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Evaluation and comparison of the results of the Alvarado scoring system with acute inflammatory response score in the diagnosis of acute appendicitis based on the pathological evidence

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Abstract

Introduction: Although appendectomy is the most common reason for abdominal surgery, acute appendicitis (AA) diagnosis remained a challenging issue using various scoring systems.
Objectives: The current study aims to investigate the diagnostic value of the Alvarado scoring system versus the acute inflammatory response score (AIRS) in the diagnosis of AA.
Patients and Methods: The current cross-sectional study was conducted on 120 patients who underwent appendectomy between 2019 and 2020. The on-admission Alvarado and AIRS scores were evaluated for the patients. Besides, the histopathological study of the resected tissues was considered the gold standard. The receiver operating characteristics (ROC) curve was depicted for the scoring systems, and sensitivity, specificity, negative predictive value (NPV) and positive predictive value (PPV), and area under the curve (AUC) were calculated.
Results: The sensitivity, specificity, NPV, and PPV of Alvarado criteria for scores >4 equaled 89.3%, 23.5%, 35.2%, and 89.3%, respectively. These amounts were calculated as 96.1%, 82.3%, 77.7%, and 97% for the AIRS, respectively. Moreover, at cut-points >8, the sensitivity of 32.1%, specificity of 100%, PPV of 100%, and NPV of 15.7% have been measured for AIRS compared with 41.7%, 88.2%, 97.1%, and 29.4% for Alvarado, respectively. The measured AUC for AIRS and Alvarado criteria accounted for 0.81 and 0.72, respectively (P value <0.05). Besides, 17 (14.16%) ones had a negative appendectomy.
Conclusion: Based on the current study's findings, both AIRS and Alvarado scoring systems were reliable means to diagnose appendicitis; however, AIRS was relatively superior considering its higher specificity and PPV in scores >8 and higher sensitivity and NPV in scores >4.

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Introduction

The appendix, a small, finger-shaped appendage that branches off from the large intestine might get inflamed known as appendicitis (1). This condition is more frequent in females, is more prevalent in the second-to-fourth decades of life, and is estimated to occur in 1 per 500 persons annually. Acute appendicitis (AA) accounts for the most common causing etiology for abdominal surgeries (2,3).

Pathophysiologically, AA occurs due to an inflammatory process initiating the incidence of an obstruction in the appendix lumen due to various reasons, including fecal impaction, lymphoid hyperplasia, eating foreign bodies, parasites, and tumors, which proceeds with bacterial proliferation and mucus secretion that in turn increases the intraluminal pressure, lymphatic and venous congestion, and edema (4). Impaired vascular perfusion leads to an ischemic process and, eventually, perforation (5).

Despite all the progressions in imaging modalities such as computed tomography (CT) and ultrasonography, their unavailability and costs have retained appendicitis diagnosis according to clinical manifestations including signs, symptoms and laboratory parameters. Given that, various scoring systems have been proposed; however, one with the highest diagnostic value remained an non-responded question (6).

Key point

In this article, we have tried to compare the two scoring systems of Alvarado and the acute inflammatory response score in diagnosing acute appendicitis regarding sensitivity, specificity, and predictive values.

The Alvarado score is the most popular one primarily proposed in 1986. This scoring system contains 10 scores calculating by the summation of the parameters including anorexia, nausea/ vomiting, right lower quadrant (RLQ) abdominal pain, migration of pain to RLQ, rebound tenderness, fever (>37.3 °C), leukocytosis (>10 000 per mL), polymorphonuclear dominance (>75%). All the parameters score 1 except RLQ abdominal pain and leukocytosis that score 2. Several studies have investigated the accuracy of Alvarado scoring system to diagnose AA; however, the remarkable rate of negative appendectomy using Alvarado and the difficulties to obtain a reliable history of pediatrics caused authorities to search for more detailed and laboratory-based instrument (7,8).

