



Comparison of Modified Alvarado Score and RIPASA Scoring System in Identifying Acute Appendicitis in Patients with Confirmed Radiological Evidence of Appendicitis: An Observational Study.

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Abstract

Background: Acute appendicitis is one of the most common surgical emergencies, but its clinical presentation may overlap with other causes of acute abdominal pain. Clinical scoring systems can aid early diagnosis and reduce unnecessary investigations and negative appendectomies. This study aimed to compare the diagnostic performance of the Modified Alvarado and RIPASA (Raja Isteri Pengiran Anak Saleha Appendicitis) scoring systems in confirming acute appendicitis with radiological evidence. **Methods:** An observational study was conducted in the emergency department of Dr. Moopen's Medical College from January 2024 to January 2025. A total of 100 patients aged >18 years presenting with new-onset right-sided abdominal pain were evaluated. Patients with previously diagnosed appendicitis, unwillingness to participate, pregnancy-associated appendicitis, appendicular mass, or abscess were excluded. Detailed history, clinical examination, laboratory investigations and imaging findings were recorded, and Modified Alvarado and RIPASA scores were calculated. **Results:** The mean age was 30.76 ± 12.123 years, ranging from 18 to 78 years; 66% were males and 34% females. Right iliac fossa tenderness was present in all patients, followed by nausea/vomiting (82%), leukocytosis (58%), migratory right iliac fossa pain (49%), rebound tenderness (32%), elevated temperature (22%) and anorexia (8%). CT was performed in 56% and ultrasonography in 44% of patients. Radiological evidence confirmed acute appendicitis in 80% of cases. The Modified Alvarado score demonstrated 95.2% sensitivity, 60.4% specificity, 90.65% PPV and 73.45% NPV, with 95.4% accuracy. The RIPASA score showed higher diagnostic performance, with 98.5% sensitivity, 70.8% specificity, 98.25% PPV, 77.45% NPV and 98.8% accuracy. The AUC was 0.956 for Modified Alvarado and 0.981 for RIPASA. **Conclusion:** The RIPASA scoring system demonstrated superior diagnostic performance compared with the Modified Alvarado score. Its high sensitivity, specificity and accuracy make it a useful, rapid, non-invasive and cost-effective tool for preoperative assessment of acute appendicitis, particularly in resource-limited settings where advanced imaging may not be readily available.

Keywords: Acute Appendicitis, RIPASA Score, Modified Alvarado Score, Diagnostic Accuracy, Sensitivity, Specificity, Radiological Evidence, Acute Abdominal Pain.



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INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies and represents a major cause of emergency abdominal surgery worldwide. Approximately one in seven individuals develops appendicitis during their lifetime, with an estimated incidence of 1.5–1.9 cases per 1,000 population. The lifetime risk is approximately 8.6% in men and 6.7% in women.[1-3] Appendicitis is also the leading cause of abdominal surgery in children, highlighting its importance in both pediatric and general surgical practice.[4]

AA (Acute Appendicitis) is an acute inflammation of the vermiform appendix, usually presenting with abdominal pain that initially occurs in the periumbilical or epigastric region and subsequently migrates to the right iliac fossa. Fever, anorexia, nausea, and vomiting are common associated symptoms. However, clinical presentation varies according to the degree of inflammation, anatomical position of the appendix, and age of the patient. Despite advances in diagnosis and treatment, accurate diagnosis remains challenging because its symptoms may overlap with several other abdominal and systemic conditions.[5,6]

The decision to perform appendectomy is primarily based on clinical history, physical examination, and diagnostic investigations. Negative appendectomy rates have historically ranged from 20% to 40%, although many surgeons accept a rate of approximately 15%–20% to avoid complications such as perforation.[7] Conversely, delayed or incorrect diagnosis may result in perforation, peritonitis, morbidity, and increased healthcare costs.[8] Ultrasonography and computed tomography have improved diagnostic accuracy; however, their cost and limited availability, particularly in resource-constrained settings such as India, can restrict their widespread use.[9,10]

