

Diagnostic Accuracy of Raja Isteri Pengiran Anak Saleha (RIPASA) and Modified Alvarado Scoring System (MASS) in Acute Appendicitis

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ABSTRACT

Background: The exact diagnosis of acute appendicitis still remains a clinical problem despite the advances in imaging techniques. Clinical scoring systems such as the Modified Alvarado Scoring System (MASS) and Raja Isteri Pengiran Anak Saleha (RIPASA) score have been developed to aid in diagnosis and to decrease unnecessary appendectomies.

Purpose: This study was conducted to compare the diagnostic performance of RIPASA and MASS in patients with suspected acute appendicitis.

Methods: This prospective study was conducted over one year from April 2024 to March 2025. Ninety patients aged >10 years presenting with right iliac fossa pain and undergoing emergency appendectomy were included. All patients were evaluated using both RIPASA and MASS scoring systems. Histopathological examination (HPE) of the appendectomy specimen served as the gold standard for diagnosis.

Results: Mean age was 40.7 ± 11.7 years. Histopathological examination confirmed acute appendicitis in 67 (74.4%) patients. The mean RIPASA and MASS scores were 10.22 ± 1.45 and 7.77 ± 1.03 , respectively. Both scoring systems showed significant association with histopathological findings. ROC analysis demonstrated superior performance of RIPASA with an AUC of 0.770 compared to MASS with an AUC of 0.701. At the optimal cut-off values, RIPASA showed higher sensitivity (77.6% vs. 73.1%), specificity (73.9% vs. 60.9%), and diagnostic accuracy (77.0% vs. 70.1%) than MASS.

Conclusion: Both scoring systems were helpful to diagnose acute appendicitis. However, in this present study, the diagnostic performance of RIPASA was slightly better than MASS.

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1. Introduction

Acute appendicitis is considered to be one of the most common surgical emergencies worldwide (Chalazonitis *et al.*, 2008). The annual incidence is 1.17-1.9 cases per 1,000 people with a lifetime risk of about 6.7% in females and 8.6% in males. It is most common in individuals aged between 25 and 35 years (Din *et al.*, 2023). Accurate and early diagnosis is important in reducing the risk of complications and mortality and depends largely on clinical assessment supported by appropriate investigations (Sengupta *et al.*, 2009). However, the diagnosis of acute appendicitis still remains a challenge, because only approximately half of the patients present the classic sequence of symptoms: periumbilical pain, nausea, vomiting, and migration of pain to the right lower quadrant. Also, there are some other

conditions that can mimic the clinical picture of appendicitis (Karamanakos *et al.*, 2010).

Acute appendicitis is usually caused by obstruction of the appendiceal lumen by a fecalith, lymphoid hyperplasia, foreign body, or, less commonly, a tumor. If untreated, the obstruction may lead to increased intraluminal pressure, bacterial overgrowth, inflammation, ischemia, and ultimately perforation. The usual presentation is abdominal pain beginning around the umbilicus and later localizing to the right iliac fossa, anorexia, nausea, vomiting, fever, and localized tenderness (Lotfollahzadeh *et al.*, 2024).

Imaging modalities such as ultrasound, multidetector computed tomography (CT), and diagnostic laparoscopy have dramatically improved the evaluation of patients with acute abdominal pain. CT is one of the most accurate

imaging modalities in the diagnosis of acute appendicitis, and laparoscopy has an important role in diagnosis and treatment, especially in young women of childbearing age. These modalities help to increase diagnostic certainty before operative intervention, thereby avoiding unnecessary surgery (Gaitán *et al.*, 2014). CT scanning, however, has some disadvantages: it is expensive, not always available in some settings, and causes exposure to ionizing radiation, which is of particular concern in children due to the risk of malignancy (Brenner *et al.*, 2003).

Surgical treatment itself is not free of complications. Appendectomy may be complicated by wound infection, postoperative adhesions, incisional hernia, and perforation due to delayed diagnosis. Additionally, the unnecessary removal of a normal appendix increases healthcare costs and exposes patients to avoidable surgical risks (Khairy, 2009). Therefore, the emphasis has been on improving diagnosis and decreasing negative appendectomy rates.

Right iliac fossa (RIF) pain can be due to myriad causes, and appendicitis can present in diverse forms; thus, several clinical scoring systems have been devised to help clinicians in decision-making and to reduce unnecessary operations (Chan *et al.*, 2020). Imaging has enhanced the accuracy of diagnosis, but clinical scoring systems remain useful, particularly in resource-constrained settings where routine CT scanning may not be feasible or cost-effective (Shaligram *et al.*, 2012). The most common scoring systems are the Alvarado score and the modified Alvarado score. However, studies have shown that scoring systems developed in Western populations may not perform as well in Asian populations with reduced sensitivity and specificity reported in some settings (Dezfuli *et al.*, 2020).