Given that, another scoring instrument, Acute Inflammatory Response Score (AIRS), was raised in 2008. AIRS assesses anorexia, RLQ pain, muscular defense (low, mild and severe), fever (>38.3 °C), leukocytosis (10 000-14 999 and ≥15 000), polymorphonuclear leukocytosis (70-84% and ≥85%) and C-reactive protein (10-49 g/L and ≥50 g/L) in 12 scores. Nevertheless, AIRS use in practice revealed comparable outcomes to Alvarado and a question regarding the best scoring system to diagnose AA clinically remained non responded (9,10).

Objectives

The current study aims to investigate the values of Alvarado scoring system versus AIRS in AA diagnosing.

Patients and Methods

Study population

The current cross-sectional study has been conducted on 120 patients who underwent appendectomy are AL-Zahra and Kashani hospitals affiliated with Isfahan university of medical sciences from January 2019 to March 2020. Over 18-year-old patients with chief complaint of pain in the right iliac fossa were included. Pregnancy, distorted data, and death incidence during the surgical procedure were determined as the exclusion criteria. The study population were selected among those who met the study criteria using convenience sampling.

Data collection

The patients' demographic information including age and gender were recorded. Besides, clinical data consisted of ultrasonography and on-surgery findings were recruited. The ultrasonography interpretations were categorized as inconsistent with AA, inconsistent with AA or unavailable. On-surgery findings were recorded as non-perforated (AA, other diagnoses) and perforated.

The main scope of the study was to evaluate and compare two scoring systems of AIRS versus Alvarado which scoring methods are presented in Table 1.

The patients' resected tissues were histopathological

Table 1. Alvarado score and acute inflammatory response score criteria

Diagnosis	Alvarado	AIRS	Frequency	Percentage of incidence
Anorexia	1	1	87	72.5%
Nausea or vomiting	1		95	79.2%
Vomiting			80	67.1%
RLQ Pain	2	1	98	81.6
Migration of paint to RLQ	1		66	54.6%
Rebound tenderness	1		63	52.5%
Muscular defense				
Low		1	20	16.7%
Mild		2	85	71.1%
Severe		3	14	11.7%
Elevated temperature				
>37.3 ℃	1		45	37.5%
>38.5 ℃		1	10	8.3%
WBC count				
>10 000/mm^3	2		84	70%
10 000-14 999/mm^3		1	60	50%
≥15 000/mm^3		2	24	20%
Polymorphonuclear leucocytes				
70%–84%		1	59	49.2%
≥85%		2	32	26.6%
WBC left shift (>75% neutrophils)	1		88	73.7%
CRP value				
10-49 mg/L		1	51	42.5%
≥50 mg/L		2	34	28.3%
Total Score	**10**	12		

RLQ, Right lower quadrant; WBC, White blood cells; CRP, C-reactive protein.

Alvarado score: sum 0–4 = not likely appendicitis, sum 5–6 = equivocal, sum 7–8 = probably appendicitis, sum 9–10 = highly likely appendicitis.

Acute appendicitis response score (AIR): sum 0–4 = low probability, sum 5–8 = indeterminate group, sum 9–12 = high probability

assessed as the gold standard. All the samples were sent to a target laboratory and interpreted by an expert pathologist aiming to minimize the potential inter-observer biases.

Statistical analysis

The obtained data were entered into the Statistical Package for Social Sciences (SPSS) (version 18 SPSS Inc., Chicago, IL). Continuous data were reported as mean ± standard deviation and the categorical data as frequency and percentages. Receiver operating characteristic (ROC) curves were depicted to evaluate the values of Alvarado and AIRS to diagnose appendicitis. Given that, specificity, sensitivity, positive predictive value (PPV), negative predictive value (NPV) and area under the curve (AUC) were calculated. P-value of less than 0.05 was considered the level of significance.

Results

In the current study, data of 120 patients meeting the study criteria were recruited. The studied population had the mean age of 36.28 ± 5.43 years old and predominantly consisted of females (61.7%). Appendicitis diagnosis was confirmed in 103 (85.8%) of the individuals in pathological study of the resected tissues as the gold standard.