Clinical prediction rules combining symptoms, signs, and laboratory parameters have therefore been developed to facilitate early diagnosis and reduce unnecessary surgery. Among these, the modified Alvarado score is one of the most extensively validated scoring systems.[11] However, its diagnostic performance has varied across different populations and ethnic groups.[12] To improve diagnostic accuracy in Asian populations, the Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) score was developed.[13]

Aims and Objectives

Using radiological data as supporting evidence, the current study compares the diagnostic accuracy of the Modified Alvarado score and RIPASA score in confirming acute appendicitis in patients who present to the Emergency Medicine Department of DMMC, Kerala, with acute abdominal pain. The goals are to evaluate both scoring systems' sensitivity, specificity, positive and negative predictive values, and overall diagnostic accuracy in order to ascertain whether one offers superior diagnostic performance for the early detection of acute appendicitis.

MATERIALS AND METHODS

Study Design

This was an observational study conducted in the emergency department of Dr. Moopen's Medical College, Kerala, from January 2024 to January 2025. A sample size ranging from 85 to 150 patients was considered for the study, and eligible patients presenting with acute abdominal pain were evaluated for suspected acute appendicitis using the Modified Alvarado and RIPASA scoring systems, with radiological findings used as supportive evidence for diagnosis.

Inclusion and Exclusion Criteria

The inclusion criteria comprised patients aged >18 years presenting with new-onset right-sided abdominal pain and willing to participate in the study. The exclusion criteria included patients with a previous diagnosis of appendicitis, those unwilling to participate, pregnant patients with appendicitis, and patients presenting with an appendicular mass or appendicular abscess.

Data Collection Procedure

After receiving informed consent, clinically suspected cases of acute appendicitis admitted to the emergency room were included in the study. Relevant demographic information, presenting symptoms, vital signs, and clinical findings were documented in a structured proforma following a thorough history and clinical examination. Right iliac fossa discomfort, pain migration, anorexia, nausea and vomiting, duration of symptoms, fever, right iliac fossa tenderness, guarding, rebound tenderness, and particular signs like Rovsing's, Psoas, Obturator, and Dunphy's signals were all given special attention.

Relevant laboratory investigations, including complete blood count with total leukocyte count, urinalysis, and other biochemical investigations as clinically indicated, were performed. Imaging investigations, including ultrasonography or computed tomography of the abdomen and pelvis, were carried out when indicated.

All variables required for calculation of the RIPASA and Modified Alvarado scores were systematically documented, and the respective scores were calculated for each patient. Patients were subsequently categorized according to the predefined score interpretation criteria for both scoring systems, and the collected data were recorded for further analysis.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS), version 26.0, was used to analyse the data. The study variables were summarised using descriptive statistics, with continuous variables reported as mean and standard deviation. Receiver operating characteristic (ROC) curve analysis was used to assess the diagnostic performance of the RIPASA and Modified Alvarado scoring systems.

The diagnostic accuracy of the scoring systems was evaluated by calculating sensitivity, specificity, and area under the ROC curve (AUC). Statistical significance was defined as a p-value of less than 0.05.

RESULTS

Table 1. Demographic Characteristics of the Study Participants

Variable	Frequency (n)	Percentage (%) / Mean $\pm$ SD
Age (years)	100	30.76 $\pm$ 12.123
Minimum age	100	18
Maximum age	100	78
Sex		
Female	34	34.0
Male	66	66.0
Total	100	100.0

Table 1 illustrates the demographic characteristics of the 100 study participants. The participants had an age range of 18–78 years, with a mean age of 30.76 $\pm$ 12.123 years. Males constituted the majority of the study population (66%), while females accounted for 34%.

