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RIPASA versus Alvarado score in the assessment of suspected appendicitis in children: a prospective study

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Abstract

Background: Diagnosis of acute appendicitis remains a problem in children with right lower quadrant pain. Challenging diagnosis and fears of missing an inflamed appendix may lead to a negative appendectomy. Many scoring systems have been developed to reduce ambiguities in the diagnosis of appendicitis. Alvarado is one of the most commonly used scoring methods in pediatric patients. The RIPASA score is considered to be a better diagnostic scoring method in adults compared to Alvarado. The present study aims to compare RIPASA and Alvarado scoring systems in determining the possibility of acute appendicitis in children with right lower quadrant pain.

This study included 179 consecutive pediatric patients who were referred to pediatric surgery with suspicion of acute appendicitis. The cut-off value was >7.5 for the RIPASA score vs. ≥7 for the Alvarado score. The possibility of appendicitis was divided into three groups for the Alvarado score and four groups for the RIPASA score.

Results: In this study, 158 of 179 patients were operated on. In 140 of the operated patients, the diagnosis of appendicitis was confirmed by histopathology. The negative appendectomy rate was 11.4%. Specificity and negative predictive value of RIPASA score were higher than those of Alvarado ($p<0.001$). No difference was found between the two scores concerning sensitivity, positive predictive value, and the area under the receiver operator characteristics curve ($p>0.05$).

Conclusion: The RIPASA scoring system can be used as an alternative to the Alvarado scoring system in the management of patients with right lower quadrant pain in emergency services and pediatric outpatient clinics. With the use of the RIPASA score, more patients with a low likelihood of appendicitis can be detected and further contributed to the reduction of the negative appendectomy rate.

Keywords: Acute appendicitis, Appendectomy, Alvarado score, RIPASA score

Background

Acute appendicitis is the most common emergency surgical pathology in children. It is not easy to diagnose, especially in children younger than 5 years of age which may lead to an increased rate of perforation [1]. Diagnosis is usually established with history, physical examination and non-specific laboratory investigations such as

white blood count (WBC), Neutrophil percentage (NP), C-reactive protein (CRP), and imaging methods. Ultrasonography (USG) is the first and the most preferred imaging method due to its quick practicality and non-radiation exposure. It has disadvantages, such as failure to visualize the retrocecal appendix, as well as its dependency on the performer [2, 3]. In patients in whom USG fails to visualize the appendix, it is recommended that the patient be monitored instead of utilizing methods, such as contrast tomography (CT) or magnetic resonance imaging (MRI) or diagnostic laparoscopy [4].

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Complications such as abscess, perforation, peritonitis, and rarely sepsis may develop during monitoring [5]. Emergency operations performed in patients with suspected acute appendicitis may result in a negative appendectomy [1, 6, 7]. Many scoring systems have been developed to reduce ambiguities in the diagnosis of appendicitis. Alvarado is one of the most commonly used scoring methods in pediatric patients [2]. The RIPASA includes some parameters not included in the Alvarado score, such as age, gender, symptom duration, and urinalysis, which are not found [7, 8]. To our knowledge, in the current literature, there is no study comparing RIPASA and Alvarado scoring systems in the evaluation of the possibility of acute appendicitis in children with right lower quadrant pain.

This study aims to compare RIPASA and Alvarado scoring systems in assessing the possibility of acute appendicitis in pediatric patients with right lower quadrant pain.

Methods

This prospective study included 179 consecutive patients who had been referred to our pediatric surgery clinic with suspected acute appendicitis between July 2018 and December 2019. The Institutional Ethics Committee approved this study. Written informed consent to participate in this study was obtained from patients' parents /legal guardians. During the study period, patients with right lower quadrant pain managed conservatively or by appendectomy were included in this study. Patients younger than 5 years of age who were unable to cooperate in the physical examination were excluded from this study.

The decision to operate was made by surgeons independently other than those who conducted this study based on history, examination, laboratory, and radiological imaging. Patients were evaluated by the physicians who performed this study before the operation. Patients' age, gender, duration of symptoms, nausea, vomiting, tenderness in the right lower quadrant, migration of pain to the right lower quadrant, defensive, rebound, Rovsing's sign, fever, WBC, NP, CRP, urinalysis, and radiology reports were recorded in the pre-prepared scoring form.

Serum CRP value >5mg/L, WBC > 10,000/ μ L, NP >75% were considered high [9]. Ultrasonography reports were evaluated in three categories: appendix not visualized, normal appendix and acute appendicitis. In ultrasonography, wall thickness of the appendix >6 mm was interpreted as acute appendicitis [10].

