Section: General Surgery

Original Research Article

COMPARISON OF ALVARADO, RAJA ISTERI PENGIRAN ANAK SALEHA, APPENDICITIS INFLAMMATORY RESPONSE AND ADULT APPENDICITIS SCORE IN PREDICTING ACUTE APPENDICITIS: A STUDY OF DIAGNOSTIC ACCURACY

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ABSTRACT

Background: Acute appendicitis is a common surgical emergency in which variable clinical presentation may delay diagnosis or result in unnecessary appendicectomy. Clinical scoring systems provide rapid, economical risk assessment, although their diagnostic performance varies among populations. The objective is to document the demographic profile, clinical presentation and investigations of patients with acute appendicitis and to compare the diagnostic accuracy of the Alvarado, RIPASA, Appendicitis Inflammatory Response (AIR) and Adult Appendicitis Score (AAS) using histopathology as the reference standard.

Materials and Methods: This cross-sectional diagnostic-accuracy study included 51 patients aged 18–60 years who underwent appendicectomy at Rohilkhand Medical College and Hospital, Bareilly, from 5 May 2024 to 5 April 2025. Clinical findings, laboratory parameters and radiological investigations were recorded. All four scores were calculated preoperatively. Receiver operating characteristic analysis was performed to determine optimal cut-offs, sensitivity, specificity, predictive values, likelihood ratios and diagnostic accuracy.

Results: AIR showed the highest AUC of 0.961, followed by Alvarado (0.959), AAS (0.912) and RIPASA (0.844). At respective cut-offs of 5.5, 7.5, 14.5 and 9.25, AIR achieved the highest sensitivity (90.9%), PPV (97.56%) and accuracy (90.2%), while Alvarado showed the highest NPV (97.5%). Histopathology identified acute appendicitis in 44 patients (86.3%), acute resolving appendicitis in 4 (7.9%) and acute suppurative resolving appendicitis in 3 (5.9%).

Conclusion: AIR provided the most balanced diagnostic performance and may serve as the most practical scoring system for suspected acute appendicitis. Alvarado also retained strong diagnostic value, particularly for excluding disease, whereas AAS and RIPASA showed comparatively lower overall accuracy.

Keywords: Acute appendicitis, Alvarado score, RIPASA score, AIR score, Adult Appendicitis Score, diagnostic accuracy, histopathology.

INTRODUCTION

The vermiform appendix is a narrow, blind-ending structure arising from the caecum. Its lymphoid-rich wall contributes to mucosal immune activity, while luminal obstruction may initiate distension, bacterial proliferation, ischaemia and progressive inflammation. Untreated disease may advance to gangrene, perforation, abscess or peritonitis, making timely diagnosis clinically important.

Acute appendicitis is a common surgical emergency, but variable presentation and overlap with gastrointestinal, urinary and gynaecological disorders may lead to diagnostic delay or unnecessary appendicectomy. In a histopathology-based comparison of 132 patients, RIPASA demonstrated better overall diagnostic performance than AIR and Alvarado, whereas AIR showed comparatively greater specificity and negative predictive value.[1] AIR also demonstrated superior diagnostic accuracy to Alvarado in another comparative cohort.[2] A study comparing RIPASA with Alvarado similarly reported better diagnostic performance for RIPASA.[3] However, evaluation of multiple scoring systems in adults showed that sensitivity, specificity and optimal thresholds varied, with no score performing uniformly across all diagnostic measures.[4]

Histopathology-based assessment has further indicated that AIR may outperform Alvarado at selected cut-off values.[5] A systematic review and meta-analysis subsequently supported AIR as a useful instrument for clinical risk stratification.[6] Earlier Indian diagnostic-accuracy research found AIR and RIPASA more accurate than Modified Alvarado, with a reported negative appendicectomy rate of 15.89%.[7] Large prospective validation also showed that AIR can distinguish low-risk patients from those with a high probability of appendicitis or complicated disease.[8]

Indian prospective evidence comparing Alvarado, AIR and AAS reported the highest sensitivity with AIR, whereas Alvarado demonstrated the highest specificity.[9] Another Indian study found a greater area under the ROC curve and higher diagnostic accuracy for AIR than Alvarado.[10]

Therefore, direct comparison of Alvarado, RIPASA, AIR and AAS against histopathology at Rohilkhand Medical College and Hospital, Bareilly, is required to identify the most accurate and practical scoring system for suspected acute appendicitis.

