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Assessment of Alvarado criteria, ultrasound, CRP, and their combination in patients with suspected acute appendicitis: a single centre study

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Abstract

Background Acute appendicitis (AA) is one of the most common reasons for visiting the emergency room. The lack of proper diagnosis and rapid treatment of AA may lead to severe complications such as intestinal perforation and increased mortality. This study aimed to evaluate the diagnostic accuracy of the Alvarado criteria, ultrasound, and CRP criteria in comparison with their combined use in patients with suspected AA who presented to the emergency room.

Methods In this diagnostic accuracy study, 1411 patients with suspected AA who presented to the emergency department of Firoozabadi Hospital affiliated with Iran University of Medical Sciences and underwent appendectomy from October 2019 to October 2021 were examined. Nine hundred eighty-eight patients were enrolled. All patients were assessed using Alvarado, CRP, and ultrasound. The definitive diagnosis of AA was based on pathological findings and was considered the gold standard. Statistical analyses were performed with STATA VER 11.5. The diagnostic accuracy for each group was compared using the Pearson chi-square test. A value of $p < 0.05$ was considered statistically significant.

Results The mean age was 29.57 ± 13.66 years. The sensitivity and specificity of Alvarado in the diagnostic accuracy of appendectomy were 75.2% and 61.3% (CI = 95%), respectively. The sensitivity of ultrasound and CRP for predicting appendicitis was significantly higher than the Alvarado criteria. The diagnostic accuracy for CRP was significantly higher than ultrasound (64.9% vs. 60.7%, $P: 0.003$). The diagnostic accuracy of the simultaneous use of Alvarado + CRP and CRP + Ultrasound was significantly higher than that of Alvarado + ultrasound. The sensitivity, specificity, and diagnostic accuracy of the simultaneous use of all three criteria together (Alvarado + Ultrasound + CRP) were estimated to be 94.9%, 25.8%, and 81.5% (CI = 95%), respectively, which were significantly higher than the use of other criteria.

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Conclusion This study showed that the Alvarado criteria had inadequate diagnostic sensitivity and accuracy for diagnosing acute appendicitis. The diagnostic accuracy of acute appendicitis increases to over 90% using the three Alvarado, ultrasound, and CRP criteria at the same time.

Keywords Acute appendicitis, Alvarado, Ultrasound, CRP, Emergency, Accuracy

Introduction

Acute appendicitis (AA) is one of the most common causes of emergency room visits following acute abdominal pain [1–3]. The lifetime incidence rate of appendicitis is 8.6% among men and 6.7% among women and is much higher in the second decade of life [4, 5]. Appendicitis is an irreversible, progressive disease that eventually leads to intestinal perforation. Appendectomy is the gold standard treatment. Appendiceal perforation is associated with increased mortality compared to AA without perforation. The risk of death from non-gangrenous appendicitis is less than 0.1%, but this risk increases to 0.6% in gangrenous AA. Furthermore, perforated AA has a higher mortality rate of approximately 5% [6]. Diagnosing AA is often challenging and requires a combination of history, clinical, laboratory, and radiological findings. The symptoms of appendicitis overlap with several other conditions, especially in the early stages, making the diagnosis challenging [7, 8]. AA diagnostics can be improved and facilitated through clinical scoring systems, including physical exam results and inflammatory markers. Several scoring systems have been created to help in the early diagnosis of acute appendicitis, such as the Alvarado score, Pediatric Appendicitis Score, and Appendicitis Inflammatory Response score. These scoring systems use criteria, including common clinical and laboratory findings in patients with AA, to classify them into low, medium, or high-risk groups and can help in a timely diagnosis [9]. However, none of these scoring systems are widely accepted [10, 11].

The role of diagnostic imaging, such as ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI), is another major debate [12, 13].

