

COMPARATIVE ANALYSIS OF ACUTE INFLAMMATORY SCORE (AIR) AND ALVARADO SCORE IN DIAGNOSING ACUTE APPENDICITIS AT A TERTIARY CARE HOSPITAL

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ABSTRACT:

Objective: To determine the diagnostic accuracy of the Alvarado score and AIR score in diagnosing acute appendicitis taking histopathology as gold standard. **Study Design:** Cross Sectional (Validation) Study. **Place and duration of study:** Department of Surgery, Holy Family Hospital, Rawalpindi from March 2026 to July 2026. **Methodology:** We enrolled 97 cases presented to the ER department with suspected of acute appendicitis. The acute appendicitis was considered on the basis of a clinical diagnosis confirmed through surgical findings, histopathological examination, or imaging. The cut off value of Alvarado score was ≥ 7 or higher on Alvarado scale. AIR score was calculated on the basis of scoring system that assesses inflammation severity based on laboratory results and clinical findings. A score of ≥ 9 AIR scale was considered as cutoff. All patients underwent routine laboratory and ultrasound investigation and their Alvarado and AIR scores were recorded before undergoing to surgery. Histopathology samples were sent to hospital laboratory for confirmation of acute appendicitis. The results of histopathology were correlated with preoperative scores and diagnostic accuracy of Alvarado and AIR score were calculated. **Results:** Of 97 cases, male subjects 65(67%) and younger age range i.e. 18-30 years was commonly recorded. The sensitivity of Alvarado score was 63/78(80.8%), specificity was 17/19(89.5%), positive predictive value(PPV) was recorded a 63/65(96.9%), negative predictive value(NPV) 17/32(53.1%) and diagnostic accuracy(DA) was 80/97(82.5%) whereas these findings AIR score were recorded as 58/78(74%), 18/19(94.7%), 58/59(98.3%), 18/38(47.4%) and 76/97(78.4%) respectively. **Conclusion:** Overall, both Alvarado and AIR scores demonstrated good diagnostic utility. Alvarado provided greater sensitivity and slightly higher fixed-cut-off accuracy, whereas AIR offered greater specificity and numerically stronger ROC discrimination.

KEYWORDS: *Acute appendicitis, diagnosis, acute inflammatory score, Alvarado score, accuracy*

INTRODUCTION:

Appendicitis is one of the most common surgical emergencies among patients presenting with pain in the right iliac fossa.¹ Global lifetime prevalence of acute appendicitis(AA) is recorded in 7-8% of the cases and may present in any age group patients. It is found to be highly prevalent in Asian population including especially in Pakistan i.e. 21%.³ Timely and accurate diagnosis may help in to minimize its associated complications like peritonitis, perforation, sepsis and reduce unnecessary appendectomies and related morbidities.⁴

Various clinical and modified scoring systems including modified Alvarado score system(MAS) and appendicitis Inflammatory Response Score(AIRS) in collaboration with imaging tools like MRI, CT scan and ultrasound are commonly used for diagnosis of acute appendicitis.⁵⁻⁶ In 1986, Alvarado Scoring system was established and widely practiced due its simplicity and reliance on routine clinical and laboratory parameters. It has shown significant value as a 'rule-out' instrument at a cut-off score of 5, although its performance at higher thresholds is less specific in children and women.⁷ The AIR score incorporates clinical findings in combination with laboratory markers of inflammation. AIR, developed in 2008, combines clinical findings with inflammatory biomarkers, including C-reactive protein, clinical sign and symptoms and is identified by the 2020 WSES guidelines for diagnostic purposes of suspected acute appendicitis^{8,9}.

Tariq et al¹⁰ assessed and compared the diagnostic performance of both AIR and Alvarado scoring system by using histopathological findings as the reference standard. Their findings reveal male participants as 66.9% while females as 33.1%, mean age was computed as 26.48 $\pm$ 6.11 years. The diagnostic evaluation showed 80.1% sensitivity, 92.3% specificity and 81.7% accuracy for the Alvarado score whereas the AIR score provided 72.6% sensitivity, 94.2% specificity and 75.5% diagnostic accuracy.

