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Diagnostic Accuracy of the RIPASA and Alvarado Scores in Screening for Acute Appendicitis: A Histopathology-Based Retrospective Validation Study

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Abstract. Background: Acute appendicitis is the most common abdominal surgical emergency, yet its diagnosis remains a clinical dilemma owing to frequently atypical presentations. Clinical scoring systems were developed to expedite and improve diagnostic accuracy. This study aimed to compare the diagnostic accuracy of the RIPASA and Alvarado scores against histopathology as the gold standard. Methods: A retrospective cross-sectional analytic study of 125 patients with suspected acute appendicitis who underwent appendectomy at Hj. Bunda Halimah Hospital, Batam, between 1 January 2022 and 31 December 2024. The Alvarado (cut-off ≥7) and RIPASA (cut-off ≥7.5) scores were derived from medical records and compared with histopathology. Sensitivity, specificity, positive (PPV) and negative (NPV) predictive values, accuracy, and the area under the curve (AUC) were analysed. Results: Histopathology confirmed appendicitis in 114 of 125 patients (91.2%; negative appendectomy rate 8.8%). The Alvarado score yielded a sensitivity of 87.7%, specificity 63.6%, PPV 96.1%, NPV 33.3%, and accuracy 85.6% (AUC 0.797; 95%CI 0.715–0.863). The RIPASA score yielded a sensitivity of 91.2%, specificity 54.5%, PPV 95.4%, NPV 37.5%, and accuracy 88.0% (AUC 0.847; 95%CI 0.772–0.905). Conclusion: Both scores demonstrated good and comparable discriminative capacity; RIPASA tended to be more sensitive and marginally more accurate, whereas Alvarado was more specific. The overlapping AUC confidence intervals preclude a conclusion of statistically significant superiority of RIPASA. Both instruments are suitable screening tools in resource-limited, imaging-scarce settings.

Keywords: Acute Appendicitis; Alvarado Score; Diagnostic Test; Histopathology; RIPASA Score.

1. INTRODUCTION

Acute appendicitis is one of the most frequently encountered abdominal surgical emergencies worldwide, with an estimated lifetime risk of 7–8% (Ferris et al., 2017). Population-based systematic reviews indicate that the incidence of appendicitis is relatively stable in Western countries but tends to rise in newly industrialised regions, including Asia (Ferris et al., 2017; Wickramasinghe et al., 2021). In Indonesia, data from the National Household Health Survey rank appendicitis among the most common causes of abdominal emergencies requiring surgery, so that accurate early diagnosis carries substantial clinical and service-delivery implications (Rahmayanti & Bastina, 2019).

The principal challenge in managing acute appendicitis is achieving a rapid and accurate diagnosis. Delayed diagnosis increases the risk of perforation, peritonitis, and sepsis, whereas over-diagnosis leads to negative appendectomy, which has been reported to reach 15–30% in some series (Ohle et al., 2011; Shuaib et al., 2017). Imaging modalities such as ultrasonography and computed tomography can improve diagnostic accuracy, but their availability is limited in many health facilities, particularly in resource-constrained settings (Pifeleti et al.,

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2022). This situation has driven the development of clinical scoring systems that are simple, inexpensive, and applicable at the bedside.

The Alvarado score, introduced in 1986, is the most widely used clinical scoring system; it comprises eight parameters spanning symptoms, signs, and laboratory findings, with a range of 0–10 (Alvarado, 1986). Although practical, several studies have shown that the sensitivity and specificity of the Alvarado score decline when applied to Asian and Middle Eastern populations, partly because the instrument was developed in a population dominated by males, young adults, and individuals of European descent (Chong et al., 2010; Shuaib et al., 2017). Moreover, the Alvarado score does not account for age, sex, symptom duration, or urinalysis findings, which may limit its accuracy (Malik et al., 2017).

