

Study to Compare the Appendicitis Inflammatory Response Score (AIR) and Alvarado Score in Patients Undergoing Appendicectomy**Ganeriwala Rupal¹, Sharma Dhiraj², Dewangan Manish³**^{1,2,3}Jawaharlal Nehru Hospital and Research Centre, Bhilai, Chhattisgarh

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Conflict of interest: Nil

Abstract:

Introduction: Acute appendicitis (AA) is one of the commonest surgical emergencies and appendicectomy is one of the commonest operations performed by general surgeons. In developing and low-income countries where radiological tools are not widely available, a simple and effective scoring system without tomographic or imaging studies could help in preventing misdiagnosis and decrease the rate of negative appendicectomies. This study evaluated the role of Appendicitis inflammatory response (AIR) score and compared it with Alvarado score in patients with AA.

Materials and Methods: This was a prospective, observational, cross-sectional study involving 60 patients aged 16 or more years that presented with signs and symptoms of acute appendicitis and underwent appendicectomy in the Department of General Surgery, Jawaharlal Nehru Hospital and Research Center, Bhilai, India, over a period of 24 months. Based on the physical and laboratory examinations, scores (AIR and Alvarado) were calculated. Subsequently, the patient underwent appendicectomy and diagnosis of acute appendicitis was established on the basis of histopathological examination (HPE).

Results: In this study patients were predominantly male and belonged to the age group of 21 – 30 years (36.67%). Pain in Right iliac fossa (RIF) (100%) and tenderness in RIF (60%) were the most common symptoms and signs, respectively. The AIR score had a sensitivity, specificity, Positive predictive value (PPV), Negative predictive value (NPV), and accuracy of 73.91%, 71.43%, 89.47%, 45.45%, and 73.33%, respectively. Similarly, the Alvarado score had a sensitivity, specificity, PPV, NPV, and accuracy of 69.57%, 42.86%, 80.00%, 30.00%, and 63.33%, respectively. At a cut-off of 6.5, the AIR score had better predictive ability than Alvarado score (AUC: 0.739 vs 0.571).

Conclusion: The AIR score was superior to Alvarado score in predicting AA. AIR score had high negative predictive value thereby reducing negative appendicectomies.

Keywords: Acute appendicitis, Alvarado score, Appendicitis inflammatory response score (AIR), Appendicectomy.

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Introduction

The vermiform appendix, considered by most to be a vestigial organ becomes important when it is inflamed leading to acute appendicitis (AA). [1] It is a most common clinical diagnosis in a patient presenting with acute right iliac fossa pain. [2,3] AA is the most common surgical abdominal emergency, with a lifetime incidence of 7% of the general population, lifetime risk of 8.6% in males and 6.7% in females; nevertheless, it remains a diagnostic dilemma. [1,4,5]

Appendicitis-related hospitalizations cost 3 billion dollars in 1 year within the United States alone. [6,7] Introduction of restrictions due to the novel coronavirus (COVID-19) has resulted in a significant impact on both the number of patients presenting with AA as well as their disease burden. Those who underwent appendicectomy revealed a

45.5% decrease in uncomplicated appendicitis, a 21.1% increase in perforated appendicitis and a 29% increase in gangrenous appendicitis during COVID-19 time. [8] The clinical presentation and symptoms of AA are frequently atypical and can be similar to other diseases, which makes diagnosis difficult. Delayed diagnosis, however, can lead to perforation of the appendix. [9] Until recently, a 15% negative appendicectomy rate is accepted in order to reduce the perforation rate.

An anamnesis and physical examination are the initial methods for diagnosis, as in other diseases. [10] The laboratory investigations (especially leucocyte count, C-reactive protein (CRP), and neutrophil percentage) are diagnostic aids. [11] Radiological examinations including ultrasound and computed tomography (CT) scan further aid in

making a definite diagnosis and have been reported to have high sensitivity and specificity. [12] Alvarado Scoring systems have been designed to aid clinical assessment of AA based on eight predictive clinical factors. This score doesn't include CRP, a widely accepted laboratory marker in assessment of AA. However, the Alvarado score tend to over predict diagnosis of AA in the pediatric population, contributing to increased negative appendectomy rates and consequently unnecessary morbidity and even mortality.

The Appendicitis inflammatory response (AIR) score is a newer scoring system used in suspected appendicitis, first reported in 2008. It uses seven variables including CRP with maximum score of 12 points to stratify patients into low, intermediate, and high- risk cohorts.[13] AIR score relies less on subjective symptoms such as anorexia or nausea, includes CRP and employs graded parameters, compared with the dichotomized variables in the Alvarado score.[14,15] The AIR score has been found to outperform the Alvarado score in retrospective studies in the adult population.[13,15] The studies comparing the two scores are limited on Indian subjects, hence the current study was planned with an objective to compare the role of AIR Score and Alvarado score in patients of acute appendicitis.