The most frequent complaint of the patients was RLQ abdominal pain (81.6%) followed by nausea/ vomiting (79.2%). High-grade fever (>38.5 °C) was limited to 8.3% of the patients. Detailed information about the on-admission signs/ symptoms of the patients is shown in Table 1.

The diagnostic values of Alvarado and AIRS for appendicitis diagnosis at two cut-points of >4 and >8 is demonstrated in Table 2. The sensitivity, specificity, NPV and PPV of Alvarado criteria for scores above 4 equaled 89.3%, 23.5%, 35.2% and 89.3%, respectively. These amounts were calculated as 96.1%, 82.3%, 77.7% and 97% for the AIRS, respectively. Moreover, at cut-points above 8, the sensitivity of 32.1% and specificity of 100% have been measured for AIRS compared with 41.7% and 88.2% for Alvarado, respectively. The measured AUC for AIRS and Alvarado criteria accounted for 0.81 and 0.72, respectively (P <0.05).

Abdominal ultrasonography was performed for 85 (70.8%) patients which sensitivity and specificity accounted for 72% and 100% considering the conformity of its findings with the pathological study of the resected tissues. The reports of abdominal ultrasonography were consistent with AA in 64 cases (53.4%).

Further evaluations revealed that the appendix tissue appearance was compatible with appendicitis during surgical procedure in 103 patients (85.8%) among which 23 ones (19.2%) were perforated. The mean calculated score of AIRS and Alvarado in perforated appendicitis were 7.1 and 7.6, respectively. Besides, 17 (14.16%) ones had negative appendectomy (Table 3).

One-hundred-four cases had AIRS scores above 4 among whom 3 cases were negative for appendicitis after appendectomy, while Alvarado score above 4 was given to 103 patients who underwent appendectomy of whom 11 individuals were negative.

Discussion

Acute appendicitis is one of the most common emergencies in daily surgery wards admissions which is mostly diagnosed based on clinical manifestations including physical examination and laboratory assessments. Given

Table 2. Diagnostic characteristics of the Alvarado score and AIR score according to the cutoff points 4 and 8

Diagnostic value	Alvarado		AIRS	
	>4 Point	>8 Point	>4 Point	>8 Point
Sensitivity	89.3 %	41.7 %	96.1 %	32.1 %
Specificity	23.5 %	88.2 %	82.3%	100 %
NPV	35.2%	29.4 %	77.7 %	15.7 %
PPV	89.3 %	97.1 %	97 %	100 %

AIRS, Acute Inflammatory Response Score; NPV, Negative predictive value; PPV, Positive predictive value.

Table 3. Ultrasonography – surgeon findings

Variables			Frequency	Percent
US result	Inconsistent with AA		21	17.5
	Consistent with AA		64	53.4
	No data		35	29.1
Surgeon findings	Non-perforated	AA	80	66.6
		Others[a]	17	14.1
		Total	97	80.8
	Perforated		23	19.2

US, Ultrasonography; AA, acute appendicitis

[a] Other findings such as ovarian cyst, urethral stone, etc.

that, the definite diagnosis is challenging where computed tomography is the gold standard modality to diagnose appendicitis with the sensitivity and specificity of 94% and 95%, respectively (11). Nevertheless, unavailability and costs of computed tomography as well as ultrasonography leads to propose various scoring systems for decision-making to perform appendectomy; however, their diagnostic values remained a controversial issue (12, 13).

The current study aimed to explain the value of two different diagnostic criteria for appendicitis, Alvarado and AIRS. Given that, we found that both instruments had reasonable specificity and sensitivity to diagnose appendicitis. Nevertheless, the sensitivity of AIRS in scores above 4 equaled 96.1% that was favorably more than that of Alvarado (89.3%). These findings represent that AIRS was more reliable to rule-out this diagnosis in case of suspicion. On the other hand, the specificity and PPV of AIRS in above scores were calculated as 100% for both that can be interpreted as its significant ability to confirm appendicitis diagnosis. Moreover, these amounts were calculated as 88.2% and 97.1%, respectively showing the superiority of AIRS to Alvarado again. Data in the literature regarding the use of these instruments are variable.

