Alvarado vs. Pediatric Appendicitis Score (PAS) in Acute Appendicitis of Children

Davoud Badebarin[1] , Sina Parsay[1*] , Saeed Aslanabadi[1]

[1] Department of Pediatric Surgery, Tabriz University of Medical Sciences, Tabriz, Iran

*Address for Corresponder: Dr. Sina Parsay, Department of Pediatric Surgery, Tabriz University of Medical Sciences, Tabriz, Iran (email:Sinaparsa91@gmail.com)

Abstract

Introduction: Acute appendicitis in children is associated with morbidity and mortality due to late diagnosis. Several scoring systems, such as Alvarado and PAS have been developed to help diagnose acute appendicitis in children to make the most accurate and prompt decision. The purpose of this study was to compare the efficacy and diagnostic value of these scoring systems.

Materials and Methods: In this cross-sectional study, 130 children aged 5-14 with suspected acute appendicitis were included. After the collection of demographic data, all patients were scored by Alvarado and PAS systems. The decision for surgery was made by a surgeon, independently of these scores. The diagnosis of acute appendicitis was affirmed by surgical and pathologic findings.

Results: Male: Female ratio was 1.32:1, and the average age of the patients were 9.2±2.7 years. The mean Alvarado and PAS scores were higher in patients with positive pathologic findings. Neutrophilia >75% and RLQ tenderness had the highest relationship with the diagnosis of the disease. The diagnostic value of Alvarado was higher than PAS concerning the area under the ROC curve. The cutoff point of 7 was associated with a sensitivity of 74.5% and specificity of 66.7% for the Alvarado score, and a sensitivity of 58.5% and specificity of 79.2% for the PAS score.

Conclusions: The results showed the high sensitivity of Alvarado and the high specificity of PAS. However, the sensitivity, specificity, PPV, and NPV of these criteria were not satisfactory for the confirmation of the diagnosis.

Introduction

Acute appendicitis is known as a prevalent emergency condition requiring surgery in children.[1,2] Since communicating with pediatric individuals is difficult and some of the signs and symptoms may be unspecific, diagnosis of this condition can be challenging and may lead to increasing numbers of negative appendectomies (56.7%) and delayed diagnosis, which increase the morbidity, complications, the duration of hospitalization, and treatment costs.[3-8]

Computed tomography (CT) is the modality of choice in this regard in most countries. However, imaging modalities have been recognized as one of the key sources of increasing healthcare costs. Nowadays, studies aiming to find an alternative to prevent excessive imaging have attracted considerable international attention. Although the CT may be considered as the standard diagnostic modality in these patients in tertiary and referral centers, in less-developed countries, not all the hospitals are equipped with CT-scans and in some circumstances, referring the patient to another medical center is not possible or logical due to the emergency nature of appendicitis. Furthermore, in some countries, CT- scan may not be covered by some health insurance companies and can be considered as a financial burden[1, 9-11]

This study was performed with the purpose of reducing the unnecessary exposure of the pediatric patients to ionizing radiation, medical costs and redundant surgical consultation requests in the emergency departement by acquiring a reliable diagnostic scoring system and clinical suspicion.

A number of scoring systems have been recently introduced for diagnosis of acute appendicitis[12] of which, the Alvarado score and the Pediatric Appendicitis Score (PAS) are known as the most highly accepted and reliable scales in pediatrics.[13] However, there is an inconsistency between different authors in this regard.[14, 15]

Nevertheless, few studies had compared the diagnostic values of Alvarado and PAS scoring system in acute appendicitis of children at the time of our study.

Materials and Methods

In this prospective cross-sectional study, 130 children aged 5-14 who underwent appendectomy with a primary diagnosis of acute appendicitis referred to the teaching hospitals of Tabriz-Iran were included.

After collecting demographic information, including age, sex, and body mass index all patients were evaluated by an experienced surgeon in the fastest possible time and scored based on the Alvarado scoring system and PAS scoring system.

Table 1 Demonstrates PAS and Alvarado scoring systems based on patients' signs and symptoms.

