International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Clinicopathological Study of Acute Appendicitis with Special Reference to the Role of WBC Count, C-Reactive Protein (CRP), Ultrasonography and Alvarado Score in Diagnosis

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Abstract: ***Background: Acute appendicitis is one of the most frequently encountered surgical emergencies across all age groups. Despite advances in diagnostic modalities, the condition continues to pose diagnostic challenges due to variable clinical presentation, leading to negative appendectomies and delayed intervention. Methods: This prospective observational study was conducted in the Department of General Surgery, Hi-Tech Medical College and Hospital, Bhubaneswar, from July 2024 to December 2025. A total of 140 patients presenting with clinical suspicion of acute appendicitis were evaluated using detailed clinical assessment, white blood cell count, C-reactive protein (CRP), ultrasonography (USG), and Alvarado scoring. Operative findings and histopathological examination were used as the reference standard. Results: Young adults constituted the majority of cases. Elevated inflammatory markers, higher Alvarado scores (≥7), and positive ultrasonographic findings showed strong correlation with histopathologically confirmed appendicitis. The combined diagnostic approach significantly improved diagnostic accuracy. Conclusion: Integration of clinical evaluation with laboratory markers, Alvarado scoring, and ultrasonography enhances diagnostic accuracy and reduces negative appendectomy rates.***

Keywords: Acute appendicitis, Alvarado score, Ultrasonography, Inflammatory markers, Diagnostic accuracy

1. Introduction

The surgical importance of appendicitis lies in its tendency to become inflamed, resulting in the clinical syndrome known as acute appendicitis. Acute appendicitis is the most common cause of an “acute abdomen” in young adults, and appendectomy remains the most frequently performed emergency abdominal operation, with a lifetime prevalence of approximately 1 in 7 individuals. Classically, patients present with right lower abdominal pain associated with nausea and vomiting, along with tenderness and guarding in the right iliac fossa on clinical examination. However, these symptoms and signs are not specific to appendicitis. Diagnostic uncertainty is further compounded by the variable anatomical position of the appendix. Consequently, acute appendicitis must be considered in the differential diagnosis of almost every patient presenting with acute abdominal pain, and early diagnosis remains the cornerstone of effective management.

Although the accuracy of diagnosing acute appendicitis largely depends on clinical expertise, equivocal and confusing cases are not uncommon, particularly in children, elderly patients, and females of reproductive age. This is attributable to atypical presentations and the presence of several other conditions that can closely mimic appendicitis. Literature reports a negative appendectomy rate ranging from 20% to 40%. Removal of a normal appendix not only imposes an unnecessary economic burden on patients but also strains healthcare resources. Conversely, delayed surgical intervention may result in serious complications such as perforation and generalized peritonitis. Both unnecessary surgery and delayed intervention are increasingly being scrutinized and represent significant concerns for both surgeons and patients, with considerable socio-medical implications.

This study aims to undertake a comprehensive evaluation of patients with suspected acute appendicitis based on clinical symptoms, physical examination findings, and readily available, cost-effective investigations such as total leukocyte count, C-reactive protein levels, and ultrasonography, along with the Alvarado scoring system (migratory right iliac fossa pain = 1, anorexia = 1, nausea and vomiting = 1, tenderness in the right iliac fossa = 2, rebound tenderness = 1, elevated temperature = 1, leukocytosis = 2, left shift = 1; total score = 10). These parameters will be correlated with operative findings and histopathological results. The ultimate objective is to enhance diagnostic accuracy and optimize the overall management of acute appendicitis.

2. Aims and Objectives

1) To analyse the various modes of clinical presentation of acute appendicitis.
2) To evaluate the spectrum of clinical signs observed in patients with acute appendicitis.
3) To assess the diagnostic value of investigative modalities, with special reference to total white blood cell (WBC) count, C-reactive protein (CRP), and ultrasonography (USG), in suspected cases of acute appendicitis.
4) To evaluate the effectiveness of the Alvarado scoring system in the diagnosis of acute appendicitis.
5) To improve the accuracy of diagnosis of acute appendicitis, thereby reducing the rate of negative appendectomy and minimizing unnecessary delay in surgical intervention.

3. Materials and Methods

1) **Study Area:**
Department of General Surgery, Hi-Tech Medical College and Hospital, Bhubaneswar, Odisha.

