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Clinical, Radiological and Operative Correlation in Acute Appendicitis: A Prospective Observational Study

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ABSTRACT
Background: *Acute appendicitis is the most common surgical emergency worldwide and the leading cause of acute abdomen requiring emergency appendicectomy. Despite the introduction of numerous diagnostic modalities over the past three decades, timely diagnosis still depends primarily on careful clinical assessment. The Modified Alvarado Score is widely used for clinical risk stratification, while ultrasonography offers a readily available, non-invasive means of improving diagnostic confidence. Establishing the correlation between clinical, radiological, and operative findings is essential to minimising diagnostic error, reducing negative appendicectomy rates, and preventing the complications of delayed intervention.*
Objective: *To evaluate the correlation between clinical, ultrasonographic, and intraoperative findings in patients with suspected acute appendicitis, and to determine the diagnostic accuracy of the Modified Alvarado Score and ultrasonography, individually and in combination.*
Materials and Methods: *This prospective observational study was conducted in the Department of General Surgery, Adichunchanagiri Institute of Medical Sciences, B.G. Nagara, Karnataka, over 18 months (June 2024–December 2025). One hundred consecutive patients with clinical suspicion of acute appendicitis underwent detailed history taking, clinical examination, Modified Alvarado Score assessment, laboratory investigation, and abdominal ultrasonography, followed by appendicectomy. Intraoperative findings served as the reference standard. Diagnostic performance was assessed by sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy.*
Results: *The cohort of 100 patients showed a slight male predominance and a mean age of 33.7 ±12.13 years, with the highest proportion under 20 years (20%). Right iliac fossa tenderness, nausea, vomiting, and leukocytosis were the most frequent clinical findings, and most patients scored 5–8 on the Modified Alvarado Score. Ultrasonography most often demonstrated a non-compressible, dilated appendix with an increased appendiceal diameter. Clinical diagnosis, ultrasonographic diagnosis, and operative findings correlated significantly ($p < 0.0001$).*
Conclusion: *Clinical evaluation remains the cornerstone of diagnosing acute appendicitis. Ultrasonography meaningfully improves diagnostic specificity and complements clinical assessment. An integrated approach combining the Modified Alvarado Score with ultrasonography offers a reliable, cost-effective strategy for improving diagnostic accuracy, reducing unnecessary appendicectomies, and enabling timely surgical intervention.*
Keywords: *Acute appendicitis; Modified Alvarado Score; ultrasonography abdomen*

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I. INTRODUCTION

Acute appendicitis is the most common cause of the acute surgical abdomen and remains among the leading indications for emergency abdominal surgery worldwide. Its lifetime risk is estimated at 7–8%, with peak incidence in the second and third decades of life. Although appendicitis can occur at any age, delayed diagnosis in children and the elderly carries higher morbidity because of an increased rate of perforation and a greater likelihood of atypical presentation.

Despite advances in imaging and laboratory investigation, diagnosis remains challenging: presentation ranges from classical migratory right iliac fossa pain to atypical patterns that overlap with gastrointestinal, genitourinary, and gynaecological disease. Surgeons must therefore balance the risk of delayed intervention — perforation and generalised peritonitis — against the risk of an unnecessary appendicectomy.

Clinical judgement, built on history, examination, and laboratory findings, remains fundamental. Classical signs — right iliac fossa tenderness, rebound tenderness, fever, anorexia, nausea, vomiting, and leukocytosis — retain diagnostic value, but the subjectivity of clinical assessment contributes to uncertainty, particularly in young women, children, and the elderly. The Modified Alvarado Score was developed to formalise this assessment: it incorporates symptoms, signs, and laboratory parameters to stratify the probability of appendicitis, and its simplicity has made it a mainstay of emergency decision-making, especially where resources are limited. Its sensitivity is excellent, but specificity is more limited, and reliance on the score alone can still result in avoidable negative appendicectomies.

Ultrasonography has become the principal adjunct to clinical assessment: it is inexpensive, widely available, non-invasive, and radiation-free. Graded compression ultrasonography can identify an enlarged, non-compressible appendix, an increased appendiceal diameter, periappendiceal fluid, and inflammatory fat changes, and is particularly valuable in children, pregnant women, and women of reproductive age, where radiation exposure should be minimised and gynaecological differentials excluded. Its accuracy, however, is operator-dependent and can be limited by body habitus and bowel gas.