To address these limitations, Chong et al. (2010) developed the Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) score in Brunei Darussalam, specifically designed for Asian populations. The RIPASA score comprises 15 parameters encompassing demographic data, symptoms, signs, laboratory findings, and nationality status, with an optimal cut-off of 7.5 (Chong et al., 2010). Several studies and meta-analyses have reported that the RIPASA score offers higher sensitivity and a lower negative appendectomy rate than the Alvarado score (Chong et al., 2011; Frountzas et al., 2018; Karami et al., 2017; Mehbub et al., 2023). Nevertheless, comparisons between the two scores across populations remain heterogeneous; some studies have found the Alvarado score to be more specific or comparable (Mussab et al., 2025), so validation in local populations remains necessary.

To date, validation data for both scores in the patient population of Batam City, which has its own demographic characteristics and access to care, remain limited. This study aimed to compare the diagnostic accuracy of the RIPASA and Alvarado scores in screening for acute appendicitis, using histopathological examination as the gold standard, among patients undergoing appendectomy at Hj. Bunda Halimah Hospital, Batam.

2. METHODS

Study Design and Setting

This was an observational analytic study with a cross-sectional design conducted retrospectively on medical-record data. The study was carried out at Hj. Bunda Halimah Hospital, Batam City, Riau Islands Province, Indonesia. The data collection period covered patients who underwent appendectomy from 1 January 2022 to 31 December 2024.

Population and Sample

The study population comprised all patients with suspected acute appendicitis who underwent appendectomy during the study period. Sampling was performed by total sampling of eligible medical records. Inclusion criteria were patients with a clinical suspicion of acute appendicitis who underwent appendectomy and had a histopathological examination of the appendiceal specimen, together with medical records containing all components of the Alvarado and RIPASA scores. Exclusion criteria were medical records with incomplete score components, patients with an appendiceal mass or abscess, pregnancy, and a final diagnosis other than appendiceal pathology. Based on these criteria, 125 subjects were analysed.

Variables and Instruments

The independent variable was the result of clinical screening using the Alvarado and RIPASA scores, while the dependent variable was the diagnosis of acute appendicitis established by histopathological examination as the gold standard. The Alvarado score was calculated from eight parameters (Table 1) using a threshold of ≥7 for the high-probability category, in line with common clinical practice. The RIPASA score was calculated from 15 parameters (Table 2) using a threshold of ≥7.5 for the high-probability category, as recommended by the score developers (Chong et al., 2010).

Table 1. Components and Weighting of the Alvarado Score

Parameter	Score
Symptoms	
Migration of pain to the right iliac fossa (RIF)	1
Nausea and vomiting	1
Anorexia	1
Signs	
RIF tenderness	2
Rebound tenderness	1
Fever	1
Laboratory	
Leucocytosis	2
Neutrophilia (shift to the left)	1
Maximum score	**10**

Interpretation: <5 = not appendicitis; 5–6 = possible appendicitis; 7–8 = probable appendicitis; 9–10 = appendicitis. Source: adapted from Alvarado (1986) [3] and Pifeleti et al. (2022) [7].

Table 2. Components and Weighting of the RIPASA Score

Parameter	Score
Sex — male	1
Sex — female	0.5
Age — ≤40 years	1
Age — >40 years	0.5
Symptom — RIF pain	0.5
Symptom — migration of pain	0.5
Symptom — anorexia	1
Symptom — nausea and vomiting	1

Duration of symptoms — ≤48 hours	1
Duration of symptoms — >48 hours	0.5
Sign — RIF tenderness	1
Sign — guarding	2
Sign — rebound tenderness	1
Sign — Rovsing's sign	1
Sign — fever	2
Laboratory — leucocytosis	1
Laboratory — negative urinalysis	1
Foreign national registration identity card (FNRIC)	1

Interpretation: <5 = not appendicitis; 5–7 = possible appendicitis; 7.5–11.5 = probable appendicitis; >12 = appendicitis. Source: adapted from Chong et al. (2010) [4] and Karami et al. (2017) [6].

Statistical Analysis

Subject characteristics are presented as frequency distributions and percentages. The diagnostic validity of each score was assessed using a 2×2 contingency table against histopathology, from which sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were computed and interpreted. The discriminative capacity of both scores was evaluated using receiver operating characteristic (ROC) curve analysis by calculating the area under the curve (AUC) with its standard error (SE) and 95% confidence interval (95%CI). An AUC of 0.5 indicates no discriminative ability, whereas values approaching 1 indicate perfect discrimination. Differences were considered significant at $p<0.05$. Analyses were performed using standard statistical software.