2) **Study Population:**
All patients admitted in General Surgery Ward of Hi-Tech Medical College and Hospital, Bhubaneswar, from July 2024 to December 2025 with provisional clinical diagnosis of acute appendicitis. Chronic appendicitis and paediatrics populations were excluded from this study.

3) **Sample Size:**
Total 140 patients were included in this study.

4) **Study Design:**
It was a prospective observational study.

5) **Parameters Studied:**

a) Various modes of presentation of acute appendicitis:
- Pain - Site, migration, character
- Anorexia
- Nausea
- Vomiting
- Fever
- Constipation
- Diarrhoea
- Dysuria

b) Clinical Signs Observed in Acute Appendicitis
- Tachycardia
- Pyrexia
- Localized tenderness in the right iliac fossa (RIF)
- Muscle guarding over the RIF
- Rebound tenderness in the RIF
- Generalized abdominal tenderness
- Pointing sign
- Dunphy's sign
- Rovsing's sign
- Psoas sign
- Obturator sign
- Tenderness on digital rectal examination (DRE)

c) Role of Investigative Procedures in Acute Appendicitis

Total Leukocyte Count (TLC)
- As per the Alvarado scoring system, a TLC ≥10,000/mm³ was considered a positive cutoff value.

Differential Leukocyte Count (DLC)
- Neutrophil predominance ≥75% was taken as a positive cutoff value in accordance with the Alvarado score.

C-Reactive Protein (CRP)
- A CRP value ≥6 mg/L was considered indicative of inflammation and taken as a positive result.

Ultrasonography (USG) of Abdomen and Pelvis
- Ultrasonography was performed using a linear array transducer (7–14 MHz) on a Xario (Toshiba) machine, employing the graded compression technique over the right iliac fossa and the site of maximum tenderness.
- Anatomical landmarks including the caecum, iliac vessels, and psoas muscle were identified.
- An inflamed appendix was visualized as a non-compressible, blind-ending, aperistaltic tubular structure arising from the caecum, with an outer diameter of ≥6 mm.
- Supporting ultrasonographic findings included peri-appendiceal fluid collection, presence of appendicolith, increased echogenicity of peri-appendiceal fat, and phlegmon formation.
- Failure to meet the above criteria was considered suggestive of a normal appendix.

d) Role of the Alvarado Scoring System in the Diagnosis of Acute Appendicitis

The **Alvarado score (MANTRELS)** was applied as follows:

Parameter	Score
Migratory right iliac fossa pain	1
Anorexia	1
Nausea or vomiting	1
Tenderness in right iliac fossa	2
Rebound tenderness	1
Elevated temperature (≥37.3°C)	1
Leukocytosis (TLC ≥10,000/mm³)	2
Left shift of neutrophils (≥75%)	1
Total score	10

- A **score ≥7** was considered diagnostic of acute appendicitis.

4. Results

A total of **140 patients** with a clinical diagnosis of acute appendicitis were included in the study. The disease showed a female predominance, with a male-to-female ratio of **1:1.5**, accounting for **40% males** and **60% females**. Incorrect clinical diagnosis was more frequent in the female population, occurring in **65.71%** of cases.

All patients underwent a detailed clinical evaluation along with preoperative investigations, including total leukocyte count (TLC), differential leukocyte count (DLC), C-reactive protein (CRP) estimation, and assessment using the Alvarado scoring system. Preoperative ultrasonography (USG) was performed in **96 patients (68.57%)**.

Of the 140 patients, **132** underwent emergency appendectomy. **Four** patients underwent emergency laparotomy for pelvic pathology, comprising **two cases of ruptured ectopic pregnancy** and **two cases of twisted ovarian cyst**. **Two** patients responded to conservative management—one diagnosed with right ureteric calculus and the other with a right tubo-ovarian mass. Additionally, **two** patients with an appendicular lump were initially managed conservatively and subsequently underwent **interval appendectomy**.

Histopathological examination revealed an inflamed appendix in **103** of the **132** patients who underwent emergency appendectomy, while **29** patients had a histologically normal appendix. Both patients who underwent interval appendectomy also had histopathologically

confirmed appendicitis. Consequently, among the **140** patients with an initial clinical diagnosis of acute appendicitis, **105** were confirmed to have appendicitis, while **35** were classified as non-appendicitis cases, including **29 histologically normal appendices, 4 pelvic pathologies, 1 ureteric calculus, and 1 tubo-ovarian mass**.