Table 1: Alvarado & PSA scoring system

Variable	Alvarado Score*	PAS Score**
Migration of pain	1	1
Anorexia	1	1
Nausea or Vomiting	1	1
Tenderness in Right lower quadrant	2	2
Rebound tenderness	1	-
Elevated body temperature	1	1
Leukocytosis (≥10,000/μL)	2	1
Shift of WBC count to the left (≥75% PMN)	1	1
Cough/ percussion/ hoping cause pain in the RLQ	-	2
Total	10	10

Surgery decision making was made by the designated pediatric surgeon independently of the scoring system. All surgeries were performed by one elected pediatric surgeon via McBurney approach. The diagnosis of acute appendicitis was made by surgeon's investigation and his experience during the operation (a swollen and enlarged appendix with signs of inflammation is considered as positive for appendicitis) and also based on the pathology reports of the appendix samples which were sent to a certain pathology lab.

The data were analyzed by IBM® SPSS® release 23.0.0. Descriptive data were reported as percentage, mean ± SD. Tables and charts were drawn for variables. In order to compare the diagnostic value of Alvarado and PAS criteria for the diagnosis of acute appendicitis, sensitivity, specificity, PPV, and NPV of each of the two systems, "Fisher's exact t-test," and "Chi-square" tests were used.

The ROC curve was also plotted for both systems to determine the best cut-off point to confirm or deny detection, and the "Youden" index was used to select it (J=Max[Sn+Sp]). In this study, P values less than 0.05 were considered statistically significant.

Results

In this study, 130 children aged 5 to 14 who referred to the teaching hospitals of the Tabriz University of Medical Science, Iran, who were suspected of having acute appendicitis, were evaluated. 74 patients were males, and 56 were females. The mean age of the patients was 9.2 ± 2.7 years, with a median of 9 years (min=5, max=14).

Considering the age distribution of patients, and according to the "Kolmogorov-Smirnov" statistical test, the population did not have a normal distribution (p<0.01) **Figure 1.**
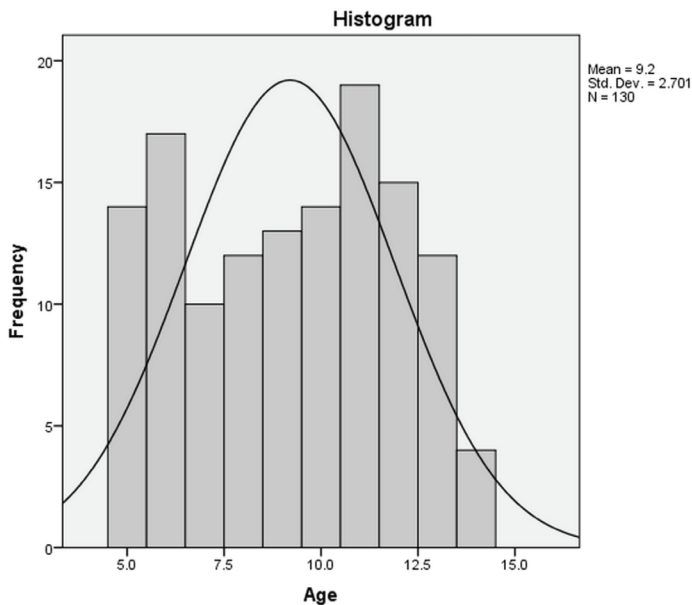
Figure -1 -age distribution of children referred to the hospitals of Tabriz University of Medical Science in 2017 with suspicion of acute appendicitis.

The mean age of the patients was 9.63 ± 2.49 years and 8.28 ± 2.81 years for female and male patients, respectively, which based on "Mann-Whitney U test" was not significantly different (p=0.15).

In the present study, 76.2% of the patients had positive findings during an appendectomy procedure, based on surgeon's investigation and experience, while pathological examinations showed 81.5% of the cases were positive for acute appendicitis. These results indicate a sensitivity of 93.4% and specificity of 100% (PPV=100%, and NPV=77.4%) for positive surgical findings for the diagnosis of acute appendicitis. The mean score of the Alvarado system in patients was 7.11 ± 1.86, with a median of 8 and the mode of 8 with an interval of 9. The median of the PAS system in these patients was 6.42 ± 1.92, with a median of 7 and a mode of 6 with an average of 9.