In 1986, Alvarado devised a 10-point clinical scoring system to diagnose AA based on symptoms and diagnostic tests in suspected patients, which includes migrating pain (1 score), anorexia (1 score), nausea (1 score), tenderness in the lower right abdominal region (2 scores), rebound (1 score), temperature increase above 37.3 (1 score), leukocytosis above 10,000 (2 scores) and left shift of white blood cells (1 score). Screening and decision-making for patient management were based on the sum of the scores and were categorized as follows. Score 1 to 4 (discharge), score 5 to 6 (admission and follow-up), and score 7 to 10 (surgery) [14].

Due to the development of new diagnostic methods, the discrepancy in different diagnostic criteria, and the Outdated Alvarado criteria (low sensitivity of

the Alvarado score for diagnosing acute appendicitis) [15–17], it is crucial to check the diagnostic accuracy of these criteria. In addition, if acute appendicitis is not properly diagnosed and treated in time, serious complications such as intestinal perforation would be inevitable, and this complication itself leads to increased mortality. Therefore, this study was conducted to retrospectively evaluate the diagnostic accuracy of the Alvarado criteria, ultrasound, and C-reactive protein (CRP) in comparison with their combined use in patients with suspected acute appendicitis who presented to the emergency room. The results of this study can help screen appendicitis patients more accurately and reduce the burden of surgeries by preventing unnecessary appendectomies.

Methods

From October 2019 to October 2021, 1411 patients presented to the emergency department of Firoozabadi Hospital with suspected appendicitis and underwent appendectomy. All patients underwent clinical and para-clinical examinations. This study was approved by the Ethics Committee of Iran University of Medical Sciences (Protocol NO: IR.IUMS.REC.1401.381) Informed consent was obtained from all patients and in the case of patients who were below the age of 18 years, informed consent was obtained from a parent and/or legal guardian at the time of admission.

In this retrospective diagnostic accuracy study, we included patients with suspected appendicitis, who consented to participate in the study and cases in which we had access to their laboratory and ultrasound findings. The exclusion criteria included patients with gastrointestinal diseases, gastrointestinal and colorectal cancers, kidney disorders, and lack of access to patient findings. In total, 988 patients were enrolled in our study.

All patients' scores were calculated according to the Alvarado criteria, which devised a 10-point clinical scoring system to diagnose AA based on symptoms and diagnostic tests in suspected patients, which includes migrating pain (1 score), anorexia (1 score), nausea (1 score), tenderness in the lower right abdominal region (2 scores), rebound (1 score), temperature increase above 37.3 (1 score), leukocytosis above 10,000 (2 scores) and left shift of white blood cells (1 score). Screening and decision-making for patient management were based on the sum of the scores and categorized as follows. Score 1 to 4 (discharge), score 5 to 6 (admission and follow-up), and score 7 to 10 (surgery) [18]. All patients underwent

Table 1 Distribution of demographic characteristics and clinical findings of patients who underwent appendectomy

Variable	988 subjects
Age (year)	31.53 ± 15.26
Sex	
• Male	640 (64.8%)
• Female	348 (35.2%)
Alvarado Score	
• < 4	49 (4.9%)
• 4–7	263 (26.2%)
• > 7	676 (68.9%)
Age group	
< 12	70 (7.1%)
13–18	112 (11.3%)
18–65	782 (79.2%)
> 65	24 (2.4%)
CRP	
• < 10	424 (42.9%)
• > 10	564 (57.1%)
Ultrasound	
• Positive	558 (56.5%)
• Negative	430 (43.5%)
Appendicitis	
• Positive	816 (82.6%)
• Negative	172 (17.4%)

ultrasonography and were simultaneously tested for blood CRP levels.

Patient demographics (age and sex) and clinical findings (ultrasound findings, laboratory findings, and Alvarado score) were evaluated by the researcher for all patients. All patients underwent appendectomy. This study's definitive diagnosis of appendicitis was based on gross surgical and pathological findings. Alvarado criteria score (approach), CRP levels (CRP > 10), ultrasound findings (evidence in favour of appendicitis (and ten combinations of diagnostic methods were compared with the surgical and pathological findings. The sensitivity, specificity, and diagnostic accuracy of the criteria and other diagnostic methods were estimated by this comparison.