The Alvarado score is based on eight clinical and laboratory parameters (Alvarado, 1986). The Modified Alvarado Scoring System (MASS) is a simple, rapid, and inexpensive method of patient assessment based on history, clinical examination, and laboratory findings. It has demonstrated a good diagnostic performance in several Western studies (Kanumba *et al.*, 2011). According to the total score, patients are divided into low, medium, and high risk for acute appendicitis (Díaz-Barrientos *et al.*, 2018).

The Raja Isteri Pengiran Anak Saleha (RIPASA) score was introduced in 2010 and was developed specifically for Asian populations. The scoring system comprises demographic, clinical, and laboratory parameters that need just two routine investigations: white blood cell count and urine routine examination (Din *et al.*, 2023). The score is interpreted as follows: <5 points = unlikely appendicitis, 5–7 points = low probability, 7.5–11.5 points = high probability, and >12 points = definite appendicitis requiring surgery (Díaz-Barrientos *et al.*, 2018). The use of RIPASA has been reported to be simple and inexpensive to use and increase

the diagnostic accuracy and decrease the rates of negative appendectomy (Din *et al.*, 2023).

In this study, we compared the scoring systems MASS and RIPASA in patients presenting with RIF pain and suspicion of acute appendicitis.

2. Material and Methods

2.1. Study Setting and Population

This research was carried out over a period of one year from April 2024 to March 2025. Patients presenting to the Surgery Outpatient Department and Emergency Room with pain in the RIF, suspected of having acute appendicitis, and undergoing emergency surgery were considered for inclusion in the study. A total of 90 patients fulfilling the eligibility criteria were enrolled. Patients aged more than 10 years of either gender were included. Critically ill patients, pregnant females, known cases of tuberculosis, patients with a previous history of pelvic inflammatory disease (PID), any abdominal mass, and those not willing to participate were excluded from the study.

2.2. Sample Size

The sample size was calculated based on a previous study that stated that almost 6% of people develop acute appendicitis at some point in their lives. The sample size was calculated using the formula $n = Z^2 \times P \times Q / L^2$, where $Z = 1.96$ at a 95% confidence interval, $P = 6\%$, $Q = 94\%$, and $L = 10\%$ absolute error. The calculated sample size was 87, and a total of 90 patients were included in the study.

3. Data Collection and Clinical Assessment

Relevant history, detailed clinical examination, and laboratory investigations were performed for all enrolled patients. Each patient was evaluated using both the MASS and the RIPASA scoring systems.

3.1. Scoring Systems

Patients were scored according to the RIPASA and MASS. For the RIPASA score, a score of <5 was considered unlikely appendicitis; 5–7.5 indicated low probability; 7.5–12 indicated high probability; and >12 indicated definite appendicitis. For the MASS, a score of <5 was considered unlikely appendicitis, 6–7 indicated low probability, 7–8 indicated high probability, and >8 indicated definite appendicitis.

3.2. Confirmation of Diagnosis and Outcome Assessment

After scoring, appropriate management of the patients was carried out. Following surgery, the diagnosis was confirmed

by intraoperative findings and histopathological examination (HPE) of the appendectomy specimen. The final diagnosis based on histopathological findings was considered the reference standard for comparison.

3.3. Statistical Analysis

Data were analyzed by comparing RIPASA and MASS with histopathological findings, which served as the gold standard for diagnosis. Sensitivity, specificity, and diagnostic accuracy of both scoring systems were calculated. The diagnostic performance of RIPASA and MASS was further assessed using ROC curve analysis, and the AUC was determined. A p-value <0.05 was considered statistically significant.

4. Results

The study enrolled a total of 90 patients with a mean age of 40.7 ± 11.7 years. More than half of the patients were aged >40 years (53.3%), while 46.7% were aged ≤40 years. The majority of the study population was represented by males (58.9%), while females represented 41.1%. Biochemical parameters were within normal limits with mean serum sodium, potassium, urea, and creatinine levels of 139.84 ± 3.29 mmol/L, 4.09 ± 0.31 mmol/L, 25.55 ± 8.74 mg/dL, and 0.75 ± 0.21 mg/dL, respectively. The average total leukocyte count was $11.09 \pm 3.25 \times 10^9/L$. The liver function-related parameters such as albumin, globulin, total protein, and ALP were also within the acceptable limits. The results show that the patients studied have a relatively balanced demographic profile and stable biochemical status (Table 1).

