World Journal of Current Medical and Pharmaceutical Research
Content available at www.saap.org.in ISSN: 2582-0222

A COMPARATIVE STUDY OF ALVARADO SCORE WITH ABDOMINAL ULTRASOUND FOR PREOPERATIVE DIAGNOSIS OF ACUTE APPENDICITIS

LAXMAN YADAV[1]*, DHANANJAY DOBHAL[2], KAMAL KANT VERMA[3], JYOTI JOSHI[4]

[1]*Assistant Professor, Department of General Surgery, VCSG Government Institute of Medical Science and Research, Uttarakhand, India.*
[2]*Associate Professor, Department of General Surgery, VCSG Government Institute of Medical Science and Research, Uttarakhand, India.*
[3]*PG Trainee, Department of General Surgery, VCSG Government Institute of Medical Science and Research, Uttarakhand, India.*
[4]*Assistant Professor, Department of Radiodiagnosis, VCSG Government Institute of Medical Science and Research, Uttarakhand, India.*

DOI: https://doi.org/10.37022/wjcmpr.v8i3.464

ARTICLE HISTORY
Received on: 14-08-2026
Revised on: 19-10-2026
Accepted on: 01-11-2026

Keywords: *Acute appendicitis, Alvarado score, Ultrasonography, Diagnostic accuracy, Negative appendectomy.*

Corresponding Author
Dr. Laxman Yadav, Assistant Professor, Department of General Surgery, VCSG Government Institute of Medical Science and Research, Uttarakhand, India

ABSTRACT

Background: Acute appendicitis is a common surgical emergency worldwide. Delayed diagnosis increases the risk of perforation and morbidity, while overdiagnosis results in unnecessary surgery. The Alvarado scoring system and abdominal ultrasonography (USG) are widely used to improve preoperative diagnostic accuracy.

Aims and Objectives: To evaluate and compare the diagnostic performance of the Alvarado score and abdominal ultrasonography against histopathological examination as the gold standard in patients with suspected acute appendicitis.

Methods: This prospective cross-sectional study was conducted at a tertiary care hospital in Uttarakhand, India, from April 2024 to November 2025. A total of 110 patients with suspected acute appendicitis were consecutively enrolled. All patients underwent clinical assessment, Alvarado scoring, laboratory investigations, and transabdominal ultrasonography. Diagnostic performance was assessed using histopathological findings. Statistical analysis was performed using SPSS version 20.0.

Results: The mean patient age was 25.63 ± 11.45 years, with male predominance (55.45%). Histopathology confirmed acute appendicitis in 97 patients (88.18%), with a negative appendectomy rate of 11.82%. The Alvarado score demonstrated sensitivity, specificity, PPV, NPV, and accuracy of 83.51%, 92.31%, 98.78%, 42.86%, and 84.55%, respectively. Ultrasonography showed corresponding values of 81.44%, 84.62%, 97.53%, 37.93%, and 81.82%.

Conclusion: Both diagnostic modalities demonstrated good diagnostic performance. The Alvarado score showed slightly higher specificity and overall accuracy than ultrasonography. Combining clinical scoring with targeted ultrasound assessment may improve diagnostic decision-making and reduce unnecessary appendectomies, particularly in resource-limited settings.

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INTRODUCTION

Acute appendicitis represents the single most common cause of an acute surgical abdomen presenting to emergency departments globally [1]. Despite more than a century of clinical experience since Reginald Fitz first characterized the condition, its definitive preoperative diagnosis remains a classic clinical challenge due to its highly variable and atypical clinical presentations [2]. The diagnostic presentation is frequently obscured in specific subsets, such as pediatric cohorts, geriatric patients, and women of reproductive age who present with overlapping gynecological conditions [3]. Diagnostic delays are directly correlated with accelerated progression toward luminal ischemia, gangrene, and subsequent perforation, leading to localized abscess formation or generalized peritonitis [4]. Conversely, diagnostic uncertainty can lead to elevated negative appendectomy rates (20%-40%), exposing patients to preventable surgical risks, anesthetic complications, and financial strain [4,5]. The modern baseline diagnostic accuracy for acute appendicitis ranges from 25% to 90% [5]. In contemporary surgical workflows, structured clinical scoring mechanisms serve as affordable, easily reproducible bedside aids. The Alvarado score, structured around the mnemonic MANTRELS (Migration of pain, Anorexia, Nausea/vomiting, Tenderness in RLQ, Rebound tenderness, Elevated temperature, Leukocytosis, Shift to left), is the

most historically validated of these clinical frameworks [6]. However, its diagnostic efficacy can be constrained by its reliance on objective laboratory shifts, which has led to variations such as the Modified Alvarado Score [7].