Ethical Considerations

The study obtained ethical clearance from the relevant institutional health research ethics committee and was conducted in accordance with the principles of the Declaration of Helsinki. As the study was retrospective and based on medical records, the confidentiality and anonymity of subject data were maintained throughout.

3. RESULTS

In this section, you need to describe the proposed method step by step. Explanations accompanied by equations and flow diagrams as illustrations will make it easier for readers to understand your research.

Subject Characteristics and Parameter Distribution

A total of 125 patients met the criteria and were analysed. The proportion of female patients (56%) was slightly higher than that of males (44%), and most were aged ≤40 years (74.4%). The most frequent symptoms and signs were, respectively, RIF pain (96.8%), fever (92%), nausea and vomiting (86.4%), and migration of pain (84%). On laboratory testing,

negative urinalysis was found in 86.4% of patients and leucocytosis in 81.6%. No subject held foreign nationality (FNRIC = 0%). The full distribution of parameters is presented in Table 3.

Table 3. Frequency Distribution of Alvarado and RIPASA Score Parameters (n = 125).

Parameter	f (%)
Sex — male	55 (44.0%)
Sex — female	70 (56.0%)
Age — ≤40 years	93 (74.4%)
Age — >40 years	32 (25.6%)
Symptom — RIF pain	121 (96.8%)
Symptom — migration of pain	105 (84.0%)
Symptom — anorexia	81 (64.8%)
Symptom — nausea and vomiting	108 (86.4%)
Duration of symptoms — ≤48 hours	58 (46.4%)
Duration of symptoms — >48 hours	67 (53.6%)
Sign — RIF tenderness	101 (80.8%)
Sign — guarding	32 (25.6%)
Sign — rebound tenderness	60 (48.0%)
Sign — Rovsing's sign	75 (60.0%)
Sign — fever	115 (92.0%)
Laboratory — leucocytosis	102 (81.6%)
Laboratory — negative urinalysis	108 (86.4%)
Laboratory — neutrophilia (shift to the left)	73 (58.4%)
Foreign national registration identity card (FNRIC)	0 (0%)

Histopathological Confirmation

Equations, theorems, and proofs must be cited in the main text. For example, the author could write the sentence: "Eq. (1) is used to calculate blablabla". This is example 1 of an equation:

Histopathological examination confirmed appendicitis in 114 of 125 patients (91.2%), whereas 11 patients (8.8%) had negative results. The negative appendectomy rate in this series was therefore 8.8%. The distribution of the screening results of both scores against the gold standard is presented in 2×2 contingency tables in Tables 4 and 5.

Table 4. 2×2 Contingency Table of the Alvarado Score against Histopathology.

Alvarado score	Histo (+)	Histo (−)	Total
Positive (≥7)	100 (TP)	4 (FP)	104
Negative (<7)	14 (FN)	7 (TN)	21
Total	114	11	125

TP = true positive; FP = false positive; FN = false negative; TN = true negative. The contingency table is derived from the reported diagnostic-test parameters (Table 6).

Table 5. 2×2 Contingency Table of the RIPASA Score against Histopathology.

RIPASA score	Histo (+)	Histo (−)	Total
Positive (≥7.5)	104 (TP)	5 (FP)	109
Negative (<7.5)	10 (FN)	6 (TN)	16
Total	114	11	125

TP = true positive; FP = false positive; FN = false negative; TN = true negative. The contingency table is derived from the reported diagnostic-test parameters (Table 6).

Diagnostic Validity

The Alvarado score yielded a sensitivity of 87.7%, specificity 63.6%, PPV 96.1%, NPV 33.3%, and accuracy 85.6%. The RIPASA score yielded a sensitivity of 91.2%, specificity 54.5%, PPV 95.4%, NPV 37.5%, and accuracy 88.0%. Thus, RIPASA provided slightly higher sensitivity and accuracy, whereas Alvarado provided higher specificity. Both scores had high PPV (>95%) but relatively low NPV, a consequence of the high prevalence of appendicitis in the sample. The complete diagnostic-test parameters are presented in Table 6 and visualised in Figure 2.

