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Original Research Article

Validation of Appendicitis Inflammatory Response (AIR) Score and Alvarado Score

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Abstract: *The scoring systems used for the diagnosis of acute appendicitis, such as the Alvarado score and the appendicitis inflammatory response score, are used for the accurate diagnosis as well as for preventing negative appendectomies.* ***Objective:*** *To validate these scores in the case of acute appendicitis.* ***Methodology:*** *This was a cross-sectional study conducted among patients enrolled from the Emergency Department of General Surgery at Jinnah Hospital, Lahore, from August 16, 2024, to February 15, 2025, with suspected acute appendicitis. A questionnaire was completed after taking a proper history, examination, and laboratory investigations, calculating the AIR and Alvarado scores, and receiving the histopathology report of the specimen. Based on the data collected, sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated for each scoring system separately.* ***Results:*** *Alvarado score was positive (>6) in 73.8% of the appendectomies, while negative in 26% appendectomies. The AIR score was positive (>4) in 76.9% of the appendectomies, while negative (<4) in 23.1% of the appendectomies. Almost 77.5% of appendectomies turned out to be positive on histopathology. The sensitivity of the Alvarado score was 89.5%, while that of the AIR score was 96.7%. The specificity of the Alvarado score was 80.55% while that of the AIR score was 91.6%. The PPV of the Alvarado score was 94.1% while that of the AIR score was 97.56%. The diagnostic accuracy of the Alvarado score was 87.5% while that of the AIR score was 95.6%.* ***Conclusion:*** *A positive AIR score is more specific and sensitive than a positive Alvarado score in accurately diagnosing acute appendicitis.*

Keywords: Acute appendicitis, Alvarado score, AIR score, Validation

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Introduction

Acute appendicitis (AA), an inflammation of the appendix, occurs due to elevated intraluminal pressure of the appendiceal lumen and translocation of bacteria secondary to appendiceal luminal obstruction (1). It is among the most common surgical emergencies worldwide. (2,3) Out of the general population, 7-12% are affected during their lifetime. Hence, the incidence calculates to about 1.5-1.9 per 1000 people. (4) The symptoms of acute appendicitis may mimic other diseases and, hence, complicate diseases like perforation when diagnosis is delayed. (5,6) On the other hand, the rate of negative appendectomy is almost 10-15%. (7) The use of diagnostic auxiliaries like signs and symptoms, clinical, laboratory, and radiology investigations can help in avoiding the above complications. (8,9) The sensitivity of computed tomography (CT) is 94% for acute appendicitis, while specificity is 95%. (10,11) However, it is costly. Hence, clinical scoring systems such as Alvarado, Tzanakis, RIPASA, and AIR score have recently demonstrated their significance. (8)

The Alvarado score enhances the accuracy of diagnosing acute appendicitis by utilizing eight clinical factors. On the other hand, the appendicitis inflammatory response (AIR) score deploys seven variables, including C-reactive protein (CRP) and anorexia or nausea. (12) Tariq et al (13) compared the diagnostic accuracy of AIR and Alvarado score for the diagnosis of acute appendicitis in the Pakistani population, keeping histopathology as the gold standard. The sensitivity of the Alvarado score was 80.1%, specificity was 92.3%, and accuracy was 81.7%. On the other hand, the AIR score had 72.6% sensitivity, 94.2% specificity, and an accuracy of 75.5%. An Indian study conducted by Jose and Rajesh (14) reported that the Alvarado score has a sensitivity of 72% and a specificity of 79% at a score greater than 6. The sensitivity decreased to 46%, although specificity increased to 93%, when the score was taken to be greater than 7. The sensitivity of the AIR score was 98% for scores greater than 5, and the specificity was 36%. The specificity increased to 97% when the score was greater than 6.

Scoring systems are necessary in settings with limited resources, such as Pakistan. These scoring systems can be helpful for clinical diagnosis, timely transfer from primary health care facilities, as well as deciding on surgery when radiology is inconclusive or unavailable. The current study was conducted to validate the appendicitis inflammatory response score based on the Alvarado score among patients undergoing appendicectomy for suspected acute appendicitis.

Methodology

This was a cross-sectional study done to validate the two scoring systems used for suspected acute appendicitis. The Ethical Review Board approved our study vide letter no. ERB18/1/10-04-2025/S1 ERB. The data were collected from the Emergency Department of General Surgery at Jinnah Hospital, Lahore, from August 16, 2024, to February 15, 2025, six months after the College of Physicians and Surgeons of Pakistan accepted the synopsis. The sample size was calculated to be 160 using a 90% confidence level, 5% margin of error, and a population proportion 50%. (13) Consecutive patients of either gender aged between 16 and 60 years presenting with right iliac fossa pain for 7 days or less, admitted in surgical emergency with suspected acute appendicitis, were considered for inclusion. The patients having a diagnosis of appendicular perforation, abscess, or mass on sonography, pregnant females, and patients having known malignancies were excluded from this study. Informed consent was taken from the patients. A questionnaire was prepared by the researcher and finalized after pre-testing. After taking basic demographic and contact details, patients were enrolled in this study. Information on

all diagnosed cases, such as sex, age, contact details, and address, was obtained. After proper history, examination, and basic laboratory tests, the AIR score was calculated.