Concurrently, imaging has become essential for managing the acute abdomen. While computed tomography (CT) offers high sensitivity and specificity, its routine implementation is limited by high costs, ionizing radiation risks, and structural unavailability in rural or peripheral emergency facilities [8]. Graded-compression abdominal ultrasonography (USG) offers an alternative non-invasive, radiation-free, and dynamic imaging platform that is highly applicable in pediatric populations and pregnant individuals [9]. Nevertheless, ultrasound performance remains inherently operator-dependent and can be limited by mechanical factors like interloop bowel gas or abdominal obesity [10].

This prospective validation study evaluates the individual and comparative diagnostic performance of the Alvarado score and abdominal ultrasound in a tertiary care healthcare framework in Uttarakhand. The goal is to optimize triage models, reduce negative appendectomy rates, and improve resource utilization.

MATERIALS AND METHODS

Study Setting and Design

This prospective, cross-sectional study was conducted within the Department of General Surgery at the Veer Chandra Singh Garhwali Government Institute of Medical Sciences and Research (VCSGGIMS&R), Srinagar, Pauri Garhwal, Uttarakhand, between April 1, 2024, and November 30, 2025. Formal clearance was obtained from the Institutional Ethics Committee prior to initiation.

Selection of Participants

A sample size of 110 patients presenting with clinical indications suggestive of acute appendicitis was recruited via consecutive convenient sampling.

Inclusion Criteria: All individuals aged 12 years presenting directly to the emergency triage or outpatient clinics with right lower quadrant abdominal pain, migratory pain patterns, localized abdominal tenderness, guarding, or accompanying systemic inflammatory features.

Exclusion Criteria: Patients presenting with a palpable right iliac fossa inflammatory mass (appendiceal lump), pregnant individuals, patients under 12 years of age, cases of incidental appendectomy, or individuals unwilling to provide written informed consent.

Clinical and Imaging Protocol

Upon admission, all subjects underwent an extensive clinical workup. Bedside parameters were logged onto a structured proforma to systematically calculate the Alvarado score.

Table 01: Alvarado Scoring Stratification

S. No.	Symptoms/Signs/Laboratory Findings	Score
1	Migratory right iliac fossa pain	1
2	Nausea/vomiting	1
3	Anorexia	1
4	Tenderness in right iliac fossa	2
5	Rebound tenderness	1
6	Elevated temperature	1
7	Leucocytosis	2
8	Shift to left	1

Total score =10

Alvarado scores were categorized into stratified risk tiers: 1-4 (Appendicitis Unlikely), 5–6 (Low Probability), 7–8 (High Probability), and 9–10 (Definitive Appendicitis).

All suspected individuals underwent Transabdominal ultrasonography. Sonographic criteria establishing acute appendicitis included: An Aperistaltic, non-compressible blind-ended tubular structure in the right iliac fossa with an outer anteroposterior diameter ≥6 mm; appendiceal wall thickening > 3mm; presence of an intraluminal obstructing appendicolith; and secondary inflammation indicators like periappendiceal fluid or increased echogenicity of surrounding mesenteric fat.

Reference Standard Assessment

Surgical interventions were performed based on serial clinical examinations and overall judgment, irrespective of specific imaging or scoring values. Cases with an Alvarado score < 7 were operated on due to persistent clinical symptoms, high clinical suspicion, or supportive ultrasound findings. During appendectomy, intraoperative findings (e.g., inflammation, perforation, faecolith presence, and peri-appendiceal fluid collection) were documented. All surgical specimens were submitted for histopathological examination.