Overall, operative interventions were performed in **138 patients**, which included **132 emergency appendectomies, 4 emergency surgeries for pelvic pathology, and 2 interval appendectomies**.

Table 1: Age Distribution (n= 140)

Age Group (in years)	Appendicitis Group (n=105)		Non- Appendicitis Group (n=35)		Total (n=140)	
	No.	%	No.	%	No.	%
13- 20	33	31.43	13	37.14	46	32.86
21- 30	42	40.00	10	28.57	52	37.14
31- 40	23	21.90	8	22.86	31	22.14
41- 50	4	3.81	3	8.57	7	5.00
51- 60	2	1.90	0	0.00	2	1.43
≥ 61	1	0.95	1	2.86	2	1.43

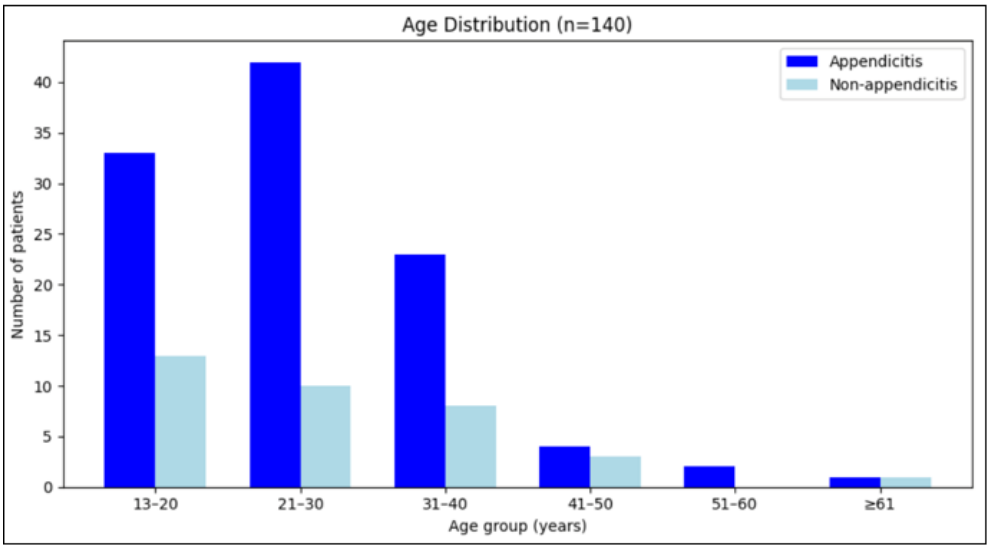

Figure 1: Distribution of Age

Table 2: Sex Distribution (n= 140)

Sex	Appendicitis Group (n=105)		Non- Appendicitis Group (n=35)		Total (n=140)	
	No.	%	No.	%	No.	%
Male	42	40.00	12	34.29	54	38.57
Female	63	60.00	23	65.71	86	61.43

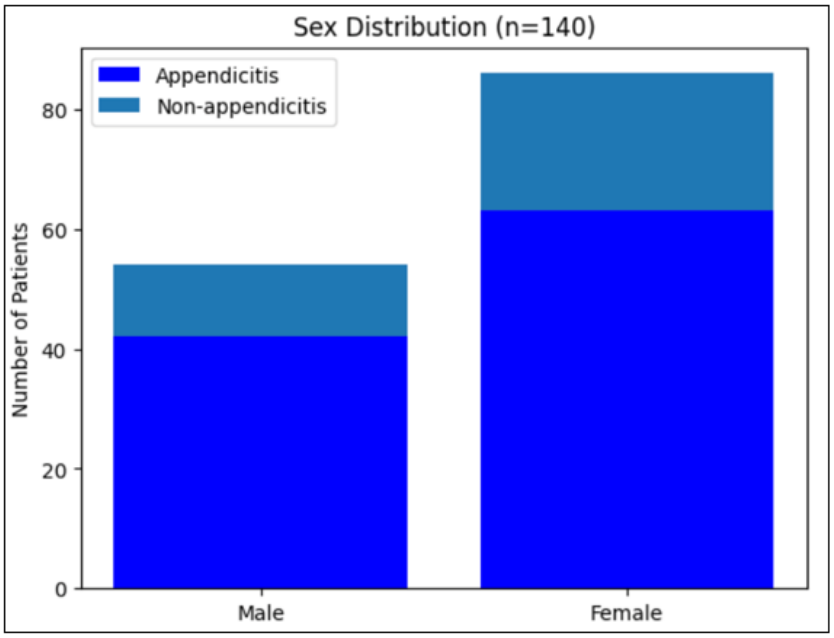

Figure 2: Sex Distribution

Table 3: Preoperative CRP value in mg/L (n= 140)

