

Original article

A comparative study on the diagnostic validity of three scoring systems in the diagnosis of acute appendicitis in emergency centres

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ABSTRACT

Background: Considering the inconsistencies on the validity scoring systems in the diagnosis of acute appendicitis, our aim was to compare the accuracy of the three Anderson, Alvarado and Alvarado + CRP scoring systems in the diagnosis of patients with suspected acute appendicitis.

Methods: This was a prospective observational study performed on patients 15–65 years complained of abdominal pain in the RLQ with a high clinical suspicion of acute appendicitis within two years. The scoring systems of Anderson, Alvarado, and Alvarado + CRP were recorded using a pre-prepared questionnaire by a senior emergency medicine assistant. Acute appendicitis was confirmed based on the histopathologic findings. Written informed consent was obtained from all the patients before entering the study.

Results: 200 patients were enrolled in the study. In 159 cases diagnosed with appendicitis based on histopathological findings, Anderson, Alvarado, and Alvarado scoring systems were able to identify 121, 152, and 147 cases respectively. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 77%, 19%, 78%, 17 and 64% in Anderson, 95%, 7%, 75%, 30% and 77% in Alvarado, and 92%, 7%, 79%, 20%, and 75% in Alvarado + CRP scoring systems, respectively.

Conclusion: Anderson scoring system had lower diagnostic accuracy than the Alvarado system. The role of CRP as an adjunct test to increase the accuracy of the Alvarado scoring system in the diagnosis of acute appendicitis has been under question. Given the inconsistent results of the scoring systems in the diagnosis of acute appendicitis, there is a need to develop a more precise clinical-paraclinical scoring system for this condition.

African relevance

- The diagnosis of acute appendicitis in the emergency centre is a challenging task.
- Several diagnostic systems with variable accuracy have been developed.
- The role of CRP in the diagnosis of acute appendicitis is still unclear

Introduction

Acute appendicitis is the most common diagnosis in the patients with abdominal pain in the right lower quadrant (RLQ) referred to the emergency centre. Although numerous scoring systems have been defined, the diagnosis of acute appendicitis is not easily made in this condition. In fact, false positive results are still reported in 15–30% of cases [1].

The Alvarado system is one of the most important scoring systems

which has been used to diagnose acute appendicitis for more than two decades. This system is a simple and inexpensive strategy exploiting 3 symptoms, 3 signs and 2 laboratory criteria (i.e. leukocytosis and neutrophilia) [2].

The diagnostic scoring systems along with laboratory and biochemical tests have been more reliable to diagnose acute appendicitis in some studies. C-reactive protein (CRP) is an inflammatory marker which has been used to increase the accuracy of diagnostic scoring systems [3–5]. However, its diagnostic accuracy has been variable in different studies [7,8].

The Anderson scoring system is another diagnostic tool for acute appendicitis; however, a few researches have been done on the accuracy of this system. The recent system exploits 2 symptoms, 2 signs, and 3 laboratory tests (leukocytosis, neutrophilia, and CRP). Regarding the low sensitivity and specificity of the Alvarado system, the Anderson system was developed to augment the diagnostic accuracy of acute appendicitis [9].

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Considering the above-mentioned, our aim was to compare the diagnostic accuracies of three Anderson, Alvarado and Alvarado + CRP scoring systems in the diagnosis of suspected acute appendicitis.

Methods

This was a prospective observational study performed on patients with abdominal pain in the RLQ referred to two emergency centres in Kerman, located in the southeast of Iran from July 2017 to July 2019.

The study was approved by the Ethics Committee of Kerman University of Medical Sciences. [IR.KMU.AH.REC.1398.022].

All the patients complained of abdominal pain in the RLQ with a high clinical suspicion of acute appendicitis were included to the study. Patients younger than 14 and older than 65 years, pregnant women, patients with a history of recent infection, and those diagnosed with other conditions than acute appendicitis were excluded.

A total of 200 patients, who met the inclusion criteria, were enrolled in this study.