Table 2. Distribution of Modified Alvarado Score Components Among Study Participants

Modified Alvarado Score Component	Frequency (n)	Percentage (%)
Migratory right iliac fossa pain	49	49
Nausea/vomiting	82	82
Anorexia	8	8
RIF tenderness	100	100
Rebound tenderness	32	32
Elevated temperature	22	22
Leukocytosis	58	58
Total score	100	100

Table 2 demonstrates the distribution of the clinical and laboratory components of the Modified Alvarado Score. Right iliac fossa tenderness was the most frequently observed finding, present in all 100 participants (100%). Nausea/vomiting was present in 82%, followed by leukocytosis in 58% and migratory right iliac fossa pain in 49%. Rebound tenderness, elevated temperature and anorexia were observed in 32%, 22% and 8% of participants, respectively.

Table 3. Distribution of RIPASA Score Components Among Study Participants

RIPASA Score component	Frequency (n)	Percentage (%)
Age >40 years	19	19
Age <40 years	83	83
Male	63	63
Female	40	40
RIF pain	92	92
Pain migration to RIF	17	17
Anorexia	4	4
Nausea and vomiting	81	81
Duration of symptoms <48 hours	62	62
Duration of symptoms >48 hours	33	33
RIF tenderness	99	99
Guarding	17	17
Rebound tenderness	31	31
Rovsing sign	18	18
Fever >37°C and <39°C	21	21
Raised WBC	52	52
Negative urine analysis	18	18
Foreign NRC	0	0
Total score – RIPASA	100	100

Table 3 observes the distribution of individual RIPASA score components among the study participants. RIF tenderness was the most common finding (99%), followed by RIF pain (92%) and nausea/vomiting (81%). Symptoms lasting less than 48 hours were reported in 62% of participants, while raised WBC was noted in 52%. Rebound tenderness was present in

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31%, whereas guarding and pain migration to the RIF were each observed in 17%. Anorexia was the least frequent symptom (4%), and no participant had a foreign NRC.

Table 4. Imaging Modality and Final Histopathological Diagnosis

Variable		Frequency (n)	Percentage (%)
Imaging modality	CT	56	56.0
	USG	44	44.0
Final diagnosis (HPR)	Acute appendicitis	80	80.0
	No appendicitis	20	20.0
	Total	100	100.0

Table 4 illustrates the imaging modalities used and the final histopathological diagnosis of the study participants. CT was performed in 56% of cases, whereas USG was used in 44%. On final histopathological examination, acute appendicitis was confirmed in 80% of participants, while 20% had no evidence of appendicitis.

Table 5. Diagnostic Performance of the Modified Alvarado Score

Parameter	Value
Area under the curve (AUC)	0.956
Standard error	0.018
Asymptotic significance	0.000
95% CI – Lower bound	0.920
95% CI – Upper bound	0.992
Sensitivity	95.2%
Specificity	60.4%
PPV	90.65%
NPV	73.45%
Accuracy	95.4%
ROC cut-off with reported high performance	2.50
Sensitivity at cut-off 2.50	1.000
1 – Specificity at cut-off 2.50	0.900

Table 5 summarizes the diagnostic performance of the Modified Alvarado Score based on ROC curve analysis. The Modified Alvarado Score demonstrated an AUC of 0.956 (95% CI: 0.920–0.992), indicating excellent discriminatory ability. The overall sensitivity, specificity, PPV, NPV and accuracy were 95.2%, 60.4%, 90.65%, 73.45% and 95.4%, respectively. The ROC coordinates showed a sensitivity of 1.000 at a threshold of 2.50, with 1 – specificity of 0.900.

Table 6. Diagnostic Performance of the RIPASA Score

Parameter	Value
Area under the curve (AUC)	0.981
Standard error	0.011
Asymptotic significance	0.000
95% CI – Lower bound	0.959
95% CI – Upper bound	1.000
Sensitivity	98.5%
Specificity	70.8%
PPV	98.25%
NPV	77.45%
Accuracy	98.8%
ROC cut-off with reported high sensitivity	5.25
Sensitivity at cut-off 5.25	0.963
1 – Specificity at cut-off 5.25	0.200

Table 6 summarizes the diagnostic performance of the RIPASA Score using ROC curve analysis. The RIPASA Score showed an AUC of 0.981 (95% CI: 0.959–1.000), demonstrating excellent discriminatory ability. The reported sensitivity, specificity, PPV, NPV and accuracy were 98.5%, 70.8%, 98.25%, 77.45% and 98.8%, respectively. At a threshold of 5.25, the sensitivity was 0.963 with 1 – specificity of 0.200.