Although widely used for diagnosing AA, the Alvarado score has limited accuracy, among female and paediatric patients may lead to unnecessary appendectomies. The AIR score incorporates inflammatory biomarkers and appears more accurate, however, evidence from non-Western populations remains limited. The present study compares the diagnostic performance of the AIR and Alvarado scores among patients treated at a tertiary care hospital in Pakistan. The findings may help reduce negative appendectomy rates and improve patient outcomes.

MATERIAL & METHODS:

This Cross Sectional (Validation) Study was conducted at Department of Surgery, Holy Family Hospital, Rawalpindi from March 2026 to July 2026, following the approval of synopsis by Ethical Review Committee. A minimum sample of 97 patients was estimated by using a diagnostic accuracy, on a 95% confidence level, anticipated disease prevalence of 80.1%, anticipated disease prevalence of 80.1%, 72.3% expected sensitivity, 94.2% expected specificity and 10% absolute precision. Eligible participants were consenting adults older than 18 years, who attended the emergency department with clinically suspected acute appendicitis, underwent surgical intervention and providing informed consent were included in our cohort. Exclusion criteria included previous appendectomy, chronic abdominal condition, chronic appendicitis or an acute condition mimicking appendicitis; were pregnant or lactating; had incomplete records; were immunocompromised; had major relevant comorbidities; or were allergic to the anaesthetic agents or antibiotics used. The criteria for acute appendicitis in our study was based on clinical diagnosis (confirmed on imaging/surgical findings followed by histopathological examination). The cut off value of Alvarado score was ≥ 7 or higher on Alvarado scale. AIR score was calculated on the basis of scoring system that assesses inflammation severity based on laboratory results (C-reactive protein, white blood cell count, neutrophil count) and clinical findings (fever, abdominal tenderness). A score of ≥ 9 AIR scale was considered as cutoff. Regarding diagnostic accuracy was measured in terms of sensitivity i.e. ability of Alvarado score and AIR score to detect those who AA, Specificity i.e. ability of Alvarado score and AIR score to exclude those who don't have AA. True positive i.e. patients having Alvarado score and AIR score as well as on histopathology. True negative was considered if patients having no AA on histopathology as well as on Alvarado score and AIR score. False positive was: patients having AA on Alvarado score and AIR score but not on histopathology. False negative (FP): patients having no AA on Alvarado score and AIR score but have on histopathology. Positive Predictive Value: It was the probability that a patient with a positive Alvarado score and AIR score results actually have AA and Negative predictive value was the probability that a patient with a negative Alvarado score and AIR score results actually do not have AA. All patients underwent routine laboratory and ultrasound investigation. Alvarado and AIR scores were recorded. A consultant surgeon performed all the surgeries. Histopathology samples were sent to hospital laboratory for confirmation of acute appendicitis. The results of histopathology were correlated with preoperative scores and diagnostic accuracy of Alvarado and AIR score were calculated. All data was recorded on a purposefully designed proforma. All the collected information was transferred to SPSS version 25 and analysed accordingly. Mean and standard deviation was calculated for all quantitative variables like age, duration of symptoms, CRP, PMN, Alvarado and AIR scores. Frequency and percentage was calculated for all qualitative variables like gender, symptoms of AA. Diagnostic accuracy was calculated for both scores. Sensitivity, specificity, PPV, NPV, and diagnostic accuracy were calculated by constructing 2x2 table as follows: Diagnostic accuracy was also calculated. We also controlled effect modifiers such as age, gender, duration of symptoms by stratification. Post stratification diagnostic accuracy was calculated.

RESULTS

Among the 97 patients, the mean age was 26.72 ± 5.70 years, 73 (75.3%) were aged 18–30 years and 24 (24.7%) were aged >30 years. Males comprised 65 (67.0%) patients and females 32 (33.0%). Right iliac fossa pain was present in 90 (92.8%) of cases, tenderness in 80 (82.5%), and $\geq 37.3^\circ\text{C}$ in 83(85.6%). Patients had experienced symptoms for a mean duration of 38.82 ± 13.18 hours, however, 83(85.6%) cases were presented after 24 hours of their first complaint. Mean values of Alvarado and AIR scoring systems were also calculated and presented as 7.66 ± 2.40 and 7.63 ± 2.98 , respectively. Alvarado score system at prespecified cut-offs reveals positive cases in 65(67.0%) of the cases while 59(60.8%) in AIR score. The confirmed cases of acute appendicitis on histopathological examination were recorded in 78(80.4%). The detailed clinical profile, demographic details and laboratory findings are presented in Table I.

