

Comparative Evaluation of Clinical Scoring Systems and Development of a Combined Predictor Score for Acute Appendicitis

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ABSTRACT

Background: Acute appendicitis remains a common surgical emergency in which variable clinical presentations can result in diagnostic uncertainty and negative appendectomy. Clinical scoring systems provide structured assessment, but their performance may vary between populations. This study compared six established scoring systems and evaluated a newly formulated combined predictor score in a secondary-care hospital population. **Materials and Methods:** This cross-sectional observational study included 100 patients older than 12 years presenting with suspected acute appendicitis and scheduled for appendectomy at Victoria Hospital attached to BMC-RI Bengaluru between July 2025 and July 2026. Clinical, laboratory, operative and histopathological data were collected. Alvarado, Modified Alvarado Scoring System, Teicher, Fenyo, Ohmann and RIPASA scores were calculated for each patient. Candidate predictors were assessed using sensitivity, specificity, risk ratio, Yates-corrected Chi-square and *P*-values. A 16-item combined predictor score was formulated by assigning one point to each significant predictor. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and receiver operating characteristic (ROC) area under the curve (AUC). **Results:** Sixty-seven patients had acute appendicitis and 33 had a normal appendix. RIPASA and Teicher had the highest sensitivity (97.56% each); Fenyo had the highest specificity (97.78%) and PPV (98.04%); Ohmann had the highest diagnostic accuracy among the established scores (93.70%). The new combined predictor score achieved 95.12% sensitivity, 95.56% specificity, 97.50% PPV, 91.49% NPV, and 95.28% diagnostic accuracy at a cutoff of 10, with ROC AUC 0.99. Serum bilirubin was not significantly associated with appendicular perforation (Yates-corrected $\chi^2=0.01788$; *P* = 0.893659). **Conclusion:** Diagnostic performance varied substantially across scoring systems. In this study population, the new combined predictor score demonstrated the highest overall diagnostic accuracy and a high ROC AUC. Its simple dichotomous structure may be useful in secondary-care settings, although prospective validation in larger and more diverse populations is required before routine clinical adoption.

Keywords: Acute appendicitis, Alvarado score, Bilirubin, Clinical scoring system, Diagnostic accuracy, Fenyo, Ohmann, Predictor score, RIPASA, Teicher

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INTRODUCTION

Acute appendicitis is a frequent surgical emergency and remains diagnostically challenging because its clinical presentation is variable. Classical symptoms include right lower quadrant pain, anorexia, nausea, vomiting, and fever, but the complete classical picture is not present in every patient. The source thesis notes that initial diagnosis may be missed in approximately 20% of patients and that negative appendectomy has historically remained a substantial problem.

Clinical scoring systems combine symptoms, signs, and laboratory findings into a structured probability estimate. The Alvarado score is one of the most widely used systems, while Modified Alvarado, Teicher, Fenyo, Ohmann and RIPASA were developed or adapted to address limitations in diagnostic performance across different settings. The thesis specifically highlights the relevance of population-specific validation, particularly in Asian populations. Laboratory markers may further assist diagnosis. White-cell count, neutrophil predominance, C-reactive protein (CRP) and erythrocyte sedimentation rate were examined in the present thesis. Serum bilirubin was also assessed because hyperbilirubinemia has been proposed as a marker of complicated or perforated appendicitis. The present study therefore addressed both diagnostic scoring and the potential role of bilirubin in appendicular perforation. The Alvarado score and related scoring approaches were considered in the context of established diagnostic literature [1–4].

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Aims and Objectives

1. To compare the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the Alvarado, Modified Alvarado, Teicher, Fenyo, Ohmann and RIPASA scoring systems
2. To propose a new scoring system more suitable for the study population and compare it with the established scoring systems
3. To identify an appropriate marker for the preoperative diagnosis of appendicular perforation.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional observational study was conducted in the Department of General Surgery. The source thesis reports the study period as July 2025–July 2026.