MATERIALS AND METHODS

Study Design: A hospital-based cross-sectional diagnostic-accuracy study was conducted to compare the Alvarado, Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA), Appendicitis Inflammatory Response (AIR), and Adult Appendicitis Score (AAS) for predicting acute appendicitis.

Study Setting: Department of General Surgery, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, from 5 May 2024 to 5 April 2025.

Study Population: The study included adult patients presenting to the outpatient department or emergency services with clinical suspicion of acute appendicitis who subsequently underwent appendicectomy during the study period.

Sample Size: The sample size was calculated by formulating 4PQ/L2 where P was the previously reported sensitivity of the RIPASA score (96.7%), Q was 100 - P and L was the allowable error of 5%. The last sample was composed of 51 patients.

Inclusion Criteria

Patients of 18–60 years of age who underwent appendicectomy in Rohilkhand Medical College and Hospital.

Exclusion Criteria

Patients presenting with right iliac fossa lump, appendicular carcinoma, age less than 18 years or more than 60 years and immunocompromised patients were excluded from the study.

Data Collection and Investigations: A detailed clinical history and physical examination were performed for each participant. Laboratory investigations included complete blood count, total and differential leukocyte counts, C-reactive protein, and urine routine microscopy. Ultrasound and/or contrast-enhanced abdominal computed tomography was performed as clinically indicated. Preoperatively, Alvarado, RIPASA, AIR and AAS scores were calculated and recorded. All patients underwent appendicectomy and the excised appendix was sent for histopathological examination. Histopathology was considered the reference standard for confirming acute appendicitis. The diagnostic performance of ultrasonography and computed tomography was also assessed as a secondary outcome.

Ethical Consideration: The study was conducted after approval from the Institutional Ethics Committee. Written informed consent was obtained from each patient in a language they understood. Confidentiality, data protection, participant safety and research integrity were ensured throughout the study.

Statistical Analysis: Data were analysed using IBM SPSS version 23. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. ROC analysis was used to determine cut-off values, sensitivity, specificity and area under the curve. Predictive values, likelihood ratios and diagnostic accuracy were calculated. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: ROC Curve Analysis for Predicting Acute Appendicitis Using Alvarodo as a Predictor

Area Under the Curve					
Test Result Variable(s)	Area	Std. Error	p value	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Alvarado	.959	.035	.001*	.891	1.000

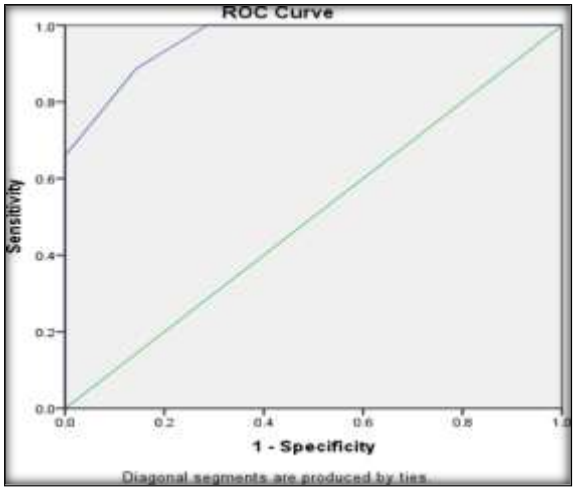
*Significant

Table 2: ROC Curve Analysis for Predicting Acute Appendicitis Using RIPASA Score as a Predictor

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**p value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
RIPASA	.844	.098	.004*	.651	1.000

*Significant

[Table 1] shows that the Alvarado score has strong discrimination ability for predicting acute appendicitis with an area under the ROC curve of 0.959 (SE 0.035; 95% CI 0.891–1.000), as indicated in Table 1. The finding was statistically significant (p=0.001) showing great diagnosis accuracy among clinically suspected cases.



