

Research Article

DIAGNOSTIC PERFORMANCE OF THE ALVARADO SCORE AND ULTRASONOGRAPHY IN ACUTE APPENDICITIS: A HOSPITAL-BASED OBSERVATIONAL STUDY

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Abstract: **Introduction:** Acute appendicitis is one of the commonest surgical emergencies. Diagnosis is primarily clinical, but atypical presentations and overlap with other causes of right lower-quadrant pain can lead to delayed diagnosis or unnecessary appendectomy. Clinical scoring systems, particularly the Alvarado score, and ultrasonography may improve diagnostic stratification while reducing unnecessary imaging and negative appendectomy. **Methods:** This hospital-based observational study was conducted among indoor patients of the Department of General Surgery at Sir Ganga Ram Hospital, New Delhi over 18 months. The thesis reports 90 patients aged 18–60 years. The Alvarado score was calculated and ultrasonography was performed, with histopathology used as the postoperative reference standard. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy. **Results:** Of 90 patients, 54 (60%) were male and 36 (40%) female. The largest age group was 21–40 years (48.88%), followed by 41–60 years (42.22%). Alvarado scores of 7–8 represented 54.44% of the cohort, while 23.33% scored 5–6 and 15.55% scored 9–10. Ultrasonography was suggestive of appendicitis in 85 patients (94.44%) and not suggestive in 5 (5.66%). The thesis reports ultrasound sensitivity of 96.39%, specificity 28.57%, PPV 94.10%, NPV 40.06% and accuracy 91.10%. The Alvarado-score analysis reports sensitivity 93.98%, specificity 14.29%, PPV 92.84%, NPV 16.71% and accuracy 87.76%. Histopathology showed inflamed appendix in 85 (94.44%) and normal appendix in 5 patients; the thesis reports a negative appendectomy rate of 2.44%, although this value appears internally inconsistent with the stated 5/90 normal histopathology cases and should be verified against the raw dataset. Open appendectomy was performed in 63 (70%) and laparoscopic appendectomy in 27 (30%). **Conclusion:** In this institutional cohort, both Alvarado scoring and ultrasonography demonstrated high sensitivity but relatively low specificity, with ultrasound showing higher reported diagnostic accuracy. The findings support using clinical scoring as a structured first-line assessment and ultrasonography as an adjunct, particularly when the clinical score is equivocal. However, the reported specificity and negative appendectomy figures should be rechecked from the 2x2 diagnostic tables before journal submission.

Keywords: Acute appendicitis; Alvarado score; ultrasonography; diagnostic accuracy; sensitivity; specificity; negative appendectomy; appendectomy

INTRODUCTION

Acute appendicitis remains a common surgical emergency and is a frequent cause of acute abdominal pain requiring surgical evaluation. The supplied thesis notes that approximately 6–7% of the general population may develop appendicitis during their lifetime, with incidence peaking in younger age groups.

Diagnosis is based on history, examination, laboratory investigations and, when required, imaging. Classic migration of pain from the periumbilical region to the

right lower quadrant, anorexia, nausea/vomiting, fever and localized tenderness are helpful but are neither universally present nor sufficiently specific to establish the diagnosis in every patient. The thesis appropriately describes ultrasonography as an accessible, non-invasive and repeatable investigation that may reduce negative appendectomy.

Clinical scoring systems were developed to standardize bedside assessment. The Alvarado score assigns points to migration of pain, anorexia, nausea/vomiting, right iliac fossa tenderness, rebound tenderness, fever,

leukocytosis and neutrophil shift. The thesis reproduces the 10-point structure and proposes the score as a simple, inexpensive diagnostic aid.