There was a significant correlation between the scores of the Alvarado system and the PAS according to the Pearson correlation test, so with an increase in the score of the Alvarado, the PAS score also increased (p<0.01, R=0.93).

Alvarado scores among subjects with positive pathologic findings (7.40 ± 1.81) and those without positive pathologic findings (5.83 ± 1.52), was significantly different according to the "Mann-Whitney U test", which means the mean Alvarado score was higher in those subjects whose pathologic findings were positive (p<0.01).

These results were also valid in evaluating the PAS scores in patients; the mean PAS score was 1.86 ± 6.70 and 1.71 ± 5.21 in patients with and without positive pathologic reports, respectively (p<0.01) **Figure 2**.

Examining the prevalence of clinical findings in each scoring system, tenderness in the right lower quadrant (90%), nausea and vomiting (86%), leukocytosis (85% 4%), anorexia (81.5%), neutrophil percentage higher than 75% (66%), fever (greater than 37.3 °C) (48%), rebound tenderness in the right lower quadrant (43.1%), migration of pain to the right lower quadrant (33.8%), and increase in body temperature (greater than or equal to 38°C) (20%), in sequence, had the most common prevalence among the patients, as shown in **Figure 3**.

Evaluating the relationship between the diagnostic criteria of the two systems, according to the logistic regression test, the neutrophil percentage
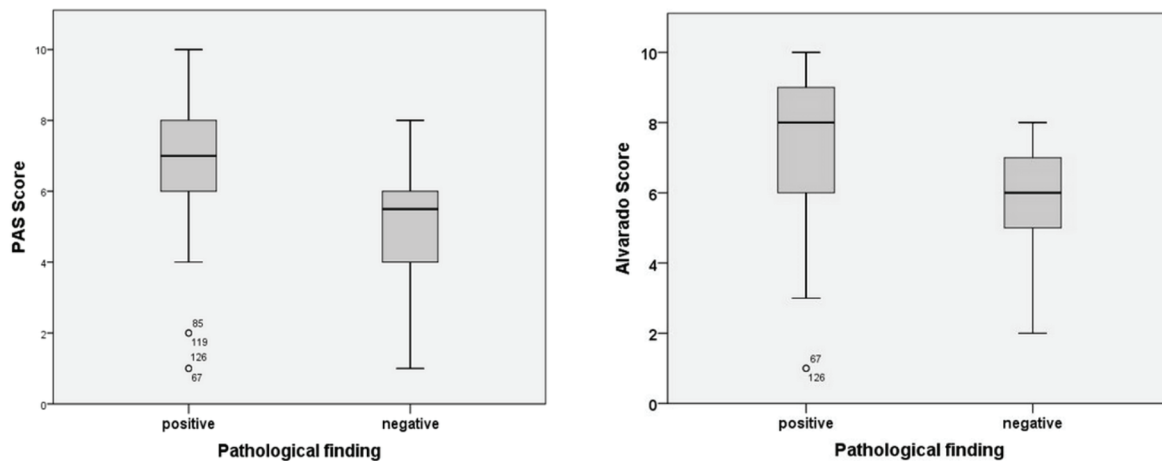
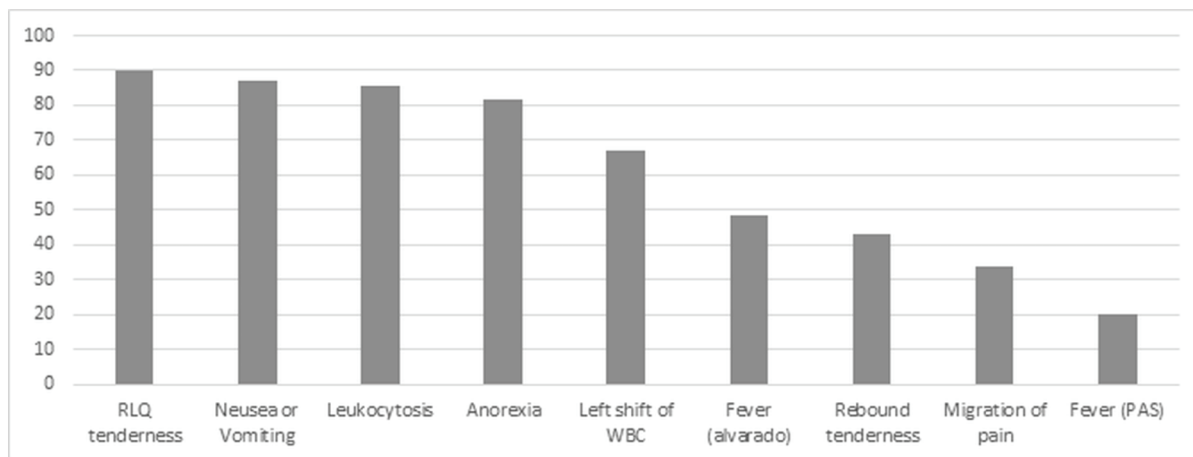**Figure 2:** Mean score of Alvarado and PAS against pathologic finding