Aim & Objective: To study and compare the role of appendicitis inflammatory response score and Alvarado score in patients undergoing appendectomy.

Materials and Methods

This was a prospective, observational, cross-sectional study approved by the Institutional Ethics Committee performed over a period of 24 months i.e., from November 2021 to October 2023, in the Department of General Surgery, Jawaharlal Nehru Hospital and Research Center, Bhilai, Chhattisgarh, India. All patients who presented with sudden-onset, non-traumatic, right lower quadrant (RLQ) pain, and underwent appendectomy were included.

A total of 68 patients were initially screened for the study eligibility and were explained the study procedure in their native language. Of these, 5 patients did not give consent, 2 had appendicular mass, and 1 was pregnant. Excluding these 8 patients, those who signed the informed consent document (patients or relatives for patients aged < 18 years) were enrolled in the study. Following enrollment, detailed history was obtained, physical examination was performed by a senior surgery resident, and blood samples were withdrawn for performing laboratory investigations. The findings on physical and laboratory examinations were recorded in the case report form and scores (AIR and Alvarado) were calculated. Subsequently, the

decision to operate was made by a senior surgical staff member. Imaging by means of US or CT was used selectively in the present study and at discretion of the operating surgeon. The surgical procedures consisted of either a laparotomy or laparoscopic appendectomy. The diagnosis of acute appendicitis during surgery was established on the basis of macroscopic findings. The diagnosis of appendicitis was confirmed histologically in all resected specimens.

Sample size was calculated on the basis of the following formula: $(Z_{1-\alpha/2} + 1.26) \times [P_1(1 - P_1) + P_2(1 - P_2)] / (P_1 - P_2)^2 = (1.96 + 1.26) \times [0.33(1 - 0.33) + 0.79(1 - 0.79)] / (0.33 - 0.79)^2 = 20$ Where, $P_1 = 0.33$, $P_2 = 0.79$, $Z_{0.025} = 1.96$ for 95% confidence interval $1.26 =$ Conventional multiplier for 90% power Thus, sample size was calculated to be a minimum of 20 patients. Thus, a total of 60 patients were enrolled in the study.

Statistical Analysis: The collected data was analyzed with SPSS (IBM, Armonk, NY, USA) version 23.0 for Windows. The categorical and continuous variables are represented as frequency (percentage) and mean (standard deviation, SD), respectively. Pearson's Chi-square test was used to assess an association between categorical variables. Receiver operating characteristic (ROC) curve was used to examine the performance characteristics of the two scoring systems. It was used to define the cut-off value and its sensitivity and specificity for prediction of acute appendicitis at the presentation. An area under curve (AUC) of less than 0.6 suggested no discrimination, 0.6 to 0.7 suggested poor discrimination, 0.7 to 0.8 suggested acceptable discrimination, 0.8 to 0.9 suggested excellent discrimination, and more than 0.9 suggested outstanding discrimination. (16) The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of both the risk stratifications scores against HPE findings (Gold standard) were calculated and compared. A 2-tailed p-value < 0.05 was considered as statistically significant.

Results

In our study group majority patients were in age group 21-30 years (n=22) whereas least number(n=2) belong to age greater than 60 years. 63.33% (n=38) were male and rest were females. Pain in Right iliac fossa was most common symptom present in all patients followed by nausea (86.67%), vomiting (80%) while least number of patients presented with anorexia (63.33%). In this study tenderness in RIF was most common sign present in 60% of patient while rebound tenderness and fever were present in 56.67% of patients. Majority of patients had leukocytosis (10000-14900 = n=42, >15000 = n=18), while CRP level >50mg/L was present in 86.67% of patients (Table 1). As per AIR score

Majority of patient had high likelihood of appendicitis (n- 32) whereas as per Alvarado score majority had intermediate likelihood of appendicitis (n- 30) (table 2). According to histopathological diagnosis majority patients had Acute appendicitis (n- 40), followed by perforative appendicitis (n-10) and suppurative appendicitis (n-6).

Normal appendix was found in 4 patients. On both AIR and Alvarado score majority patients with acute appendicitis had intermediate score, while

greater number of patients with both perforative and suppurative score had high AIR score than Alvarado score (Table 3). On ROC curve analysis AUC for AIR score was 0.739 and for Alvarado score was 0.571. With a cut off of 6.5 sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of AIR was better than Alvarado Score (Table 4).

At a cut off of 6.5, AIR score had better predictive ability than Alvarado score (AUC- 0.739 vs 0.571) (Table 5, Figure 1).