RIPASA and Alvarado scores were calculated prospectively for only this study. RIPASA and Alvarado Scores are presented in Table 1.

Table 1 RIPASA and Alvarado scoring systems

Diagnostic criteria	RIPASA	Alvarado
Male	1	-
Female	0.5	-
Age <39.9 years	1	-
Age >40 years	0.5	-
RIF pain	0.5	-
Pain migration to RIF	0.5	1
Anorexia	1	1
Nausea &vomiting	1	1
Duration of symptoms ≤ 48h	1	-
Duration of symptoms >48 h	0.5	-
RIF tenderness	1	2
Guarding	2	-
Rebound tenderness	1	1
Rovsing's sign	2	-
Fever >37.3 °C	1	1
WBC >10,000	1	2
Negative urine analysis	1	-
Foreign national registration identity card	1	-
Shift to left (neutrophilia)	-	1
Total score	17.5	10

RIF right iliac fossa, WBC white blood cell

The possibility of appendicitis was divided into three groups for the Alvarado score and four groups for the RIPASA score. RIPASA score was considered very high at ≥12, high at 7.5–11.5, moderate at 5–7, and low probability at <5; Alvarado score was considered high at ≥7, moderate at 5–6, and of low probability at 0–4 [1, 11].

Appendix specimens were evaluated microscopically in three categories: negative appendectomy (lymphoid hyperplasia), acute appendicitis, and complicated appendicitis (gangrenous appendicitis or perforated) [9].

The accuracy rate, sensitivity, specificity, negative predictive values (NPV), positive predictive values (PPV), and receiver operator characteristics curve (ROC) analysis were performed for RIPASA and Alvarado scoring systems.

Statistical methods

Data obtained in this study were statistically analyzed using SPSS Statistics for Windows, Version 22.0. (IBM Corp. Released 2013. Armonk, NY). Categorical variables were expressed as numbers (*n*) and percentages (%) and the Kolmogorov-Smirnov test was used to examine the normal distribution of continuous data. Numerical variables with normal distribution were shown as mean ± standard deviation. Normally distributed numerical variables were compared by Student's *t*-test. The cut-off value was >7.5 for the RIPASA score vs. ≥7 for the

Alvarado score [12]. Pearson's chi-square test was used to determine whether there was a difference between RIPASA and Alvarado scores concerning accuracy, sensitivity, specificity, positive predictive value, negative predictive value, and area under the ROC curve (AUC). In all data, $p < 0.05$ was considered statistically significant.

Results

Of the 179 patients included in the present study, 33.5% were girls and 66.5% were boys and the mean age was 11.6 ± 3.2 years (5–17 years). Of the patients, 81.6% had WBC elevation, 70.9% had NP elevation, and 55.3% had CRP elevation. In 71.5% of patients, USG was reported as acute appendicitis. The diagnosis of appendicitis was confirmed by histopathological examination in 140 of the patients who had been operated on with a preliminary diagnosis of acute appendicitis. Pathology reports demonstrated 11.4% negative appendectomy (lymphoid hyperplasia), 68.4% acute appendicitis, 20.2% complicated appendicitis (14.5% gangrenous appendicitis, 5.7% perforated appendicitis) (Table 2). The accuracy rates of

Table 2 Demographics and clinical characteristics of the patients participated to the study

Demographic	n (%)
Mean age \pm SD (years)	11.6 \pm 3.2 (5–17)
Gender	
Female	60 (33.5)
Male	119 (66.5)
WBC (μL)	
<10,000	33 (18.4)
>10,000	146 (81.6)
NP (%)	
<75	52 (29.1)
>75	127 (70.9)
CRP(mg/l)	
<5	80 (44.7)
>5	99 (55.3)
US	
Not visualized	17 (9.5)
The appendiceal wall thickness(mm)	
≤ 6	34 (18.9)
>6	128 (71.5)
HPE	
Lymphoid hyperplasia	18 (11.4)
Acute appendicitis	108 (68.4)
Phlegmonous appendicitis	23 (14.5)
Perforated appendicitis	9 (5.7)

WBC white blood count, NP neutrophil percentage, CRP C-reactive protein, US ultrasonography, HPE histopathological examination

WBC, NP, CRP, and USG were 75.9%, 82.6%, 63.6%, and 86.5%, respectively.