Accordingly, Zeb et al investigated the values of three scoring systems including Alvarado, AIRS and Raja Isteri Pengiran Anak Saleha appendicitis (RIPASA) in which in agreement with our findings they represented the superiority of AIRS (81.8%) over Alvarado (63.6%) considering its higher specificity. However, they considered cut-point of 5 for AIRS and 7 for Alvarado to extract these data. Moreover, the sensitivity of Alvarado was higher than AIRS, a finding in contrast to our findings (6).

Another confirmatory study was conducted by Jose and Rajesh where they presented higher specificity of AIRS compared with Alvarado at cut-point of ≥6 for AIRS accounting for 97% compared with that of 93% for Alvarado at cutoff of >7. Besides, they insisted on a significant drop in the sensitivity of Alvarado by increasing the cutoff point from ≥6 (72%) to ≥7 (46%) indicating the appropriateness of Alvarado to diagnose appendicitis at scores equal and above 7 and rule-out this diagnosis in lower scores (14).

Similarly, Karki and Hazra reported that AIRS outweigh Alvarado considering its higher sensitivity equaling 96.91% in comparison to that of Alvarado (94.30%). Besides, the measured AUC in their study was considerably higher in AIRS (0.701) than Alvarado (0.580) showing the reliability of this conclusion. Although their study design was totally similar to ours the measured specificities at both cut-points of >4 and >8 were remarkably lower than what we found for both AIRS and Alvarado (15).

In general, despite the acceptable value of both scoring systems to diagnose appendicitis, we want to lean to AIRS compared with Alvarado, mostly due to the superior outcomes of this scoring system in the current study, but because of another point. The assessed parameters in both systems are relatively similar, but AIRS includes C-reactive protein, as well. Accordingly, its utility in pediatric population might outweigh Alvarado as children have difficulties to identify nausea, anorexia, and migration of pain.

Appendectomy based on clinical manifestations leads to 15-30% negative appendectomies which imposes a significant burden on both patients and healthcare systems (12,13). We also found a negative appendectomy rate of 14.6% which was consistent with the other studies. also 13% in the study of Hale et al (16) and 15% in the study by Andersson and colleagues (17). However, the reported rate by Zeb et al was notably less than the mentioned studies (8.5%) (6) and what Memon et al presented was remarkably higher (28.5%) than the others (18). Moreover, we found higher rate of negative appendectomy using Alvarado compared with AIRS. Accordingly, it is assumed that the applied instrument by which appendicitis was diagnosed might have had a deep impact on the negative appendectomies represented by different studies.

Conclusion

Based on findings of the current study, both AIRS and Alvarado scoring systems were reliable means to diagnose appendicitis. However, AIRS was relatively superior considering its higher specificity and PPV in scores>8 and higher sensitivity and NPV in scores >4.

Limitations of the study

The small sample population of the study and failure to evaluate other scoring systems such as RIPASA score are the notifying limitations of the current study. Besides, considering other probable confounding variables including the patients' age, gender, the interval between pain initiation and referral to the hospital, the interval between pain initiation and the surgical procedure, and the interval between hospitalization and surgery could affect the study outcomes and provide a better vision about the applied scoring systems.

Authors' contribution

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Conflicts of interest

The authors declare that they have no competing interests.

Ethical issues

The research conducted in this study adhered to the principles outlined in the Declaration of Helsinki and was approved by the Ethics Committee of Isfahan University of Medical Sciences (Ethical code #IR.MUI.MED.REC.1399.667). The study protocol was explained to the patients. They were informed about the importance of their medical data for scientific research, were reassured about the confidentiality of their personal information, and then signed a written consent form. Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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