After admission, all the patients were evaluated by a senior emergency medicine assistant and completed a pre-prepared questionnaire under supervision of the assistant. Then blood samples were taken and immediately transferred to the laboratory to determine white blood cell (WBC), polymorphonuclear (PMN) and CRP. The Anderson, Alvarado and Alvarado + CRP scoring systems were calculated and recorded for each patient during the clinical examination and after preparation of laboratory tests and histopathological results (Tables 1–3). Medical counseling to perform surgery was requested for all the patients, and the decision to proceed with surgery was made by a senior surgical assistant. Meanwhile, all the patients were followed up by an emergency medicine assistant. The definite diagnosis of acute appendicitis was confirmed based on the histopathological results of the removed appendix. Written informed consent was obtained from all the patients.

SPSS 20 software was used to analyse the data. The data was described using percentage. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each scoring system. A *p*-value < 0.05 was considered as statistically significant.

Results

During the study period, a total of 262 patients with clinical suspicion of acute appendicitis were included within two years. Of them, 62 patients were excluded from the study and 200 patients were enrolled (Fig. 1). Of these, 159 (79.5%) were diagnosed with acute appendicitis based on histopathological findings. The mean age of the patients was 25.27 ± 10.94 years. Considering gender, 109 (54.5%) and 91 (45.5%) were female and male, respectively. There was a significant relationship between CRP level and diagnosis of acute appendicitis (*P* = 0.04).

Regarding the probability of acute appendicitis, the patients were subdivided into 3, 4 and 3 subgroups based on the Anderson, Alvarado,

Table 1
Anderson score^a.

Variables	Level	Score
Pain or tenderness in right lower quadrant		1
Vomiting		1
Body temperature	≥ 38.5 °C	1
Rebound tenderness or muscular defense	Slight/moderate/strong	1/2/3
WBC count	10–14.9 × 10 ⁹ /l/≥ 15.0 × 10 ⁹ /l	½
Proportion neutrophils	70%–84%/≥ 85%	½
CRP concentration	10–49 mg/l/≥ 50 mg/l	½

^a 1–4 Low probable; 5–8 Intermediate probable; 9–12 High probable.

Table 2
Alvarado score^a.

Variables	Score
Migratory right iliac fossa pain	1
Nausea/vomiting	1
Anorexia	1
Tenderness in the right iliac fossa	2
Rebound tenderness in the right iliac fossa	1
Elevated temperature	1
Leukocytosis	2
Shift to the left of neutrophils	1
Total	10

^a 1–4 Impossible; 5–6 Possible; 7–8 Probable; 9–10 Very probable.

Table 3
Alvarado + CRP score^a.

Variables	Score
Migratory right iliac fossa pain	1
Nausea/vomiting	1
Anorexia	1
Tenderness in the right iliac fossa	2
Rebound tenderness in the right iliac fossa	1
Elevated temperature	1
Leukocytosis	2
Shift to the left of neutrophils	1
CRP concentration (10–49 mg/l/≥ 50 mg/l)	½

^a 1–4 Low probable; 5–8 Intermediate probable; 9–12 High probable.

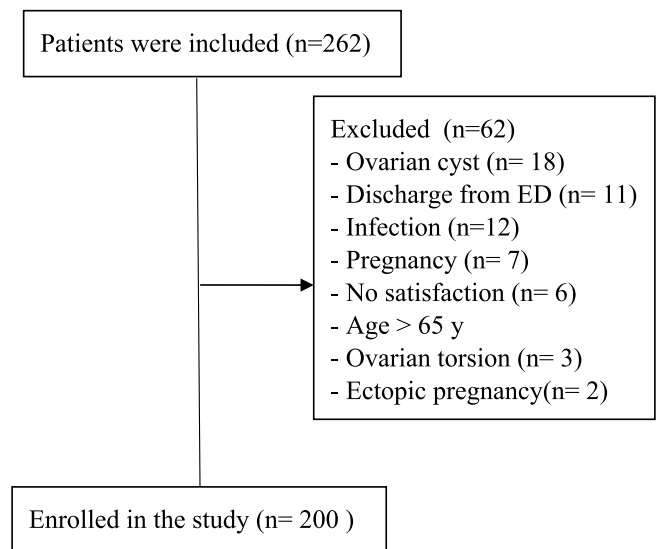


Fig. 1. Flow chart showing enrollment of patients.