Following data collection, all patient data were analysed using SPSS for Windows Version 11.5 (SPSS, Inc., Chicago, IL, USA). To check the normality of quantitative data, the Kolmogorov–Smirnov test was used. Parametric tests such as t-test were used for variables with a normal distribution, and for variables with a nonnormal

distribution, nonparametric Mann–Whitney tests were used to compare variables in two groups. Sensitivity, specificity, and positive and negative predictive values were calculated for the test. The chi-square test was used to compare qualitative variables in the two groups. A *p*-value less than 0.05 was considered significant.

Results

Demographic and clinical characteristics of patients

Overall, 988 patients with appendectomies were examined. The mean age of the patients was 31.53 ± 15.26. Among participants, 7.1% were in the children group and 11.3% were adolescents, also, 2.4% were above 65 years old. A total of 640 (64.8%) were male, and 348 (35.2%) were female. Based on the Alvarado criteria, 676 (68.9%) patients scored 7 to 10 and were candidates for surgery. Among all the patients based on ultrasound findings, 558 (56.5%) had evidence in favor of appendicitis. Patients' CRP levels were determined, and 564 (57.1%) had abnormal CRP (CRP > 10). The postsurgical pathology index as a standard criterion showed that 816 (82.6%) patients had appendicitis and had undergone surgery properly. (Table 1)

Sensitivity, specificity, positive predictive value, and negative predictive value of Alvarado based on pathology findings after surgery

The sensitivity and specificity of the Alvarado criteria for predicting appendectomy were 75.2% and 61.3%, respectively. The positive and negative predictive values of these criteria were 89.6% and 35.8%, respectively (Table 2).

Comparison of sensitivity and diagnostic accuracy of combined criteria

The sensitivity of the Alvarado criteria and CRP for predicting appendicitis was significantly higher than ultrasound (*P* < 0.05). CRP diagnostic accuracy was significantly higher than ultrasound (63.5% versus 60.6%, *P*: 0.035). The simultaneous use of the Alvarado criteria + CRP is significantly more accurate than that of the Alvarado criteria + ultrasound. (86.2% vs. 80.6%, *P*: 0.003). The sensitivity and diagnostic accuracy of the simultaneous use of CRP + ultrasound were 90.5% and 82.1%, respectively, which were significantly higher than the

Table 2 Estimation of sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of criteria

Criteria	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy
CRP	63.5% (51,76.2)	71% (68.5,83.2)	90.6% (84.7,97.2)	30.5% (18,43.3)	64.9% (58.1,79.7)
Alvarado	75.2% (66,85.4)	61.3% (55.2,69.1)	89.6% (78.5,96.1)	35.8% (28,48.6)	72.6% (61.4,78.3)
Ultrasound	60.6% (50,70.3)	61.3% (47.7,73.4)	87.3% (75.1,93)	26.1% (17.8,34.5)	60.7% (55.6,66.1)
Alvarado + CRP	92% (84.1,98.7)	38.7% (24.7,56)	86.8% (73.2,96.7)	52.1% (40.5,64.1)	86.2% (81,91.3)
Alvarado + Ultrasound	88.3% (73,96.2)	38.7% (24,53.7)	86.4% (78.8,93.3)	42.8% (29.1,62.5)	80.6% (69.8,88.7)
CRP + Ultrasound	90.5% (86.1,95.5)	45.2% (34,55.3)	87.9% (78.4,95.1)	51.8% (44.4,58.9)	82.1% (77.4,85.7)
Alvarado + Ultrasound + CRP	94.2% (89.2,99.5)	25.8% (18.2,22.9)	84.8% (78.6,91.3)	50% (45.1,56.7)	81.5% (73.9,89.4)

use of Alvarado+ultrasound. (P: 0.001) However, the use of this criterion was not significantly different from the Alvarado criteria+CRP simultaneously (P: 0.26). The sensitivity, specificity, and diagnostic accuracy of the simultaneous use of Alvarado criteria+ultrasound+CRP were estimated to be 94.2%, 25.8%, and 81.5%, respectively, which were significantly higher than other diagnostic methods and combinations (Table 2).