The distribution of scores was as follows. RIPASA was very high in 5.6%, high in 67.1%, moderate in 26.8% and low in 0.5% whereas Alvarado was high in 57%, moderate in 27.8%, and low in 15.2% (Table 3). Conservative management was applied to 21 of the patients, while 158 of them received surgical treatment (Table 4).

In our study, the sensitivity and specificity of RIPASA score were 76.9% and 87.1 %, while those of Alvarado score were 84.6% and 55.4%, respectively. This demonstrated statistically significant superiority of the RIPASA score in terms of specificity ($P < 0.001$).

PPV and NPV were 93.1% and 61.2% in RIPASA score vs. 95.1% and 44.2% in the Alvarado score, respectively. The NPV was significantly higher for the RIPASA score compared to the Alvarado score ($p < 0.001$).

The accuracy rate was 84.4% in the RIPASA score vs. 73.2% in the Alvarado score. With ROC curve analysis applied, AUC was 0.827 (0.75–0.90) in the RIPASA score vs. 0.826 (0.74–0.90) in the Alvarado score. The AUC accuracy rate of RIPASA and Alvarado scores were not different ($p = 0.97$) (Table 5).

Since the number of foreign patients ($n = 5$) was very low in our study, there was no significant change as a result of the inclusion of these patients.

Discussion

Diagnosis of acute appendicitis remains a problem in children with right lower quadrant pain. In laboratory tests, the increase in WBC count, NP, and CRP can be interpreted in favor of appendicitis, but the diagnostic value of these tests is low [3, 13]. Although ultrasonography is usually performed for diagnosis in patients with suspected appendicitis, the detection rate of the appendix vermiciformis by ultrasonography varies between 2 and 82% [5]. Challenging diagnosis and fears of missing an inflamed appendix may lead to the negative appendectomy at a rate of 15–27% [1, 6, 7]. Since only patients with right lower quadrant pain referred to pediatric surgery were evaluated in our study, the rate of negative appendectomy (11.4%) was relatively low compared to previous studies. Currently, there is a tendency for patients with suspected appendicitis to be observed rather than operated and to perform surgery in patients who do not respond to medical treatment and observation. Using scoring systems, identifying patients with a low probability of appendicitis may contribute to the reduction of negative appendectomies.

While some studies have reported that the RIPASA score is more valuable in adult patients [11, 14, 15], other studies have reported higher accuracy and sensitivity but lower specificity for the RIPASA score compared

Table 3 The distribution of scores in patients with right lower quadrant pain

Score N(%)	RIPASA		Alvarado	
	Appendicitis	Other diseases	Appendicitis	Other diseases
Low	0 (0)	1 (0.5)	9 (5.1)	18 (10.1)
Moderate	19 (10.6)	29 (16.2)	34 (18.9)	16 (8.9)
High	111 (62.0)	9 (5.1)	97 (54.2)	5 (2.8)
Very high	10 (5.6)	0 (0)		

to the Alvarado scoring system [16, 17]. In a study conducted by Díaz-Barrientos et al., the findings showed that the RIPASA score had no advantage over the Alvarado score [18]. Another study was reported that no significant difference was found in ROC analysis between RIPASA and Alvarado scores concerning the area under the curve [19]. In our study, the specificity of the RIPASA scoring system was higher than Alvarado in children with right lower quadrant pain. The results of our study support that more parameters in the RIPASA score increase the specificity. Our study suggests that the RIPASA score may be more useful than Alvarado in identifying patients with a low probability of appendicitis in the differential diagnosis of patients with suspected appendicitis.

Various studies have reported the NPV value of the RIPASA score in the range of 10.1–97.6% [11, 14, 16–18, 20, 21], while the NPV value in the Alvarado score has been reported as 64–87.8% [1, 13]. It has been stated that the Alvarado score does not have sufficient PPV and NPV to determine the need for surgery [1, 3]. In our study, the NPV value was higher in the RIPASA score (60%) than the Alvarado score (45.3%). Our results suggest that the NPV value of the RIPASA score is higher due to the patient's history, duration of symptoms, pain in the right lower quadrant, guarding, Rovsing's sign, and urine test. In addition, it was concluded that history and repeated examinations have an

important role in the differential diagnosis of patients with right lower quadrant pain.

