The Role of Alvarado and Pediatric Appendicitis Score in Acute Appendicitis in Children

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ABSTRACT

Aim: Acute appendicitis (AA) is the condition that most commonly requires a surgical procedure in children presenting to the emergency department with acute abdominal pain. Alvarado and Pediatric Appendicitis scores (PAS) are the most widely used scoring systems in the diagnosis of AA in children. This study aims to evaluate the effectiveness of Alvarado and PAS scores in the diagnosis of AA in children.

Materials and Methods: One hundred and two patients aged 3-17 years, who were admitted to the pediatric emergency department with acute abdominal pain and had a clinical suspicion of AA were included in this retrospective study. The demographic characteristics, laboratory and radiological findings, and Alvarado and PAS scores were obtained from the records of the patients, retrospectively. According to the results of pathology, n=48 patients for the AA group and n=54 patients for the non-AA group were identified. The AA and non-AA groups were compared in terms of PAS and Alvarado scores.

Results: The mean age of the 102 patients was 9.38±3.90 years, and 62 (60.85%) of them were male. The median PAS score was 7.79±1.2 and 5.52±1.34, and the median Alvarado score was 7.98±1.14 and 5.89±1.53 in the AA and N-AA groups, respectively (p<0.001; p<0.001). For the PAS, the cut-off score was >7 with a sensitivity of 66.7%, a specificity of 94.4%, a positive predictive value (PPV) of 91.4%, and a negative predictive value (NPV) of 76.1% (p<0.001). For the Alvarado score, the cut-off was also >7, with a sensitivity of 77.1%, a specificity of 85.2%, PPV of 82.2%, and NPV of 80.7% (p<0.001).

Conclusion: Although both PAS and Alvarado scores provide useful diagnostic information in patients suspected of AA, neither of them is enough to diagnose AA alone.

Keywords: Appendicitis, Alvarado score, children, PAS

Introduction

Acute appendicitis (AA) is the condition that most commonly requires a surgical procedure in children presenting to the emergency department with a sudden onset of abdominal pain (1).

Although the incidence is not known precisely, it is on the scale of 5.9/10,000 in the 0-9 years old age range, and 15.3/10,000 in the 10-19 years old age range in the United States of America (2). Also, in acute abdominal pain in children, AA was diagnosed for 7.4% in Australia (3). It has been shown that children with acute abdominal pain initially received other diagnoses frequently seen in children such as acute gastroenteritis, pneumonia, urinary tract infection, or mesenteric lymphadenitis (4). Perforation and related
complications can be seen if the diagnosis cannot be made in time (4-7). In contrast to this, the frequency of negative appendectomy is reported to be at rates of 3.7-17% (7,8). Abdominal ultrasound (USG) is the most commonly used radiological method to help in making a correct diagnosis. Its sensitivity varies from 66.2% to 85% according to the practitioner’s experience (8-10). The sensitivity of abdominal computed tomography (CT) is reported to be 95-97%, but there are risks such as radiation and post-contrast reactions (11,12). Therefore, scoring systems based on symptoms, physical examination, and laboratory findings have begun to be used. The Alvarado score, which was initially applied in adults, is also used in children. Subsequently, the Pediatric Appendicitis score (PAS) was developed by Samuel (13) in 2002. The Alvarado score and PAS have been reported to reduce the use of CT in the diagnosis of AA for patients between 3 and 16 years of age (14,15). This study aims to determine the PAS and Alvarado scores in patients admitted to the pediatric emergency department and considered to have AA, and to compare them in terms of applicability, safety, and specificity in the diagnosis of AA.

Materials and Methods
The retrospective observational study was conducted between November 2014 and November 2015, in the Clinic of Pediatric Emergency of Okmeydani Training and Research Hospital. The study included children aged 3-17 years who were admitted to the pediatric emergency department. Those patients who had a pain duration of less than 96 hours and were considered to have AA (abdominal sensitivity and defense or rebound tenderness positivity) after an examination by a pediatrician were included in this study. Pregnant patients, patients with chronic inflammatory bowel disease, cystic fibrosis, or sickle cell anemia, patients who had undergone a previous abdominal operation or abdominal tomography within the last two weeks and those who had received corticosteroids for more than two weeks, and immunosuppressed patients were not included in this study. The information cards of each patient were filled out before surgical consultation. Consent forms were obtained from the parents or the children. The age, gender, duration of pain, complaint (complaints of abdominal pain and duration, fever, nausea-vomiting, diarrhea, upper respiratory tract infection) physical examination findings (right lower quadrant sensitivity, defense, rebound tenderness, percussion/cough/right lower quadrant sensitivity with jumping) leukocyte count and neutrophil percentages, biochemistry, C-reactive protein, complete urine test, and PAS and Alvarado score parameters were marked on the forms of these patients.

