

Original Research Article

COMPARATIVE STUDY TO ASSESS THE EFFICACY OF THE MODIFIED ALVARADO SCORING SYSTEM VERSUS THE RAJA ISTERI PENGIRAN ANAK SALEHA (RIPASA) APPENDICITIS SCORING SYSTEM IN THE DIAGNOSIS OF ACUTE APPENDICITIS

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ABSTRACT

Background: Acute appendicitis is one of the most common surgical emergencies, and its diagnosis remains largely clinical. Scoring systems such as the Modified Alvarado Scoring System (MASS) and the Raja Isteri Pengiran Anak Saleha (RIPASA) score have been developed to improve diagnostic accuracy and reduce reliance on imaging, but their comparative performance in South Asian populations continues to be debated. The objective is to compare the predictive accuracy of MASS and the RIPASA scoring system in the diagnosis of acute appendicitis, using histopathological examination as the reference standard.

Materials and Methods: This hospital-based, cross-sectional analytical study was conducted in the Department of General Surgery, Maharaja Agrasen Medical College, Agroha, over 12 months (October 2023 to September 2024). One hundred patients presenting with right iliac fossa (RIF) pain of less than 72 hours' duration were enrolled after excluding perforation/lump, pregnancy, prior urolithiasis or pelvic inflammatory disease, and age below 12 years. All patients were scored using both MASS and RIPASA and were managed according to the RIPASA-based protocol; the final diagnosis was based on intraoperative findings, histopathology, or imaging follow-up. Data were analysed using SPSS version 25, with the chi-square test, Pearson correlation, and receiver-operating-characteristic (ROC) curve analysis; $p < 0.05$ was considered significant.

Results: Of the 100 participants, 61% were male and 33% were aged 31–40 years. RIF pain and RIF tenderness were present in all patients (100%), while migratory pain (86%), nausea/vomiting (87%) and fever (63%) were the other common features. Histopathology confirmed appendicitis in 61% of cases. The mean RIPASA score was 7.6 ± 1.5 , with a sensitivity of 83.6%, specificity of 100%, positive predictive value (PPV) of 100%, negative predictive value (NPV) of 79.6%, and an area under the ROC curve (AUC) of 0.964 ($p < 0.001$) at a cut-off of 7. The mean MASS score was 6.2 ± 1.7 , with a sensitivity of 88.5%, specificity of 35.9%, PPV of 68.4%, NPV of 66.7%, and an AUC of 0.747 ($p < 0.001$) at a cut-off of 6. A statistically significant correlation was observed between the two scores ($r = 0.547$, $p < 0.001$).

Conclusion: While MASS demonstrated marginally higher sensitivity, the RIPASA score showed markedly superior specificity and overall diagnostic accuracy (higher AUC) than MASS. RIPASA is therefore recommended as the preferred scoring tool for diagnosing acute appendicitis in this population, particularly in resource-limited settings, with ultrasonography as a useful adjunct in equivocal cases.

Keywords: Acute appendicitis; RIPASA score; Modified Alvarado score; diagnostic accuracy; ROC curve; histopathology.

INTRODUCTION

Acute appendicitis is a common and urgent surgical condition characterised by inflammation of the appendix, a small tube-shaped pouch attached to the caecum. It can affect individuals of any age but is most prevalent between 10 and 30 years.^[1] Its pathogenesis typically begins with luminal obstruction—caused by faecoliths, lymphoid hyperplasia, foreign bodies, or, rarely, tumours.^[2,3] leading to increased intraluminal pressure, impaired venous and lymphatic drainage, ischaemia, and bacterial overgrowth, which together produce inflammation and, if untreated, necrosis and perforation with the risk of peritonitis and sepsis.^[4,5] Clinically, acute appendicitis typically presents with periumbilical pain that migrates to the right iliac fossa, accompanied by fever, nausea, vomiting, and anorexia, with tenderness at McBurney's point being its classical sign. Diagnosis remains primarily clinical, though it may be supported by ultrasonography or computed tomography, particularly in atypical presentations.^[6] However, imaging carries drawbacks such as cost, radiation exposure, and limited availability, prompting the development of clinical scoring systems to improve diagnostic accuracy while reducing unnecessary imaging and negative appendectomy rates.^[7]