CRP value in Mg/L	Appendicitis Group (n=105)		Non- Appendicitis Group (n=35)		Total (n=140)	
	No.	%	No.	%	No.	%
< 6	8	7.62	30	85.71	38	27.14
6- 50	76	72.38	5	14.29	81	57.86
50- 100	17	16.19	0	0.00	17	12.14
> 100	4	3.81	0	0.00	4	2.86

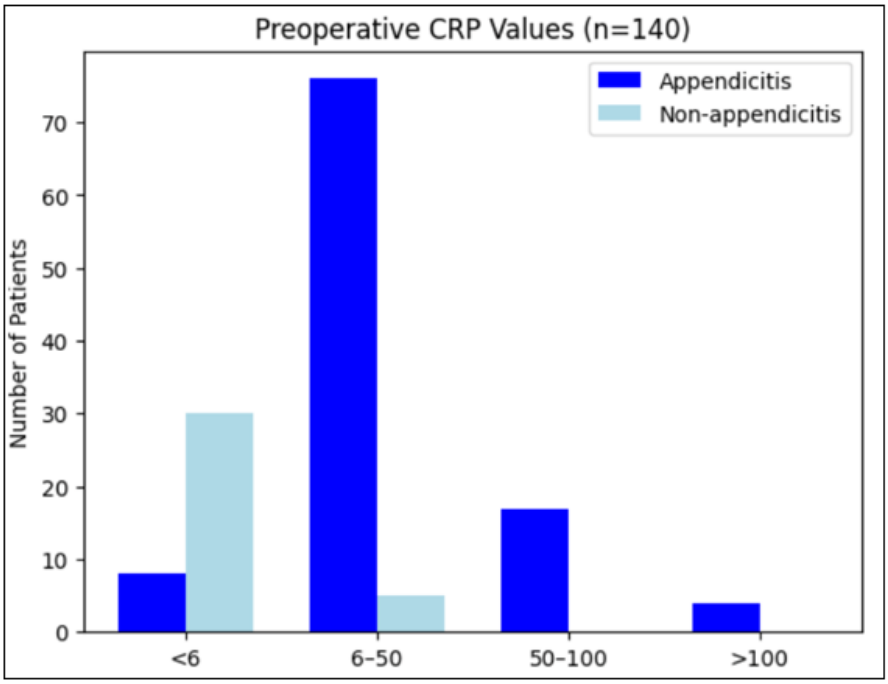

Figure 3: Distribution of Pre-op CRP Values

Table 4: Alvarado Score (n= 140)

Alvarado Score	Appendicitis Group (n=105)		Non- Appendicitis Group (n=35)		Total (n=140)	
	No.	%	No.	%	No.	%
9- 10	36	34.29	1	2.86	37	26.43
7- 8	57	54.29	9	25.71	66	47.14
5- 6	11	10.48	12	34.29	23	16.43
≤ 4	1	0.95	13	37.14	14	10.00