[Table 2] shows good discriminatory ability of RIPASA score for prediction of acute appendicitis with an area under ROC curve of 0.844 (SE 0.098; 95% CI 0.651–1.000). The finding was statistically significant (p=0.004). This supports its diagnostic utility in clinically suspected situations.

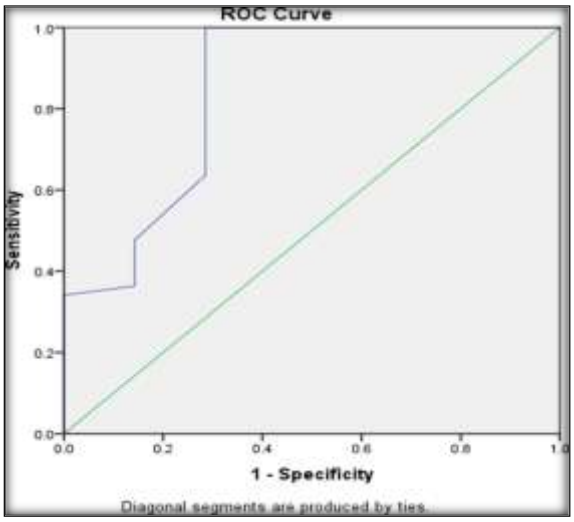


Table 3: ROC Curve Analysis for Predicting Acute Appendicitis Using AIR Score as a Predictor

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**p value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
AIR	.961	.039	.001*	.885	1.000

*Significant

[Table 3] reveals that the AIR score had high discriminatory ability for predicting acute appendicitis (AUC: 0.961; SE: 0.039; 95% CI: 0.885–1.000). The statistically significant result (p=0.001) shows a high diagnostic performance in clinically suspected patients.

Table 4: ROC Curve Analysis for Predicting Acute Appendicitis Using AAS Score as a Predictor

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**p value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
AAS	.912	.058	.001	.799	1.000

*Significant

[Table 4] shows that the AAS showed strong discriminating power for prediction of acute appendicitis (area under the ROC curve 0.912; SE 0.058; 95% CI 0.799-1.000) (Table 4). It is a statistically significant result (p=0.001) showing high diagnostic ability among clinically suspected cases.

As shown in [Table 5], the AIR score was shown to have the highest sensitivity (90.9%), PPV (97.56%), PLR (6.36), and overall accuracy (90.2%). Alvarado exhibited the highest NPV (97.5%) while RIPASA and AAS had poorer specificity and diagnostic accuracy.

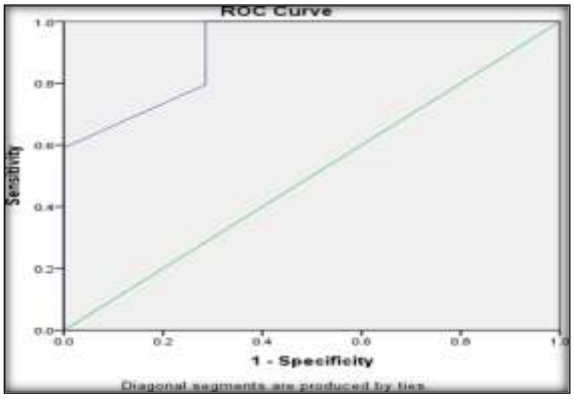


Table 5: Comparison Of Different Diagnostic Predictive Values Of Alvarado, RIPASA, AIR And AAS Scores In Predicting Acute Appendicitis

	Cut-off	Sensitivity	Specificity	PPV	NPV	PLR	NLR	Accuracy
Alvarado	7.5	88.6	85.7	54.55	97.5	6.2	0.13	88.24
RIPASA	9.25	88.6	71.4	95	45.45	3.02	0.19	84.31
AIR	5.5	90.9	85.7	97.56	60	6.36	0.11	90.2
AAS	14.5	88.6	71.4	95.12	50	3.1	0.16	86.27

*PLR= Positive Likelihood ratio, * NLR – Negative likelihood ratio

Table 6: Distribution Of the Patients Based on Histopathology Report

Histopathology report	Number of patients (n= 51)	Percentage (%)
Acute appendicitis	44	86.3
Acute Resolving appendicitis	4	7.9
Acute Suppurative resolving appendicitis	3	5.9
Total	51	100.0

[Table 6] shows that Histopathological examination revealed acute appendicitis in 44 (86.3%) patients, acute resolving appendicitis in 4 (7.9%) patients and acute suppurative resolving appendicitis in 3 (5.9%) patients indicating that most of the resected specimens had active acute inflammation.