Table 7. Comparison of Modified Alvarado and RIPASA Scores for Predicting Appendicitis

Diagnostic Parameter	Modified Alvarado Score	RIPASA Score
Area under the curve (AUC)	0.956	0.981
Standard error	0.018	0.011
Asymptotic significance	0.000	0.000
95% CI – Lower bound	0.920	0.959
95% CI – Upper bound	0.992	1.000
Sensitivity	95.2%	98.5%
Specificity	60.4%	70.8%
PPV	90.65%	98.25%
NPV	73.45%	77.45%
Accuracy	95.4%	98.8%

Table 7 compares the diagnostic performance of the Modified Alvarado and RIPASA scores in predicting acute appendicitis. The RIPASA Score demonstrated a higher AUC than the Modified Alvarado Score (0.981 vs. 0.956). RIPASA also showed higher sensitivity (98.5% vs. 95.2%), specificity (70.8% vs. 60.4%), PPV (98.25% vs. 90.65%), NPV (77.45% vs. 73.45%) and accuracy (98.8% vs. 95.4%). Both scoring systems demonstrated statistically significant ROC performance with an asymptotic significance of 0.000.

DISCUSSION

One hundred patients who were clinically suspected of having AA were assessed in this study. Participants in the study ranged in age from 18 to 78, with a mean age of 30.76 ± 12.12 years. The study population was made up of 34% females and 66% males. The demographic profile matched the results of earlier research. Shuaib et al.[14] reported a mean age of 26.8 ± 13.2 years, with females accounting for 47.1% and males for 52.9% of the study population. Mehbub et al.[15] reported that 55% of participants were female and 45% were male, with a mean age of 28.0 ± 8.7 years. The slightly higher proportion of males in the present study may reflect differences in the study population and demographic characteristics of the study setting.

Regarding the individual parameters of the Modified Alvarado Score, right iliac fossa tenderness was the most frequently observed finding and was present in 100% of patients. Nausea and vomiting were reported in 82%, leukocytosis in 58%, migratory right iliac fossa pain in 49%, and rebound tenderness in 32% of patients. Fever was observed in 22%, whereas anorexia was the least frequently reported symptom, occurring in only 8% of patients. These findings demonstrate that local tenderness and gastrointestinal symptoms were more consistently present than some of the systemic and constitutional features of AA. The relatively low frequency of anorexia and fever also highlights the variability in clinical presentation and the limitations of relying on individual symptoms in isolation.

The RIPASA score showed a broadly similar pattern, with right iliac fossa tenderness being the most common finding, present in 99% of patients, followed by right iliac fossa pain in 92% and nausea and vomiting in 81%. Symptoms lasting less than 48 hours were reported in 62% of patients, while raised white blood cell count was observed in 52%. Rebound tenderness was present in 31%, whereas guarding and migration of pain to the right iliac fossa were each observed in 17%. Regarding demographic components of the RIPASA score, 83% of patients were below 40 years of age, while 63% were male and 40% were female. Fever was present in 21%, Rovsing's sign in 18%, and negative urinalysis in 18%. Anorexia was reported in only 4% of cases, and no patient had foreign NRC.

The findings of the present study can be compared with those reported by Mehbub et al.[15] In their study, migratory pain was reported in 60.7% of patients, anorexia in 34%, and nausea or vomiting in 47.3%. Rebound tenderness was present in 44.7%, abdominal guarding in 62%, and Rovsing's sign in 28%. Positive urinalysis was observed in 52.7%, while fever and leukocytosis were reported in 92% and 93.3%, respectively. Symptoms lasting less than 48 hours were reported in 76.7%. The differences between the present study and Mehbub et al.[15] may be attributable to differences in patient characteristics, disease severity, diagnostic thresholds, and the clinical setting in which the patients were evaluated.