Table 6. Diagnostic-Test Parameters of the Alvarado and RIPASA Scores

Statistic	Alvarado	RIPASA
Sensitivity	**87.7%**	**91.2%**
Specificity	**63.6%**	**54.5%**
Positive predictive value (PPV)	**96.1%**	**95.4%**
Negative predictive value (NPV)	**33.3%**	**37.5%**
Accuracy	**85.6%**	**88.0%**

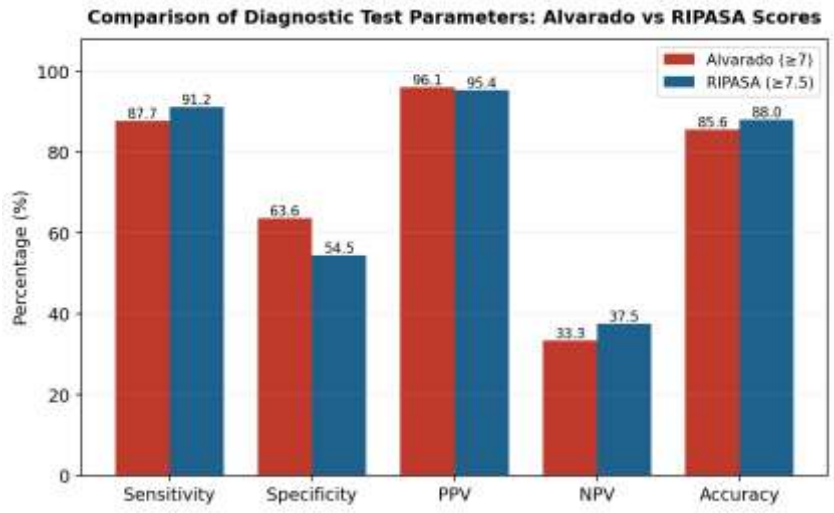

Figure 1. Comparison of the diagnostic-test parameters of the Alvarado and RIPASA scores.

ROC Analysis and Discriminative Capacity

ROC analysis showed an AUC of 0.847 (SE 0.0597; 95%CI 0.772–0.905) for the RIPASA score and 0.797 (SE 0.0730; 95%CI 0.715–0.863) for the Alvarado score (Table 7, Figure 1). Both AUC values fall within the good-discrimination range. The difference in AUC between the two scores was 0.050; however, their confidence intervals overlapped substantially, so the discriminative advantage of RIPASA cannot be regarded as statistically significant without a paired curve-comparison test (e.g., the DeLong test), which was beyond the scope of this analysis.

Table 7. Comparison of the AUC of the RIPASA and Alvarado Scores.

Variable	AUC	SE	95%CI (lower–upper)
RIPASA	0.847	0.0597	0.772 – 0.905
Alvarado	0.797	0.0730	0.715 – 0.863

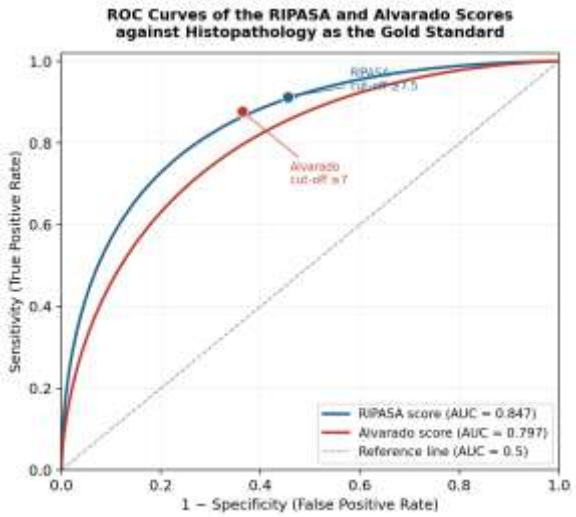

Figure 2. ROC curves of the RIPASA and Alvarado scores against histopathology as the gold standard. Curves are drawn using a binormal model anchored to the reported AUC values; coloured points mark the operating cut-off of each score.

