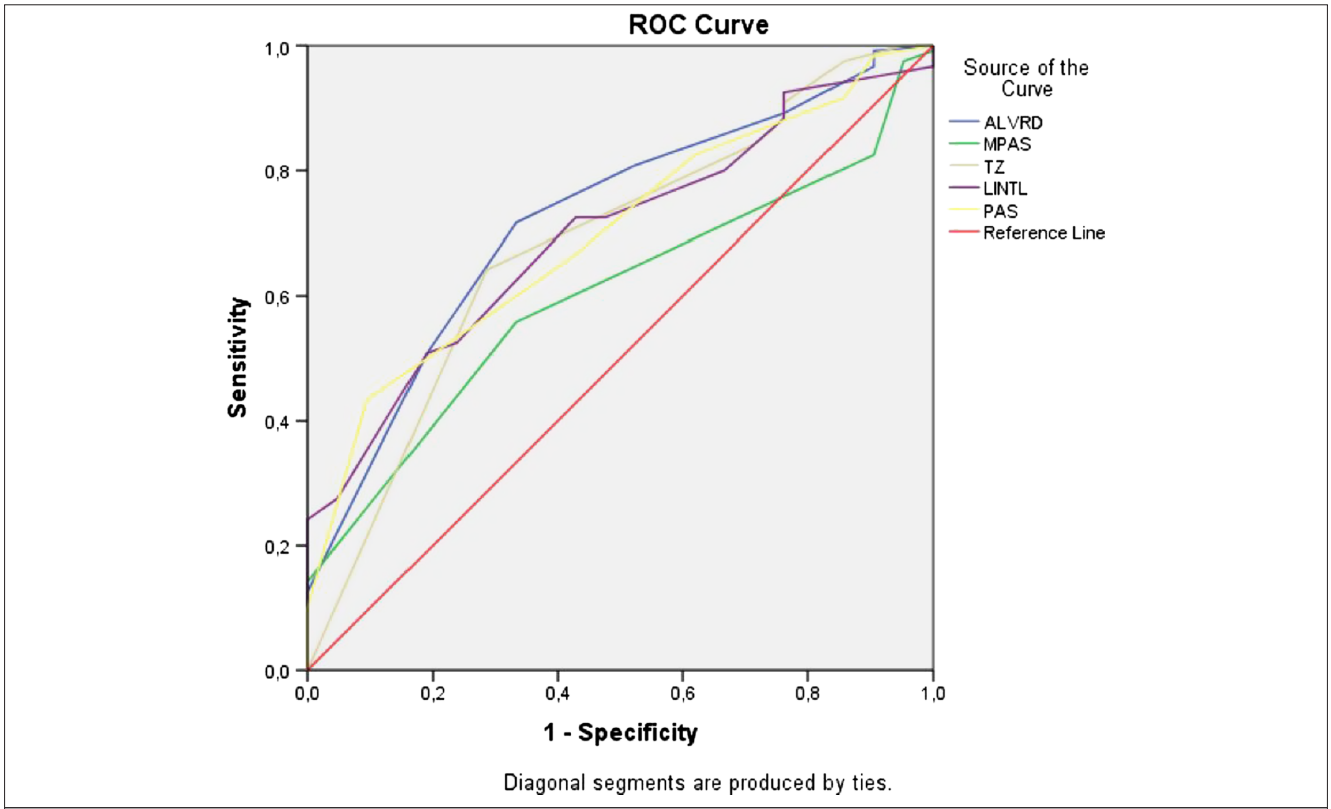

Figure 1. The receiver operating characteristic curve for the present scoring systems.

Studies in children reported that the Alvarado scoring system has low specificity and sensitivity for the diagnosis of appendicitis in children.[2,5,11] On the contrary, Escribá et al[12] concluded that the system had a diagnostic value. We found that this scoring system had 80.8% sensitivity, 42.9%, specificity, 88.9% PPV, and 28.1% NPV for the diagnosis of appendicitis. Although the AUC values of all tests were close to each other, the Alvarado scoring system had the highest AUC value, assuming the best discrimination ability. However, in 23 of 120 patients who had histopathologically proven appendicitis, the Alvarado score was below the cut-off point. Therefore, we think that the Alvarado scoring system had a low diagnostic sensitivity.

Pediatric appendicitis score was defined by Samuel in 2002.[1] Samuel, in his study with 1170 children aged 4-15 years, found its sensitivity (100%), specificity (92%), PPV (96%), and NPV (99%) as indicated.[13] Contrary to Samuel, Aydın et al[1] and Pogorelic et al[2] emphasized that PAS alone was not sufficient in diagnosing appendicitis in childhood. In our study, we found that PAS had 91.7% sensitivity, 14.3% specificity, 85.9% PPV, and 23.1% NPV in predicting the diagnosis of pediatric appendicitis. We have concluded that PAS was successful in detecting appendicitis cases owing to its higher diagnostic sensitivity. However, its low specificity values decreased its reliability and accuracy rate.

