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# A Prospective Study to Compare Appendicitis Inflammatory Response (AIR) Score and Alvarado Score for Prediction of Acute Appendicitis

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**Abstract**
As clinical evaluation provides the best and most accurate diagnostic modality for appendicitis, many clinical scoring systems have been developed over the years. This has aided the clinician to a large extent in coming to the right diagnosis and providing early management. Patients presenting with pain in the right lower quadrant of abdomen to the General Surgery department, who after clinical examination are provisionally diagnosed to have acute appendicitis are taken up for the study. In this study, Sensitivity of AIR score to predict acute appendicitis at cut-off point of score 8 was 11.11% and specificity was 100%. Positive Predictive Value (PPV) showed an estimate of 100% and the Diagnostic accuracy of AIR score was also found to be 20%.

## INTRODUCTION

The abdomen is commonly compared to a Pandora's box and for a good reason. Since the abdomen contains numerous viscera and other anatomical components, the diseases of the abdomen give rise to a lot of clinical curiosity. A meticulous examination of the abdomen and clinical correlation is one of the most important diagnostic tools and becomes the cornerstone of management in many conditions presenting with abdominal pain. Despite the vast advances in the medical field in terms of imaging and other investigation modalities, the importance of clinical examination cannot be stressed upon enough[1].

Acute appendicitis is one of the common causes for acute abdomen in any general surgical practice[2]. From the time that it was first described by Reginald Heber Fitz in 1886[3], it has remained a topic of serial research works for various factors ranging from its etiology to its management options.

One of the most researched fields pertaining to appendicitis is the one involving diagnosis. Over the years, various types of investigations including laboratory and radiological have been studied in detail with the aid of trials. These were conducted in the hope of finding the most sensitive test for diagnosing acute appendicitis. But despite vast advances in the field of medicine, it has been time and again opined by various clinicians that diagnosis of appendicitis relies mainly upon the clinical features.

As quoted by Bailey and Love, Notwithstanding advances in modern radiographic imaging and diagnostic laboratory investigations, the diagnosis of appendicitis remains essentially clinical, requiring a mixture of observation, clinical acumen and surgical science[1]. So, early and right diagnosis of acute appendicitis is important. Appendicitis, which if caught early and managed appropriately, can be the most uneventful surgery, while the other end of the spectrum is also true, that when missed, appendicitis can turn into a disease with great morbidity and mortality.

As clinical evaluation provides the best and most accurate diagnostic modality for appendicitis, many clinical scoring systems have been developed over the years. This has aided the clinician to a large extent in coming to the right diagnosis and providing early management. What began as a single scoring system evolved into many over the years, as people constantly made modifications to the existing scoring systems based on the local demographics or by adding more factors. This brought along the next problem, of finding the scoring system with the maximum sensitivity and diagnostic accuracy. As a result, multiple studies have been done with randomized controlled trials comparing various scoring systems in different parts of the world. To date, the most commonly used scoring system worldwide is the Alvarado scoring system[4]. So, any new scoring system that has been developed is usually first compared to the Alvarado scoring system. The Appendicitis Inflammatory Response (AIR) Score was published in 2008 and is similar to the Alvarado score in many aspects but emphasizes the inflammatory response laboratory results and seems to perform better compared to the Alvarado score[5,6]. In the present study, the Appendicitis Inflammatory Response Score (AIR) and the Alvarado score are compared among the local population in the western Orissa of India, to find out which scoring system is more relevant and applicable, in order to aid early diagnosis of acute appendicitis.

## MATERIALS AND METHODS

**Study Design:** A prospective comparative study.

**Study Population:** Patients presenting with pain in the right lower quadrant of the abdomen to the General Surgery department, who after clinical examination are provisionally diagnosed to have acute appendicitis, are taken up for the study.

**Inclusion Criteria:** The patients admitted to the General Surgery department with suspicion of acute appendicitis during the study period. The population consisted of all patients who presented with complaints of sudden-onset, non-traumatic right lower quadrant (RLQ) pain.

**Exclusion Criteria:**

- Patients presented with non-right iliac fossa pain.
- Patients presented with traumatic abdominal pain.
- Patients admitted by other specialties for other complaints but subsequently developed right iliac fossa pain.
- Chronic abdominal pain.