Statistical Analysis

Anonymized data records were managed in Microsoft Excel and analyzed using IBM SPSS version 20.0. Concordance and correlation among parameters were analyzed using Chi-square and Student's t-tests, while direct comparative variation between the Alvarado score and ultrasound performance was assessed using the McNemar test. Statistical significance was defined as a p-value <0.05.

RESULTS

Demographics and Clinical Presentations

The study population of 110 patients had a mean age of 25.63 ± 11.45 years. The majority fell within the younger age ranges, with 40.00% aged ≤20 years and 43.64% between 21-35 years. The cohort included 61 males (55.45%) and 49 females (44.55%), resulting in a male-to-female ratio of 1.24:1.

The most frequent symptom was nausea or vomiting, observed in 100 cases (90.91%), followed by migratory right iliac fossa pain in 94 cases (85.45%), and anorexia in 62 cases (56.36%). On physical assessment, localized tenderness within the right lower quadrant was the most common sign, documented in 102 patients (92.73%), while elevated core body temperature was present in 89 patients (80.91%), and rebound tenderness was noted in 26 patients (23.64%). Laboratory evaluation showed leukocytosis in 96 cases (87.27%) and a relative neutrophil left-shift in 43 cases (39.09%).

Alvarado Scoring Stratification

The mean Alvarado score across the cohort was 7.36 ± 1.45. Distribution arrays demonstrated that 82 individuals (74.55%) presented with a high-probability score, 26 individuals (23.64%) fell within the intermediate score range (5–6), and 2 individuals (1.82%) scored in the low-probability category (1-4) (Table 01).

Table 1: Distribution of patients according to baseline Alvarado Score (N=110)

Alvarado Score	No. of Patients	Percentage
1-4	2	1.82
5-6	26	23.64
7-10	82	74.55
Total	110	100.00
Mean±SD	7.36±1.45	

Ultrasound and Intraoperative Profiling

Preoperative ultrasound was positive for acute appendicitis features in 81 cases (73.64%) and negative or equivocal in 29 cases (26.36%). The primary ultrasound findings included a non-compressible, aperistaltic tubular structure in 81 patients (73.64%), distinct periappendiceal abscess collections in 17 patients (15.45%), and isolated mesenteric adenitis in 12 patients (10.91%).

Intraoperative assessment showed an acutely inflamed appendix in 97 procedures (88.18%). Complicated features included a perforated appendix with an isolated abscess in 19 patients (17.27%) and a perforated appendix with an appendicolith in 17 patients (15.45%). A macroscopically normal appendix was found in 13 cases (11.82%).

Histopathological Diagnosis Correlation

Final histopathological analysis confirmed acute appendicitis in 97 specimens (88.18%), while 13 specimens (11.82%) showed a histologically normal appendix, establishing negative appendectomy rate of 11.82%.

Cross-tabulation of a positive Alvarado score against final histopathology demonstrated that 81 out of 82 clinically positive cases were confirmed to have acute appendicitis, while 1 case was false-positive. Of the 28 patients with a negative Alvarado score, 16 were false-negatives (diagnosed with appendicitis on HPE) and 12 were true-negatives (Table 02).

Table 02: Cross-tabulation of Alvarado Score and Ultrasound against Histopathology ($N=110$)

Parameter		Final diagnosis/Histopathology Report				Total	P-Value
		Positive (n)		Negative (n)			
		No. of Patients	Percentage	No. of Patients	Percentage	No. of Patients	
Alvarado Result	Positive	81	98.78	1	1.22	82	<0.001
	Negative	16	57.14	12	42.86	28	

Parameter		Final diagnosis/Histopathology Report				Total	P-Value
		Positive (n)		Negative (n)			
		No. of Patients	Percentage	No. of Patients	Percentage	No. of Patients	
USG Result	Positive	79	97.53	2	2.47	81	<0.001
	Negative	18	62.07	11	37.93	29	

For ultrasound, cross-tabulation showed 79 true-positive findings, 2 false-positive cases, 18 false-negative findings, and 11 true-negative determinations (Table 02).