However, contemporary evidence shows that the Alvarado score is best regarded as a risk-stratification tool rather than a stand-alone diagnostic test. A systematic review of 42 validation studies found that a low threshold around 5 had high sensitivity for ruling out appendicitis, whereas the ≥ 7 threshold was more useful for ruling in disease but had variable specificity across men, women and children.[1] A 2022 meta-analysis comparing Alvarado and RIPASA reported summary sensitivity and specificity of 0.72 and 0.77 for Alvarado, respectively, indicating moderate diagnostic performance and substantial heterogeneity.[2] A newer 2025 meta-analysis of clinical scores in adults found that RIPASA had higher pooled diagnostic performance than Alvarado, although Alvarado remained the most extensively studied score.[3]

Ultrasonography is attractive because it avoids ionizing radiation, is relatively inexpensive and can be repeated. Its diagnostic performance is operator-dependent and affected by body habitus, appendix position and visualization. A prospective study comparing ultrasound and modified Alvarado score found that ultrasound performance varied with threshold and that both clinical and imaging information can be useful in suspected appendicitis.[4]

The combination of a clinical score and ultrasound may be particularly useful in equivocal cases. A 2024 study evaluating diagnostic pathways found that combining a clinical score with ultrasound was associated with a higher probability of correct preoperative diagnosis, particularly among patients with equivocal scores of 4–6.[5] This is consistent with the thesis rationale that patients with intermediate scores may benefit from additional investigation rather than immediate surgery. The ultimate reference standard in surgical cohorts is usually histopathological examination of the appendix. The negative appendectomy rate is clinically important because unnecessary appendectomy carries operative and anesthetic risks, while excessive reluctance to operate can increase perforation and complicated appendicitis. Therefore, an ideal diagnostic strategy should maximize sensitivity while maintaining acceptable specificity.

The present thesis evaluates the role of the Alvarado score and ultrasonography in diagnosing acute appendicitis in an Indian tertiary-care setting. The study is relevant because it evaluates an inexpensive clinical

tool alongside a readily available imaging modality and correlates findings with histopathology.

2. Aim and Objectives

Aim: To evaluate the role of the Alvarado score and ultrasonography in diagnosing acute appendicitis.

- To determine the distribution of Alvarado scores among patients with suspected acute appendicitis.
- To evaluate the sensitivity, specificity, PPV, NPV and accuracy of the Alvarado score.
- To evaluate the sensitivity, specificity, PPV, NPV and accuracy of ultrasonography.
- To correlate clinical/imaging findings with postoperative histopathology.
- To assess the negative appendectomy rate.
- To describe the pattern of open and laparoscopic appendectomy.

MATERIALS AND METHODS

3.1 Study design and setting

Hospital-based observational study conducted in the indoor patients of the Department of General Surgery, Sir Ganga Ram Hospital, New Delhi, and associated hospitals/health centres for 18 months, as stated in the thesis.

3.2 Participants

The final reported cohort comprised 90 patients aged 18–60 years. The thesis reports 54 males and 36 females.

3.3 Diagnostic assessment

Alvarado scoring was performed using the 10-point score. Ultrasonography was performed in patients with suspected appendicitis. The thesis also describes CT abdomen as an additional investigation when ultrasonography did not establish the diagnosis.

3.4 Reference standard

Histopathological examination of the removed appendix was used to classify the appendix as inflamed or normal. The thesis reports 85 inflamed appendices and 5 normal histopathology results.

3.5 Statistical analysis

The thesis reports diagnostic test characteristics including sensitivity, specificity, PPV, NPV and accuracy and uses statistical comparison for selected tables. Where a p-value is explicitly provided in the thesis, it is retained. No new p-values have been calculated in this manuscript.

RESULTS

Gender	No.	%
Male	54	60
Female	36	40
Total	90	100
Age group	No.	%
18–20	8	8.88
21–40	44	48.88
41–60	38	42.22
Total	90	100
Alvarado category	No.	%
0–4 (unlikely)	6	6.66
5–6 (possible)	21	23.33
7–8 (probable)	49	54.44
9–10 (very probable)	14	15.55
Total	90	100
Alvarado score	Acute appendicitis cases	%
2	1	1.1
3	2	2.2
4	3	3.3
5	15	17
6	6	6.7
7	19	21
8	30	33
9	14	16
Total	90	100
Ultrasonography result	No.	%
Suggestive	85	94.44
Not suggestive	5	5.66
Total	90	100
Diagnostic measure		Ultrasonography
Sensitivity		96.39%
Specificity		28.57%
PPV		94.10%
NPV		40.06%
Accuracy		91.10%
Disease prevalence		92.20%
Diagnostic measure		Alvarado score
Sensitivity		93.98%
Specificity		14.29%
PPV		92.84%
NPV		16.71%
Accuracy		87.76%
Disease prevalence		92.20%
Histopathology	No.	%
Inflamed appendix	85	94.44
Normal appendix	5	5.56
Total	90	100
Procedure	No.	%
Open appendectomy	63	70
Laparoscopic appendectomy	27	30
Total	90	100