## RESULTS AND DISCUSSIONS

Based on the distribution of the scores of the Alvarado scoring system ranging from 1-10, a score of 6 had the maximum number of patients with 18% of the total patients, followed by scores of 9 and 5 with 17% of the total patients in each score, a score of 7 with 14% of the total patients and a score of 2 with the least number of patients (1%).

**With the Final Alvarado Scores, Patients were Classified into 3 Categories:**

- 23% of patients with a score $\leq$ 4.
- 57% of patients with a score 5-8.
- 20% of patients with a score >8.

Out of the total 100 patients, the maximum number of patients (57%) fell into the intermediate

group of scores 5-8, which has an intermediate probability of acute appendicitis. Only 20% of patients had scores >8, which has a very high probability of acute appendicitis and 23% of patients had scores <4, with a low probability of acute appendicitis.

Among the final AIR scores of 1-12, the score with the maximum number of patients is score 5 with 28% of patients, followed by score 6 with 19% and scores 7 and 8 with 14% each. Score 1 had the least percent of patients with only 1%.

**With the Final AIR Score, Patients were Classified into 3 Categories:**

- 15% of patients with a score=4.
- 75% of patients with a score 5-8.
- 10% of patients with a score >8.

Out of the total 100 patients, the maximum number of patients (75%) fell into the intermediate group of scores 5-8, which has an intermediate probability of acute appendicitis. Only 10% of patients had scores >8, which has a very high probability of acute appendicitis and 15% of patients had scores <4 with a low probability of acute appendicitis.

The AIR score diagnosed 85 patients as acute appendicitis (at score >4), of which 5 patients were false positive cases. The AIR score ruled out acute appendicitis (at score <4) in 15 patients, of which 10 patients were false negatives.

AIR diagnosed 10 cases of acute appendicitis (at score >8) with no false positive cases. It was the positive side of the score. AIR diagnosed 90 cases of acute appendicitis with a score $\leq$8, out of which 10 were false positives.

Alvarado score diagnosed 77 patients as acute appendicitis (at score >4), of which 7 patients were false positive cases. Alvarado score ruled out acute appendicitis (at score <4) in 23 patients, of which 20 patients were false negatives.

Alvarado score diagnosed 20 cases of acute appendicitis (at score >8) with no false positive cases and 80 cases with a score $\leq$8, with 10 false positive cases.

In this study, the sensitivity of Alvarado score to predict acute appendicitis at the cut-off point of score 4 was 77.78% and the specificity was 30.00%. The Positive Predictive Value (PPV) showed an estimate of 90.91% and the diagnostic accuracy of Alvarado score was found to be 73% at the cut-off point of score 4.

In this study, the sensitivity of Alvarado score to predict acute appendicitis at the cut-off point of score 8 was 22.20% and the specificity was 100%. The Positive Predictive Value (PPV) showed an estimate of 100%, and the diagnostic accuracy of Alvarado score was found to be 30%.

In this study, the sensitivity of AIR score to predict acute appendicitis at the cut-off point of score 4 was 88.98% and the specificity was 50.00%. The Positive Predictive Value (PPV) showed an estimate of 94.12%, and the diagnostic accuracy of AIR score was also found to be high (85%).

In this study, the sensitivity of AIR score to predict acute appendicitis at the cut-off point of score 8 was 11.11% and the specificity was 100%. The Positive Predictive Value (PPV) showed an estimate of 100%, and the diagnostic accuracy of AIR score was also found to be 20%.

The ROC (Receiver Operating Characteristic) curve was drawn to illustrate the prediction of acute appendicitis using the Alvarado and AIR scores. The ROC curve is interpreted using the AUC (Area under the Curve), which ranges from 0-1. A higher AUC indicates better predictive performance. The AUC for the Alvarado score is 0.696, whereas the AUC for the AIR score is 0.826. This clearly shows that the AIR score predicts acute appendicitis more effectively than the Alvarado score.

In our study, the efficacy of Appendicitis Inflammatory Response (AIR) score and the Alvarado score were evaluated and compared at different cut-off levels of scores 4 and 8.