Discussion

Various studies have assessed the accuracy of different diagnostic methods for acute appendicitis separately. To date, a few comprehensive studies have compared the sensitivity and specificity of using combined diagnostic methods such as the simultaneous use of the Alvarado criteria, ultrasound findings, and CRP. This study aimed to compare the diagnostic accuracy of various screening methods in patients with appendicitis who were candidates for appendectomy.

Based on our study's results, the Alvarado criteria's sensitivity and specificity for predicting appendectomy were 75.2% and 61.3%, respectively, indicating the low diagnostic accuracy of this test to diagnose the need for appendectomy correctly, which was foreseeable due to the old datedness of these criteria. A combination of these criteria and other methods could increase its sensitivity and accuracy. Furthermore, the diagnostic sensitivity, specificity and accuracy of CRP were significantly higher than ultrasound alone. The Alvarado criteria, CRP levels, and ultrasound, were respectively the most accurate for diagnosing appendicitis. Additionally, our study showed that the use of combined methods was significantly more accurate than the use of a single method for the diagnosis of appendicitis. The diagnostic accuracy of the simultaneous use of two Alvarado+CRP criteria was significantly higher than using two Alvarado+Ultrasound criteria. The diagnostic accuracy of the simultaneous use of CRP+ultrasound was close to 82% and superior to Alvarado criteria+ultrasound. There was no significant superiority in using the CRP+Ultrasound method over the simultaneous use of CRP+Alvarado criteria. The sensitivity and diagnostic accuracy of the combination of Alvarado+Ultrasound+CRP were 94.2% and 81.5%, respectively, which were significantly higher than other methods in correctly predicting the need for appendectomy. Limited studies have evaluated the diagnostic accuracy of the combined use of diagnostic methods. However, studies have assessed the diagnostic accuracy of the single use of these criteria, which is consistent with the results of our study [16, 19–22].

Toney Jose et al. [23] compared the diagnostic accuracy of the Alvarado and Appendicitis Inflammatory Response Score (AIR score) in 130 patients (53 women and 77 men) with clinical manifestations of appendicitis

who underwent appendectomy. They reported the sensitivity and specificity of the Alvarado criteria to be 72% and 79%, respectively. Moreover, they showed that the sensitivity and specificity of the AIR score, which is a combination of the Alvarado score and CRP, were significantly higher than the Alvarado criteria, and according to the sensitivity of this score for the diagnosis of acute appendicitis, the Alvarado score needs to alternate with better diagnostic methods. SAT Dezfuli et al. compared the diagnostic accuracy of the Alvarado and RIPASA criteria in 212 patients who were candidates for appendectomy and reported the sensitivity and specificity of the Alvarado criteria to be 53.9% and 70.18%, respectively. Moreover, they showed that the sensitivity and specificity of the RIPASA criteria were significantly higher than the Alvarado criteria. In our study, the sensitivity and diagnostic accuracy of the simultaneous use of Alvarado+Ultrasound+CRP criteria were 94.2% and 81.5%, respectively, which was almost equal to the sensitivity and diagnostic accuracy of RIPASA criteria demonstrated in the study by Dezfuli et al. [19]. On the other hand, in a study in 2022, MT Naeem et al. [22] examined the diagnostic accuracy of the Alvarado criteria in 120 appendectomy patients and reported the sensitivity of this criterion to be 83.3%, which is significantly higher than our study. their sample size was small and this difference in the two studies can be justified by the difference in the size of the sample examined in the two studies.