Shivakumar et al.[16] reported that 100% of patients experienced pain in the right lower quadrant, while anorexia was present in 58.57%. Nausea and vomiting occurred in 48.57%, fever in 37.14%, and right iliac fossa tenderness in 94.28%. Rebound tenderness was observed in 84.28%, guarding in 77.14%, and Rovsing's sign in 65.71%. Compared with these findings, the present study demonstrated a higher frequency of nausea and vomiting but lower frequencies of anorexia, fever, rebound tenderness, guarding, and Rovsing's sign. Such variation further emphasizes that the clinical manifestations of AA may differ considerably among patient populations.

In the present study, CT was the most commonly used imaging modality and was performed in 56% of patients, while ultrasonography was used in 44%. Following clinical and radiological evaluation, AA was confirmed in 80% of cases, whereas 20% were diagnosed as not having appendicitis. The relatively high proportion of confirmed cases reflects the high clinical suspicion among patients included in the study. The use of CT and ultrasonography in conjunction with clinical scoring systems may improve diagnostic confidence, particularly in patients with equivocal clinical presentations.

Comparing the diagnostic performance of the Modified Alvarado and RIPASA scores was the main goal of the current investigation. With a PPV of 90.65% and NPV of 73.45%, the Modified Alvarado Score showed sensitivity of 95.2% and specificity of 60.4%. 95.5% of the diagnoses were accurate. By contrast, the RIPASA score showed an overall diagnostic accuracy of 98.8% with sensitivity of 98.5%, specificity of 70.8%, PPV of 98.25%, and NPV of 77.45%. These results show that while both scoring systems did a good job of identifying individuals with AA, the RIPASA score showed better overall diagnostic performance in this investigation.

The results of the current study's Modified Alvarado Score were similar to those published in earlier research. According to Sirpaili et al.[17] the sensitivity was 42%, the specificity was 100%, the PPV was 100%, and the NPV was 20.8%. Sensitivity was 88.9%, specificity was 68.7%, PPV was 93.6%, and NPV was 31.2%, according to Damburaci N et al.[18] Sensitivity was 61.3%, specificity was 71.4%, PPV was 94.2%, and NPV was 19.6%, according to Banepali N et al.[19] A sensitivity of 75%, specificity of 41.6%, PPV of 93.7%, and NPV of 12.5% were reported by Díaz-Barrientos C Z et al.[20] While Singla A et al.[21] reported a sensitivity of 53.3%, specificity of 100%, PPV of 100%, and NPV of 19.2%, Shuaib A et al.[14] showed a sensitivity of 82.8%, specificity of 56%, PPV of 89.3%, and NPV of 42.4%. As a result, while the Modified Alvarado score's specificity was in between the reported values, its sensitivity was better in the current study than in the majority of these earlier investigations.

In the current study, the RIPASA score regularly showed excellent diagnostic performance. Sensitivity of 98.71%, specificity of 80.0%, PPV of 97.46%, and NPV of 88.89% were reported by Pachya U et al.[22] With a total accuracy of 85.2%, Damburaci N et al.[18] showed a sensitivity of 94.04%, specificity of 87.5%, PPV of 97.5%, and NPV of 12.5%. Sensitivity was 97.2%, specificity was 57.1%, PPV was 94.5%, and NPV was 72.7%, according to Banepali N et al.[19] According to Shuaib A et al.[14] the diagnostic accuracy was 93.38%, with a sensitivity of 94.5%, specificity of 88%, PPV of 97.2%, and NPV of 78.5%. While Singla A et al.[21] showed a sensitivity of 95.6%, specificity of 80.0%, PPV of 97.7%, and NPV of 66.7%, Díaz-Barrientos C Z et al.[20] reported a sensitivity of 93.3%, specificity of 8.3%, PPV of 91.8%, and NPV of 10.1%. These studies' findings show that while specificity and NPV vary significantly amongst groups, the RIPASA score typically retains high sensitivity and PPV.