According to previous studies, a neutrophil count ≥75% and a body temperature over 38 °C were accepted as fever. The parameters of PAS and Alvarado scores and their scoring systems are shown in Table I (16-18). All the patients underwent USG, and USG was considered to be positive in the presence of signs such as a fixed appendix, no compression, round transverse image appendix, thickening in the intestine wall, appendix inner diameter >6 mm, decreased mobility, irregular appearance in appendix, and peri-appendicular fluid appearance (9,10). All other USG findings were accepted as negative. A pediatric surgeon consulted with all the patients. The pediatric surgeon and the radiologist were not informed about the PAS and Alvarado scores. Other laboratory data and the radiological and pathological results of the patients were obtained from the system records. Those patients who were discharged

<table>
<thead>
<tr>
<th>Feature</th>
<th>Point value</th>
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<tbody>
<tr>
<td>Migration of pain</td>
<td>1</td>
<td>Migration of pain</td>
<td>1</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1</td>
<td>Anorexia</td>
<td>1</td>
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<tr>
<td>Nausea/vomiting</td>
<td>1</td>
<td>Nausea/vomiting</td>
<td>1</td>
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<tr>
<td>Signs RLQ tenderness</td>
<td>2</td>
<td>Signs RLQ tenderness</td>
<td>2</td>
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<tr>
<td>Rebound pain</td>
<td>1</td>
<td>Cough/hopping/percussion tenderness in the RLQ</td>
<td>2</td>
</tr>
<tr>
<td>Elevation of temperature</td>
<td>1</td>
<td>Elevation of temperature</td>
<td>1</td>
</tr>
<tr>
<td>Leukocytosis ≥10³/L</td>
<td>2</td>
<td>Leukocytosis ≥10³/L</td>
<td>1</td>
</tr>
<tr>
<td>Polymorphonuclear neutrophilia ≥75%</td>
<td>1</td>
<td>Polymorphonuclear neutrophilia ≥75%</td>
<td>1</td>
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<tr>
<td>Total</td>
<td>10</td>
<td>Total</td>
<td>10</td>
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Score <4 low, 5-6 intermediate, 7-10 high risky, Score <3 low, 4-6 intermediate, 7-10 high risky, RLQ: Right lower quadrant
of them were male. Based on the pathological diagnoses, one patient had lymphoid hyperplasia, one patient had normal tissue, and one patient had carcinoid tumor. These 3 patients were excluded from the AA group and included in the non-AA group. The number of patients was 48 (47.1%) in the AA group and 54 (52.9%) in the non-AA group. There was no statistically significant difference between the two groups in terms of age, gender, and admission times. The most common finding (97.9%) of those patients in the AA group was sensitivity in the right lower quadrant. While there was a statistically significant difference between the AA group and the non-AA group in terms of sensitivity in the right lower quadrant, pain in the right lower quadrant with cough/percussion/hopping, migration of pain to the right lower quadrant, rebound tenderness, leukocytosis, or shift to the left, there was no statistically significant difference between the two groups in terms of anorexia, nausea-vomiting, or fever (Table II).

Among the patients in the AA group, the minimum PAS and Alvarado score was 5, the maximum score was 10 and all of patients who had scores of either 9 or 10 were in the AA group, while in the non-AA group, the minimum PAS and Alvarado score was 3, and the maximum score was 8.

For the PAS score, the cut-off value was >7, [95% confidence interval (CI), area under curve (AUC)=0.88±0.3] sensitivity was 66.7%, specificity was 94.4%, PPV was 91.4%, and the NPV was 76.1% (p<0.001) (Figure 1). For the Alvarado score, the cut-off value was >7, (95% CI, AUC was 0.87±0.03), sensitivity was 77.1%, specificity was 85.2%, PPV was 82.2%, and NPV was 80.7% (p<0.001) (Figure 1). By using the DeLong method, no statistically
significant difference was found between the AUROC levels for Alvarado and PAS variables (p=0.530).