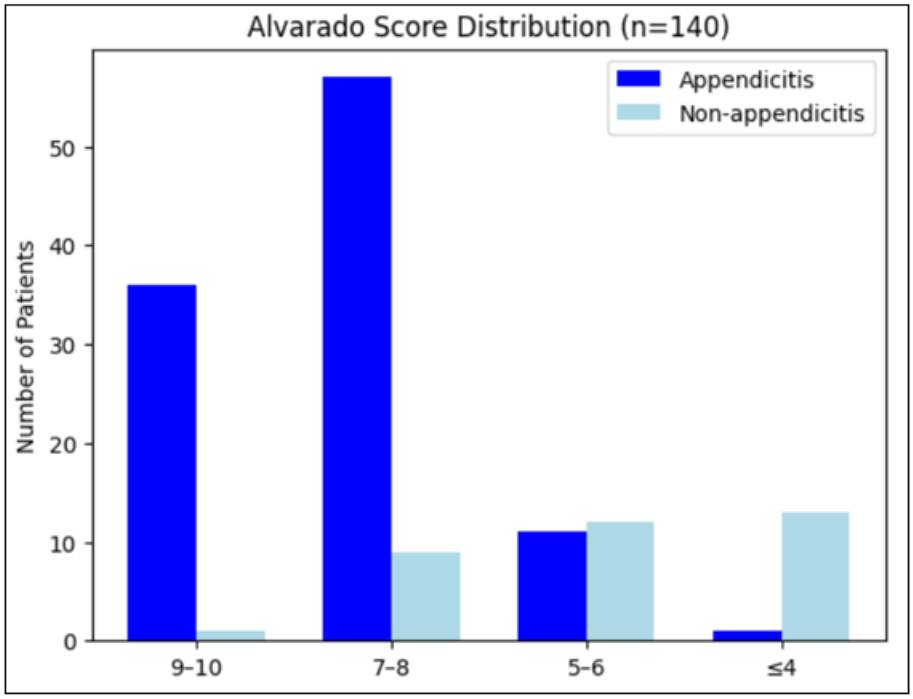

Figure 4: Distribution of Alvarado Score

Table 5: USG Results (n= 96)

USG Findings	Appendicitis Group (n=72)		Non- Appendicitis Group (n=24)		Total (n=96)	
	No.	%	No.	%	No.	%
Aperistaltic Blind Ending Tube	67	93.06	2	8.33	69	71.88
Outer Transverse diameter ≥ 6mm	66	91.67	1	4.17	67	69.79
Non- Compressibility	55	76.39	2	8.33	57	59.38
Loculated Peri Appendiceal Fat	59	81.94	0	0.00	59	61.46
Prominent Peri Appendiceal Fat	37	51.39	0	0.00	37	38.54
Appendicolith	31	43.06	1	4.17	32	33.33

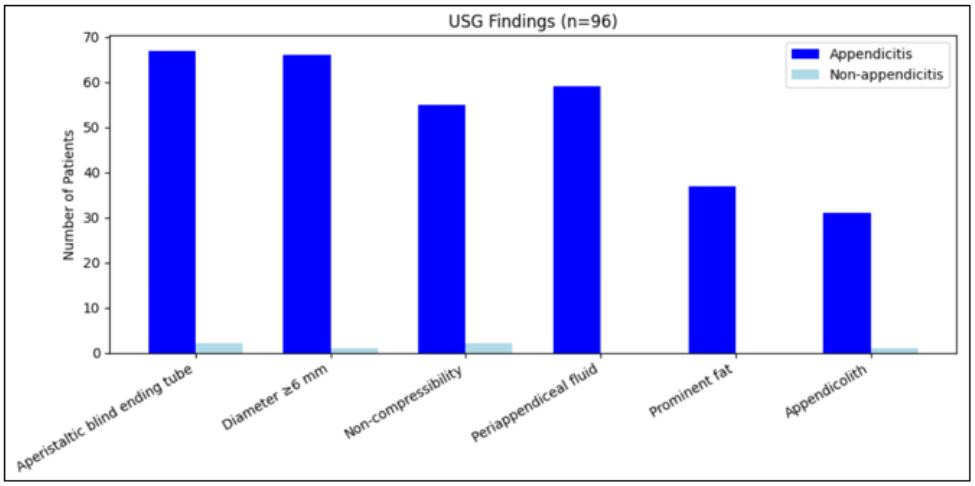

Figure 5: Distribution of USG results

5. Discussion

The findings of this study corroborate previous literature demonstrating that a multimodal diagnostic approach improves accuracy in diagnosing acute appendicitis. CRP and ultrasonography were particularly useful adjuncts in equivocal cases.

6. Conclusion

A combined diagnostic approach incorporating clinical assessment, inflammatory markers, Alvarado scoring, and ultrasonography significantly improves diagnostic accuracy and reduces negative appendectomy rates.

Ethical Approval
The study was approved by the Institutional Ethics Committee of Hi-Tech Medical College and Hospital, Bhubaneswar. Written informed consent was obtained from all patients.

Funding
Nil.

Conflict of Interest
None declared.

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