Figure 3: Frequency percentage of Alvarado and PAS scores

more than 75% and RLQ tenderness possessed the highest correlation with the correct diagnosis (Exp=6.15, 6.01).

Comparing the diagnostic value of the Alvarado and PAS scale, the diagnostic value of the Alvarado was somewhat higher than the PAS based on the area below the ROC chart (0.77 vs. 0.73), but the difference as not significant (p=0.8) **Figure 4**.

However, according to Figure4, Alvarado's criterion was more sensitive, and PAS was more specific.

For defining the cut-off point for the Alvarado scoring system, considering the sensitivity of 74.5% and specificity of 66.7%, the cut-off point was considered to be 7, and for the PAS criteria, with the sensitivity of 58.5% and specificity of 79.2%, the cut-off point was considered to also be 7.
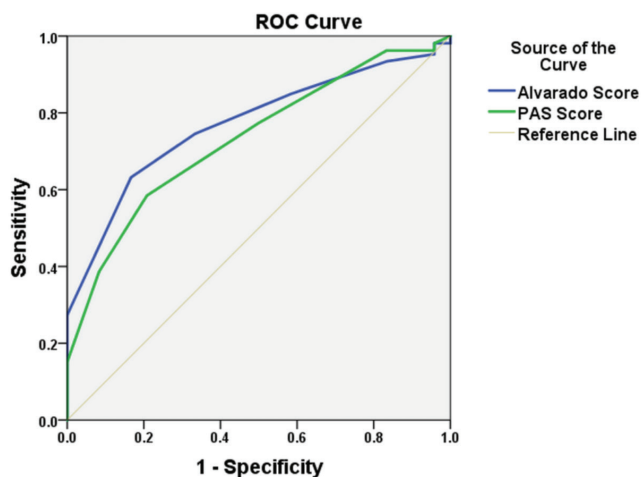
Figure 4: A cut-off point in the Alvarado and PAS scores

Based on the previously mentioned materials, PPV and NPV for Alvarado system were 90.8% and 37.2%, respectively. In addition, PPV and NPV for the PAS system were calculated as 92.5% and 30.2%, respectively.

Discussion

Pain in the abdomen is a common complaint of patients in pediatric clinics. According to the fact that acute appendicitis is considered as the most common surgical emergency condition in pediatric patients, early diagnosis of this disease is crucial. On the other hand, there may be some diagnostic challenges while dealing with the pediatric population, especially preverbal children, which make the diagnosis more problematic. Delayed diagnosis may result in complications, high rate of morbidity and mortality. [4, 5, 8, 16]

Many scoring systems have been created in order

to evaluate the probability of acute appendicitis in patients with acute abdominal pain and help with prompt and accurate diagnosis. [13, 16, 17]

In this prospective cross-sectional study, we found higher diagnostic value for the Alvarado scoring system in comparison with PAS by analyzing the data obtained from 130 children with acute abdominal pain. Also, the results of this study showed a higher sensitivity for Alvarado and a higher specificity for PAS scoring systems compared to each other.