Table I: Demographic, clinical, and laboratory characteristics of the patients (n=97)

Characteristic	Category/summary	Result
Age (years)	Mean $\pm$ SD; median (IQR); range	26.72 ± 5.70 ; 26.0 (9.0); 18–40
Age group	18–30 years	73 (75.3%)
	>30 years	24 (24.7%)
Gender	Male	65 (67.0%)
	Female	32 (33.0%)
Right iliac fossa pain	Present	90 (92.8%)

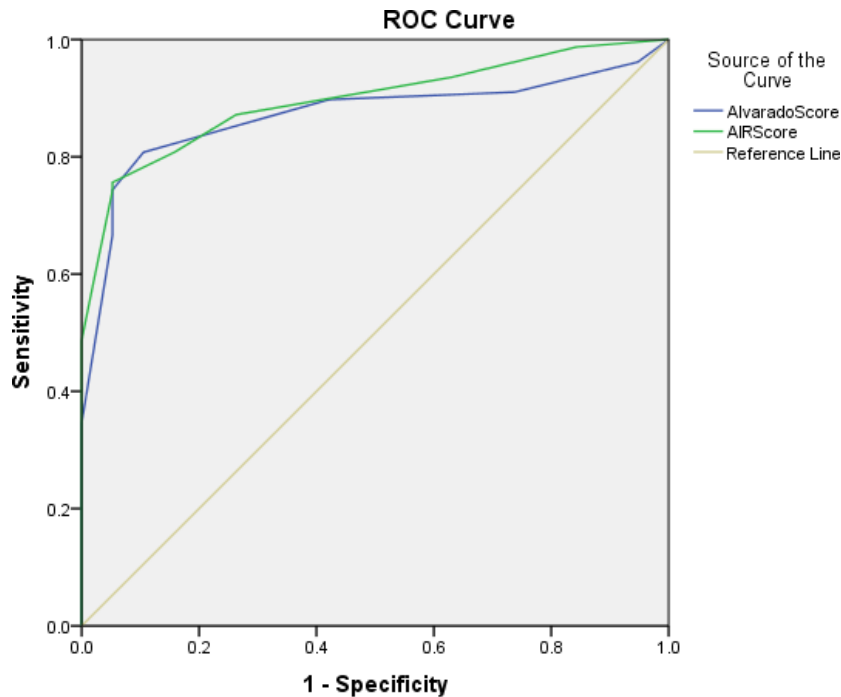
Characteristic	Category/summary	Result
Migration of pain to RIF	Present	58 (59.8%)
RIF tenderness	Present	80 (82.5%)
Rebound tenderness	None	18 (18.6%)
	Light	13 (13.4%)
	Medium	30 (30.9%)
	Strong	36 (37.1%)
Nausea/vomiting	Present	61 (62.9%)
Anorexia	Present	64 (66.0%)
Temperature $\geq 37.3^{\circ}\text{C}$	Present	83 (85.6%)
Temperature ($^{\circ}\text{C}$)	Mean $\pm$ SD; median (IQR); range	38.10 $\pm$ 0.71; 38.1 (1.0); 36.6–39.4
WBC ($\times 10^9/\text{L}$)	Mean $\pm$ SD; median (IQR); range	13.78 $\pm$ 3.62; 13.0 (5.4); 6.3–20.4
PMN (%)	Mean $\pm$ SD; median (IQR); range	80.55 $\pm$ 9.60; 82.0 (14.3); 57.4–95.0
CRP (mg/L)	Mean $\pm$ SD; median (IQR); range	65.18 $\pm$ 43.99; 49.5 (79.6); 2.7–149.2
Symptom duration (hours)	Mean $\pm$ SD; median (IQR); range	38.82 $\pm$ 13.18; 40.0 (21.0); 9–60
Symptom duration	≤ 24 hours	14 (14.4%)
	> 24 hours	83 (85.6%)
Alvarado score	Mean $\pm$ SD; median (IQR); range	7.66 $\pm$ 2.40; 9.0 (4.0); 2–10
AIR score	Mean $\pm$ SD; median (IQR); range	7.63 $\pm$ 2.98; 9.0 (6.0); 2–12

