



# Importance of Pediatric Appendicitis Scoring System and Ultrasonography in the Diagnosis of Acute Appendicitis in Children

## Çocuklardaki Akut Apandisit Tanısında Pediatrik Apandisit Skorlama Sistemi ve Ultrasonografinin Önemi

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### ABSTRACT

**Objective:** Acute abdominal pain is one of the most common reasons for applying to pediatric emergency services. Acute appendicitis is the most common cause of surgery for acute abdominal pain. In our study, we determined the effectiveness of the Pediatric Appendicitis Scoring System and abdominal ultrasonography (USG) in the diagnosis of acute appendicitis.

**Methods:** The study population consisted of patients who applied to the pediatric surgery service, were diagnosed with acute appendicitis, and underwent surgery. The files of the patients were retrospectively analyzed between 01.05.2020 and 01.01.2021, and data were obtained. The study population consisted of 182 patients.

**Results:** A total of 64.8% (n=118) of the cases were male. When the cut-off value was 7 for pediatric appendicitis score (PAS), the sensitivity was 37.3% and the specificity was 75%. The PAS score was found to be higher in those with appendicitis findings (6.01±1.65) on USG than in those without (4.46±1.19) (p=0.001). Abdominal tomography was performed in 38 patients, and appendicitis was detected in 27 patients. When the pathology results were examined, complicated appendicitis was detected in 17 cases, and negative appendectomy was performed in 8 cases.

**Conclusion:** Various scoring systems have been developed to diagnose acute appendicitis in children. For the PAS system, different cut-off values were used in different studies. In our study, the relationship between imaging results and PAS was examined because of the low specificity and sensitivity compared with the literature. it may be appropriate to use PAS and USG together for diagnosis.

**Keywords:** Abdominal pain, appendicitis, children, pediatric appendicitis score, score

### ÖZ

**Amaç:** Akut karın ağrısı çocuk acil servislerine en sık başvuru sebeplerindedir ve bunlar içerisindeki en sık cerrahi nedeni akut apandisitler oluşturmaktadır. Çalışmamızda akut apandisit tanısında pediatrik apandisit skorlama sistemi ve karın ultrasonografisinin (USG) etkinliğinin saptanması amaçlanmıştır.

**Yöntem:** Çalışma 01.05.2020 ve 01.01.2021 tarihleri arasında tamamlanmıştır. Çocuk acil servisine başvuran ve akut apandisit ön tanısı ile çocuk cerrahisi tarafından opere edilen hastalar çalışma evrenini oluşturmaktadır. Çalışma evreni 182 olgudan oluşmaktadır. Veriler retrospektif olarak hasta kayıtlarından toplanmıştır.

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**Bulgular:** Olguların %64,8'i (118) erkekti. PAS için cut-off değer 7 alındığında sensitivitesi %37,3 spesifitesi ise %75 olarak bulundu. USG'de apandisit bulgusu olanların (6,01±1,65) olmayanlara göre (4,46±1,19) PAS skoru daha yüksek bulunmuştur (p=0,001). Otuz sekiz hastaya abdominal tomografi çekilmiş, 27 olguda apandisit bulgusu saptanmıştır. Patoloji sonuçları incelendiğinde 17 olguda komplike apandisit mevcut iken, 8 olguda negatif apendektomi yapılmıştı.

**Sonuç:** Çocuklarda akut apandisit tanısında çeşitli skorlama sistemleri geliştirilmiştir. Pediatrik apandisit skorlama sistemi için farklı çalışmalarda farklı cut-off değerleri kullanılmıştır. Çalışmamızda literatüre göre PAS özgüllük ve duyarlılığının düşük saptanması nedeni ile görüntüleme sonuçları ile PAS arasındaki ilişki incelenmiştir. Tanı için PAS ve USG'nin birlikte kullanılmasının uygun olabileceği düşünülmektedir.