Considering the facts mentioned above, the prompt diagnosis of acute appendicitis is lifesaving. However, unneeded diagnostic procedures and surgeries should be avoided. Unnecessary appendectomies possess a rate between 8.4% to 56.7% in children,[3] while in our study, we found a rate of 18.5% for negative appendectomies.

The Alvarado score was first described by Alfredo Alvarado in 1986. He performed a retrospective cohort study on a population of 305 patients, both adults and pediatrics with suspected appendicitis. The initial aim of their study was to distinguish that which patient should be directly referred to the operating room after the primary evaluation. Alvarado proposed only observation for patients with a score of 5 or 6 and the surgical approach for those who own a score of 7 and higher. He also clarified that the individuals with a score of equal to 5 or under were less likely to have acute appendicitis and could have been discharged.[13] Several studies have aimed to assess the accuracy of the Alvarado scoring system. Hsiao et al. found the Alvarado system as a useful method

for diagnosing acute appendicitis after evaluating 222 patients.[18] In a prospective cohort study by Schneider et al.,[19] they evaluated 588 pediatric patients with acute abdominal pain using the Alvarado system. The authors recommended a cut-off value of 7 is associated with a high probability of acute appendicitis (PPV=65%, NPV=46%, sensitivity=72% and specificity = 81%).

According to the mentioned studies and other similar ones, the validation and accuracy of Alvarado score have been established for being utilized in patients suspected of having acute appendicitis. [9, 18, 19]

The result of our study concerning Alvarado score was consistent with the other reported studies (sensitivity of 74.5%, specificity of 66.7%, PPV of 90.8%, and NPV of 37.2%).

Based on a prospective evaluation of 1170 patients with acute appendicitis aged 4 to 15 on a cohort study during five years, Samuel[17] presented the PAS scoring system in 2002. He reached a sensitivity, specificity, PPV and NPV of 100%, 92%, 96%, and 99%, respectively. Samuel concluded that the presence of appendicitis is unlikely among the patients with a score of less than 6; however, a score of 6 and higher was remarkably related to appendicitis.[17]

Schneider et al.[19] found that if the cutoff point is set at a score of 6 or greater, it shows a sensitivity of 82%, specificity of 65% and PPV of 54%. Bhatt et al.[14] in their prospective observational study on 275 children aged 4 to 18, found the sensitivity of 92.8% and a specificity of 69.3%,considering the

score of 6 and higher as their cut-off point. On the other hand, Goldman et al.[15] said that if the score of 7 were considered as the cut-off point, the sensitivity and specificity would be 94% and 98%, respectively. The inconsistency in the mentioned results may be explainable by the difference in their study populations. Some studies recommend only observation for the score of 5 and 6 and proceeding to the surgery in cases with a score of 7 or higher in both scoring systems.[13, 20]

In our study, we found that a PAS score of 7 or higher (rather than the score of 6 originally proposed by Samuel) results in a sensitivity of 58.5%, a specificity of 79.2%, a PPV of 92.5%, and a NPV of 30.2% which was somehow different from the previous mentioned results.

It can be concluded that although the mean scores of Alvarado and PAS in our patients were lower than previous studies, the scores of the both Alvarado and PAS systems were considerably higher in patients with acute appendicitis than those who did not have the disease.

Based on the area below the ROC **Figure 4**, the diagnostic value was higher in the Alvarado system than the PAS (0.77 vs. 0.73). However, according to the chart's shape, Alvarado's criterion was more sensitive, and the PAS was more specific.

Conclusion

The results of this study showed the higher sensitivity of Alvarado criterion and more specificity of the PAS. However, the sensitivity, specificity, PPV, and NPV of these criteria were not considered enough to confirm the diagnosis

of acute appendicitis. Therefore, the surgeon's decision and the aid from other paraclinical methods, such as medical imaging is necessary for the accurate diagnosis.