Modified Pediatric Appendicitis Score is another common scoring system used in children that is formulated by removing the blood tests evaluated in PAS. Khanafer et al[6] reported that MPAS alone was not sufficient in diagnosing appendicitis and suggested that it should have been supported by additional laboratory tests and imaging methods. We found out that MPAS had the highest sensitivity compared to the other scoring systems. Although its diagnostic sensitivity rate was high as 99.2%, it had 85% PPV without any NPV (0%) and specificity (0%). According to our study, we think that MPAS was not specific for the diagnosis of pediatric appendicitis.

Another appendicitis scoring system developed for children is the Lintula scoring system which was described by Hannu Lintula in 2005 with a study on 131 children. The Lintula scores range from 0 to 32 points and a score of ≥21 points is suggestive of emergency appendectomy.[14] Sencan et al[5] reported that the Lintula scoring system was not sufficient for prompt diagnosis. On the contrary, Yoldas et al[15] suggested that Lintula was a useful scoring system for the diagnosis of appendicitis. We found that it had 72.5% sensitivity, 57.1% specificity, 90.6% PPV, and 26.7% NPV. Although the Lintula scoring system had low sensitivity, it had the highest specificity compared to the other systems and therefore revealed that it could recognize patients without appendicitis better than the other scoring systems.

Tzanakis scoring system was used in the diagnosis of appendicitis in recent years. This system was described by Nikolaos E. Tzanakis in 2005. The Tzanakis scoring system evaluates clinical findings and USG results and WBC in combination. The highest possible score is 15, and scores ≥ 8 indicate the presence of appendicitis.[16] In adult studies, the authors have concluded that the Tzanakis scoring system was an effective modality for establishing an accurate diagnosis of acute appendicitis.[3,17,18] In our study, it had 97.5% sensitivity, 14.3% specificity, 86.7% PPV,

and 50% NPV. We found that the Tzanakis scoring system had the highest diagnostic accuracy rate (85.1%) and NPV when compared to the other systems. Given that scoring systems aim to eliminate the need for further investigation, the balance between high sensitivity and NPV versus lower specificity is acceptable for making the diagnosis.[6] Therefore, although our series consists of a small number of patients, we think that the Tzanakis scoring system which is defined for adult cases may be used as an alternative scoring system in cases with childhood appendicitis.

Our negative appendectomy rate was 14.8%. We consider that the detection of positive USG findings for appendicitis might have caused such an increased rate. If we had used the Lintula scoring system before surgery, 12 out of 21 patients who did not have appendicitis histopathologically would not have undergone surgery. Therefore, our negative appendectomy rate could have dropped to the lowest rate of 6.38%. Negative predictive values would have been 8.51% for Alvarado and 12.7% for PAS and for Tzanakis scoring systems, while there would be no change in the NPV with the use of MPAS.

Diagnostic accuracy rates of the scoring systems may be affected by demographics. Scoring systems in the management of appendicitis are more successful in the Western World when compared with the Middle East and Asia.[19] Therefore, in our study, we think that demographic characteristics might also have been effective in the evaluation of the scoring systems.

Recently, the Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) and the Acute İnflammatory Response (AIR) scoring systems have been developed.[20,21] Raja Isteri Pengiran Anak Saleha Appendicitis, which was exclusively designed for use in Asian populations, consists of 17 items and an additional parameter.[20,21] The AIR scoring system is another clinical criterion used for the diagnosis of appendicitis and has been well known in validation studies performed during the last decade.[21] We planned to add these scoring systems in our next study.

The limitation of this study is that in order to perform the analyses for the predictive values of the scoring systems, our survey was carried out in a group of patients with the histopathologically proven diagnosis of appendicitis. Of course, the inclusion of the patients with abdominal pain might have provided extra knowledge, but our aim was to evaluate the scoring systems with the best diagnostic predictive value in "true" appendicitis in children. Evaluation of the patients with abdominal pain for longer follow-up periods and using the present and a possible "new" scoring system in wider case series may constitute the subject of our next study.

In conclusion, the present scoring systems may assist in establishing the diagnosis of appendicitis and reducing negative appendectomy rates in children. The Lintula scoring system has the lowest negative appendectomy rate due to its high specificity compared to Alvarado, PAS, MPAS, and Tzanakis scoring systems. Tzanakis scoring system has the highest accuracy rate in the diagnosis of appendicitis among all existing scoring systems, so it may be used as an alternative scoring system for children.