Participants

The thesis reports 100 patients. Inclusion criteria were patients older than 12 years scheduled for appendectomy for suspected acute appendicitis. Patients aged 12 years, those with viral hepatitis, chronic liver disease or hemolytic disease, those with preoperatively diagnosed appendicular abscess, and pregnant women were excluded.≥

Data Collection and Reference Standard

Demographic information, symptom history, examination findings, laboratory investigations, operative findings, and histopathology were recorded. Operative macroscopic assessment and histopathological examination were used to establish the

final diagnosis. In the analyzed cohort, 67 patients had acute appendicitis, and 33 had a normal appendix (Table 1).

Scoring Systems and New Predictor

Alvarado, Modified Alvarado, Teicher, Fenyo, Ohmann, and RIPASA scores were calculated. Candidate predictors were assessed individually, and significant predictors were combined into a16-item score with one point assigned to each selected variable.

Statistical Analysis

The thesis states that R software version 4.3.2 was used. Chi-square tests were used for categorical comparisons and Student’s *t*-test for continuous variables. Statistical significance was defined as *P* < 0.05, with diagnostic performance assessed using sensitivity, specificity, PPV, NPV, accuracy, and receiver operating characteristic (ROC) area under the curve (AUC).

RESULTS

Study Population

Among 100 patients, 67 had acute appendicitis, and 33 had a normal appendix. Patients younger than 40 years constituted 85% of the cohort; 58 had appendicitis, and 27 had a normal appendix. Males constituted 82% of the cohort and females 18%. Sex was not significantly associated with diagnosis (*P* = 0.197). Symptoms lasting <2 days were strongly associated with acute appendicitis (60/63 vs. 7/37; *P* < 0.001). Table 2 summarizes the demographic and symptom-duration distribution.

Comparison of Established Scoring Systems

RIPASA and Teicher had the highest sensitivity at 97.56%. Fenyo had the highest specificity (97.78%) and PPV (98.04%). Teicher and RIPASA had the highest NPV (94.87%), while Ohmann achieved the highest diagnostic accuracy among the established systems (93.70%). Table 3 presents the comparative diagnostic performance of all six established scoring systems and the new predictor score.

Table 1: CRP and serum bilirubin categories by diagnostic outcome. CRP >10 mg/dL was significantly associated with acute appendicitis (*P*<0.001), whereas serum bilirubin was not significantly associated with acute appendicitis (*P*=0.159)

Parameter	Acute appendicitis	Normal appendix	Total
CRP <10 mg/dL	23	16	45
CRP >10 mg/dL	44	17	70
Bilirubin <2 mg/dL	25	13	38
Bilirubin >2 mg/dL	42	20	62

CRP: C-reactive protein

Table 2: Demographic and symptom-duration distribution reported in the thesis

Variable	Acute appendicitis	Normal appendix	Total
Age <40 years	58	27	85
Age ≥40 years	9	6	15
Male	55	27	82
Female	12	6	18
Symptoms <2 days	60	3	63
Symptoms >2 days	7	30	37

Table 3: Comparative diagnostic performance of the six established scoring systems and the new predictor score

Metric	Alvarado (%)	MASS (%)	Teicher (%)	Fenyo (%)	Ohmann (%)	RIPASA (%)	New predictor (%)
Sensitivity	86.59	80.49	97.56	60.98	96.34	97.56	95.12
Specificity	88.89	82.22	82.22	97.78	88.89	82.22	95.56
PPV	93.42	89.19	90.91	98.04	94.05	90.91	97.50
NPV	78.43	69.81	94.87	57.89	93.02	94.87	91.49
Diagnostic accuracy	87.40	81.10	92.13	74.02	93.70	92.13	95.28

MASS: Modified Alvarado scoring system, PPV: Positive predictive value

Table 4: ROC AUC values reported in the thesis

Scoring system	AUC
Alvarado	0.94
Modified Alvarado scoring system	0.92
Teicher	0.90
Ohmann	0.93
Fenyo	0.90
New combined predictor	0.99