The thesis reports that 57 patients (63.33%) had Alvarado scores of 7–8, although the detailed severity table gives 49 patients (54.44%) in the 7–8 category. The manuscript retains the detailed table value of 49/90 for the severity distribution and flags the 57/90 statement as an internal inconsistency requiring raw-data verification.

The thesis reports ultrasound sensitivity 96.39%, specificity 28.57%, PPV 94.10%, NPV 40.06% and accuracy 91.10%. The thesis separately reports Alvarado sensitivity 93.98%, specificity 14.29%, PPV 92.84%, NPV 16.71% and accuracy 87.76%.

Open appendectomy accounted for 70% and laparoscopic appendectomy for 30% in the final reported table.

DISCUSSION

This study evaluated two commonly available approaches to suspected acute appendicitis—clinical risk stratification using the Alvarado score and abdominal ultrasonography—against histopathology. The cohort was predominantly male (60%) and concentrated in the 21–40-year age group, consistent with the well-recognized occurrence of appendicitis in young adults. The most frequent Alvarado category was 7–8, accounting for 54.44% in the detailed severity table. The concentration of patients in the higher-risk range is expected in a cohort selected for surgical evaluation and therefore should not be interpreted as the distribution of scores in an unselected emergency population. The thesis itself reports that scores 7–8 were the dominant group and that score 8 was the single most frequent score.

The reported sensitivity of the Alvarado score was high (93.98%), while specificity was low (14.29%). This pattern is clinically plausible: a sensitive score may help identify patients unlikely to be safely discharged when the score is low, but a high score alone may not adequately distinguish appendicitis from other inflammatory conditions. This interpretation is consistent with the systematic review by Ohle et al., which found excellent sensitivity at a low cut point but substantially less reliable specificity at the ≥ 7 threshold.[1]

The 2022 meta-analysis comparing Alvarado with RIPASA similarly found moderate pooled performance for Alvarado, with summary sensitivity 72% and specificity 77%, and considerable between-study heterogeneity.[2] The higher sensitivity and lower specificity observed in the present cohort may therefore reflect case selection, disease prevalence, local thresholds and the fact that the study included patients already considered sufficiently suspicious for operative management.

Ultrasonography showed a reported sensitivity of 96.39% and accuracy of 91.10%, exceeding the corresponding reported accuracy of the Alvarado score. This supports the practical value of ultrasound as an adjunctive test. However, the low reported specificity of 28.57% means that a positive ultrasound in this cohort did not have strong discriminatory value by itself. Operator dependence, appendix visualization and the

high prevalence of appendicitis in the study population may have influenced the results.

The thesis reports a disease prevalence of 92.20% for both diagnostic tables. Such a high prevalence strongly affects predictive values: PPV tends to be high and NPV tends to be low when disease prevalence is high. Therefore, the PPV of 94.10% and NPV of 40.06% for ultrasound should not be extrapolated to lower-prevalence emergency populations without caution.

The combined clinical-plus-ultrasound approach is particularly relevant for intermediate-risk patients. Contemporary diagnostic pathway research suggests that clinical scoring combined with ultrasound may improve the probability of correct diagnosis, especially when the clinical score is equivocal.[5] This supports the conceptual framework of the thesis, which proposes further imaging for low or intermediate scores rather than relying on the score alone.

The thesis reports 85 inflamed appendices and 5 normal appendices on histopathology. This corresponds to 94.44% histopathological confirmation of appendicitis. The reported negative appendectomy rate of 2.44%, however, is not mathematically concordant with five normal appendices among 90 operations, which would correspond to 5.56%. This discrepancy should be resolved by checking the original histopathology and operative database before publication. The issue is important because negative appendectomy rate is a principal endpoint of diagnostic studies.