The Alvarado score, described by Alfredo Alvarado in 1986, combines symptoms, signs, and laboratory findings into a 10-point scale predicting the likelihood of appendicitis and has shown good sensitivity and specificity, particularly in male patients with typical presentations.^[8,9] However, its accuracy is reduced in subgroups such as females and the elderly, in whom atypical presentations are more common. The Raja Isteri Pengiran Anak Saleha (RIPASA) score was subsequently developed at the Raja Isteri Pengiran Anak Saleha Hospital, Brunei Darussalam, to address these limitations in Asian populations.^[10] incorporating additional parameters such as age, sex, and duration of symptoms to provide a more comprehensive assessment.^[11] Early studies from Brunei, India, and Pakistan reported higher sensitivity and specificity for RIPASA than for the Alvarado score in these populations, especially in atypical or female presentations.^[12] although its universal applicability outside Asian settings remains debated.^[13]

A reliable and universally applicable scoring system is particularly valuable in healthcare settings with limited access to advanced imaging or a high volume of patients with acute abdominal pain, where an accurate, low-cost, and easy-to-use tool can reduce diagnostic delay, minimise unnecessary surgery, and improve the efficiency of care. This study was therefore undertaken to compare the diagnostic accuracy of the Modified Alvarado Scoring System (MASS) and the RIPASA scoring system against histopathology as the reference standard, in patients

undergoing appendicectomy for suspected acute appendicitis.

MATERIALS AND METHODS

Study design and setting: This was a hospital-based, analytical study with a cross-sectional design, conducted in the Department of General Surgery, Maharaja Agrasen Medical College, Agroha, Hisar, over a period of 12 months (October 2023 to September 2024), following approval from the Institutional Ethics Committee for Human Research.

Study population: The study population comprised patients presenting with right iliac fossa (RIF) pain of less than 72 hours' duration to the Surgery outpatient department and emergency department of the institute.

Inclusion and exclusion criteria

Patients aged 12 years and above presenting with RIF pain of <72 hours' duration were included. Patients with documented appendicular perforation or lump, or pain of >72 hours' duration; pregnant women; patients with a previous history of urolithiasis or pelvic inflammatory disease; and children below 12 years of age were excluded.

Sample size: The sample size was calculated using the reported sensitivity of the RIPASA score (94.7%) and a prevalence of histopathologically proven acute appendicitis of 80.6%, as reported by Chong et al.¹² At a precision of 5% and 95% confidence level, the calculated sample size was 96.7, rounded off to 100 patients.

Ethical considerations: Approval was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants. Confidentiality and anonymity of patient information were maintained throughout the study.

Clinical protocol and scoring: Preoperative data—including history, clinical examination, and laboratory investigations (haematological and biochemical) and, where indicated, ultrasonography or computed tomography—were recorded for each patient. Patients were kept nil per oral and received intravenous antibiotics (cefotaxime, metronidazole, and amikacin, subject to normal renal function) at the time of diagnosis, and were monitored daily with vital signs and systemic examination.

Each patient was independently scored using both MASS and the RIPASA scoring system and classified as follows:

RIPASA: Definite (score >12), High Probability (7.5–12), Low Probability (5–7.5), and Unlikely (<5).

MASS: Definite (≥8), Probable (6–7), Compatible (5–6), and Not sure (<5).

Management followed the RIPASA-based protocol: patients in the High Probability or Definite category underwent immediate surgery; those in the Low Probability category underwent contrast-enhanced CT for further evaluation; and those in the Unlikely category were evaluated for alternative causes of abdominal pain. The final diagnosis of

appendicitis was based on intraoperative findings and histopathological examination (HPE) of the resected specimen, or, for patients managed non-operatively, on CT findings and clinical course. The scores from both systems were compared against this final diagnosis.