Computed tomography offers superior accuracy and is often the modality of choice in equivocal cases, but radiation exposure, limited access, and cost restrict its routine use in many developing-country settings, where ultrasonography remains the primary imaging tool. Comparatively few studies have examined clinical, ultrasonographic, and intraoperative findings together in the same patient cohort, even though this comparison is what best establishes the true diagnostic performance of each modality and the most effective combined strategy.

This study was undertaken to evaluate that correlation prospectively — comparing the Modified Alvarado Score, ultrasonography, and operative findings in patients with suspected acute appendicitis — with the aim of improving early diagnosis, reducing unnecessary appendicectomy, and supporting timely surgical intervention. We hypothesised that the combination of the Modified Alvarado Score and preoperative ultrasonography would yield greater diagnostic accuracy than either modality used alone.

II. MATERIALS AND METHODS

2.1 Study Design

This prospective observational study evaluated the correlation between clinical, radiological, and operative findings in patients with suspected acute appendicitis. It was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B.G. Nagara, Karnataka.

2.2 Study Setting and Duration

The study was carried out in the Department of General Surgery, Adichunchanagiri Institute of Medical Sciences, a tertiary care teaching hospital affiliated with Adichunchanagiri University, over 18 months, from June 2024 to December 2025.

2.3 Study Population

All consecutive patients presenting to the emergency department or surgical outpatient department with clinical suspicion of acute appendicitis during the study period were screened for eligibility. One hundred patients meeting the inclusion criteria were enrolled after written informed consent.

Inclusion Criteria

- Age ≥18 years.
- Clinical features suggestive of acute appendicitis.
- Willingness to undergo surgical management.
- Written informed consent provided.

Exclusion Criteria

- Appendicular mass managed conservatively.
- Appendicular abscess requiring drainage.
- Generalised peritonitis secondary to perforated appendicitis.
- Previous appendicectomy.
- Pregnancy.
- Unwillingness to participate.
- Medically unfit for surgery.

2.4 Sample Size
A convenience sample of 100 consecutive patients with suspected acute appendicitis was included, considered adequate to evaluate the correlation between clinical, radiological, and operative findings and to permit meaningful statistical analysis.

2.5 Study Methodology
All patients underwent a standardised clinical evaluation by the surgical team, comprising a detailed history and a comprehensive physical examination.
History-taking covered:

- Duration and migration of abdominal pain
- Anorexia
- Nausea and vomiting
- Fever
- Previous episodes of similar pain
- Associated bowel or urinary symptoms

Physical examination focused on:

- Right iliac fossa tenderness
- Rebound tenderness
- Guarding
- Rovsing's sign
- Psoas sign
- Obturator sign
- Body temperature and pulse rate
- Signs of localised or generalised peritonitis

Routine laboratory investigations included complete blood count, total and differential leukocyte count, urine routine examination, and serum biochemistry as indicated.

2.5.1 Modified Alvarado Score
The Modified Alvarado Score was calculated for every patient using standard criteria: migration of pain, anorexia, nausea or vomiting, right iliac fossa tenderness, rebound tenderness, elevated temperature, and leukocytosis. Patients were categorised as follows: 1–4, appendicitis unlikely; 5–6, equivocal; 7–9, highly suggestive of acute appendicitis. Clinical decisions were guided by the overall clinical picture rather than the score in isolation.

2.5.2 Ultrasonographic Evaluation
All patients underwent abdominal ultrasonography by graded compression technique, performed by experienced radiologists who were blinded to the Modified Alvarado Score wherever feasible. The following parameters were assessed: visualisation of the appendix, maximum appendiceal diameter (>6 mm), non-compressibility, wall thickening, appendicolith, periappendiceal fat stranding, periappendiceal fluid collection, evidence of perforation or abscess, and alternative abdominal or pelvic pathology. Findings were classified as positive or negative for acute appendicitis.

2.5.3 Operative Management
Patients with clinical and/or radiological evidence of acute appendicitis underwent emergency appendicectomy. The choice between open and laparoscopic appendicectomy was guided by surgeon preference, patient characteristics, and intraoperative findings. The following were documented at surgery: position of the appendix; degree of inflammation, congestion, suppuration, gangrene, or perforation; appendicular abscess; appendicolith; and any alternative intra-abdominal pathology. Operative findings were taken as the reference (gold) standard for diagnostic comparison, and resected specimens were routinely sent for histopathological examination per institutional protocol.