Our study showed that by adding CRP, ultrasound or both to the Alvarado criteria for the diagnosis of AA, the sensitivity and accuracy of the diagnosis of appendicitis increased significantly. M Zouari et al. [17] examined the diagnostic accuracy of CRP, ultrasound and the Alvarado criteria in 402 children under 14 years of age who were candidates for appendectomy and showed that the simultaneous use of ultrasound and the Alvarado criteria significantly increased the sensitivity and diagnostic accuracy of appendicitis, which was in line with the results of our study. However, in their study, unlike ours, they did not report a significant difference in the sensitivity for adding CRP to the Alvarado criteria. This difference can be justified because they included only children under 14 years of age in their study, and the role of the CRP index in children is different from adults. In line with the results of our study, S Ozkan et al. [16] reported that the sensitivity of the ultrasound and Alvarado criteria in predicting appendicitis was 71% and 54%, respectively. In 2020, MW Elsherbiny et al. [24] reported the sensitivity and diagnostic accuracy of the Alvarado criteria alone as 56.8% and 61%, respectively, and the sensitivity and diagnostic accuracy of ultrasound as 71.6% and 72.7%, respectively. They showed that adding ultrasound to the Alvarado criterion significantly increases

the sensitivity and diagnostic accuracy of this criterion, which corresponds to the results of our study.

In general, our study had strengths and weaknesses that need to be pointed out. The most important weakness of our study was the unintentional exclusion of acute appendicitis cases despite all the laboratory and clinical conditions. In such cases, acute appendicitis was not diagnosed by the surgeons, and they did not undergo appendectomy, which could have affected the results of the study. The most important strength of the present study was the investigation and comparison of the simultaneous diagnostic accuracy of the Alvarado criteria, ultrasound, and CRP in a suitable sample size of patients suspected of having appendicitis for the first time in Iran.

Conclusion

Our study showed that the Alvarado criteria did not have adequate diagnostic sensitivity and accuracy for the diagnosis of acute appendicitis. The addition of ultrasound or CRP to the Alvarado criteria greatly improves the sensitivity and diagnostic accuracy of these criteria. The sensitivity of acute appendicitis increases significantly (above 90%) by simultaneously using the three Alvarado+ultrasound+CRP criteria. The use of this index can help and be used in the accurate detection of acute appendicitis, and it reduces the burden of surgeries by preventing unnecessary appendectomies.