DISCUSSION

The Alvarado score yielded an AUC of 0.959, standard error 0.035, p=0.001, and 95% confidence interval of 0.891–1.000, indicating excellent discrimination for acute appendicitis within this surgical population. Zeb Muhammed et al. (2020).[1] also proved similar diagnostic performance with 85.2% sensitivity, 85.7% specificity and 84% accuracy. Aslam Faiqa et al (2022).[3] sensitivity and accuracy were 85% and 84% respectively. Safaee Mashumeh et al. (2024)5 72% specificity 82% accuracy. By comparison, Meena et al,[9] (2023) reported 100% specificity but only 60.64% sensitivity and 63% accuracy. DEY et al (2023).[4] had lower AUC (0.681) and lower discrimination.

The AUC of the RIPASA score was 0.844 with a standard error of 0.098, p=0.004 and 95% confidence interval 0.651–1.000, indicating good discriminatory ability of the score for acute appendicitis. Chisthi et al. (2020)7 presented similar diagnostic strength with AUC of 0.910, 87.78% sensitivity, 76.47% specificity and 85.98% accuracy. Sensitivity 96.7%, specificity 82.3% and accuracy 91% (Zeb Muhammed et al., 2020) 90% accuracy, 82% specificity, 95% sensitivity (2022) Aslam et al Similar performance across settings but varies by population Gan DEY et al. (2023),[4] had a lower AUC of 0.724 with a sensitivity of 72.7% and a specificity of 62.3%.

The AUC for AIR was 0.961 (standard error: 0.039, p=0.001, 95% confidence interval: 0.885– 1.000) which shows good discrimination for acute appendicitis. Chisthi et al. (2020).[7] achieved a very similar AUC of 0.947 with sensitivity of 97.78% and accuracy of 86.92%. An accuracy of 92% and specificity of 85% was reported by Jose et al. (2021).[2] 91% accuracy and 92.55% sensitivity were achieved (Meena et al 2023).[9] Safaee Mashumu et al,[5] (2024) reported 90% accuracy and 86% specificity. Andersson et al,[8] reported AUC of 0.83 for any appendicitis and 0.89 for complicated disease. Deepak et al. (2024),[10] got only 20% at cut-off.[8]

The AAS demonstrated excellent discrimination for acute appendicitis with an AUC of 0.912 (standard error 0.058, p=0.001, 95% confidence interval 0.799-1.000). Clinically useful performance was seen with AAS with 84.04% sensitivity, 83.33% specificity and 84% accuracy (Meena et al. 2023).[9] Gan DEY et al (2023),[4] showed less discrimination with AAS AUC of 0.719 at a cut-off of 14 with 60.2% sensitivity and 75.4% specificity. However, AIR AUC of 0.947 and RIPASA of 0.910 was reported in Chisthi et al (2020) 7. Andersson et al,[8] (2021) reported AIR AUCs of 0.83 for any appendicitis and 0.89 for complicated disease.

At cut-offs of 7.5, 9.25, 5.5, and 14.5, Alvarado, RIPASA, AIR, and AAS achieved accuracies of 88.24%, 84.31%, 90.2%, and 86.27%, respectively. AIR had the highest sensitivity (90.9%), PPV (97.56%), PLR (6.36), and lowest NLR (0.11), while Alvarado had the highest NPV (97.5%). Also, AIR was proved to be better by Jose et al (2021),[2] Safaee Mashumeh et al (2024),[5] Meena et al,[9] (2023) and Roland Andersson et al. (2025).[6] However, RIPASA was reported to be the best performing score by Zeb Muhammed et al (2020),[1] and Aslam Faiqa et al. (2022).[3] Gan DEY et al,[4] (2023) reported moderate performance in all the four systems.