Statistical analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS version 25. Continuous variables were expressed as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. The chi-square test was used to compare categorical variables and Student's t-test for continuous variables. Diagnostic accuracy (sensitivity, specificity, positive and

negative predictive values) and receiver-operating-characteristic (ROC) curve analysis, including the area under the curve (AUC), were computed for both scoring systems against the final diagnosis. Correlation between the two scores was assessed using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 100 patients presenting with right iliac fossa pain met the inclusion criteria and were enrolled in the study.

Table 1: Demographic and clinical characteristics of study participants (N=100)

Characteristic	Category	n	%
Age group (years)	≤ 20	24	24
	21–30	27	27
	31–40	33	33
	>40	16	16
Sex	Male	61	61
	Female	39	39
Right iliac fossa pain	Present	100	100
	Absent	0	0
Migratory pain	Present	86	86
	Absent	14	14
Anorexia	Present	17	17
	Absent	83	83
Nausea/vomiting	Present	87	87
	Absent	13	13
Fever	Present	63	63
	Absent	37	37
Duration of pain	<48 hours	70	70
	>48 hours	30	30
RIF tenderness	Present	100	100
	Absent	0	0
Rebound tenderness	Present	49	49
	Absent	51	51
Past history of appendicitis	Present	45	45
	Absent	55	55
Rovsing's sign	Present	16	16
	Absent	84	84
Urinalysis	Positive	31	31
	Negative	69	69
Shift to left (leucocytosis)	Present	71	71
	Absent	29	29
USG evidence of appendicitis	Positive	65	65
	Negative	35	35

Inference: The cohort showed a male predominance (61%) with the highest proportion of patients in the 31–40-year age group (33%). RIF pain and RIF tenderness were universal findings (100%), confirming their role as consistent diagnostic signs, whereas migratory pain (86%) and nausea/vomiting (87%) were frequent but not invariable. Anorexia

(17%) and Rovsing's sign (16%) were comparatively uncommon, indicating variability in symptom expression. Leucocytosis with a left shift (71%) and a positive USG (65%) supported the inflammatory and imaging correlates of appendicitis in the majority of patients.

Table 2: Distribution of study participants according to RIPASA score (N=100)

RIPASA category	Frequency (n)	Percentage (%)
Low probability (5–7.5)	49	49
High probability (7.5–12)	50	50
Definite (>12)	1	1
Total (Mean $\pm$ SD = 7.6 ± 1.5)	100	100

Inference: The mean RIPASA score was 7.6 ± 1.5 . Half of the participants (50%) fell in the High Probability category and only one patient (1%) was

classified as Definite, indicating that most patients required further evaluation (imaging or observation)

rather than being triaged directly to surgery on RIPASA score alone.

Table 3: Distribution of study participants according to Modified Alvarado Score – MASS (N=100)

MASS category	Frequency (n)	Percentage (%)
Not sure (<5)	21	21
Probable (6–7)	41	41
Compatible (5–6)	30	30
Definite (≥8)	8	8
Total (Mean ± SD = 6.2 ± 1.7)	100	100

Inference: The mean MASS was 6.2±1.7. The largest group (41%) fell into the Probable category, while only 8% were classified as Definite, suggesting that

MASS alone offered less clear-cut triage than RIPASA in this cohort, with a substantial proportion (21%) categorised as ‘Not sure’.

Table 4: Final diagnosis of study participants based on histopathology/intraoperative findings (N=100)

Final diagnosis	Frequency (n)	Percentage (%)
Appendicitis confirmed	61	61
Appendicitis not confirmed	39	39
Total	100	100

Inference: Histopathology/intraoperative assessment confirmed acute appendicitis in 61% of participants, establishing the reference standard against which the

diagnostic performance of MASS and RIPASA was evaluated.