Table 1: Distribution of patients according to Age, Gender, Presenting Symptoms and signs, and laboratory investigations

		n-(60)	%	
Age Group	<20	10	16.67	
	21-30	22	36.67	
	31-40	14	23.33	
	41-50	8	13.33	
	51-60	4	06.67	
	>60	2	03.33	
Gender	Male	38	63.33	
	Female	22	36.67	
Presenting Symptoms	Pain in RIF	60	100	
	Nausea	52	86.67	
	Vomiting	48	80.00	
	Pain migrating to RIF	40	66.67	
	Anorexia	38	63.33	
Presenting Signs	Tenderness in RIF	36	60.00	
	Guarding	30	50.00	
	Rebound Tenderness	Light	2	56.67
		Medium	16	
		strong	16	
	Fever	≥ 37.3°C	18	56.67
> 38.5°C		16		
Laboratory Investigations	Leucocytosis(/mm ³)	10000-14900	42	70.00
		≥ 15000	18	30.00
	Polymorphonuclear leuko-cytosis (%)	70-84	32	53.33
		≥ 85	28	46.67
	CRP Level (mg/L)	10-49	8	13.33
		>50	52	86.67

Table 2: Distribution of patients according to likelihood of appendicitis

Score	Likelihood of Appendicitis	n-(60)
AIR	Low	6
	Intermediate	22
	High	32
ALVARADO	Low	2
	Intermediate	30
	High	26

AIR: ≤4 – Low, 5-7 – Intermediate, >7 – High. Alvarado: ≤ 4- Low, 5-8 – Intermediate, >8- High

Table 3: Distribution of patients according to histopathological diagnosis and scores

Scores					
		Normal	Acute Appendicitis	Perforative Appendicitis	Suppurative Appendicitis
AIR	Low	4	2	0	0
	Intermediate	0	22	0	0
	High	0	16	10	6

ALVARADO	Low	2	0	0	0
	Intermediate	2	22	6	2
	High	0	18	4	4

Table 4: Predictive performance of AIR and Alvarado scores

Parameters	Air		Alvarado	
	Values	95%CI	Values	95% CI
AUC	0.739	0.527-0.951	0.571	0.319-0.824
Sensitivity	73.91%	51.59-89.77	69.57%	47.08-86.79
Specificity	71.43%	29.04-96.33	42.86%	09.90-81.59
PPV	89.47%	71.99-96.57	80.00%	66.60-88.92
NPV	45.45%	26.61-65.70	30.00%	12.98-55.18
Accuracy	73.33%	54.11-87.72	63.33%	43.86-80.07

Table 5: Comparison ROC analysis parameters of both risk scores.

Score	AUC	95% CI	p- Value
AIR	0.739	0.527-0.951	0.059
ALVARADO	0.571	0.319-0.824	0.573

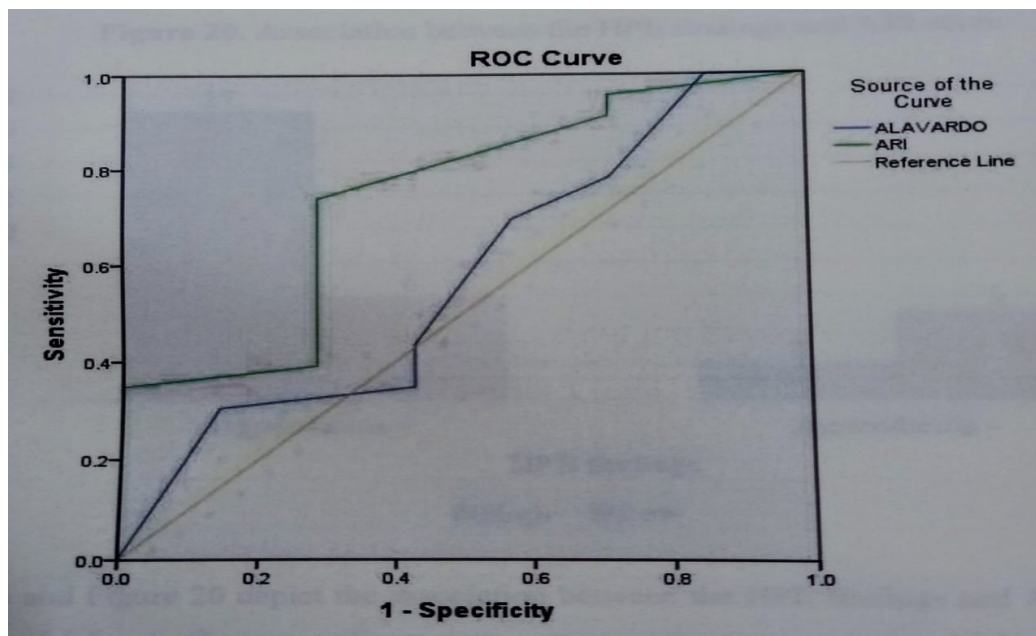


Figure 1: Comparison ROC analysis parameters of both risk scores

Discussion

Acute appendicitis is one of the commonest surgical emergencies, and appendectomy is one of the commonest surgical procedures performed by general surgeons. Delayed diagnosis of acute appendicitis can lead to perforation with its associated morbidity and mortality, while a wrong diagnosis leads to a negative appendectomy. The diagnosis of AA remains challenging, particularly for inexperienced surgeons. In developing countries and low-income countries, a simple and effective scoring system without tomographic or imaging studies could help in preventing misdiagnosis and decrease the rate of negative appendectomies. In this study, 60 patients were submitted to assessment by both scoring systems and comparisons were made. All patients underwent