Histopathology revealed acute appendicitis in 44 of 51 patients (86.3%), acute resolving appendicitis in 4 (7.9%) and acute suppurative resolving appendicitis in 3 (5.9%). Thus, all the resected specimens showed some inflammatory pathology of the appendix. Zeb Muhammed et al (2020),[1] Gan DEY et al (2023),[4] Evaluation of clinical scores by using histopathology as the diagnostic reference was also done by Chisthi et al,[7] (2020) and Meena et al (2023).[9] The negative appendicectomy rate was 15.89% as reported by Chishti et al (2020).[7] Zeb Muhammed et al,[1] (2020) reviewed 132 suspected cases with histopathological confirmation. Exact histopathological subtype distributions were not provided in the supplied comparative reports, making the resolving and suppurative-resolving categories a distinct observation.

CONCLUSION

The comparative evaluation of Alvarado, RIPASA, AIR, and AAS against histopathological findings showed that all four systems were useful for diagnosing acute appendicitis, although their performance differed. AIR provided the strongest overall discrimination, with an AUC of 0.961, sensitivity of 90.9%, specificity of 85.7%, PPV of 97.56%, and diagnostic accuracy of 90.2%. Alvarado also performed well, especially in terms of exclusion with an NPV of 97.5% and accuracy of 88.24%. AAS had good diagnostic ability but RIPASA had lower specificity and overall accuracy in this population. Histopathology of all 51 specimens removed confirmed inflammatory appendiceal pathology: acute, resolving and suppurative resolving appendicitis. These findings support AIR as the most balanced and clinically practical score, while Alvarado remains valuable for ruling out disease and reducing unnecessary operative intervention.

REFERENCES

1. Zeb M, Khattak SK, Samad M, Shah SS, Shah SQ, Haseeb A. Comparison of Alvarado score, appendicitis inflammatory response score (AIR) and Raja Isteri Pengiran Anak Saleha appendicitis (RIPASA) score in predicting acute appendicitis. Heliyon. 2023 Jan 1;9(1).
2. Jose T, Rajesh PS. Appendicitis inflammatory response score in comparison to Alvarado score in acute appendicitis. The Surgery Journal. 2021 Jul;7(03):e127-31.
3. Aslam F, Adil S, Tahir S. The RIPASA score in comparison to the ALVARADO score for diagnosis of acute appendicitis. The Professional Medical Journal. 2022 Apr 30;29(05):629.
4. Gan DE, Nik Mahmood NR, Chuah JA, Hayati F. Performance and diagnostic accuracy of scoring systems in adult patients with suspected appendicitis. Langenbeck's Archives of Surgery. 2023 Jul 6;408(1):267.
5. Safaee M, Samani RE, Talebzadeh H, Sam MS. 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. Immunopathologia Persa. 2024 Jan 13;10(2):e40606.
6. Andersson RE, Stark J. Diagnostic value of the appendicitis inflammatory response (AIR) score. A systematic review and meta-analysis. World Journal of Emergency Surgery. 2025 Feb 8;20(1):12.
7. Chisthi MM, Surendran A, Narayanan JT. RIPASA and air scoring systems are superior to alvarado scoring in acute appendicitis: Diagnostic accuracy study. Annals of medicine and surgery. 2020 Nov 1;59:138-42.
8. Andersson M, Kolodziej B, Andersson RE. Validation of the appendicitis inflammatory response (AIR) score. World Journal of Surgery. 2021 Jul;45(7):2081-91.
9. Meena R, Sharma AK, Kalwaniya DS, Tolat A, Tyagi G, Rohith VN, Gurivelli PK. Evaluation of diagnostic accuracy of Alvarado, appendicitis inflammatory response and adult appendicitis scoring system in diagnosing acute appendicitis: A prospective cohort study. JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH. 2023 Jan 1;17(1):PC08-11.
10. Deepak TK, Sankar TS, Prabhu T, Guttedar AA. A Prospective Study to Compare Appendicitis Inflammatory Response (air) Score and Alvarado Score for Prediction of Acute Appendicitis. Res. J. Med. Sci. 2024 Aug 9;18:73-7.