RIPASA and Alvarado scoring systems can be used in the management of patients with right lower quadrant pain. It has been reported that acute appendicitis can be excluded in patients with low scores in both scoring systems [1, 6, 11]. In our study, appendicitis was not detected in patients with low RIPASA scores. However, contrary to the literature, appendicitis was detected in 5.1% of the patients who were evaluated with low Alvarado scores. Therefore, we think that the RIPASA scoring system is more useful in identifying patients with a low probability of appendicitis and who do not need emergency surgery in children with abdominal pain. In patients with moderate Alvarado scores and moderate or high RIPASA scores monitoring and score repetition or US were recommended [1, 6, 11]. In our study, the rate of negative appendectomy was similar in patients with moderate Alvarado scores and moderate and high RIPASA scores. In patients with high Alvarado scores and very high RIPASA scores, surgery is recommended [1, 6, 11]. In our study, negative appendectomy was not detected in patients who were evaluated with a very high RIPASA scores, but negative appendectomy was detected at a rate of 2.8% in patients who were evaluated with high Alvarado scores. According to the results of our study, pediatric patients with right lower quadrant pain and low RIPASA scores can be discharged.

Table 4 Scoring and management of patients included in the study

Score	N (%)	Management		HPE	
		Conservative	Underwent surgery	Negative appendectomy	Appendicitis
RIPASA					
Low	1 (0.5)	0 (0)	1 (0.5)	1 (0.5)	0 (0)
Moderate	48 (26.8)	21 (11.7)	27 (15.1)	8 (4.5)	19 (10.6)
High	120 (67.1)	0 (0)	120 (67.1)	9 (5.1)	111 (62.1)
Very high	10 (5.6)	0 (0)	10 (5.6)	0 (0)	10 (5.6)
Alvarado					
Low	27 (15.2)	10 (5.6)	17 (9.5)	8 (4.5)	9 (5.1)
Moderate	50 (27.9)	11 (6.2)	39 (21.8)	5 (2.8)	34 (18.9)
High	102 (56.9)	0 (0)	102 (56.9)	5 (2.8)	97 (54.2)

HPE histopathological examination

Table 5 Comparison between the RIPASA and Alvarado scoring systems with respect to different variables

Score in (95%CI)			
	RIPASA >7.5	Alvarado ≥7	P value
Sensitivity	76.9 (60.7–88.9)	84.6 (72.6–95.7)	0.731
Specificity	87.1 (79.6–91.6)	55.4 (60.9–76.8)	<0.001
PPV	93.1 (87.3–96.8)	95.1 (88.9–98.4)	0.304
NPV	61.2 (46.2–74.8)	44.2 (32.8–55.9)	<0.001
Accuracy	84.4 (79.0–89.7)	73.2 (66.7–79.7)	0.803
AUC	0.827 (0.75–0.90)	0.826 (0.74–0.90)	0.970

CI confidence interval, PPV positive predictive value, NPV negative predictive value, AUC areas under the curve

Observation, score repetition, or further investigation is required in patients with low, moderate, and high Alvarado scores and moderate and high RIPASA scoring systems. Surgery may be recommended in patients with very high RIPASA scores.

Limitations of the study

This study was conducted in a single center; the number of patients was small and only patients with abdominal pain referred to pediatric surgery were evaluated.

Conclusions

The RIPASA scoring system can be used as an alternative to the Alvarado scoring system in the management of patients with right lower quadrant pain in emergency services and pediatric outpatient clinics. With the use of the RIPASA score, more patients with a low likelihood of appendicitis can be detected and further contributed to the reduction of the negative appendectomy rate. Thus, hospital costs can be reduced, and time and labor loss can be prevented.

Further studies with more patients and multi-center studies are required to strengthen the results of this study.

Abbreviations

RIPASA: Raja Isteri Pengiran Anak Saleha Appendicitis; WBC: White blood count; NP: Neutrophil percentage; CRP: C-reactive protein; USG: Ultrasonography; CT: Contrast tomography; MRI: Magnetic resonance imaging; NPV: Negative predictive values; PPV: Positive predictive values; ROC: Receiver operator characteristics curve; AUC: Area under the receiver operator characteristics curve

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Authors' contributions

T.Ö. and M.A. contributed to the literature search and the study design; T.Ö. and M.A. contributed to the data collection, statistical data analysis, data interpretation, and the drafting of manuscript and approved the final version.

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Availability of data and materials

The datasets (SPSS files) used and/or analyzed during the current study are available from the corresponding author on a reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Clinical Studies Ethics Committee of Health Sciences University (06.07.2018 / Number: 119). Written informed consent to participate in the study was obtained from their parents /legal guardians.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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