Table 5: Correlation between RIPASA and MASS scores (N=100)

Comparison	r-value	p-value
RIPASA vs MASS	0.547	<0.001*

*Statistically significant. Inference: A moderate, statistically significant positive correlation was observed between the RIPASA and MASS scores (r=0.547, p<0.001), suggesting that although the two

systems weight clinical parameters differently, they trend together and may be used in a complementary manner.

Table 6: Diagnostic performance of RIPASA score categories against final diagnosis (N=100)

RIPASA category	Appendicitis, n (%)	Not appendicitis, n (%)	Total
High probability/Definite	51 (83.6)	0 (0.0)	51
Low probability	10 (16.4)	39 (100.0)	49
Total	61 (100.0)	39 (100.0)	100

At a cut-off score of ≥7 (High Probability/Definite), the RIPASA score yielded a sensitivity of 83.6%, specificity of 100%, positive predictive value of 100%, and negative predictive value of 79.6%, with an area under the ROC curve of 0.964 (p<0.001). Inference: RIPASA demonstrated excellent specificity (100%) and a very high AUC (0.964),

indicating that a High Probability/Definite RIPASA classification reliably ruled in appendicitis with virtually no false positives, making it particularly useful for confidently selecting patients for surgery without unnecessary appendectomy.

Table 7: Diagnostic performance of MASS categories against final diagnosis (N=100)

MASS category	Appendicitis, n (%)	Not appendicitis, n (%)	Total
Probable/Compatible/Definite	54 (88.5)	25 (64.1)	79
Not sure	7 (11.5)	14 (35.9)	21
Total	61 (100.0)	39 (100.0)	100

At a cut-off score of ≥6 (Probable/Compatible/Definite), MASS yielded a sensitivity of 88.5%, specificity of 35.9%, positive predictive value of 68.4%, and negative predictive value of 66.7%, with an area under the ROC curve of 0.747 (p<0.001).

Inference: MASS achieved marginally higher sensitivity than RIPASA but at the cost of markedly

lower specificity (35.9%), reflecting a considerable false-positive rate (25 of 39 patients without appendicitis were still classified as probable/compatible/definite). This indicates a tendency of MASS toward over-diagnosis in this cohort.

Table 8: Comparative diagnostic accuracy of RIPASA and MASS scoring systems (N=100)

Parameter	RIPASA	MASS
Mean score $\pm$ SD	7.6 $\pm$ 1.5	6.2 $\pm$ 1.7
Sensitivity (%)	83.6	88.5
Specificity (%)	100.0	35.9
Positive predictive value (%)	100.0	68.4
Negative predictive value (%)	79.6	66.7
Area under ROC curve (AUC)	0.964	0.747
p-value	<0.001	<0.001

Inference: Taken together, RIPASA outperformed MASS in overall diagnostic accuracy, as reflected by its substantially higher AUC (0.964 vs 0.747), specificity, and predictive values, despite a marginally lower sensitivity. This pattern indicates that RIPASA is the more reliable single tool for confirming acute appendicitis and minimising negative appendicectomies in this population, while MASS may be more useful as a sensitive screening step.

DISCUSSION

This study evaluated the predictive accuracy of the Modified Alvarado Scoring System (MASS) and the RIPASA scoring system in diagnosing acute appendicitis against histopathology as the reference standard. The findings highlight distinct strengths and limitations of each system when situated within the broader literature.