**Anahtar Kelimeler:** Karın ağrısı, apandisit, çocuk, pediatrik apandisit skoru, skor

## INTRODUCTION

Acute abdominal pain is one of the most common causes of admission to the pediatric emergency department. Acute appendicitis is the most common cause of surgery for acute abdominal pain. The most common age range of acute appendicitis is 6-12 years.<sup>1,2</sup>

Approximately one-third of childhood cases do not show typical findings. Therefore, it is sometimes difficult to diagnose acute appendicitis. Delays in diagnosis are associated with increased mortality and morbidity. Assistive imaging techniques and scoring systems are essential.<sup>3</sup>

Standard diagnostic methods for diagnosing acute appendicitis consist of history, physical examination, and laboratory tests.<sup>4</sup> Routine imaging methods in the emergency department are time consuming. In addition, it does not have a feature to make a definitive diagnosis or exclude the diagnosis. Imaging of the appendix using effective ultrasonography (USG) can be difficult, and the nature of the application depends on the practitioner. Computed tomography (CT) is unsuitable for routine use in children because of radiation exposure and the associated long-term cancer risk.<sup>5</sup>

The pediatric appendicitis score (PAS) was published by Samuel in 2002.<sup>6</sup> PAS is used in the diagnosis of acute appendicitis in many centers because it is a non-invasive and reliable method.<sup>7</sup>

In the literature, studies in which PAS and USG findings and pathology results are evaluated together are limited. Our study aimed to determine the effectiveness of PAS and USG in the diagnosis of acute appendicitis.

## METHODS

The study population consisted of patients who applied to the pediatric surgery service diagnosed with acute appendicitis and underwent surgery. The patients' files were retrospectively analyzed between May 1, 2020 and January 1, and data were obtained. The demographic characteristics of the patients (age, sex, season), duration of pain, clinical findings and laboratory results (hemogram parameters and C-reactive protein level), USG findings, abdominal CT findings, PAS score at the time of admission to the pediatric emergency service, and histopathological

results were recorded. An appendix diameter of 6 mm on USG was considered significant for appendicitis. Appendicitis was defined as complicated appendicitis if there was an intra-abdominal abscess, fecal peritonitis, or extensive adhesions.

Patients who were under the age of four years, had a history of analgesic and antibiotic use before admission, had chronic neurological diseases, had previous intra-abdominal surgery, and had chronic diseases related to the gastrointestinal system (such as inflammatory bowel disease and familial Mediterranean fever) were excluded from the study.

The PAS system includes eight parameters and is evaluated over 10 points. According to the scoring system,  $\leq 3$  were considered low risk, 4-7 was considered medium risk, and  $\geq 7$  were considered high risk. The PAS system is shown in Table 1.

The ethics committee of the study was approved by the Aydın Adnan Menderes University Faculty of Medicine Non-invasive Clinical Research Ethics Committee on 17.02.2021 with the number E.5514.

## Statistical Analysis

The Statistical Package for Social Science 21.0 program was used to conduct the analysis. Conformity to normal distribution was evaluated according to the Kolmogorov-Smirnov test, histogram, and skewness-kurtosis coefficients. Categorical measures are presented as numbers and percentages. Continuous measurements are summarized as the mean and standard deviation for those with normal distribution and median and minimum-maximum values for those who did not. The correlation between the ordinal order of the appendicitis pathology result and the PAS score was evaluated using Kendall's correlation test. Normally distributed pairs were evaluated using Student's t-test, and triple groups were evaluated using one-way ANOVA receiver operating characteristic (ROC) curve analysis was performed to determine the cut-off value of the PAS score. In this study, the sensitivity and specificity of USG findings, PASs, and patient pathology results were evaluated by calculating positive and negative predictive values. The type I error level was taken as  $\alpha=0.05$ .

## RESULTS

A total of 214 patients underwent surgery for acute appendicitis between May 1, 2020 and January 1, 2022. Of the 182 cases included in the study, 118 (64.8%) were male. The median age was 141.5 (50-211) months. When the time of admission to the hospital with acute appendicitis symptoms was examined, it was seen that most admissions were in the summer [31.3% (n=57)] and winter [29.7% (n=54)] seasons. It was lower in spring [19.2% (n=35)] and autumn [19.8% (n=36)].

The median PAS value was 6 (2-10). When the findings in PAS were examined, the most common finding was leukocytosis (84%), and the least common finding was fever (7.7%). The distribution of PAS findings is shown in Table 2.