4. DISCUSSION

This study compared the diagnostic accuracy of the RIPASA and Alvarado scores in 125 patients with acute appendicitis using histopathology as the gold standard. The principal finding is that both scores have good and comparable discriminative capacity, with RIPASA tending to be more sensitive and slightly more accurate, whereas Alvarado is more specific. This pattern is consistent with the design of the two instruments: RIPASA contains more parameters (15 versus 8), including age, sex, symptom duration, and urinalysis, enabling it to capture more cases of appendicitis and reduce the proportion of false negatives (Chong et al., 2010; Malik et al., 2017).

The RIPASA sensitivity of 91.2% in this study is consistent with previous reports, which generally place RIPASA sensitivity in the high range. Chong et al. (2010, 2011) reported a RIPASA sensitivity of approximately 88% at a cut-off of 7.5, with a significant reduction in the negative appendectomy rate, while the meta-analysis by Frountzas et al. (2018) found a pooled RIPASA sensitivity of 94%. A Southeast Asian study using histopathology as the gold standard likewise showed superior RIPASA sensitivity compared with Alvarado (Mehbub et al., 2023). The Alvarado sensitivity in this study (87.7%) is higher than that reported in several

Asian-population studies that found lower Alvarado sensitivity (Chong et al., 2010; Shuaib et al., 2017), which may be influenced by the high prevalence of confirmed appendicitis in the sample.

Specificity is an interesting point of difference. In this study, Alvarado was more specific (63.6%) than RIPASA (54.5%). Inter-study variation in specificity is wide; for example, Karami et al. (2017) reported higher RIPASA specificity in their population, whereas other studies found comparable or lower specificity (Shuaib et al., 2017). The lower specificity of RIPASA may be explained by the tendency of this instrument to classify more patients as high-risk, thereby increasing sensitivity at the cost of additional false positives. In the context of screening for acute appendicitis, this trade-off is often considered acceptable because the cost of missing a case (perforation, peritonitis) is higher than that of a controlled negative appendectomy (Ohle et al., 2011).

The positive predictive values of both scores were high (>95%), whereas their negative predictive values were low (33.3% and 37.5%). Because PPV and NPV depend on prevalence, this result is a direct consequence of the high prevalence of confirmed appendicitis in the sample (91.2%). In other words, a positive score is highly reliable for supporting the diagnosis, but a negative score does not necessarily exclude appendicitis in a population with high pre-test probability. The practical implication is that patients with a low score still require clinical observation or additional investigation rather than immediate discharge.

ROC analysis reinforced the main conclusion: the RIPASA AUC (0.847) was higher than that of Alvarado (0.797), but the confidence intervals of the two overlapped. A similar pattern has been reported in several comparative studies, including those that found the AUCs of the two scores to be close or even marginally favouring Alvarado (Mussab et al., 2025). Therefore, any claim of superiority of one score must be accompanied by a paired curve-comparison test and an adequate sample size. Overall, these findings support the use of both scores as valid screening tools, particularly in facilities with limited access to imaging, as emphasised in resource-limited care contexts (Pifeleti et al., 2022).

This study has several limitations. First, the retrospective, medical-record-based design is susceptible to selection and information bias and to limitations in data completeness. Second, all subjects were patients who underwent appendectomy, so the disease spectrum was limited (verification/spectrum bias) and disease prevalence was high, affecting predictive values and specificity. Third, the study was conducted at a single centre, so generalisation of the findings should be made with caution. Fourth, the AUC comparison did not include a paired

statistical test. Prospective multicentre studies with larger samples, including non-operated patients, are needed to confirm these findings..

5. CONCLUSIONS

Both the RIPASA and Alvarado scores demonstrated good discriminative capacity in screening for acute appendicitis with histopathology as the gold standard. The RIPASA score tended to be more sensitive (91.2% versus 87.7%) and slightly more accurate (88.0% versus 85.6%), with a higher AUC (0.847 versus 0.797), whereas the Alvarado score was more specific (63.6% versus 54.5%). Because the AUC confidence intervals of the two scores overlapped, the discriminative advantage of RIPASA cannot yet be concluded to be statistically significant. Both instruments are suitable as simple, inexpensive diagnostic aids, particularly in facilities with limited imaging.

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