Ethical Consideration

This study has been approved by the ethics committee of Tabriz University of Medical Science with the reference number of 5/d/39769-57393.

Conflict of Intereast

The authors declare that they have no competing interests.

References

1. Sivit CJ, Siegel MJ, Applegate KE, et al: When appendicitis is suspected in children. Radiographics 2001;21(1):247-62.

2. Glass CC, Rangel SJ, editors: Overview and diagnosis of acute appendicitis in children. Seminars in pediatric surgery; 2016: Elsevier.

3. Smink DS, Finkelstein JA, Kleinman K, et al: The effect of hospital volume of pediatric appendectomies on the misdiagnosis of appendicitis in children. Pediatrics 2004;113(1):18-23.

4. Mallick MS: Appendicitis in pre-school children: a continuing clinical challenge. A retrospective study. International Journal of Surgery 2008;6(5):371-3.

5. Lee SL, Stark R, Yaghoubian A, et al: Does age affect the outcomes and management of pediatric appendicitis? Journal of pediatric surgery 2011;46(12):2342-5.

6. Pogorelic Z, Rak S, Mrklic I, et al: Prospective validation of Alvarado score and Pediatric Appendicitis Score for the diagnosis of acute appendicitis in children. Pediatric emergency care 2015;31(3):164-8.

7. Macco S, Vrouenraets BC, de Castro SMM: Evaluation of scoring systems in predicting acute appendicitis in children. Surgery 2016;160(6):1599-604.

8. Alvarado A: Improved alvarado score (MANTRELS) for the early diagnosis of acute appendicitis. Int J Surg Res Pract 2019;6:98.

9.   Mandeville K, Pottker T, Bulloch B, et al: Using appendicitis scores in the pediatric ED. The American journal of emergency medicine 2011;29(9):972-7.

10.   Nishizawa T, Maeda S, Goldman RD, et al: Predicting need for additional CT scan in children with a non-diagnostic ultrasound for appendicitis in the emergency department. The American journal of emergency medicine 2018;36(1):49-55.

11.   Shah SR, Sinclair KA, Theut SB, et al: Computed tomography utilization for the diagnosis of acute appendicitis in children decreases with a diagnostic algorithm. Annals of surgery 2016;264(3):474-81.

12.   Kulik DM, Uleryk EM, Maguire JL: Does this child have appendicitis? A systematic review of clinical prediction rules for children with acute abdominal pain. Journal of clinical epidemiology 2013;66(1):95-104.

13.   Alvarado A: A practical score for the early diagnosis of acute appendicitis. Annals of emergency medicine 1986;15(5):557-64.

14.   Bhatt M, Joseph L, Ducharme FM, et al: Prospective validation of the pediatric appendicitis score in a Canadian pediatric emergency department. Academic Emergency Medicine 2009;16(7):591-6.

15.   Goldman RD, Carter S, Stephens D, et al: Prospective validation of the pediatric appendicitis score. The Journal of pediatrics 2008;153(2):278-82.

16.   van Amstel P, Gorter RR, van der Lee JH, et al: Ruling out Appendicitis in Children: Can We Use Clinical Prediction Rules? Journal of Gastrointestinal Surgery 2019;23(10):2027-48.

17.   Samuel M: Pediatric appendicitis score. Journal of pediatric surgery 2002;37(6):877-81.

18.   Hsiao KH, Lin LH, Chen DF: Application of the MANTRELS scoring system in the diagnosis of acute appendicitis in children. Acta paediatrica Taiwanica= Taiwan er ke yi xue hui za zhi 2005;46(3):128-31.

19.   Schneider C, Kharbanda A, Bachur R: Evaluating appendicitis scoring systems using a prospective pediatric cohort. Annals of emergency medicine 2007;49(6):778-84. e1.

20.   Tan E, Severijnen R, Rosman C, et al: Diagnosis and treatment of acute appendicitis in children: a survey among Dutch surgeons and comparison with evidence-based practice. World journal of surgery 2006;30(4):512-8.