Those with an appendicitis score of seven and above were considered high risk, and those with scores of three and below were considered low risk. Accordingly, 37.9% (n=69) of the patients were at high risk, 57.7% were moderate (n=105), and 4.4% (n=8) were low risk.

When the laboratory characteristics were examined, a C-reactive protein (CRP) level above 5 mg/mL was set as positive, and CRP positivity was present in 59.3% of the patients (n=108). The properties of the hemogram parameters are listed in Table 3.

Item	Score
Anorexia	1
Nausea or vomiting	1
Migration of pain	1
Fever >38 °C	1
Pain with cough, percussion or hopping	2
Right lower quadrant tenderness	2
White blood cell count >10.000 cells/microL	1
Neutrophils plus band forms >7500 cells/microL	1
<b>Total</b>	<b>10</b>

USG was performed in 91.2% (n=166) of the patients. In the USG performed, the diameter of the appendix was 6 mm in 128 cases (77.1%). Acute appendicitis was found in 27 (71.1%) of 38 patients who underwent abdominal CT. Imaging findings are shown in Table 4.

When the pathology results were examined, non-complicated appendicitis was present in 86.3% (n=157) of the patients, complicated appendicitis was present in 9.3% (n=17), and lymphoid tissue hyperplasia (negative appendectomy) was present in 4.4% (n=8).

The relationship between the imaging results and PAS in children was evaluated. The PAS score was found to be higher in patients with appendicitis findings ( $6.01 \pm 1.65$ ) on USG than in those without ( $4.46 \pm 1.19$ ) ( $p=0.001$ ). The sensitivity of ultrasound according to pathology was 78.1%, its specificity was 57.1%, the positive predictive value was 97.6%, and the negative predictive value was 10.2%. A statistically significant correlation was found between the pathological findings and PAS ( $p=0.006$ ). When the relationship was evaluated in detail, PAS was found to be higher in patients with complicated appendicitis ( $7.06 \pm 1.91$ ) than in the other two groups (non-complicated appendicitis:  $5.89 \pm 1.61$ , negative appendectomy:  $5.00 \pm 1.92$ ) (Table 5). A weak positive correlation was found between negative appendectomy, non-complicated appendicitis, and progression to

Clinical findings	Cases (n)	Frequency (%)
Anorexia	108	59.3
Nausea or vomiting	101	55.5
Migration of pain	46	25.3
Fever >38 °C	14	7.7
Pain with cough, percussion or hopping	78	42.9
Right lower quadrant tenderness	138	75.8
White blood cell count >10.000 cells/microL	153	84.1
Neutrophils plus band forms >7500 cells/microL	142	78.0

PAS: Pediatric appendicit score

	Mean	SD	Median (IQR)	Minimum-maximum
<b>Leukocyte (cells/microL)</b>	15630.71	5179.80	15715.0 (7055.0)	4880.0-29150.0
<b>Neutrophil (cells/microL)</b>	12009.71	5182.16	12225.0 (7462.5)	2340.0-27070.0
<b>Lymphocyte (cells/microL)</b>	2465.32	1540.00	2135.0 (1875.0)	298.0-7700.0
<b>Hb (mg/dL)</b>	13.08	1.30	13.0 (1.5)	9.1-17.2
<b>Platelets (cells/microL)</b>	310098.90	77938.99	301000.0 (103750.0)	170000.0-770000.0

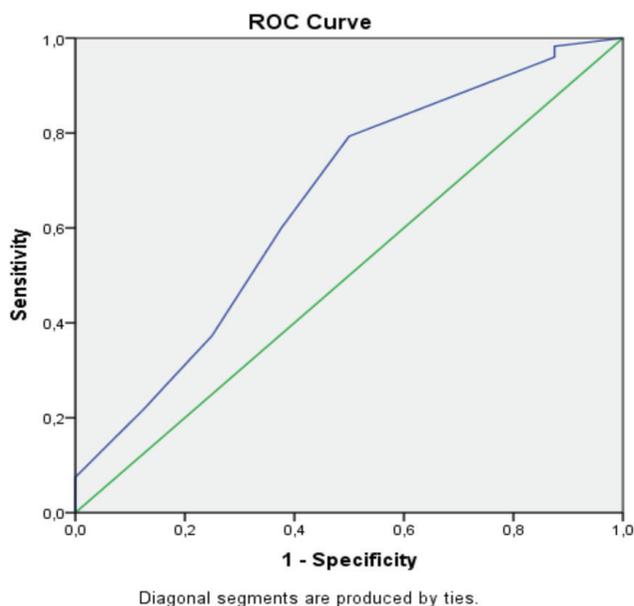
SD: Standard deviation, Hb: Hemoglobin, IQR: Interquartile range