Table 1: Baseline Characteristics and Clinical Features of the Study Population (n=90)

Variable	n (%) / Mean±SD
Mean age	40.7 ± 11.7 years
Age ≤40 years	42 (46.7)
Age >40 years	48 (53.3)
Male	53 (58.9)
Female	37 (41.1)
Serum sodium (mmol/L)	139.84±3.29
Serum potassium (mmol/L)	4.09±0.31
Serum urea (mg/dL)	25.55±8.74
Serum creatinine (mg/dL)	0.75±0.21
HCO ₃ ⁻ (mmol/L)	25.10±2.90
TLC (×10 ⁹ /L)	11.09±3.25
Chloride (mmol/L)	101.76±3.01
ALP (U/L)	4.48±0.70
Albumin (g/dL)	4.48±0.70

Globulin (g/dL)	3.27±0.59
Total protein (g/dL)	7.14±0.65

The most frequent clinical manifestations were RIF pain and RIF tenderness, each seen in 93.3% of patients. Fever/raised temperature and negative urinalysis were observed in 85.6% of cases; raised WBC count and left shift were observed in 83.3% of cases. Rebound tenderness was found in 82.2% of the patients. The study population had pain migration, RLQ tenderness, nausea/vomiting, and Rovsing sign in an approximate ratio of two-thirds. Guarding was found in 58.9% of patients. The duration of symptoms was evenly distributed, with 50.0% presenting within 48 hours and 50.0% presenting after 48 hours of symptom onset. The mean score of RIPASA was 10.22 ± 1.45 , and the mean score of MASS was 7.77 ± 1.03 , reflecting a high probability of acute appendicitis in the studied patients (Table 2).

Table 2: Distribution of Clinical Variables Included in RIPASA and MASS

Variable	n (%)
Migration of pain	58 (64.4)
RIF pain	84 (93.3)
RLQ tenderness	57 (63.3)
RIF tenderness	84 (93.3)
Rebound tenderness	74 (82.2)
Anorexia	56 (62.2)
Nausea/Vomiting	57 (63.3)
Fever/Elevated temperature	77 (85.6)
Guarding	53 (58.9)
Rovsing sign	57 (63.3)
Raised WBC count	75 (83.3)
Left shift	75 (83.3)
Negative urinalysis	77 (85.6)
Symptoms ≤48 hours	45 (50.0)
Symptoms >48 hours	45 (50.0)
RIPASA score (Mean±SD)	10.22±1.45
MASS score (Mean±SD)	7.77±1.03

Comparison of RIPASA and MASS categories showed a high agreement between both classification systems. The majority of patients with MASS scores of 7-8 (89.1%) and >8 (86.4%) were in the RIPASA 7.5-12 category. All patients with MASS scores of 6-7 were within the RIPASA 7.5-12 range. A small proportion of patients with MASS scores of 7-8 (7.3%) and >8 (13.6%) had RIPASA scores >12. There was no statistically significant correlation between the two scoring systems ($p=0.485$), and the distribution of patients according to the score categories was similar (Table 3).

Table 3: Relationship Between RIPASA and MASS Categories

RIPASA Category	MASS 6–7 (n=13)	MASS 7–8 (n=55)	MASS >8 (n=22)	P value
5–7.5	0	2 (3.6)	0	0.485 $\chi^2= 3.45$
7.5–12	13 (100.0)	49 (89.1)	19 (86.4)	
>12	0	4 (7.3)	3 (13.6)	

A comparison of the scoring systems with histopathological findings revealed that both RIPASA and MASS were significantly associated with the final diagnosis of acute appendicitis. Among histopathology-positive patients, 77.6% had a RIPASA score >10, and 73.9% of histopathology-negative patients had a RIPASA score ≤ 10 ($p < 0.001$). Likewise, 73.1% of histopathology-positive patients had MASS scores ≥ 7.5 , and 60.9% of histopathology-negative patients had scores < 7.5 ($p = 0.003$). Both scoring systems were found to be useful in predicting acute appendicitis, with RIPASA being more strongly associated with histopathological confirmation (Table 4).