Table 5: Diagnostic performance of the new predictor score across cutoffs

Cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
2	100	8.89	66.67	100	67.72
3	100	17.78	68.91	100	70.87
4	100	42.22	75.93	100	79.53
5	100	53.33	79.61	100	83.46
6	100	57.78	81.19	100	85.04
7	100	64.44	83.67	100	87.40
8	98.78	73.33	87.10	97.06	89.76
9	98.78	86.67	93.10	97.50	94.49
10	95.12	95.56	97.50	91.49	95.28
11	91.46	100	100	86.54	94.49
12	81.71	100	100	75.00	88.19
13	65.85	100	100	61.64	77.95
14	42.68	100	100	48.91	62.99
15	18.29	100	100	40.18	47.24

Table 6: Serum bilirubin and appendicular perforation among patients with acute appendicitis

Serum bilirubin	Perforation	No perforation	Total
>2 mg/dL	1	3	4
<2 mg/dL	9	54	63
Total	10	57	67

ROC Analysis

The source thesis reports ROC AUC values of 0.94 for Alvarado, 0.92 for Modified Alvarado, 0.90 for Teicher, 0.90 for Fenyo, and 0.93 for Ohmann. The new combined predictor score had the highest reported AUC at 0.99. Table 4 presents the reported ROC AUC values.

New Combined Predictor Score

Each selected predictor was assigned one point. The maximum possible score was 16. In the study cohort, scores ranged from 1 to 15. A cutoff of 10 produced sensitivity 95.12%, specificity 95.56%, PPV 97.50%, NPV 91.49%, and diagnostic accuracy 95.28%. Table 5 presents diagnostic performance across cutoffs.

Serum Bilirubin and Appendicular Perforation

Among the 67 patients with acute appendicitis, 10 had appendicular perforation, and 57 did not. Only 1 of 4 patients with bilirubin >2 mg/dL had perforation, compared with 9 of 63 patients with bilirubin <2 mg/dL. The Yates-corrected Chi-square value was 0.01788 with $P = 0.893659$, indicating no statistically significant association. Table 6 presents the bilirubin and perforation distribution.

Discussion

The principal finding is that diagnostic performance varied considerably among scoring systems in this cohort. RIPASA and Teicher demonstrated the highest sensitivity, Fenyo the highest specificity and PPV, and Ohmann the highest diagnostic accuracy among the established scores. The new combined predictor score achieved 95.12% sensitivity and 95.56% specificity at a cutoff of 10, with PPV 97.50%, NPV 91.49%, accuracy 95.28%, and AUC 0.99. This suggests strong internal discrimination in the present

cohort, but external validity cannot be assumed because the score was derived and evaluated in the same 100-patient population. Serum bilirubin was not significantly associated with appendicular perforation in this study. Of 10 perforated cases, only one had bilirubin >2 mg/dL, and the reported P value was 0.893659. The present data therefore do not support serum bilirubin as a useful standalone pre-operative marker for perforation in this cohort.

CONCLUSION

In this cohort of 100 patients evaluated for suspected acute appendicitis, diagnostic performance varied substantially across established clinical scoring systems. RIPASA and Teicher had the highest sensitivity, Fenyo the highest specificity and PPV, and Ohmann the highest diagnostic accuracy among established scores. The newly formulated combined predictor score achieved the highest reported overall diagnostic accuracy (95.28%) at a cutoff of 10, with sensitivity 95.12%, specificity 95.56%, PPV 97.50%, NPV 91.49%, and AUC 0.99.

Serum bilirubin was not significantly associated with appendicular perforation. The new predictor score is promising as a risk-stratification tool, but external prospective validation in larger multicenter cohorts is required before clinical implementation.

ETHICS AND CONSENT

The source thesis states that informed written consent was obtained. The specific ethics committee approval number was not available in the source material and has not been invented.

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