complicated appendicitis and PAS ( $r=0.182$ ;  $p=0.005$ ) (Kendall's correlation test).

Sensitivity and specificity were calculated at different cut-off values to determine the optimal cut-off value for the pediatric appendicitis score (Table 6). The ROC curve is shown in Figure 1. When the score cut-off value was set to 7 (area under the curve= $0.656$ ;  $p=0.137$ ), the sensitivity of PAS was 37.3%, specificity was 75.0%, positive predictive value was 97.0%, negative predictive value was 5.2%, and test validity was 39.0%.

### DISCUSSION

Abdominal pain is one of the most common reasons for admission to the emergency department during childhood. Acute appendicitis is one of the most common emergency surgical pathologies in pediatric surgery. Anamnesis, physical examination, and laboratory and imaging techniques are the methods used for diagnosis. In particular, in the younger age group, it is difficult to diagnose acute appendicitis because of the difficulty of taking anamnesis and non-specific clinical findings. If the diagnosis is delayed, a non-complicated appendix may progress and perforate. This may lead to increased morbidity and mortality. In the first evaluation at the time of application, a definitive diagnosis can be made at a rate of 50-70%.<sup>8</sup> Despite a detailed anamnesis, repeated physical examination, blood tests, and additional imaging techniques, there may be delays in diagnosis at a rate of 5.9-27.6%.<sup>9,10</sup>



**Figure 1.** PAS score's ROC curve

PAS: Pediatric appendicit score, ROC: Receiver operating characteristic

The popularity of USG, which is one of the imaging methods used in diagnosis, has recently increased due to the lack of exposure to ionizing radiation and its practical use. However, the power of USG in diagnosing acute appendicitis is limited due to the experience of the person performing the procedure and the recent increase in pediatric obesity.<sup>11</sup> Magnetic resonance imaging is not routinely preferred, especially in children, because it requires sedation and the length of the acquisition period. However, the CT imaging method can be used in cases where it is difficult to diagnose, despite its disadvantages. In our study, USG was performed in 166 (91.2%) of 182 patients who underwent surgery with a prediagnosis of acute appendicitis. A finding in favor of acute appendicitis was found in 128 patients. In a study conducted by Erbay et al.<sup>12</sup> with 114 cases, it was reported that when the appendix diameter was considered abnormal at 6 mm or more in an USG examination, the sensitivity of USG was 76.4%, and the specificity was 80% in the diagnosis of acute appendicitis. In another study conducted by Gezer et al.<sup>13</sup>, the sensitivity of USG in the diagnosis of acute appendicitis was 71.96%, and the specificity was 48.78%. Acute appendicitis was found in 27 (71.1%) of 38 patients who underwent CT.

Scoring systems have been developed using clinical features and simple laboratory tests to diagnose acute appendicitis faster, thereby reducing complications, negative appendectomy rate, and cost and workload. PAS, one of these scoring systems, was designed by Samuel in 2002. Samuel<sup>14</sup> reported that the sensitivity of PAS was 100% and the specificity was 92% in his series consisting of 1.170 patients. As a result of this study, it was stated that a PAS score of 5 or less ruled out the diagnosis of appendicitis in the patient, and a score of 6 or above made the patient diagnosed with appendicitis with a very high probability. However, although there are many articles in the literature on the cut-off value of PAS, there are still disagreements. In another study by Schneider et al.<sup>15</sup> in 2007, the cut-off score was accepted as six and above, and the sensitivity was 82%