On evaluation, it was found that for score >4, the AIR score had sensitivity of 88.89% while the Alvarado score had 77.78% sensitivity. The specificity of AIR score was 50% while the Alvarado score had only 30%

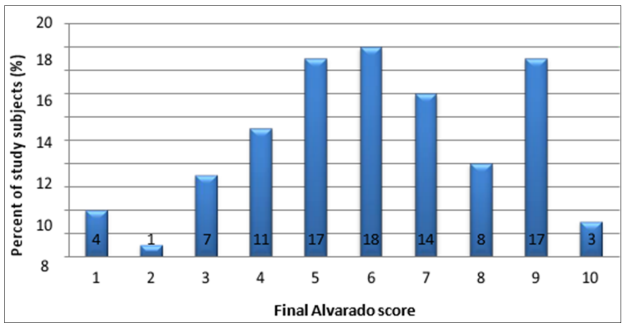


Fig 1: Distribution of study subjects according to final Alvarado score

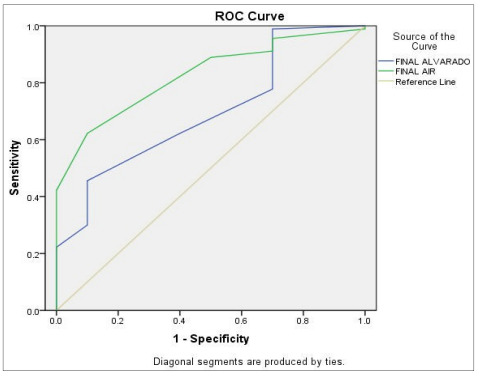


Fig 2: ROC Curve Showing Prediction of Acute Appendicitis

**Table 1: Distribution of Study Subjects according to the Alvarado Score (N = 100)**

| Alvarado Score | No. of patients | Percentage (%) |
|---|---|---|
| ≤4 | 23 | 23.0 |
| 5-8 | 57 | 57.0 |
| >8 | 20 | 20.0 |

**Table 2: Distribution of Study Subjects according to the Final AIR Score (N = 100)**

| Final AIR score | No. of patients | Percentage (%) |
|---|---|---|
| 3 | 4 | 4.0 |
| 4 | 4 | 4.0 |
| 5 | 28 | 28.0 |
| 6 | 19 | 19.0 |
| 7 | 14 | 14.0 |
| 8 | 14 | 14.0 |
| 9 | 4 | 4.0 |
| 10 | 3 | 3.0 |
| 11 | 3 | 3.0 |

**Table 3: Distribution of Study Subjects according to the AIR Score (N = 100)**

| AIR score | No. of patients | Percentage (%) |
|---|---|---|
| ≤4 | 15 | 15.0 |
| 5-8 | 75 | 75.0 |
| >8 | 10 | 10.0 |

**Table 4: Correlation of AIR Score with Histopathological Findings at Cut-off Point of Score 4**

| AIR Score | Acute Appendicitis (No. of patients) | Normal Appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| ≤4 | 10 | 5 | 15 |
| >4 | 80 | 5 | 85 |
| Total (No. of patients) | 90 | 10 | 100 |

**Table 5: Correlation of AIR score with Histo-Pathological findings at cut-off point of score 8**

| AIR Score | Acute Appendicitis (No. of patients) | Normal Appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| ≤8 | 80 | 10 | 90 |
| >8 | 10 | 0 | 10 |
| Total (No. of patients) | 90 | 10 | 100 |

**Table 6: Correlation of Alvarado Score with Histopathological Findings at Cut-off Point of Score 4**

| Score | Acute Appendicitis (No. of patients) | Normal Appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| ≤4 | 20 | 3 | 23 |
| >4 | 70 | 7 | 77 |
| Total (No. of patients) | 90 | 10 | 100 |

**Table 7: Correlation of Alvarado Score with Histopathological Findings at Cut-off Point of Score 8**

| Score | Acute Appendicitis (No. of patients) | Normal Appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| ≤8 | 70 | 10 | 80 |
| >8 | 20 | 0 | 20 |
| Total (No. of patients) | 90 | 10 | 100 |

**Table 8: Diagnostic Characteristics of Alvarado Score According to Cut-off Point of Score 4**

| Alvarado score | Acute Appendicitis (No. of patients) | Normal appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| >4 | 70 | 7 | 77 |
| ≤4 | 20 | 3 | 23 |
| Total (No. of patients) | 90 | 10 | 100 |
| Sensitivity = 77.78% | | | |
| Specificity =30% | | | |
| Positive Predictive Value = 90.91% | | | |
| Negative Predictive Value =13.04% | | | |
| Diagnostic accuracy = 73% | | | |