2.5.4 Outcome Measures
Primary outcome: the correlation between clinical diagnosis and operative findings, between ultrasonographic diagnosis and operative findings, and between clinical diagnosis and ultrasonographic findings.
Secondary outcomes: sensitivity and specificity of the Modified Alvarado Score; sensitivity and specificity of ultrasonography; PPV and NPV; overall diagnostic accuracy; and the negative appendicectomy rate.

2.6 Statistical Analysis

Data were entered in Microsoft Excel and analysed using SPSS software. Continuous variables are expressed as mean ±standard deviation, and categorical variables as frequency and percentage. Associations between categorical variables were analysed using the chi-square test or Fisher's exact test, as appropriate. Sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy were calculated using standard formulas. A p-value <0.05 was considered statistically significant.

2.7 Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B.G. Nagara. [No. AIMS/IEC/049/2024]. Written informed consent was obtained from every participant prior to enrolment. Patient confidentiality and anonymity were maintained throughout, and all data were used exclusively for academic and research purposes.

III. RESULTS

3.1 Patient Characteristics

A total of 100 patients with suspected acute appendicitis were included. There was a slight male predominance, and the mean age was 33.7 ±12.13 years, with most patients in the second to sixth decades of life. Patients under 20 years formed the largest single group (20%), while the 31–40, 51–60, and 61–70 year groups each contributed 17%.

Variable	Value
Total patients	100
Mean age (years)	33.7 ±12.13
Male sex	Slight predominance
Most affected age group	<20 years (20%)

Table 1. Baseline demographic characteristics

3.2 Clinical Presentation

Right iliac fossa tenderness was the most consistent clinical finding, followed by nausea, vomiting, migration of pain, anorexia, and leukocytosis. These classical features underpinned the Modified Alvarado Score and reflected a high level of clinical suspicion across the cohort.

3.3 Modified Alvarado Score

Most patients scored between 5 and 8, indicating a moderate-to-high probability of acute appendicitis. Scores of 7 (23%) and 8 (22%) were most common, followed by 5 (18%) and 6 (16%); only a small proportion scored below 5, consistent with a predominantly classical clinical presentation.

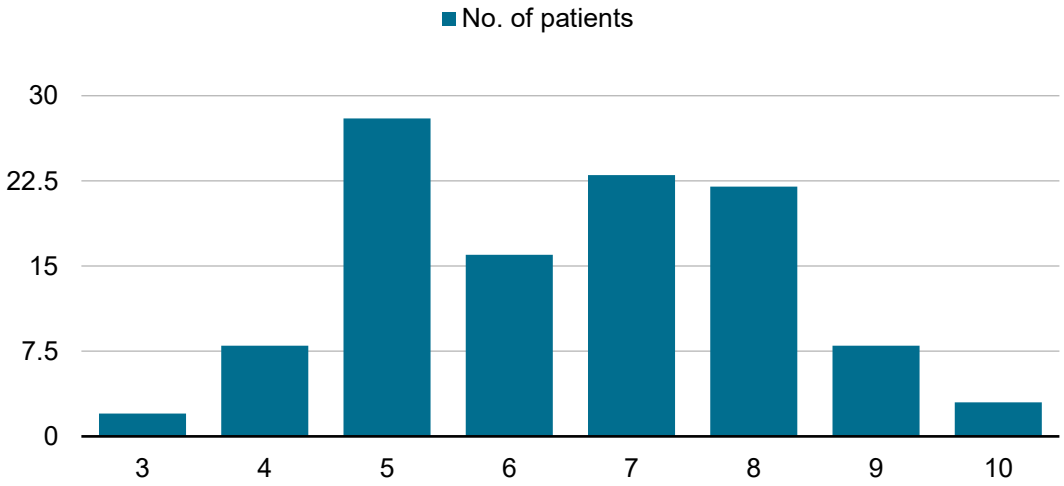

Fig. 1. Distribution of Modified Alvarado Score

3.4 Ultrasonographic Findings

Ultrasonography identified characteristic features of acute appendicitis in most patients, most commonly visualisation of the appendix, an appendiceal diameter >6 mm, non-compressibility, a target sign, localised adynamic ileus, and periappendiceal inflammatory change. A small number of patients had appendicular abscess on imaging, underscoring the value of ultrasonography in identifying complicated disease preoperatively.