Table 4. Findings of imaging			
		n	%
USG (n=166)	Free fluid	51	30.7
	Mesenteric lymphadenopathy	33	19.9
	<6 mm	13	7.8
	≥6 mm	128	77.1
	Could not be visualized	25	15.1
CT (n=38)	Free fluid	3	7.8
	<6 mm	5	13.1
	≥6 mm	27	71.1
	Could not be visualized	6	15.8

CT: Computed tomography, USG: Ultrasonography

		PAS		
		Mean±SD	t/F	p
USG	There is appendicitis (n=128)	6.01±1.65	3.269	0.001
	No appendicitis (n=13)	4.46±1.19		
CT	There is appendicitis (n=27)	6.15±1.63	0.974	0.338
	No appendicitis (n=5)	5.40±1.14		
Pathology	Uncomplicated appendicitis (n=157)	5.89±1.61	5.228	0.006
	Negative appendectomy (n=8)	5.00±1.92		
	Complicated appendicitis (n=17)	7.06±1.91		

Student's t-test, one-way ANOVA was used.  
CT: Computed tomography, USG: Ultrasonography, PAS: Pediatric appendicit score, SD: Standard deviation

PAS score	Sensitivite (%)	Specificity (%)	LR	AUC	%95 CI	p
Cut-off: 5	69.5	56.2	1.58	0.656	0.447-0.864	0.137
Cut-off: 6	48.6	68.7	1.55			
Cut-off: 7	37.3	75.0	1.49			
Cut-off: 8	14.6	87.5	1.16			

LR: Likelihood ratio, PAS: Pediatric appendicit score, CI: Confidence interval, AUC: Area under the curve

and the specificity 65%. Bhatt et al.<sup>7</sup> in a prospective study emphasized that a PAS score of 4 and below is significant in excluding the diagnosis of appendicitis, and a value of 8 and above is significant in diagnosing appendicitis. Furthermore, with these cut-off values, the sensitivity was 92.8% and the specificity was 69.3%. In another study, Goldman et al.<sup>16</sup> stated that a PAS score of 2 would be valid in excluding the disease, and a score of 7 would be significantly effective in diagnosing appendicitis and stated that the sensitivity was 94% and the specificity was 98% at these values. In our study, sensitivity and specificity were calculated at different cut-off values to determine the optimal cut-off value for PAS. When the score cut-off value was 7, the sensitivity of PAS was 37.3%, the specificity was 75.0%, the positive predictive value was 97.0%, the negative predictive value was 5.2%, and the test validity was 39.0%. In our study, the sensitivity and specificity rates were found to be low compared with those reported in the literature. Due to the low specificity and sensitivity compared with the literature, the relationship between imaging results and PAS in children was investigated. In line with the data, it was thought that PAS or imaging methods alone were ineffective in diagnosing acute appendicitis.

### Study Limitations

The limitations of the study are the retrospective design of the study, the analysis of the database, and the inclusion of only patients who underwent surgery at our center.

### CONCLUSION

It is essential to evaluate patients who apply to the pediatric emergency services with the complaint of abdominal pain in terms of acute appendicitis and make an early diagnosis. However, PAS alone is not an effective method for diagnosing acute appendicitis in children because the anamnesis and clinic are non-specific and examination findings differ. Although imaging methods are effective in diagnosis, they are weak in excluding diagnosis. The positive predictive value of USG was found to be high and the negative predictive value was low. Therefore, USG should not be used for exclusion in the diagnosis of appendicitis. For these reasons, in addition to the history and physical examination in the diagnosis of acute appendicitis, it may be appropriate to use PAS and USG in combination for diagnosis.

### Ethics

**Ethics Committee Approval:** The ethics committee of the study was approved by the Aydın Adnan Menderes University Faculty of Medicine Non-invasive Clinical Research Ethics Committee on 17.02.2021 with the number E.5514.

**Informed Consent:** Retrospective study.

**Peer-review:** Externally peer-reviewed.

### Authorship Contributions

Surgical and Medical Practices: M.O.K., O.D., Concept: Ş.D., M.M., Y.K.Y., Design: Ş.D., M.M., Data Collection or

Processing: Ş.D., M.O.K., O.D., Analysis or Interpretation: Ş.D., M.M., Y.K.Y., M.O.K., O.D., Literature Search: Ş.D., M.M., Writing: Ş.D., M.M., Y.K.Y.

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