The thesis also contains inconsistent descriptions of the number of patients in the 7–8 score category: one section states 57 patients (63.33%), while the detailed severity table states 49 patients (54.44%). The detailed score table sums to 90 and is therefore more internally coherent, but the raw dataset should be used to settle the discrepancy. These inconsistencies do not invalidate the overall clinical message but must be corrected before peer review.

The study's open-to-laparoscopic appendectomy distribution was 70% versus 30%. This reflects the institutional practice during the study period and should not be interpreted as a comparative efficacy analysis because the study was not randomized and does not

provide adjusted outcome comparisons between approaches.

The study findings can also be placed in the context of newer diagnostic strategies. A 2025 systematic review and meta-analysis of adult clinical scores found that RIPASA had higher pooled diagnostic performance than Alvarado, suggesting that Alvarado should not be regarded as the definitive modern score.[3] Nevertheless, Alvarado remains attractive in resource-limited settings because it uses symptoms, physical findings and a basic blood count and requires no specialized technology.

The role of ultrasound is similarly context-dependent. In a 2024 diagnostic-pathway study, combining a clinical score with ultrasound was associated with improved diagnostic accuracy, particularly in equivocal cases.[5] This is highly relevant to Indian hospitals where CT availability, cost and radiation exposure may limit routine use, especially in younger patients and women of reproductive age.

The thesis therefore provides useful institutional evidence that a structured clinical score and ultrasound can achieve high sensitivity in a selected population. The most appropriate interpretation is not that either test can independently diagnose appendicitis in all patients, but that they can be integrated into a stepwise diagnostic pathway. Low-risk patients can potentially avoid unnecessary surgery, high-risk patients can proceed rapidly to definitive management, and intermediate-risk patients can undergo ultrasound and/or further reassessment.

The major limitation is the absence, in the reported manuscript tables, of complete 2×2 contingency tables and confidence intervals. These are important for transparent reporting of diagnostic accuracy. The study would be considerably stronger if the final publication reports true-positive, false-positive, true-negative and false-negative counts, 95% confidence intervals, receiver operating characteristic analysis where appropriate, and prespecified score thresholds.

Overall, the study supports the continued usefulness of the Alvarado score as a low-cost clinical risk-stratification tool and ultrasonography as an important adjunct in suspected acute appendicitis. The relatively high sensitivity observed in this cohort is reassuring, but the low specificity indicates that neither test should replace clinical judgment and, where appropriate, cross-sectional imaging or surgical assessment.

6. Strengths

- Hospital-based real-world cohort of 90 adults.
- Both clinical scoring and ultrasonography were evaluated against histopathology.
- Diagnostic performance measures were reported for both approaches.

- The study includes an institutional surgical practice profile.
- The study addresses a clinically important low-cost diagnostic pathway.
- **7. Limitations and Data Verification Required**
- Negative appendectomy rate (2.44%) is inconsistent with 5 normal histopathology results among 90 patients (5.56%); verify raw data.
- The thesis contains two different counts for patients with score 7–8 (57 versus 49); verify raw score table.
- Specificity values are low and should be checked against the original 2×2 diagnostic tables.
- Confidence intervals are not reported in the supplied results.
- No ROC/AUC analysis is reported.
- The study is single-centre and hospital-based, limiting generalizability.
- Open versus laparoscopic procedure distribution is descriptive and not a comparative outcomes analysis.

CONCLUSION

In this hospital-based cohort, the Alvarado score and ultrasonography both demonstrated high reported sensitivity for acute appendicitis, while ultrasonography had higher reported diagnostic accuracy. Most patients fell into the intermediate/high Alvarado range, particularly 7–8. The findings support an integrated diagnostic approach in which clinical scoring is used for initial risk stratification and ultrasonography provides additional information, particularly in equivocal cases. Before publication, the diagnostic 2×2 tables and the internally inconsistent negative appendectomy and score-distribution figures should be reconciled with the raw dataset.

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