Table 4: Comparison of RIPASA and MASS Scores with Histopathological Findings

Score System	Cut-off	HPE Positive n (%)	HPE Negative n (%)	p-value
RIPASA	>10	52 (77.6)	6 (26.1)	<0.001 $\chi^2= 19.84$
RIPASA	≤ 10	15 (22.4)	17 (73.9)	
MASS	≥ 7.5	49 (73.1)	9 (39.1)	0.003 $\chi^2= 8.64$
MASS	<7.5	18 (26.9)	14 (60.9)	

ROC curve analysis showed that the RIPASA scoring system had better diagnostic performance than the MASS for diagnosis of acute appendicitis. RIPASA had a higher AUC of 0.770 as compared to MASS (AUC 0.701). At the optimal cut-off values, RIPASA showed higher sensitivity (77.6% vs 73.1%), specificity (73.9% vs 60.9%), and diagnostic accuracy (77.0% vs 70.1%) than MASS. Thus, these results indicate that RIPASA is a more accurate and reliable scoring system for the diagnosis of acute appendicitis in the studied population (Table 5).

Table 5: Diagnostic Performance of RIPASA and MASS for Acute Appendicitis

Parameter	MASS	RIPASA
Cut-off value	7.5	9.75
AUC (95% CI)	0.701 (0.580–0.823)	0.770 (0.657–0.883)
p-value	0.004	<0.001
Sensitivity (%)	73.1	77.6
Specificity (%)	60.9	73.9
Diagnostic Accuracy (%)	70.1	77.0

5. Discussion

Acute appendicitis is one of the leading causes of emergency abdominal surgery worldwide. Accurate early diagnosis is critical, since delay in treatment is associated with increased risk of perforation, generalized peritonitis, longer hospitalization, postoperative complications, and costs of care, whereas overdiagnosis leads to unnecessary appendectomies. The correct diagnosis is difficult to establish, especially in children, elderly patients, and women of reproductive age, where multiple gastrointestinal, genitourinary, and gynecological diseases may simulate its presentation (Stephens & Mazzucco, 1999). Delayed diagnosis can lead to perforation, sepsis, and postoperative complications, while overdiagnosis can lead to unnecessary appendectomies. Reported negative appendectomy rates vary from 20% to 40%, and some authors have accepted higher rates to avoid missing cases that may progress to perforation (Antevil *et al.*, 2006). Imaging modalities such as ultrasonography and CT offer better diagnostic accuracy, but their routine use increases healthcare costs and may not be feasible in all settings, especially in resource-limited countries (Livingston *et al.*, 2007). Therefore, clinical scoring systems still play an important role in the assessment of suspected acute appendicitis.

The MASS is popular because of its simplicity and ease of use. However, a number of studies have shown a lower diagnostic performance in Asian populations than in Western populations. To overcome these limitations, the RIPASA score was developed. It has additional demographic and clinical variables such as age, gender, and duration of symptoms. Previous studies have suggested that RIPASA may have better diagnostic accuracy in Asian patients (Nanjundaiah *et al.*, 2014).

In this study, 53.3% of patients were above 40 years, and 58.9% were males. There was no significant association between age and gender ($p=0.753$), and the age distribution was similar in males and females. Similar demographic patterns of predominance of young and middle-aged adults with a slight male preponderance among patients presenting with acute appendicitis have also been reported by previous studies (Inteti *et al.*, 2024; Lal *et al.*, 2021; Verma *et al.*, 2025; Zeb *et al.*, 2023).

The mean RIPASA score in our study was 10.22 ± 1.45 . The most frequent findings were pain and tenderness in the right iliac fossa, which were present in 93.3% of patients. Fever was recorded in 85.6% and increased white blood cell counts in 83.3%. Other common symptoms were nausea/vomiting, anorexia, migration of pain, and Rovsing's sign. These results are in agreement with the findings of previous studies (Regar *et al.*, 2017; Shuaib *et al.*, 2017; Singla *et al.*, 2016), which also reported that RIF pain and tenderness

were the most consistent clinical features in patients suspected of appendicitis.

In this study the mean ($\pm$ SD) MASS score was 7.77 ± 1.03 . Migration of pain, tenderness in the right lower quadrant, rebound tenderness, fever, leukocytosis, and left shift were seen in a significant number of patients. Similar observations have been reported in past research (Lal *et al.*, 2021; Patel *et al.*, 2025). These observations support the usefulness of MASS for the identification of patients with a high probability of acute appendicitis.

When the two scoring systems were compared, there was a significant overlap between the higher categories of the two systems. Most of the patients with a MASS score of 7–8 and >8 were in the RIPASA range of 7.5–12. However, no statistically significant association was found between the two scoring systems ($p=0.485$). These findings are consistent with a past study that also showed that both scoring systems placed most of the patients in categories suggestive of appendicitis (Lal *et al.*, 2021).