Alvarado scoring system had sensitivity 63/78(80.8%), specificity 17/19(89.5%), PPV63/65(96.9%), NPV17/32(53.1%)and DA80/97(82.5%) whereas these findings AIR score shows sensitivity 58/78(74%), specificity 18/19(94.7%), PPV58/59(98.3%), NPV18/38(47.4%) and DA76/97(78.4%).

Table II: Overall diagnostic performance of the Alvarado and AIR scores against histopathology

Measure	Alvarado score (≥ 7)	AIR score (≥ 9)
Positive classification, n (%)	65 (67.0%)	59 (60.8%)
True positive, n	63	58
False positive, n	2	1
False negative, n	15	20
True negative, n	17	18
Sensitivity, % (95% CI)	80.8 (70.7–88.0)	74.4 (63.7–82.7)
Specificity, % (95% CI)	89.5 (68.6–97.1)	94.7 (75.4–99.1)
PPV, % (95% CI)	96.9 (89.5–99.2)	98.3 (91.0–99.7)
NPV, % (95% CI)	53.1 (36.4–69.1)	47.4 (32.5–62.7)
Diagnostic accuracy, % (95% CI)	82.5 (73.7–88.8)	78.4 (69.2–85.4)
χ^2 ; p-value	34.101; <0.001	30.612; <0.001
AUC (95% CI); p-value	0.871 (0.796–0.945); <0.001	0.895 (0.831–0.960); <0.001

The following ROC analysis demonstrates AUC for Alvarado and AIR Scores. The AUC of Alvarado Score=0.871(95% CI: 0.796-0.945; $p<0.001$) and 0.895(95% CI: 0.831-0.960; $p=0.001$) for AIR score. The prespecified cut-offs of >7 was for Alvarado score and >9 for AIR. Figure 1.



Diagonal segments are produced by ties.

Figure 1: Receiver Operating Curve comparing Alvarado and AIR scores

AUC=0.871(95% CI: 0.796-0.945 for Alvarado)

AUC=0.895(95% CI: 0.831-0.960 for AIR)

The detailed stratified analysis for confounding variables i.e. age, gender and duration of symptoms is presented in the following Table III.

Table III: Overall and stratified diagnostic performance of the Alvarado and AIR scores

Stratum	Score	Sensitivity, n/N (%)	Specificity, n/N (%)	PPV, n/N (%)	NPV, n/N (%)	Accuracy, n/N (%)
Overall	Alvarado	63/78 (80.8)	17/19 (89.5)	63/65 (96.9)	17/32 (53.1)	80/97 (82.5)
	AIR	58/78 (74.4)	18/19 (94.7)	58/59 (98.3)	18/38 (47.4)	76/97 (78.4)
Age 18–30 years	Alvarado	50/59 (84.7)	12/14 (85.7)	50/52 (96.2)	12/21 (57.1)	62/73 (84.9)
	AIR	47/59 (79.7)	13/14 (92.9)	47/48 (97.9)	13/25 (52.0)	60/73 (82.2)
Age >30 years	Alvarado	13/19 (68.4)	5/5 (100.0)	13/13 (100.0)	5/11 (45.5)	18/24 (75.0)
	AIR	11/19 (57.9)	5/5 (100.0)	11/11 (100.0)	5/13 (38.5)	16/24 (66.7)
Male	Alvarado	43/52 (82.7)	12/13 (92.3)	43/44 (97.7)	12/21 (57.1)	55/65 (84.6)
	AIR	36/52 (69.2)	12/13 (92.3)	36/37 (97.3)	12/28 (42.9)	48/65 (73.8)
Female	Alvarado	20/26 (76.9)	5/6 (83.3)	20/21 (95.2)	5/11 (45.5)	25/32 (78.1)
	AIR	22/26 (84.6)	6/6 (100.0)	22/22 (100.0)	6/10 (60.0)	28/32 (87.5)
Duration hours ≤24	Alvarado	2/5 (40.0)	8/9 (88.9)	2/3 (66.7)	8/11 (72.7)	10/14 (71.4)
	AIR	0/5 (0.0)	9/9 (100.0)	Not estimable	9/14 (64.3)	9/14 (64.3)
Duration hours >24	Alvarado	61/73 (83.6)	9/10 (90.0)	61/62 (98.4)	9/21 (42.9)	70/83 (84.3)
	AIR	58/73 (79.5)	9/10 (90.0)	58/59 (98.3)	9/24 (37.5)	67/83 (80.7)