The demographic profile showed a predominance of males (61%) and of participants aged 31–40 years (33%), consistent with Chong et al., who reported appendicitis to be most prevalent in younger age groups, particularly males, owing to dietary and anatomical factors.^[12] This male predominance is also in line with Nanjundaiah et al., who reported a similar demographic trend in an Indian population.^[13] Clinical presentations were consistent with established diagnostic patterns: RIF pain and tenderness were universal, underscoring their role as hallmark features, while the high prevalence of migratory pain (86%) and nausea/vomiting (87%) mirrors the emphasis placed on these features by Shuaib et al. as key components of both scoring systems.^[11] Conversely, the comparatively low prevalence of anorexia (17%) suggests variability in symptom presentation, consistent with the heterogeneity described by Frountzas et al. in their meta-analysis.^[14] Fever, present in 63% of patients, aligns with Arroyo-Rangel et al., who noted it to be common but not universal, particularly in early appendicitis.^[15] while the left shift in leucocyte count observed in 71% of patients is consistent with Karapolat, who identified leucocytosis as a reliable inflammatory marker.^[16] Rebound tenderness, present in only 49% of cases, echoes the variable prevalence reported by Butt et al.^[17]

The diagnostic performance of RIPASA in this study (sensitivity 83.6%, specificity 100%) is comparable to that reported by Akbar et al., who found RIPASA to balance sensitivity and specificity effectively,

particularly in resource-limited settings,^[18] and to Mumtaz et al., who emphasised its role in reducing unnecessary surgery among patients with atypical presentations.^[19] In contrast, MASS showed marginally higher sensitivity (88.5%) but substantially lower specificity (35.9%), consistent with Diaz-Barrientos et al., who reported MASS to be a less specific tool than RIPASA, particularly in Asian populations.^[20] and with the limitations in differentiating appendicitis from other causes of abdominal pain described by Noor et al.^[21]

Histopathological confirmation of appendicitis in 61% of participants is consistent with the role of histopathology as the diagnostic gold standard described by Malik et al., who used it to validate clinical scoring tools such as RIPASA and MASS22. The moderate but significant correlation between RIPASA and MASS scores ($r=0.547$, $p<0.001$) supports their complementary utility, in agreement with the meta-analysis by Frountzas et al., which recommended combined use of scoring systems for improved diagnostic accuracy.^[14] Ultrasonography was positive in 65% of participants, reflecting its value as an adjunct to clinical scoring, as noted by Bhatnagar and Chavan,^[23] although its limitations in early or atypical presentations, as highlighted by Singla et al., were also apparent in this study.^[24]

The ROC analysis demonstrated a markedly higher AUC for RIPASA (0.964) than MASS (0.747), consistent with Alnjadat and Abdallah, who reported superior AUC values for RIPASA reflecting its population-specific design.^[25] and with Pasumarthi and Madhu, who highlighted its adaptability across diverse demographic and clinical settings.^[26] These findings, together with the observed limitations of MASS in atypical or overlapping presentations,^[12] support the inclusion of additional demographic and symptom-related parameters in RIPASA as a means of achieving more precise clinical decision-making.

Limitations: This single-centre study, though adequately powered for its stated objective, may have limited generalisability to other settings. The exclusion of pregnant women and children below 12 years restricts the applicability of the findings to these subgroups. Histopathology, used as the sole reference standard, may not capture cases of clinically or radiologically diagnosed appendicitis managed non-operatively, and the operator-dependent nature of ultrasonography may have introduced additional variability. The cost-effectiveness of implementing either scoring system was not assessed. Multicentric studies with larger,

more diverse cohorts are needed to validate and generalise these findings.

CONCLUSION

This study demonstrates that the RIPASA scoring system offers superior diagnostic accuracy compared with the Modified Alvarado Scoring System for acute appendicitis, particularly through its higher specificity, predictive values, and area under the ROC curve. The inclusion of additional demographic and clinical parameters in RIPASA enhances its diagnostic precision and adaptability, especially in resource-limited settings and populations with atypical presentations, whereas the lower specificity of MASS limits its ability to differentiate appendicitis from other causes of abdominal pain. Histopathology remains the gold standard for confirming diagnosis, and the combined use of RIPASA with ultrasonography can further improve diagnostic precision. Multicentric validation and the incorporation of additional diagnostic parameters are recommended to refine these scoring tools further.

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