and Alvarado + CRP scoring systems, respectively. Overall, 22 (11%), 57 (28.5%), and 88 (44%) of the patients acquired high probable in the Anderson, Alvarado, and Alvarado + CRP scoring systems, respectively (Table 4). Comparisons between Anderson, Alvarado and Alvarado + CRP scoring systems with histopathological results have been shown in Table 5. While 159 appendicitis cases were confirmed with histopathological findings, 121, 152, and 147 of these were identified using Anderson, Alvarado, and Alvarado + CRP scoring systems, respectively. The sensitivity, specificity, PPV, NPV and accuracy were 77%, 19%, 78%, 17% and 64% in the Anderson, 95%, 7%, 80%, 30%, and 77% in the Alvarado, and 92%, 7%, 79%, 20%, and 75% in the Alvarado + CRP scoring systems, respectively. Also, likelihood ratio of positive/negative test and area under curve were 0.94/1.22, 0.52 in the Anderson, 1.03/0.60, 0.62 in the Alvarado and 0.99/1.03 and 0.62 in the Alvarado + CRP, respectively (Table 6).

Table 4
Frequency of Anderson, Alvarado and Alvarado-CRP Scores among Participants.

Score	Subgroup	No. of cases	Percentage
Anderson	1–4	46	23
	5–8	132	66
	9–12	22	11
	Total	200	100
Alvarado	1–4	10	5
	5–6	47	23.5
	7–8	86	43
	9–10	57	28.5
	Total	200	100
Alvarado -CRP	1–5	15	7.5
	6–8	97	48.5
	9–12	88	44
	Total	200	100

Table 5
Comparison between Anderson, Alvarado, Alvarado-CRP Scoring and histopathological reports among Participants.

Score		Histopathology		
		No appendicitis	Appendicitis	Total
Anderson	No appendicitis	8	38	46
	Appendicitis	33	121	154
	Total	41	159	200
Alvarado	No appendicitis	3	7	10
	Appendicitis	38	152	190
	Total	41	159	200
Alvarado -CRP	No appendicitis	3	12	15
	Appendicitis	38	147	185
	Total	41	159	200

Discussion

The accurate diagnosis of acute appendicitis in the emergency centre is problematic. In this regard, several scoring systems with different sensitivities and specificities have been developed. In the present study, the Anderson scoring system was less sensitive while more specific than the Alvarado and Alvarado + CRP systems to diagnose acute appendicitis. This indicated that incorporating CRP to the Alvarado system did not increase its sensitivity and specificity compared to the Alvarado scoring system.

Because of low sensitivity and specificity of the Alvarado scoring system for diagnosis of appendicitis in the Middle East, a new scoring system (i.e. Anderson) was developed. The new system consisted of 2 symptoms, 2 signs, and 3 laboratory parameters and respective to the Alvarado scoring system, placed more stress on paraclinical tests. In particular, CRP was incorporated with WBC and PMN in the Anderson system. In a study by Choudhary et al., 50 patients with acute appendicitis were assessed by the Anderson scoring system which rendered diagnostic sensitivity and specificity of 76% and 100% respectively [9]. In another study by Goel et al. on patients with acute appendicitis, the Anderson scoring system delivered 73.7% sensitivity and 100% specificity compared

to histopathology. Out of 100 patients studied in the recent report, 70 patients had Anderson score above 8 which was consistent with histopathological results. Furthermore, 30 patients showed a score < 8 from whom 25 were diagnosed with appendicitis by histopathology. The PPV and NPV were reported as 100% and 16.67% in the recent study, respectively [10]. In our study on patients with abdominal pain in the RLQ and suspected appendicitis, the sensitivity, specificity, PPV, NPV and accuracy of the Anderson system were 77%, 19%, 17%, 78%, and 64%, respectively. Compared with the study of Goel et al., our observation indicated a respectively lower specificity which may be due to the fact that only 11% of our patients had a score above 8.

The diagnosis of acute appendicitis is a challenge in emergency situations, especially when paraclinical findings are uncertain. The Alvarado is one of the oldest scoring systems for diagnosis of acute appendicitis, particularly in preoperative conditions. In this system, only the WBC and PMN paraclinical parameters are exploited while the rest diagnostic criteria are based on clinical presentations. In a study by Ahmad et al. on patients with abdominal pain in the RLQ, the sensitivity and specificity of Alvarado system were 74.68% and 26.87%, respectively. These results indicated that although this system is helpful in the diagnosis of appendicitis, it is not much effective in preventing laparotomies in non-appendicitis cases [11]. It is noteworthy that the recent study was performed on patients with Alvarado scores above 6. Koppad et al. reported that the sensitivity, specificity, PPV, NPV of Alvarado system were 98.5%, 87%, 94.36% and 96.42%, respectively [12]. In another retrospective cohort study by Apisanthanarak et al. [13], the Alvarado scoring system was not found as a reliable system for diagnosis of acute appendicitis. Altogether, the diagnostic validity of the Alvarado system has been variable in various studies. In our study, the sensitivity, specificity, PPV, NPV, and accuracy of the Alvarado system were 95%, 7%, 80%, 30%, and 77%, respectively. Although the reported results are inconsistent, the sensitivity of this system has been high in different studies. Nevertheless, low Alvarado score cannot rule out acute appendicitis.