Histopathological examination, that is, the gold standard for diagnosis, confirmed acute appendicitis in 67 patients (74.4%) and negative findings in 23 patients (25.6%). Similar histopathological confirmation rates have been reported by previous studies (Interi *et al.*, 2024; Nanjundaiah *et al.*, 2014; Regar *et al.*, 2017; Rodrigues & Sindhu, 2017; Sanjive & Ramaiah, 2019; Shuaib *et al.*, 2017; Singla *et al.*, 2016).

There was a strong association between RIPASA scores and histopathological findings ($p < 0.001$). Of the 2025 pathology-positive patients, 77.6% had RIPASA scores >10 , whereas the majority of histopathology-negative patients had RIPASA scores ≤ 10 . Similarly, the MASS scores were also significantly associated with the histopathological diagnosis ($p=0.003$), although the strength of association is lower than that observed with RIPASA. These findings are in agreement with the findings of a previous study (Patel *et al.*, 2025), which found significant correlations between both scoring systems and histopathological confirmation of appendicitis.

Furthermore, our study demonstrated the superiority of RIPASA over MASS in ROC curve analysis. AUC for RIPASA was 0.770 as compared to 0.701 for MASS. RIPASA also had higher sensitivity (77.6% vs. 73.1%), specificity (73.9% vs. 60.9%), and diagnostic accuracy (77.0% vs. 70.1%). Previous studies (Nanjundaiah *et al.*, 2014; Chishti *et al.*, 2020; Inteti *et al.*, 2024; Malik *et al.*, 2017; Muthukumar *et al.*, 2017; Sanjive & Ramaiah, 2019; Shuaib *et al.*, 2017; Subramani *et al.*, 2017; Zeb *et al.*, 2023) reported similar findings and all concluded that RIPASA was more sensitive and diagnostically accurate than MASS. Some studies have reported higher specificity with

MASS (de Jesus *et al.*, 2020; Shah *et al.*, 2017). However, the overall evidence favors RIPASA in Asian populations.

Both MASS and RIPASA were useful in the diagnosis of acute appendicitis. Sensitivity, specificity, and diagnostic accuracy of RIPASA were slightly higher than those of MASS, but differences were modest. Therefore, both scoring systems may be useful in clinical practice, especially in settings where advanced imaging is not readily available. The main strength of this prospective study is that it provides useful regional data comparing the two scoring systems and supports their role in reducing unnecessary appendectomies.

Some limitations of this study are noted. The study was conducted at a single center with a relatively small sample size, which may limit the generalizability of the findings. Only patients who had an appendectomy were included, which may lead to a selection bias. The present study did not compare the scoring systems with imaging modalities such as ultrasonography or CT. In addition, the diagnostic estimates may have been imprecise because of the small sample size, although the associations were statistically significant. These findings need to be confirmed in larger, multi-center studies. Further studies with a large sample size are required to validate the findings of this study.

6. Conclusion

Both RIPASA and MASS were good at diagnosing acute appendicitis; however, RIPASA had better diagnostic performance, with better sensitivity (77.6% vs. 73.1%), specificity (73.9% vs. 60.9%), and diagnostic accuracy (77.0% vs. 70.1%). The RIPASA score is based on simple clinical findings and basic laboratory investigations, which make it easy in application and cost-effective. Routine clinical application of the RIPASA score in the diagnosis of appendicitis could improve diagnostic confidence, reduce negative appendectomies, and facilitate early surgical intervention. Further multicenter studies with larger sample sizes are needed to confirm these findings.

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Authorship Contribution

All authors equally contributed to the conception, conduct, analysis, interpretation, and preparation of the manuscript and approved the final version.

Ethical Approval

Present study was approved by the institute ethics committee of Maharishi Markandeshwar Medical college & Hospital, Solan (Ref No. MMCH/IEC/24/843).

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Declarations

The authors declare that the manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. All sources of information used in this study have been appropriately acknowledged and cited.

Data Availability Statement

The data are not publicly available due to patient confidentiality but may be made available from the corresponding author (Kumar, D) on reasonable request, subject to appropriate ethical approval.

Human and Animal Rights

The study was approved by the Institute Ethics Committee of Maharishi Markandeshwar Medical College & Hospital, Solan (Ref. No. MMCH/IEC/24/843). Written informed consent was obtained from all participants. No animals were involved.

Figure Permission

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AI Disclosure Statement

The authors declare that no artificial intelligence (AI) tools were used in the writing, analysis, or preparation of this manuscript.

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