Ethics Committee Approval: This study was approved by Ethics committee of University of Health Sciences, Kanuni Training and Research Hospital, Trabzon (Approval No: 2019/43).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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REFERENCES

1. Aydın D, Turan C, Yurtseven A, et al. Integration of radiology and clinical score in pediatric appendicitis. *Pediatr Int*. 2018;60(2):173-178. [CrossRef]
2. Pogorelić Z, Rak S, Mrklić I,Jurić I. Prospective validation of Alvarado score and Pediatric Appendicitis Score for the diagnosis of acute appendicitis in children. *Pediatr Emerg Care*. 2015;31(3):164-168. [CrossRef]
3. Korkut M , Bedel C, Karancı Y, Avcı A, Duyan M. Accuracy of Alvarado, Eskelinen, Ohmann, RIPASA and Tzanakis scores in diagnosis of acute appendicitis; a cross-sectional study. *Arch Acad Emerg Med*. 2020;8(1):e20.
4. Yazar AS, Erdoğan S, Şahin C, Güven Ş. Reliability of ultrasonography and the Alvarado scoring system in acute appendicitis. *Turk J Pediatr*. 2018;60(2):173-179. [CrossRef]
5. Sencan A, Aksoy N, Yıldız M, Okur Ö, Demircan Y, Karaca I. The evaluation of the validity of Alvarado, Eskelinen, Lintula and Ohmann scoring systems in diagnosing acute appendicitis in children. *Pediatr Surg Int*. 2014;30(3):317-321. [CrossRef]
6. Khanafer I, Martin DA , Mitra TP, et al. Test characteristics of common appendicitis scores with and without laboratory investigations: a prospective observational study. *BMC Pediatr*. 2016;16(1):147. [CrossRef]
7. Mandrekar JN. Receiver operating characteristic curve in diagnostic test assessment. *J Thorac Oncol*. 2010;5(9):1315-1316. [CrossRef]
8. Becker T, Kharbanda A, Bachur R. Atypical clinical features of pediatric appendicitis. *Acad Emerg Med*. 2007;14(2):124-129. [CrossRef]
9. Kollár D, McCartan DP, Bourke M, Cross KS, Dowdall J. Erratum to: predicting acute appendicitis? A comparison of the Alvarado score, the appendicitis inflammatory response score and clinical assessment. *World J Surg*. 2015;39(1):112. [CrossRef]
10. Alvarado A. A practical score for the early diagnosis of acute appendicitis. *Ann Emerg Med*. 1986;15(5):557-564. [CrossRef]
11. Schneider C, Kharbanda A, Bachur R. Evaluating appendicitis scoring systems using a prospective pediatric cohort. *Ann Emerg Med*. 2007;49(6):778-784,784.e1. [CrossRef]
12. Escribá A, Gamell AM, Fernández Y, Quintillá JM, Cubells CL. Prospective validation of two systems of classification for the diagnosis of acute appendicitis. *Pediatr Emerg Care*. 2011;27(3):165-169. [CrossRef]
13. Samuel M. Pediatric appendicitis score. *J Pediatr Surg*. 2002;37(6):877-881. [CrossRef]

14. Lintula H , Pesonen E, Kokki H, Vanamo K, Eskelinen M. A diagnostic score for children with suspected appendicitis. *Langenbecks Arch Surg*. 2005;390(2):164-170. [CrossRef]
15. Yoldaş O, Karaca T, Tez M. External validation of Lintula score in Turkish acute appendicitis patients. *Int J Surg*. 2012;10(1):25-27. [CrossRef]
16. Tzanakis NE, Efstathiou SP, Danulidis K, et al. A new approach to accurate diagnosis of acute appendicitis. *World J Surg*. 2005;29(9):1151-1157. [CrossRef]
17. Malla BR, Batajoo H. Comparison of Tzanakis score vs Alvarado score in the effective diagnosis of acute appendicitis. *Kathmandu Univ Med J (KUMJ)*. 2014;12(45):48-50. [CrossRef]
18. Sigdel GS, Lakhey PJ, Mishra PR. Tzanakis score vs. Alvarado score in acute appendicitis. *JNMA J Nepal Med Assoc*. 2010;49(178):96-99.
19. Kartal K, Yazıcı P, Ünlü TM, Uludağ M, Mihmanlı M. How to avoid negative appendectomies: can US achieve this? *Ulus Travma Acil Cerrahi Derg*. 2017;23(2):134-138. [CrossRef]
20. Chisthi MM, Surendran A, Narayanan JT. RIPASA and air scoring systems are superior to Alvarado scoring in acute appendicitis: diagnostic accuracy study. *Ann Med Surg (Lond)*. 2020;59:138-142. [CrossRef]
21. Karami MY, Niakan H, Zadebagheri N, Mardani P, Shayan Z, Deilami I. Which one is better? Comparison of the acute inflammatory response, raja isteri Pengiran Anak Saleha appendicitis and Alvarado scoring systems. *Ann Coloproctol*. 2017;33(6):227-231. [CrossRef]