CRP is an acute-phase protein which is increased in inflammatory conditions and tissue damages. Various studies have reported the diagnostic value of this parameter in distinguishing acute appendicitis. In several studies on patients with acute appendicitis; however, CRP has not been recommended for the diagnosis of acute appendicitis [14–16]. In another three-year study performed by Al-Abed et al. on 447 patients with acute appendicitis, CRP was noted as a beneficial parameter in the diagnosis of acute appendicitis and the decision to perform surgical operation [17]. In one study on patients with acute appendicitis in 2019, sensitivity, specificity, PPV, and NPV of CRP were 72.62%, 38.5%, 88.4%, and 17.9%, respectively [18]. Therefore, given the low specificity of this parameter, normal range CRP cannot exclude acute appendicitis [19]. Considering these contradictory results and questioned diagnostic value of Alvarado system [20,21], the combination of Alvarado system and CRP (Alvarado + CRP) was assessed in our study. The sensitivity, specificity, PPV and NPV of the Alvarado + CRP system were 79%, 7%, 92%, and 20%, respectively. In a study by Fatih et al. on patients suspected to have acute appendicitis, it was noted that incorporating CRP increased the diagnostic value of the Alvarado scoring system [22]. Also, Sonay et al. showed that the combination of the Alvarado scoring system and CRP increased the

Table 6
Sensitivity, Specificity, PPV¹, NPV², Accuracy, LR (+/-)^{3,4} and AUC⁵ of Anderson, Alvarado, Alvarado-CRP Scoring.

Score	Sensitivity (95%CI)	Specificity (95%CI)	PPV (95%CI)	NPV (95%CI)	Accuracy (95%CI)	LR (+) (95%CI)	LR (-) (95%CI)	AUC (95%CI) ⁶
Anderson	77 (69–82)	19 (8–34)	78 (71–84)	17 (9–30)	64 (54–71)	0.94 (0.88–1)	1.22 (0.42–3.5)	0.52 (0.43–0.61)
Alvarado	95 (91–98)	7 (1–19)	80 (74–85)	30 (11–60)	77 (71–83)	1.03 (0.97–1.08)	0.60 (0–31)	0.62 (0.53–0.71)
Alvarado-CRP	92 (87–96)	7 (1–19)	79 (73–84)	20 (7–45)	75 (68–70)	0.99 (0.94–1.05)	1.03 (0–47)	0.62 (0.53–0.71)

¹Positive predictive value, ²Negative predictive value, ^{3,4}Likelihood ratio of positive/negative test, ⁵Area under curve, ⁶Confident interval.

specificity and reduced the sensitivity of the model [6]. Nevertheless, using combination of CRP and the Alvarado system did not increase the accuracy of the model in our study.

There were some limitations in the current study. One was that we only measured CRP in day and not day-night time. Clinical examinations were not performed by a senior surgeon. Furthermore, people who did not consent to participate in the study were excluded, and those < 14 or > 65 years old were not assessed.

Conclusion

The diagnosis of acute appendicitis in the emergency centre is a challenging task. Although several diagnostic systems have been developed, their diagnostic accuracies have been variable. The Anderson scoring system showed lower diagnostic accuracy than the Alvarado system in the present study. Also, the role of CRP as an adjunct test to increase the accuracy of the Alvarado scoring system in the diagnosis of acute appendicitis has been under question. Therefore, it is advisable to develop more effective strategies to evaluate patients with suspected acute appendicitis.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Dissemination of results

Results from this study was shared with staff members at the data collection site through an informal presentation.

Authors' contribution

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: MT contributed 55%; FF 25% and MM 20%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

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Declaration of competing interest

The authors declare no conflict of interest.

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