Diagnosis of suspected cases of acute appendicitis was made on clinical grounds using the Alvarado Score. A senior registrar, registrar, or senior post-graduate resident performed all surgeries. Before surgery, CRP levels were sent, and they were later followed along with the biopsy report of the specimen, which was sent after the surgery. The final diagnosis of acute appendicitis was made based on the histopathology report. After calculating the Alvarado and AIR scores, they were compared with the histopathology report. The scoring systems were then individually evaluated for their specificity, sensitivity, positive and negative predictive values, as well as diagnostic accuracy. All collected data were entered and analyzed using SPSS 22.0. To address effect modifiers, data were stratified by age, gender, obesity, and duration of pain. A post-stratification Chi-square test was applied, with a p-value ≤ 0.05 considered significant. The diagnostic accuracy of the AIR score and the Alvarado score was assessed.

Results

The mean age of the patients in this study is 41.9 ± 12.9 years. The patients had to endure the symptoms of acute appendicitis for 38.35±20.48 hours before surgery. Ninety-one out of one hundred and sixty patients (56.9%) were males, while 69 (43.1%) were females. The Alvarado score was positive (>6) in 73.8% of the appendectomies, while negative in 26% appendectomies. The AIR score was positive (>4) in 76.9% of the appendectomies, while it was <4 in 23.1% of the appendectomies. Almost 77.5% of appendectomies turned out to be positive on histopathology. The sensitivity of the Alvarado score was 89.5%, while that of the AIR score was 96.7%. The specificity of the Alvarado score was 80.55% while that of the AIR score was 91.6%. The PPV of the Alvarado score was 94.1% while that of the AIR score was 97.56%. The NPV of the Alvarado score was 69.04% while it was 89.18% for the AIR score. The diagnostic accuracy of the Alvarado score was 87.5% while that of the AIR score was 95.6%. Almost 94% of patients with positive histopathology had a positive AIR score ($p < 0.001$), while 90% of patients with a positive Alvarado score had positive histopathology ($p < 0.001$) in males. Similar findings were also noted in females. Of the 97% of patients who had symptoms for less than 24 hours, 97% had a positive AIR score, while 92% of these patients had a positive Alvarado score. The AIR score was 97% positive when histopathology was also positive in obese patients, and it also showed 97% sensitivity in obese patients. In comparison, Alvarado was positive in 86% cases when histopathology was positive (Tables 1-6).

Table 1: Demographics of the patients (n=160)

Variable		No.	%
Gender	Male	91	56.9
	Female	69	43.1
Body mass index	Obese	48	30.0
	Non-obese	112	70.0
Alvarado Score	Positive (>6)	118	73.8
	Negative (≤6)	42	26.3
AIR Score	Positive (>4)	123	76.9
	Negative (≤4)	37	23.1
Histopathology findings	Negative		22.5
	Positive		77.5

Table 2: Descriptive statistics of the patients (n=160)

Variable	Mean±SD
Age (years)	41.89±12.97
Duration of symptoms (hours)	38.35±20.48
Alvarado score	4.99±2.39
AIR Score	5.78±2.83

Table 3: Diagnostic accuracy of the Alvarado score

Alvarado score	Histopathology		Total
	Positive	Negative	
Positive	111 (89.5%)	7 (19.4%)	118
Negative	13 (10.5%)	29 (80.6%%)	42
Total	124	36	160
Sensitivity	89.51%	Specificity	80.55%
Positive predictive value	94.06%	Negative predictive value	69.04%
Diagnostic accuracy	87.50%		

Table 4: Diagnostic accuracy of the AIR score

AIR score	Histopathology		Total
	Positive	Negative	
Positive	120 (96.8%)	3 (8.3%)	118
Negative	4 (3.2%)	33 (91.7%%)	42
Total	124	36	160
Sensitivity	96.77%	Specificity	91.66%
Positive predictive value	97.56%	Negative predictive value	89.18%
Diagnostic accuracy	95.62%		

Table 5: Comparison of AIR score findings with histopathology findings about different variables

AIR score	Gender				Duration				Obesity			
	Male		Female		<24 Hours		>24 Hours		Non-obese		Obese	
	+	-	+	-	+	-	+	-	+	-	+	-
Positive	73 (94.8%)	2 (14.3%)	47 (100%)	1 (4.5%)	37 (97.4%)	2 (16.7%)	83 (96.5%)	1 (4.2%)	83 (96.5%)	3 (11.5%)	37 (97.4%)	-
Negative	4(5.2%)	12 (85.7%)	-	21 (95.5%)	1 (2.6%)	10 (83.3%)	3 (3.5%)	23 (95.8%)	3 (3.5%)	23 (88.5%)	1 (2.6%)	10 (100%)
Total	77	14	47	22	38	12	86	24	86	26	38	10
P value	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	

Table 6: Comparison of Alvarado score findings with histopathology findings about different variables