The USG findings were positive in 34 (70.8%) patients in the AA group, and 5 (9.3%) patients in the non-AA group. There was a significant difference in USG findings between the two groups (p<0.001) (Table II). For those patients in the AA group, PAS and Alvarado scores were in the intermediate or high risk group. There was statistically significant difference only for patients with Alvarado intermediate score in the comparison of USG results with the PAS and Alvarado scores of intermediate and high-risk group in patients in the AA group (p=0.047) (Table III). Abdominal CT was performed in 4 patients, and the results showed appendicitis in 2 of them, and the other patients underwent an operation after being evaluated by a surgeon.

Of the 51 patients who underwent surgery, negative appendectomy was seen in 3 (5.9%) patients. Of these patients, one had carcinoid tumor, one had lymphadenopathy and one had normal tissue (7-5); and the PAS and Alvarado scores of these patients were 8-8, 7-8, 7-5, respectively. Considering the pathological diagnoses of those patients

| Table II. Features of group acute appendicitis and group non-acute appendicitis |
|---------------------------------|----------------|----------------|
|                                | Med ± SD       | Med ± SD       |
| Age (year)                     | 10.09±3.79     | 8.75±3.91      |
| Duration (hour) (med)          | 33.98±25.17 (24)| 35.31±22.78 (24)|
| Alvarado score (med)           | 7.98±1.14 (8)  | 5.89±1.53 (6)  |
| PAS (med)                      | 7.79±1.2 (8)   | 5.52±1.34 (6)  |
| C-reactive protein (mg/L) (med) | 54.51±76.98 (18.58) | 31.12±62.52 (12.3) |
| Leukocytes count (10^9/L) (med) | 16804.79±4822.02 | 14211.11±6825.95 |
| Polymorphonuclear neutrophilia (10^9/L) | 12603.37±4220.14 | 10000.74±5802.04 |

| Table III. The comparison of ultrasound findings with the scores in acute appendicitis patients |
|---------------------------------|----------------|----------------|
|                                | USG (-)      | USG (+)       | p     |
|                                | n (%)        | n (%)         |
| Alvarado                       |              |               |
| 5+6                            | 20 (37.7)    | 7 (18.4)      | 0.047*|
| ≥7                             | 33 (62.3)    | 31 (81.6)     |      |
| PAS                            |              |               |
| 5+6                            | 25 (49.0)    | 11 (28.9)     | 0.056|
| ≥7                             | 26 (51.0)    | 27 (71.1)     |      |

*: p<0.05, PAS: Pediatric appendicitis score, USG: Ultrasound

1: Student t-test, 2: Mann-Whitney U test, 3: chi-square test, **: p<0.05, AA: Acute appendicitis, Non-AA: non-acute appendicitis, SD: Standard deviation, USG: Ultrasound, Med: Median
in the AA group, 31 (64.6%) patients were diagnosed with phlegmonous appendicitis, 9 (18.7%) with gangrenous appendicitis, and 8 (16.7%) with perforated appendicitis. Of the patients in the non-AA group, 18 (35.3%) were diagnosed as acute gastroenteritis, 15 (29.4%) with constipation, 13 (25.5%) with mesenteric lymphadenomegaly, 2 (3.9%) with urinary tract infections, 1 (1.9%) with dysmenorrhea, 1 (1.9%) with Henoch-Schönlein purpura, and 1 (1.9%) with nephrolithiasis.

**Discussion**

Sensitivity in the right lower quadrant is the most common finding in appendicitis and is reported at a frequency of 78-100% in different series (1,15). Among other symptoms compatible with appendicitis, the shift of pain to the right lower quadrant is seen at a frequency of 33-69%, rebound pain at a frequency of 15-68%, and pain in the right lower quadrant with cough/percussion/jumping at a frequency of 64-83.2% (15,18-21). Leukocytosis frequency is 83-93% and an increase of the neutrophil ratio frequency is seen in 75-96% of cases with appendicitis (18-21). In our study, these ratios were found to be significantly higher than those of the non-AA group (p=0.003; p=0.02).