DISCUSSION:

This study compared the effectiveness of the Alvarado and AIR scores in diagnosing acute appendicitis by using histopathological examination as the reference standard. Both scoring systems demonstrated good accuracy in identifying acute appendicitis. Using the predefined thresholds, the Alvarado score was more sensitive and marginally more accurate, while the AIR score was more specific and had a higher positive predictive value.

Despite the numerically higher area under the ROC curve for the AIR score, the difference in overall accuracy between the scoring systems was statistically non-significant. These findings demonstrate that the two scoring systems have complementary diagnostic roles without either demonstrating clear diagnostic superiority.

The mean patient age was 26.72 ± 5.70 years, with nearly three-quarters belonging to the 18–30-year age group with males accounting for 67.0% of participants. The demographic profile of the present cohort was consistent with that reported by Tariq et al.,¹⁰ who found a mean age of 26.48 ± 6.11 years and included 66.9% males. Another study by Muhi-ud-Deen and others also showed similar pattern of age of the participants and predominance of male cases.¹² Similarly, other study by Ali et al. and Gopalam co-workers supported the findings relating to predominance of male subjects.^{11,13} However, Sanabria-Arévalo and colleagues reported a comparatively older population while no male predominance.¹⁵ These variations may be attributed to differences in referral patterns, and demographic characteristics across the studies.

On histopathological examination in our study confirmed presence of acute appendicitis in 80.4% of the cases, it is consistent with other studies' findings i.e. 86.5%¹⁰, 88%¹¹, 87.6%¹² and 88.6%.¹⁶ The consistently high disease prevalence was likely related to the enrolment of patients who had already been selected for surgical treatment based on a strong clinical suspicion of appendicitis. Thus, the findings may not accurately represent the diagnostic utility of these scores among all patients with undifferentiated right lower quadrant pain.

In the present study, the Alvarado score showed 80.8% sensitivity, 89.5% specificity, 96.9% positive predictive value, 53.1% negative predictive value, and 82.5% diagnostic accuracy. These findings are closely in agreement with the study¹⁰ showing that the Alvarado score at the same cut-off of ≥ 7 and reported sensitivity in 80.1%, specificity in 92.3%, and accuracy as 81.7%. The similarity between the findings may reflect comparable demographic profiles, the identical diagnostic cut-off, and the use of histopathology as the reference standard.

The high positive predictive values reported in both studies show that an Alvarado score ≥ 7 provides strong evidence of acute appendicitis among patients already selected for surgical assessment.

Using a threshold of ≥ 9 , the AIR score achieved a sensitivity of 74.4%, 94.7% specificity, 98.3% positive predictive value, negative predictive value of 47.4%, and diagnostic accuracy of 78.4%. Tariq et al. applied the same threshold and reported a similar pattern, the AIR score had lower sensitivity but higher specificity than the Alvarado score, showing a sensitivity of 72.6% and specificity of 94.2%.¹⁰ This agreement supports the reproducibility of the AIR score performs consistently as a relatively specific rule-in instrument at higher diagnostic thresholds. This greater specificity may be explained by the use of C-reactive protein and graded inflammatory variables.