**Table 9: Diagnostic Characteristics of Alvarado Score According to Cut-off Point of Score 8**

| Alvarado score | Acute Appendicitis (No. of patients) | Normal appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| >8 | 20 | 0 | 20 |
| ≤8 | 70 | 10 | 80 |
| Total (No. of patients) | 90 | 10 | 100 |
| Sensitivity = 22.20% | | | |
| Specificity =100% | | | |
| Positive Predictive Value = 100% | | | |
| Negative Predictive Value =12.50% | | | |
| Diagnostic accuracy = 30% | | | |

**Table 10: Diagnostic Characteristics of AIR Score According to Cut-off Point of Score 4**

| AIR score | Acute appendicitis (No. of patients) | Normal appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| >4 | 80 | 5 | 85 |
| ≤4 | 10 | 5 | 15 |
| Total (No. of patients) | 90 | 10 | 100 |
| Sensitivity = 88.89% | | | |
| Specificity = 50.00% | | | |
| Positive Predictive Value = 94.12% | | | |
| Negative Predictive Value = 33.33% | | | |
| Diagnostic accuracy = 85.00% | | | |

**Table 11: Diagnostic Characteristics of AIR Score According to Cut-off Point of Score 8**

| AIR score | Acute appendicitis (No. of patients) | Normal appendix (No. of patients) | Total (No. of patients) |
|---|---|---|---|
| >8 | 10 | 0 | 10 |
| <8 | 80 | 10 | 90 |
| Total (No. of patients) | 90 | 10 | 100 |
| Sensitivity = 11.11% | | | |
| Specificity = 100% | | | |
| Positive Predictive Value = 100% | | | |
| Negative Predictive Value = 11.11% | | | |
| Diagnostic accuracy = 20.00% | | | |

specificity. The positive predictive values of the AIR score and the Alvarado score were 94% and 90% respectively. The diagnostic accuracy of the AIR score and the Alvarado scores were 85% and 73% respectively. These values are comparable to the values obtained in the study made by Castro[7].

Castro *et al.* reported that for score >4, the AIR score and Alvarado score had sensitivities of 93% and 90% respectively. The specificities of the AIR score and the Alvarado score were 85% and 55% respectively. In our study, on evaluation, it was found that for score > 8, the AIR score and the Alvarado score had specificity of almost 100% each as both had diagnosed correctly in all the patients with score >8 as acute appendicitis. The sensitivity of AIR score was only 11% while the Alvarado score had only 22% sensitivity. For score >8, both the scores had very low sensitivity. These values are comparable to the values obtained in the study made by Castro[7]. They reported that for score >8, the AIR score and Alvarado score had very low sensitivities of 11% and 22% respectively. The specificities of the AIR score and the Alvarado score were 100% and 95% respectively[7].

A similar study done by Patil *et al.* evaluated the AIR score. The results and observations of the study were comparable with our study. For score >4, the sensitivities of AIR score and the Alvarado score were 89.9% and 78.6% respectively and the specificities of the AIR score and the Alvarado score were 12.3% and 21.3%[8].

Anderson, who was the first to implement the AIR score in 2008, noted a sensitivity of 96% and a specificity of 73% with a cut-off threshold of score >4, and a sensitivity and specificity of 37% and 99% respectively when the cut-off point was score >8[5].

In our study, overall comparison of both the AIR scores and the Alvarado scores in predicting acute appendicitis was made by drawing the ROC (Receiver Operating Characteristic) curve. The curve showed that the Area under the Curve (AUC) for the Alvarado score was 0.696 and the Area under the Curve (AUC) for the AIR score was 0.826, which was higher than the AUC for the Alvarado score. Higher the AUC, better the prediction for acute appendicitis.

Thus, the AIR score has better predictivity than the Alvarado score in predicting acute appendicitis.

## CONCLUSION

The present study concludes that, in the diagnosis of acute appendicitis, the Appendicitis Inflammatory Response (AIR) scoring system outperformed the Alvarado scoring system, displaying higher sensitivity, specificity, positive predictive value and overall better diagnostic accuracy. The AIR scoring system performed almost equally or slightly better than the Alvarado scoring system with high specificity and high negative predictive value, preventing unnecessary negative appendectomies.

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