3.5 Operative Procedures

All 100 patients underwent surgery. Laparoscopic appendicectomy was performed in 55% and open appendicectomy in 45%, reflecting a growing preference for the minimally invasive approach given its association with reduced postoperative pain, shorter hospital stay, and faster recovery.

Procedure	n (%)
Laparoscopic appendicectomy	55 (55)
Open appendicectomy	45 (45)

Table 2. Operative procedures

3.6 Operative Findings

The retrocaecal position was the commonest anatomical finding, followed by pelvic and pre-ileal positions; awareness of this variation aided dissection and helped explain differences in presentation. Simple inflammation was the predominant finding (73%); gangrenous appendicitis occurred in 11%, appendicolith in 13%, appendicular abscess in 9%, and perforation in only 1%, indicating that most patients presented before advanced disease had developed.

Finding	n (%)
Inflamed appendix	73 (73)
Gangrenous appendix	11 (11)
Perforated appendix	1 (1)
Appendicolith	13 (13)
Appendicular abscess	9 (9)

Table 3. Intraoperative findings

3.7 Correlation Between Clinical, Radiological and Operative Findings

Clinical diagnosis by Modified Alvarado Score showed excellent sensitivity for identifying patients with acute appendicitis, while ultrasonography showed greater specificity and materially improved diagnostic confidence in patients with equivocal clinical findings. Clinical diagnosis, ultrasonographic diagnosis, and operative findings correlated highly significantly ($p < 0.0001$), confirming that combining clinical assessment with ultrasonography outperforms either modality used alone.

COMPARISON	TP	FP	FN	TN	SENSITIVITY	SPECIFICITY	P VALUE
CLINICAL vs RADIOLOGICAL	45	15	10	30	81.8	66.7	<0.0001
CLINICAL vs OPERATIVE	46	14	12	28	79.3	66.7	<0.0001
RADIOLOGICAL vs OPERATIVE	44	11	14	31	75.9	73.8	<0.00001

Table 4. Correlation table

3.8 Diagnostic Accuracy

The Modified Alvarado Score showed high sensitivity but comparatively lower specificity; ultrasonography showed higher specificity and improved overall accuracy. The combined approach minimised unnecessary appendicectomies while preserving timely diagnosis.

IV. DISCUSSION

This prospective study examined the relationship between clinical, ultrasonographic, and operative findings in 100 patients with suspected acute appendicitis. Careful clinical evaluation remained the cornerstone of diagnosis, but the addition of ultrasonography measurably improved specificity and overall accuracy — supporting a combined diagnostic approach, particularly for patients with equivocal presentations.

The mean age of 33.7 ±12.13 years and the slight male predominance in this cohort are consistent with the demographic pattern reported by Pieper et al., Lewis et al., and Bhangu et al., who similarly found appendicitis to affect young adults disproportionately and to occur more often in males — a pattern variously attributed to diet, lymphoid hyperplasia, and hormonal influence. Unlike several Western series, which report peak incidence in the second and third decades specifically, our cohort showed a somewhat wider age spread, likely reflecting the referral pattern of a tertiary centre.

Right iliac fossa tenderness was again the single most reliable sign, followed by nausea, vomiting, anorexia, migration of pain, and leukocytosis — a sequence consistent with the classical descriptions in Bailey & Love and the Sabiston Textbook of Surgery. No individual symptom or sign was sufficient on its own; as in prior work, diagnosis depended on the combined weight of several clinical parameters interpreted by an experienced surgeon.

Most patients scored 5–8, and those scoring ≥7 almost invariably proceeded to surgery, supporting the score's practical value at the bedside. This mirrors Alvarado's original description of high sensitivity and later work by Fenyo, Ramirez et al., and Andersson confirming its usefulness for risk stratification. As in the systematic review by Ohle et al., however, our data suggest the score is more reliably used to rule out appendicitis in low-risk patients than to confirm it in isolation, since reliance on the score alone can still lead to unnecessary appendicectomy.

A non-compressible appendix >6 mm was the most frequent sonographic finding, with target sign, periappendiceal inflammatory change, adynamic ileus, and abscess further raising diagnostic confidence. These findings align with the foundational work of Puylaert on graded compression ultrasonography and with Jeffrey et al. and Adams et al., who reported comparably high sensitivity and emphasised ultrasonography as a complement to, rather than a substitute for, clinical judgement. Because ultrasonography remains operator-dependent and can be limited by obesity, a retrocaecal appendix, bowel gas, or early disease, a negative scan should not override strong clinical suspicion.