open or laparoscopic appendectomy and assessment by histopathology was done for the excised specimen.

In our study, majority of the patients were in the age group of 21 – 30 years (36.67%) and, the mean age of the study population was 32.9 ± 12.01 years. Similarly, Walia et al. observed that maximum patients were from the 20-30 years age group (31.6%) and the mean age was 33 ± 14.1 years. Majority of the patients in this study were male (63.33%), with a male-to-female ratio of 1.7 which is consistent with, Kumar et al. who reported that males (66%) were predominantly affected and male-to-female ratio was 1.9.[17] Majority of the patients presented with pain in RIF (100%) followed by nausea (86.67%), vomiting (80%), pain migrating to RIF (66.67%), and anorexia

(63.33%). In consensus with the above findings, Kumar et al. reported that pain in RIF was uniformly present in all subjects (100%), nausea and vomiting were the second and third most common symptoms (70 and 54%) respectively. While, anorexia (50%) and pain migrating to RIF (14%) were present least common. [17]

Tenderness in RIF (60%) followed by fever and rebound tenderness (56.67%) were the most common signs observed. While, the least number of patients presented with guarding (50%). In his study, Walia et al. observed that tenderness in RIF was the most common sign (97%), followed by guarding (91%), fever (62%), and rebound tenderness (35%). [18]

In the present study, the majority of the patients had leukocytosis (10000 – 14900 /mm³) (70%), polymorphonuclear leukocytes in the range of 70-84% (53.33%), and CRP levels > 50 mg/L (86.67%). Memon et al. in his study observed that 74% patients had a leucocyte count between 10000-14900/mm³. Moreover, a CRP level in-between 10-49 mg/L was reported in 45% patients while >50 mg/L in 55% patients. [19]

We observed that for AIR score, the majority of the patients had high likelihood (53.33%) followed by intermediate likelihood (36.67%), and low likelihood of appendicitis (10%). However, on Alvarado score, the majority of the patients had intermediate likelihood (50%) followed by high likelihood (43.33%), and low likelihood of appendicitis (6.67%). Similarly, Kumar et al. reported that calculation of Alvarado score suggested that 66% patients had moderate risk, 20% had strong risk, and 14% had no risk of suffering from acute appendicitis. Additionally, assessment of AIR score suggested that majority (42%) of the patients had moderate risk, followed by strong risk (41%) and no risk (17%) of acute appendicitis. [17]

In the present study, the majority of the patients had acute appendicitis (66.67%) followed by perforative appendicitis (16.67%), and suppurative appendicitis (10%). While, the least number of patients had normal appendix (6.67%). Thus, overall negative appendectomy rate (NAR) was 6.67%. In consensus with the present study, Walia et al. observed that 88.3% patients were diagnosed with appendicitis and 11.6% patients had a normal appendix. [18]

In our study, the findings on HPE were significantly associated with AIR score (p-value = 0.001), but not with Alvarado score (p-values = 0.59). In a study, Walia et al. reported a significant association of HPE findings with both AIR (p-values = 0.001) and Alvarado scores (p-values = 0.003). In the present study, the AIR score had a sensitivity, specificity, PPV, NPV, and accuracy of

73.91%, 71.43%, 89.47%, 45.45%, and 73.33%, respectively. Walia et al. in his work reported that at a cut-off of > 7, the AIR score had a sensitivity of 88.68%, specificity of 71.43%, PPV of 95.92%, NPV of 45.45%, and accuracy of 86.67%. Similarly, the Alvarado score had a sensitivity of 69.57%, specificity of 42.86%, PPV of 80%, NPV of 30%, and accuracy of 63.33%. [18]

In the present study, at a cut-off of 6.5, the AIR score had better predictive ability than Alvarado score (AUC: 0.739 vs 0.571). In his study, Walia et al. reported that at a cut-off of 6.5, the AUC for the Alvarado score was 0.765. Similarly, Gopalam et al. also reported that the AUC of AIR score was better than that of Alvarado score (0.94 vs 0.82). [20] Thus, AIR score is superior to Alvarado scoring systems. However, in the present study, lack of statistically significant AUCs could be attributed to small sample size.

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