

Diagnostic Accuracy of Modified Alvarado Score Combined with Ultrasonography and C-Reactive Protein in Suspected Acute Appendicitis: A Retrospective Study

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Abstract

Background: Acute appendicitis remains a common surgical emergency with risk of negative appendectomy. Early diagnosis is essential to reduce morbidity(1,3), and for that purpose clinical scoring systems such as the Modified Alvarado Score (MAS) and inflammatory markers are widely used but individual diagnostic accuracy varies specially when applied alone(2,3). The aim is to evaluate the diagnostic reliability of MAS combined with abdominal ultrasonography (USG) and C-reactive protein (CRP) levels in suspected acute appendicitis. **Material and Methods:** This retrospective study included 105 patients with suspected acute appendicitis. Diagnostic performance of MAS ≥ 7 , CRP >10 mg/L, and positive USG findings and their combinations were evaluated. Histopathology served as reference standard in operated cases, while clinical follow-up confirmed non-operative cases. Sensitivity, specificity, PPV, NPV, and 95% confidence intervals were calculated. **Results:** Out of 105 patients, appendicitis was confirmed in 88 patients (83.8%). MAS demonstrated sensitivity of 92.0% and specificity of 82.4%. CRP demonstrated sensitivity of 83.0% and specificity of 76.5%. USG showed the highest individual accuracy with sensitivity of 94.3% and specificity of 88.2%. The strict combination model (all three positive) achieved 100% specificity, while the practical two-out-of-three model showed superior diagnostic performance with sensitivity of 98.9%, specificity of 94.1%, and accuracy of 98.1%($p<0.001$). **Conclusion:** Combined diagnostic assessment of MAS, CRP, and USG significantly improves diagnostic accuracy. A two-parameter positive strategy provides optimal clinical utility and reduces unnecessary surgeries.

Keywords: Acute appendicitis, Modified Alvarado score, Ultrasonography, C-reactive protein, Diagnostic accuracy.

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INTRODUCTION

Acute appendicitis is one of the most common causes of acute abdomen requiring emergency surgery worldwide. Despite advances in diagnostic techniques, accurate diagnosis remains challenging, particularly in early or atypical presentations. Clinical scoring systems such as Modified Alvarado Score is a simple and widely used clinical tool for initial assessment, while inflammatory markers such as CRP have shown additional diagnostic value. Ultrasonography using graded compression technique is a reliable first-line imaging modality. However, reliance on a single modality may lead to misdiagnosis.^[1-15]

Recent literatures suggest that combining clinical, laboratory, and imaging parameters may improve diagnostic accuracy.^[7,16,17] This study aims to evaluate the diagnostic reliability of Modified Alvarado Score combined with ultrasonography and CRP levels in patients with suspected acute appendicitis.

MATERIALS AND METHODS

This retrospective diagnostic accuracy study included 105 patients presenting with suspected acute appendicitis in the emergency department of ESIC Medical College and

Hospital, Bihta, Patna; between Oct-25 to March-26. MAS was calculated for all patients.^[2] CRP levels >10 mg/L were considered elevated based on institutional laboratory reference. Abdominal USG was performed in all cases using graded compression technique.^[11] Histopathology served as the gold standard in operated cases, while conservatively treated patients were followed clinically.

Statistical analysis: Diagnostic performance was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Chi-square test was used to assess associations between diagnostic parameters and final diagnosis. A p-value < 0.05 was considered statistically significant. Confidence intervals (95% CI) were calculated where applicable.

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RESULTS

Out of 105 patients, 88 (83.8%) were confirmed to have appendicitis, while 17 (16.2%) were categorized as non-appendicitis cases. The negative appendectomy rate was 4.3%, comparable to contemporary literature.^[21,22]

USG demonstrated the highest individual diagnostic accuracy with sensitivity of 94.3% and specificity of 88.2%; consistent with previous meta-analyses.^[9,10] MAS demonstrated sensitivity of 92.0% and specificity of 82.4%. CRP elevation correlated with inflammatory severity as

described in earlier studies.^[15,18]

The strict combination model (all three parameters positive) achieved 100% specificity and PPV, eliminating false-positive cases. However, sensitivity was reduced to 83.0%.

The practical combination model with any two of three parameters positive yielded the highest diagnostic performance with sensitivity of 98.9%, specificity of 94.1%, and overall accuracy of 98.1%. The association between combined diagnostic positivity and confirmed appendicitis was statistically significant ($p < 0.001$).

Table 1: Modified Alvarado Score (≥ 7)

	Appendicitis + (n=88)	Appendicitis – (n=17)
MAS ≥ 7	81	3
MAS < 7	7	14

Table 2: C-Reactive Protein (>10 mg/L)

	Appendicitis + (n=88)	Appendicitis – (n=17)
CRP Elevated	73	4
CRP Normal	15	13

Table 3: Ultrasonography

	Appendicitis + (n=88)	Appendicitis – (n=17)
USG Positive	83	2
USG Negative	5	15

Combination Tables

Table 4: Strict Combination (All Three Positive)

	Appendicitis + (n=88)	Appendicitis – (n=17)
All 3 Positive	73	0
Not All 3 Positive	15	17

Table 5: Practical Combination (Any Two Positive)

	Appendicitis + (n=88)	Appendicitis – (n=17)
≥ 2 Positive	87	1
< 2 Positive	1	16

DISCUSSION

This study demonstrates that combining clinical scoring, inflammatory markers, and imaging significantly improves diagnostic accuracy in acute appendicitis. The Modified Alvarado Score showed high sensitivity, making it a useful screening tool. CRP provide supportive evidence of inflammation, while ultrasonography offered high diagnostic accuracy.

The strict combination model achieved perfect specificity, indicating its usefulness in confirming diagnosis. However, the two-out-of-three model provide the best balance between sensitivity and specificity, minimizing both false-negative and false-positive cases.

Our findings support earlier studies demonstrating the utility of clinical scoring systems.^[3,7] While MAS alone performs well, combining it with CRP and USG significantly enhances specificity and overall accuracy. This aligns with evidence suggesting multimodal assessment reduces unnecessary surgery.^[20,21] High CRP levels may also indicate complicated appendicitis.^[18] The negative appendectomy rate of 4.3% observed in this study is lower than traditionally reported

rates, indicating improved diagnostic precision.

Limitations: Retrospective design, Single-center study, Limited sample size, Operator dependency of ultrasonography.

CONCLUSION

The combined use of Modified Alvarado Score, CRP, and Ultrasonography significantly enhances diagnostic precision in suspected acute appendicitis. A two-out-of-three positive parameter model offers optimal clinical decision-making support and may reduce unnecessary appendectomies.

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Conflicts of interest

There are no conflicts of interest.

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