The RIPASA score exhibited a sensitivity of 94.04%, specificity of 87.5%, PPV of 97.5%, NPV of 12.5%, and overall accuracy of 85.2%, according to Damburaci N et al.[18] They reported sensitivity of 88.09%, specificity of 68.7%, PPV of 93.6%, NPV of 31.2%, and overall accuracy of 73.4% for the Modified Alvarado Score. These results support the current investigation by showing that RIPASA has greater sensitivity and specificity than the Modified Alvarado Score. However, there were significant variances in the NPV values between the trials, which could be related to variations in patient selection and disease prevalence.

In a similar vein, Shuaib A et al.[14] found that RIPASA outperformed the Modified Alvarado Score in terms of diagnostic performance. The Modified Alvarado Score showed an overall diagnostic accuracy of 77.94%, sensitivity of 82.8%, specificity of 56%, PPV of 89.3%, and NPV of 42.4%. On the other hand, the RIPASA score showed 94.5% sensitivity, 88.0% specificity, 97.2% PPV, 78.5% NPV, and 93.38% diagnostic accuracy. These results strongly corroborate the current study's findings, which showed that RIPASA outperformed the Modified Alvarado Score in terms of sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy.

The higher performance of the RIPASA score may be attributed to the greater number of clinical and demographic parameters incorporated into the scoring system. Unlike the Modified Alvarado Score, RIPASA incorporates additional variables such as age, sex, symptom duration, negative urinalysis, and specific clinical signs. These additional parameters may allow more comprehensive assessment of patients and improve diagnostic discrimination. The inclusion of demographic and clinical characteristics may be particularly useful in populations where the presentation of AA differs from that of the populations in which other scoring systems were originally developed.

In the present study, the Modified Alvarado Score demonstrated a high sensitivity of 95.2%, indicating that it was effective in identifying patients with AA. However, its specificity was comparatively lower at 60.4%, suggesting that a proportion of patients without AA may also have scored above the diagnostic threshold. In contrast, RIPASA demonstrated both higher sensitivity (98.5%) and specificity (70.8%). The higher PPV of RIPASA (98.25%) compared with the Modified Alvarado Score (90.65%) indicates that patients classified as positive by RIPASA were more likely to have confirmed AA.

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Similarly, the NPV of RIPASA (77.45%) was higher than that of the Modified Alvarado Score (73.45%), suggesting a modestly better ability of RIPASA to identify patients without the disease.

The current results show that RIPASA and Modified Alvarado are both effective clinical scoring methods for evaluating suspected AA. With greater sensitivity, specificity, PPV, NPV, and total predictive accuracy, RIPASA demonstrated better diagnostic performance. However, due to its simplicity and convenience of use, the Modified Alvarado Score showed great sensitivity and might continue to be helpful as a preliminary screening tool. When more diagnostic discrimination is needed, RIPASA might be especially helpful.

Limitations

This study has certain limitations that should be considered while interpreting the findings. The study included only patients aged above 18 years; therefore, the findings may not be generalizable to the pediatric population. Furthermore, the study was conducted in a specific geographic area with a relatively small sample size, which may limit the generalizability of the results to the wider Indian population.

CONCLUSION

The RIPASA scoring system is a simple, rapid, cost-effective, non-invasive, and reliable diagnostic tool for acute appendicitis, demonstrating better sensitivity, specificity, and overall diagnostic accuracy than the Modified Alvarado Score, particularly in the Indian population. Based on clinical findings and basic laboratory investigations, it can facilitate early diagnosis, reduce unnecessary imaging and negative appendectomies, and support timely referral for surgical management. Although its role may be limited in tertiary centres where advanced imaging is readily available, the RIPASA score remains particularly valuable in rural, peripheral, and resource-limited healthcare settings where access to imaging is restricted.

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