Several investigators have found AIR to outperform the Alvarado score. Ali et al. reported sensitivity and accuracy values of 89.4% and 88.0% for AIR, whereas the corresponding values for Alvarado were 74.2% and 74.6%.¹¹ Consistently, Liaqat and workers also demonstrated higher specificity, sensitivity and accuracy (90.1%)⁹ of AIR than Alvarado scoring system. The AIR accuracy was recorded in 89.2% in a study by Muhi-ud-Deen compared with 69.7% of Alvarado.¹² Nevertheless, an AIR threshold of ≥ 6 was applied rather than the ≥ 9 cut-off used in the present study. A lower diagnostic threshold generally increases sensitivity and may partly account for the observed superiority of AIR. Thus, comparisons among studies should be interpreted in relation to the diagnostic threshold used.

The superior discriminatory performance of AIR was also observed by Gopalam et al.¹³ by recording AUCs of 0.94 for AIR and 0.82 for Alvarado, corresponding values reported by Jayanand et al. were 0.976 and 0.898.¹⁴ The AUC in this study was numerically greater for AIR than for Alvarado although both scores showed good discriminatory ability. This finding is compatible with their accuracy estimates at the selected cut-offs. ROC-derived AUC summarises discriminatory ability across the entire range of thresholds, while sensitivity, specificity, and accuracy describe performance at a particular threshold. However, its sensitivity may be reduced when performance is assessed at the comparatively stringent cut-off of ≥ 9 .

Conversely, not all studies have established the superiority of AIR. Kishe et al. reported greater sensitivity and AUC for Alvarado than for AIR, with respective AUCs of 0.89 and 0.77.¹⁶ Their study included only 35 patients, and approximately two-thirds had received antibiotics before assessment, which may have altered temperature, inflammatory markers and consequently the AIR score. Sanabria-Arévalo et al., in a larger study of 358 patients, reported AUCs of 0.767 for Alvarado and 0.741 for AIR, with no statistically significant difference between the two scores ($p=0.266$).¹⁵ Their findings support the present observation that neither scoring system was unequivocally superior. Differences among studies may be explained by sample size, disease prevalence, timing of presentation, prior treatment, population characteristics and variation in diagnostic cut-offs.

The positive predictive values were high for both scores, whereas their negative predictive values were relatively low. This is clinically important because predictive values are influenced by disease prevalence. The

high prevalence of histologically confirmed appendicitis in the present cohort increased the probability that a positive score represented true disease but reduced the reliability of a negative result. Therefore, neither an Alvarado score below 7 nor an AIR score below 9 should independently be used to exclude appendicitis in a population with strong clinical suspicion. Such patients may require repeated clinical evaluation and selective imaging, particularly when symptoms persist or evolve.

Exploratory subgroup analysis showed that both scores were more accurate among younger patients and those presenting after 24 hours. Alvarado performed better among males, whereas AIR showed greater accuracy among females. Gopalam et al. similarly observed that AIR performed well among diagnostically difficult groups, including women.¹³ Nevertheless, the present subgroup estimates were based on small denominators and should be interpreted cautiously. This was particularly evident among patients presenting within 24 hours, where only five histopathologically positive cases were available and AIR did not identify any case at the cut-off of ≥ 9 . In early appendicitis, fever, leukocytosis, neutrophilia and CRP may not yet have reached the thresholds required for a high AIR score. A high cut-off may consequently favour specificity at the expense of sensitivity during the early phase of the disease.

The findings have practical relevance in resource-constrained emergency departments. The Alvarado score is simple, inexpensive and relatively sensitive, making it useful for initial clinical assessment. AIR provides greater specificity and incorporates more objective inflammatory parameters, making a high score particularly useful for identifying patients with a strong probability of appendicitis. However, both scores should support rather than replace clinical judgement. Patients with intermediate or discordant scores may benefit from observation, reassessment and selective ultrasonography or computed tomography.

The comparison of two well practiced scoring systems for evaluation of acute appendicitis compared with histopathological examination was the major strength of this study in addition to ROC analysis. However, being single center study, the adaptability of the results are limited and requires validation through multicenter studies.

CONCLUSION:

The diagnostic performance of both scoring systems was acceptable, whereas Alvarado scoring system showed higher sensitivity and overall diagnostic accuracy than AIR score, however, AIR score had more specificity and stronger ROC discrimination than Alvarado.

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