Alvarado score	Gender				Duration				Obesity			
	Male		Female		<24 Hours		>24 Hours		Non-obese		Obese	
	+	-	+	-	+	-	+	-	+	-	+	-
Positive	70 (90.9%)	4 (28.6%)	41 (87.2%)	3 (13.6%)	35 (92.1%)	5 (41.7%)	76 (88.4%)	2 (8.3%)	78 (90.7%)	6 (23.1%)	33 (86.8%)	1 (10%)
Negative	7 (9.1%)	10 (71.4%)	6 (12.8%)	19 (86.4%)	3 (7.9%)	7 (58.3%)	10 (11.6%)	22 (91.7%)	8 (9.3%)	20 (76.9%)	5 (13.2%)	9 (90%)
Total	77	14	47	22	38	12	86	24	84	26	38	10
P value	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	

Discussion

Symptoms of acute appendicitis are vague and unusual in about 50% of all cases. Pain radiating from the umbilical region to the right iliac region, elevated temperature, anorexia, as well as guarding are common symptoms of AA. (15) This may hamper the accurate diagnosis, giving rise to complications like perforation. In such circumstances, a negative appendectomy rate of 20% was thought to be reasonable in the past to prevent delay in diagnosis. However, this bore considerable cost to both healthcare and the patient. (16) In uncomplicated cases of acute appendicitis, only antibiotics can be helpful, provided proper diagnosis is made. (17) In such cases, scoring systems come into play. The Alvarado score, which focuses on signs and symptoms, may aid in accurate diagnosis. (18) On the other hand, the AIR score is also frequently used. (19)

The patients' mean age in our study was 41.9±12.9 years, which was closer to the median age of 39 [27-54] in an American survey of Meier et al. (20) However, 29,948 [51.3%] females were diagnosed with appendicitis, which contrasts with our results of 91 (56.9%) patients who were males. This may be because females endure pain for longer due to socio-economic differences in the West, and males have more opportunities for treatment.

The sensitivity of the Alvarado score was 89.5%, while that of the AIR score was 96.7% in the present study. The specificity of the Alvarado score was 80.55% while that of the AIR score was 91.6%. The PPV of the Alvarado score was 94.1% while that of the AIR score was 97.56%. The NPV of the Alvarado score was 69.04% while it was 89.18% for the AIR score. The diagnostic accuracy of the Alvarado score was 87.5% while that of the AIR score was 95.6%. In a past Pakistani study, it was found that the Alvarado score had 88.4% sensitivity, 63.6%specificity, a PPV of 96.4%, a 33.3%NPV, and 86.3% accuracy. AIR score had 77.7% sensitivity, 81.8% specificity, PPV of 97.9%, 25% NPV, and diagnostic accuracy of 78.03%. (5) Both Alvarado and the AIR score showed more sensitivity and specificity. However, the sensitivity of the AIR score was higher in our study.

Almost 94% of patients with positive histopathology had a positive AIR score ($p < 0.001$), while 90% of patients with a positive Alvarado score had positive histopathology ($p < 0.001$) in males. Similar findings were also noted in females. In this study, 97% patients having symptoms for less than 24 hours have a positive AIR score, while 92% of these patients have a positive Alvarado score. The AIR score was positive 97% of the time when histopathology was also positive in obese patients, while also showing 97% sensitivity in obese patients. In contrast, Alvarado was positive in 86% of cases when histopathology was positive. Hassan et al (21) in the UK concluded that 59 out of 73 (80.8%) patients had AA on histopathology. They found a significant correlation between histopathology reports and the AIR score ($P = 0.000$) as well as the Alvarado score ($P = 0.011$). They further concluded that the AIR score has 77.97% sensitivity and 85.71% specificity, while the Alvarado score has 67.80% sensitivity and 78.57% specificity. An Iranian study showed that in patients of acute appendicitis, the Alvarado score has a sensitivity of 89.3%, a specificity of 23.5%, an NPV of 35.2%, and a PPV of 89.3%. The AIR score, on the other hand, had a sensitivity of 96.1%, a specificity of 82.3%, an NPV of 77.7%, and a PPV of 97% for the AIRS, respectively. (22) This study was contradicted by Poillucci et al (23), according to which the sensitivity of the AIR score was 19.7%. They, however, used a cutoff value of 8. The specificity was 95.9%, 96.9% PPV, and 15.5% NNV.

The above findings suggest that the AIR score has a better diagnostic profile compared to the Alvarado score. The high specificity and sensitivity rates demonstrated that not only does it correctly identify actual positive cases, but also accurately identifies true negatives, leading to timely intervention and preventing unnecessary surgeries. Hence, it can also help with atypical presentations. (5) Both the Alvarado and AIR scores are valuable diagnostic tools as they are easy to use even in settings with limited resources like ours. In the present study, the AIR score proved its superiority over the Alvarado score. Both these scoring systems, when deployed, can lessen the need for radiology investigations and unnecessary surgeries (24)

Conclusion

The appendicitis inflammatory response score has both greater sensitivity and specificity for the accurate diagnosis of acute appendicitis. Hence, it can be employed by surgeons working in the emergency room for this purpose on a routine basis. It can also eliminate the need for radiological investigations to support the diagnosis.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (ERB18/1/10-04-2025/S1)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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