Samuel (13) determined the cut-off value to be 6 for the PAS. The cut-off value has been reported to be between 7-10, sensitivity to be between 61-86%, and specificity to be between 50-96% for the PAS in the different studies (15,19-22). The PPV values were between 50.7% and 90.1%, and NPV values were between 38% and 87.9% (15,19,20,23,24). Similarly, the cut-off value was >7, sensitivity was 66.7%, specificity was 94.4%, PPV was 91.4%, and NPV was 76.1% in our study. The cut-off values for the Alvarado score were similar to PAS. While the cut-off value was 7, the sensitivity was 68.5% to 89%, specificity was 59% to 81%, PPV was 54.9% to 93.1% and NPV was 46% to 85.3% (15,18-20,23,24). Similarly, in our study, the cut-off value was >7, while the sensitivity was 77.1%, specificity was 85.2%, PPV was 82.2%, and NPV was 80.7% for the Alvarado score. In our study, all of the patients had intermediate or high-risk scores for both PAS and Alvarado scores. On the other hand, when analyzed with ROC, there was no statistically significant difference in sensitivity, specificity, PPV and NPV between the PAS and Alvarado scores.

In the diagnosis of AA, the sensitivity of abdominal USG varies according to the experience of the practitioner, the visualization of the appendix, the gender of the patient, the patient’s body weight, and the visualization of the perforated appendicitis. The abdominal USG sensitivity for AA diagnosis varies between 53% and 88.2% and specificity between 84% and 93% in different series (10,16,23,25-28). On the other hand, the false positive USG frequency is seen to be between 5% and 30% (23,29-31). It has been suggested that the USG positivity and diagnosis rate increases as the duration of pain increases in these patients (27). Although Alvarado and PAS recommends radiological methods, especially USG, for those patients with intermediate scores, some other centers also recommend using radiological methods for those patients with lower scores (28,29). In our study, abdominal USG was found to be positive in 70.8% of those patients in the AA group, and in 9.3% of those patients in the N-AA group. Sincavage et al. (25) showed intermediate risk AS (4-6), US was positive for appendicitis in 21%. Our study had similar results.

Perforation can be a fatal complication in AA in children. Perforation frequency between 7.5% and 30% has been reported in various studies (16,29,32,33). According to the results of the pathologic examinations, the simple or phlegmonous appendicitis is reported at a frequency of 25% to 57.1%, gangrenous or suppurative appendicitis at a frequency of 34% to 45%, and perforated appendicitis at a frequency of 12% to 21% (4,32,33). In our study, 31 (64.6%) patients were diagnosed with simple appendicitis, 9 (18.7%) patients with gangrenous appendicitis, and 8 (16.7%) patients with perforated appendicitis.

In children, negative appendectomy rates are reported between 3.7% and 13% in different series (7,8,16,32,33). While it is expected that the rate of negative appendectomy in high-score patients is low, Zúñiga et al. (33) found negative appendectomy to be at a rate of 4.95% in those with a PAS score above eight. In our study, all patients with a score of more than 8 were in the AA group. The pathologic diagnoses were normal tissue, fecaliths, lymphoid hyperplasia, pinworm, granuloma, Meckel's diverticulum, granuloma, fibrose obliteration, and carcinoid tumor (34,35). Three (5.9%) patients had a negative appendectomy. The scores of these 3 patients were between 5 and 8 and they were diagnosed as normal tissue, lymphoid hyperplasia and carcinoid tumor pathologically. The patient who was pathologically diagnosed with carcinoid tumor had an Alvarado score of 8, a PAS score of 8, leukocytosis, and shift to the left, but no USG findings. If positive USG findings, leukocytosis and neutrophyl count >75% are not observed together in a patient, close follow-up and radiologic re-evaluation should be considered.

**Study Limitations**

Firstly, this study was conducted with a limited number of patients. Secondly, the patients were not all examined
by the same physician. Finally, the fact that the patients did not apply within the same period following the onset of the complaint is thought to affect the clinical staging, laboratory findings, and radiological findings.

**Conclusion**

AA is a condition that is still hard to diagnose in children presenting with acute abdominal pain in the emergency department. Although both Alvarado and PAS scores provide useful information in patients suspected of having AA in the pediatric emergency department, neither of them is enough to diagnose AA alone. The possibility of AA is high in children with a PAS and Alvarado score of 5 or more in the presence of radiological findings. There is a need for new parameters in the scoring system.

**Ethics**

**Ethics Committee Approval:** Permission from the local ethics committee for this study was received from Okmeydani Training and Research Hospital Ethics Committee (09/02/2016-416).

**Informed Consent:** Consent forms were obtained from the parents or the children.

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

**Authorship Contributions**


**Conflict of Interest:** None of the authors had conflict of interest.

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**References**