Diagnostic Performance Comparison

The Alvarado score achieved a sensitivity of 83.51%, a specificity of 92.31%, a PPV of 98.78%, an NPV of 42.86%, and an overall accuracy of 84.55%. Ultrasound demonstrated a sensitivity of 81.44%, a specificity of 84.62%, a PPV of 97.53%, an NPV of 37.93%, and an accuracy of 81.82% (Table 3).

Table 03: Diagnostic Efficiency Parameters Comparison

Parameter	Alvarado Result vs USG Result	Alvarado Result vs Histopathology Result	USG Result vs Histopathology Result
Sensitivity	93.83	83.51	81.44
Specificity	79.31	92.31	84.62
Positive Predictive Value	92.68	98.78	97.53
Negative Predictive Value	82.14	42.86	37.93
Accuracy	90	84.55	81.82

The Alvarado scoring tool demonstrated a slightly higher specificity and overall diagnostic accuracy than Trans abdominal ultrasound in this study population. McNemar testing showed no statistically significant difference between the diagnostic performance of the two independent modalities ($p > 0.05$), indicating they offer comparable diagnostic value. However, the high PPV observed when both modalities were concordant underscores the value of a combined diagnostic approach.

DISCUSSION

Preoperative diagnostic precision in suspected acute appendicitis is essential to optimize clinical outcomes and lower rates of negative appendectomies. This prospective validation study compared the established Alvarado scoring system with graded-compression abdominal ultrasound. The cohort's demographics align with established epidemiological trends, showing a peak incidence in the second and third decades of life (mean age 25.63 ± 11.45 years) and a notable male predominance (55.45%), consistent with observations by Pallavi et al. [11] and Sawant et al. [12].

The classical clinical presentation was highly prevalent in this study: localized right lower quadrant tenderness occurred in 92.7% of cases, and nausea or vomiting was noted in 90.91%. These findings match data from Sardar et al. [13], indicating that thorough physical and history evaluations remain foundational to clinical triage.

In this study, Alvarado score showed a sensitivity of 83.51% and a specificity of 92.31%. This high specificity aligns with findings by Al-Wageeh et al. [14], who reported a sensitivity of 94.62% and a specificity of 87.80% using a cut-off value of 6. However, some studies evaluate variations like the Modified Alvarado Score or RIPASA due to variations in laboratory tracking across regions [15,16]. For example, Desai and Vasaiya [15] found that the RIPASA score (88%) outperformed the Modified Alvarado Score (66%) in overall diagnostic accuracy.

Preoperative ultrasound showed a sensitivity of 81.44% and a specificity of 84.62%, which is comparable to its

performance in other regional evaluations. Kasabe and Relekar [17] reported a sensitivity of 94.26% and a specificity of 88.88% for ultrasound. Samudre and Munde [18] also noted that while clinical scores offer immediate utility, ultrasound provides valuable anatomical specificity to identify complications or alternative pathologies, such as mesenteric adenitis or pelvic fluid.

The negative appendectomy rate in our study was 11.82%. This is lower than traditional historical baselines (20%-40%) and is consistent with modern series that integrate clinical tracking with imaging adjuncts [19,20]. While the Alvarado score demonstrated slightly higher specificity and accuracy than ultrasound in our study, the difference was not statistically significant ($p > 0.05$).

Both modalities individual show a lower negative predictive value (42.86% for the Alvarado score and 37.93% for ultrasound), indicating that a negative result on either test alone is insufficient to safely rule out acute appendicitis. This highlights the importance of a combined diagnostic approach, where ultrasound is used to clarify equivocal clinical scores (scores of 5–6), helping to reduce unnecessary surgeries while ensuring timely intervention for true cases of appendicitis.

CONCLUSION

Both the Alvarado scoring system and Trans abdominal ultrasound are highly effective non-invasive modalities for the preoperative diagnosis of acute appendicitis. In this population, the clinical Alvarado score exhibited a slightly superior specificity and overall diagnostic accuracy compared to ultrasound. Utilizing a structured approach that couples clinical scoring parameters with targeted ultrasound imaging maximizes diagnostic reliability and helps minimize negative appendectomies in resource-limited settings.

FUNDING

Nil

AUTHOR CONTRIBUTION

All Authors are contributed equally

ACKNOWLEDGEMENT

Not Declared.

CONFLICT OF INTEREST

Not Declared

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