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Author contributions

A.T., F.O., K.M. and A.T. wrote the main manuscript text. K.M., K.K.H., A.Z. and D.E. acquired data. M.B. and K.M. analyzed the data. All authors reviewed the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the declaration of Helsinki at all times. This study was approved by the Ethics Committee of Iran University of Medical Sciences (Protocol NO: IR.IUMS.REC.1401.381). Informed consent was obtained from all patients and in the case of patients who were below the age of 18 years, informed consent was obtained from a parent and/or legal guardian at the time of admission. Collecting and analyzing the patients' information was done anonymously and using a code to prevent disclosure.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- Mohamed A, Bhat N. Acute appendicitis dilemma of diagnosis and management. *Internet J Surg*. 2010;23(2):1528–8242.
- Naaeder S, Clegg-Lamprey J, Dakubo J. Acute appendicitis. Current Challenges with their Evolving Solutions in Surgical Practice in West Africa: A Reader. 2015(1).
- Baird DL, Simillis C, Kontovounisios C, Rasheed S, Tekkis PP. Acute appendicitis. *BMJ*. 2017;357.
- Lin K-B, Chan C-L, Yang N-P, Lai RK, Liu Y-H, Zhu S-Z, Pan R-H. Epidemiology of appendicitis and appendectomy for the low-income population in Taiwan, 2003–2011. *BMC Gastroenterol*. 2015;15(1):1–13.
- Ferris M, Quan S, Kaplan BS, Molodecky N, Ball CG, Chernoff GW, Bhala N, Ghosh S, Dixon E, Ng S. The global incidence of appendicitis: a systematic review of population-based studies. *Ann Surg*. 2017;266(2):237–41.
- Flum DR. Acute appendicitis—appendectomy or the antibiotics first strategy. *N Engl J Med*. 2015;372(20):1937–43.
- Serres SK, Cameron DB, Glass CC, Graham DA, Zurakowski D, Karki M, Anandwar SP, Rangel SJ. Time to appendectomy and risk of complicated appendicitis and adverse outcomes in children. *JAMA Pediatr*. 2017;171(8):740–6.
- Bundy DG, Byerley JS, Liles EA, Perrin EM, Katznelson J, Rice HE. Does this child have appendicitis? *Jama*. 2007;298(4):438–451.
- Snyder MJ, Guthrie M, Cagle S. Acute appendicitis: efficient diagnosis and management. *Am Family Phys*. 2018;98(1):25–33.
- Gregory S, Kuntz K, Sainfort F, Kharbada A. Cost-effectiveness of integrating a clinical decision rule and staged imaging protocol for diagnosis of appendicitis. *Value Health*. 2016;19(1):28–35.
- Andersson M, Andersson RE. The appendicitis inflammatory response score: a tool for the diagnosis of acute appendicitis that outperforms the Alvarado score. *World J Surg*. 2008;32:1843–9.
- Sammalkorpi HE, Mentula P, Leppäniemi A. A new adult appendicitis score improves diagnostic accuracy of acute appendicitis—a prospective study. *BMC Gastroenterol*. 2014;14(1):1–7.
- Sippola S, Virtanen J, Tammilehto V, Grönroos J, Hurme S, Niiniviita H, Lietzen E, Salminen P. The accuracy of low-dose computed tomography protocol in patients with suspected acute appendicitis: the OPTICAP study. *Ann Surg*. 2020;271(2):332–8.
- Alvarado A. A practical score for the early diagnosis of acute appendicitis. *Ann Emerg Med*. 1986;15(5):557–64.
- Al Awaysih MM, Nofal MN, Yousef AJ. Evaluation of Alvarado score in diagnosing acute appendicitis. *Pan Afr Med J*. 2019;34.
- Ozkan S, Duman A, Durukan P, Yildirim A, Ozbakan O. The accuracy rate of Alvarado score, ultrasonography, and computerized tomography scan in the diagnosis of acute appendicitis in our center. *Niger J Clin Pract*. 2014;17(4):413–8.
- Zouari M, Jallouli M, Louati H, Kchaou R, Chtourou R, Kotti A, Dhaou MB, Zitouni H, Mhiri R. Predictive value of C-reactive protein, ultrasound and Alvarado score in acute appendicitis: a prospective pediatric cohort. *Am J Emerg Med*. 2016;34(2):189–92.
- Ohle R, O'Reilly F, O'Brien KK, Fahey T, Dimitrov BD. The Alvarado score for predicting acute appendicitis: a systematic review. *BMC Med*. 2011;9(1):139.
- Dezfuli SAT, Yazdani R, Khorasani M, Hosseinikhah SA. Comparison between the specificity and sensitivity of the RIPASA and Alvarado scoring systems in the diagnosis of acute appendicitis among patients with complaints of right iliac fossa. *AIMS Public Health*. 2020;7(1):1.
- Sharma K, Thomas S, Chopra A, Choudhury M. Evaluation of the diagnostic accuracy of eight reported clinical scoring systems in the diagnosis of acute appendicitis. *Indian J Surg*. 2022;84(4):741–8.

21. Al-Tarakji M, Zarour A, Singh R, Ghali MS. The role of Alvarado score in predicting acute appendicitis and its severity in correlation to histopathology: a retrospective study in a Qatar population. *Cureus*. 2022;14(7).
22. Naeem MT, Jamil MA, Anwar MI, Raza H, Asad A, Jamil H, Tahir MJ, Bai J, Chauhan TME, Asghar MS. Diagnostic accuracy of Alvarado scoring system relative to histopathological diagnosis for acute appendicitis: a retrospective cohort study. *Annals Med Surg*. 2022;81:104561.
23. Jose T, Rajesh PS. Appendicitis inflammatory response score in comparison to Alvarado score in acute appendicitis. *Surg J (N Y)*. 2021;7(3):e127–31.
24. Elsherbiny MW, Emile SH, Abdelnaby M, Khafagy W, Elshobaky A. Assessment of the diagnostic accuracy of alvarado scoring system combined with focused ultrasound in the diagnosis of acute appendicitis. *J Br Surg*. 2020;107(12):e594–5.

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