Simple inflammation predominated, with gangrene, perforation, appendicolith, and abscess considerably less common — suggesting most patients were treated before progression to complicated disease. The retrocaecal position was again the commonest, broadly consistent with Wakeley's classic series reporting this position in roughly two-thirds of cases; recognising this variability remains clinically relevant to presentation, examination, and operative technique.

4.1 Correlation Between Clinical, Radiological and Operative Findings

A key strength of this study is the direct, within-patient comparison of clinical assessment, ultrasonography, and operative findings. All three correlated significantly ($p < 0.0001$), indicating that both clinical examination and ultrasonography reliably predict operative findings, with clinical assessment contributing sensitivity and ultrasonography contributing specificity. This complementary relationship is consistent with the WSES Jerusalem guidelines, which recommend structured clinical assessment supported by imaging rather than reliance on any single test.

4.2 Clinical Implications

These findings carry practical weight in resource-limited settings. The Modified Alvarado Score is inexpensive, rapid, and reproducible; ultrasonography is widely available, avoids ionising radiation, and is particularly useful in children, young adults, and women of reproductive age. Used together, they can improve diagnostic confidence, reduce unnecessary appendicectomy, identify complicated disease earlier, shorten hospital stay, lower cost, and improve outcomes.

4.2.1 Strengths of the Study

- Prospective design.
- Standardised clinical assessment using the Modified Alvarado Score.
- Uniform ultrasonographic evaluation.

- Operative findings used as the reference standard.
- Consecutive enrolment, minimising selection bias.
- Direct within-patient comparison of clinical, radiological, and operative findings.

4.2.2. Limitations

This was a single-centre study, which may limit generalisability, and the sample of 100 patients may be underpowered for subgroup analysis. Ultrasonography is inherently operator-dependent, and accuracy may vary with radiologist experience. Computed tomography was not routinely used in equivocal cases because of cost and radiation concerns. Larger multicentre studies incorporating modern imaging and validated prediction models would help refine the diagnostic pathway further.

4.3. Overall Interpretation

Neither clinical examination nor ultrasonography performs adequately in isolation; the two are complementary, with clinical evaluation offering sensitivity and ultrasonography offering specificity and the exclusion of alternative diagnoses. The combination of careful clinical examination, Modified Alvarado Score assessment, and targeted ultrasonography represents a practical, cost-effective, evidence-based approach to diagnosing acute appendicitis in routine surgical practice.

V. CONCLUSIONS

Acute appendicitis remains one of the most common causes of the acute abdomen requiring emergency surgery. Despite advances in laboratory and imaging investigation, accurate diagnosis still depends on meticulous clinical evaluation supported by appropriate radiology.

The Modified Alvarado Score proved a valuable tool with high sensitivity, useful for identifying patients who need early surgical assessment, though its more limited specificity means it should not be relied on alone to confirm the diagnosis. Ultrasonography was an effective adjunct, adding specificity through characteristic sonographic features, detecting complications such as abscess, and helping exclude alternative causes of right iliac fossa pain.

Clinical, ultrasonographic, and operative findings correlated significantly ($p < 0.0001$), confirming that integrating structured clinical assessment with preoperative ultrasonography improves diagnostic accuracy beyond either modality alone. These findings support the routine combined use of the Modified Alvarado Score and ultrasonography as a practical, safe, and cost-effective strategy — particularly where computed tomography is not readily available — to enable earlier diagnosis, reduce negative appendicectomy, limit complications, and improve outcomes.

Future multicentre studies with larger cohorts, incorporating computed tomography, magnetic resonance imaging, inflammatory biomarkers, and artificial-intelligence-based predictive models, may further refine the diagnostic pathway for acute appendicitis.

DECLARATIONS

Ethics Approval and Consent to Participate

The study was approved by the Institutional Ethics Committee of Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, B.G. Nagara, Karnataka. Written informed consent was obtained from all participants prior to enrolment.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

KN conceived the study, collected the data, performed the statistical analysis, interpreted the findings, and drafted the manuscript. CSH supervised the study, contributed to study design, critically revised the manuscript for important intellectual content, and approved the final version. Both authors read and approved the final manuscript.

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Abbreviations

- MAS – Modified Alvarado Score
- USG – Ultrasonography
- CT – Computed Tomography
- PPV – Positive Predictive Value
- NPV – Negative Predictive Value
- RIF – Right Iliac Fossa
- IEC – Institutional Ethics Committee

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