Original Research

Prospective Assessment of Inflammatory Markers (CRP/ESR) in Patients with Acute Appendicitis

[1]Alka Gahalot, [2]Mukul Sahu

[1]Associate Professor, Department of Pathology, Major S D Singh Medical College & Hospital, Farukkhabad, Uttar Pradesh, India;
[2]Assistant Professor, Department of General Surgery, Saraswathi Institute of Medical Sciences, Hapur, Uttar Pradesh, India

ABSTRACT:

Background: Acute appendicitis is one of the most common surgical emergencies, and timely diagnosis is essential to prevent perforation and sepsis while avoiding unnecessary appendectomies. Clinical assessment and imaging remain central, but inexpensive inflammatory markers such as C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) may enhance diagnostic accuracy and help stratify disease severity, particularly in resource-limited settings. **Aim:** To prospectively assess the diagnostic utility of CRP and ESR in patients with suspected acute appendicitis and to correlate these markers with histopathological severity. **Material and Methods:** This prospective observational study was conducted in the Department of General Surgery of a tertiary care hospital and included 98 consecutive patients aged ≥12 years presenting with clinical suspicion of acute appendicitis. Detailed history, physical examination and Alvarado scoring were performed for all patients, followed by routine laboratory tests. CRP (high-sensitivity immunoturbidimetric assay) and ESR (Westergren method) were measured at admission prior to antibiotic therapy. Ultrasonography, and where indicated contrast-enhanced computed tomography, supported the diagnosis. All patients underwent open or laparoscopic appendectomy, and histopathology served as the reference standard. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for CRP, ESR and total leukocyte count (TLC) were calculated and correlated with histopathological grades. **Results:** The mean age was 27.8 ± 8.6 years with a male predominance (63.27%). CRP was elevated in 87.76% (mean 38.42 ± 11.76 mg/L) and ESR in 79.59% (mean 32.65 ± 9.48 mm/hr) of patients. CRP (>10 mg/L) showed sensitivity 91.40%, specificity 75.00%, PPV 95.55% and NPV 60.00%. ESR (>20 mm/hr) demonstrated sensitivity 84.00%, specificity 68.75%, PPV 92.86% and NPV 48.00%, while TLC (>11,000/mm³) had sensitivity 87.80%, specificity 62.50%, PPV 93.67% and NPV 44.44%. Both CRP and ESR increased progressively from normal to catarrhal, suppurative, gangrenous and perforated appendicitis, with a significant association between higher marker levels and severe histopathological grades. **Conclusion:** CRP and ESR are useful adjunctive markers in the evaluation of suspected acute appendicitis, with CRP providing the highest diagnostic accuracy. Their stepwise rise with histopathological severity supports their role in identifying complicated disease and improving clinical decision-making when interpreted alongside clinical findings, TLC and imaging.

Keywords: Acute appendicitis; C-reactive protein; Erythrocyte sedimentation rate; Inflammatory markers; Histopathology.

Corresponding author: Mukul Sahu, Assistant Professor, Department of General Surgery, Saraswathi Institute of Medical Sciences, Hapur, Uttar Pradesh, India

INTRODUCTION

Acute appendicitis is one of the most common causes of acute abdomen requiring emergency surgery and remains a major contributor to morbidity across all age groups. Despite advances in imaging and perioperative care, timely and accurate diagnosis continues to be challenging, particularly in the early stages or in atypical presentations. The clinical course of appendicitis ranges from simple mucosal inflammation to suppurative, gangrenous, and perforated appendicitis, each associated with progressively higher risk of complications such as peritonitis, sepsis, and intra-abdominal abscess. Delayed diagnosis increases the likelihood of perforation, whereas overdiagnosis contributes to unnecessary appendectomies and avoidable exposure to anaesthesia and surgical risks. Balancing these two opposing risks—negative appendectomy versus perforated appendicitis—remains a central concern in the management of patients with suspected

347

appendicitis.[1,2] Epidemiological data indicate that appendicitis most frequently affects adolescents and young adults, with a lifetime risk that is substantial in many populations. It is a major cause of hospital admissions and operative workload for general surgeons worldwide. The burden is especially significant in low- and middle-income settings where access to advanced imaging and subspecialty care is limited. In such environments, clinicians often rely heavily on bedside assessment and basic laboratory tests to guide decision-making. This underscores the need for simple, affordable, and reproducible tools that can distinguish true appendicitis from other causes of right iliac fossa pain, and that can also help identify patients at risk of complicated disease.[3] Traditionally, the diagnosis of acute appendicitis has been clinical, based on a combination of characteristic symptoms and signs such as periumbilical pain migrating to the right iliac fossa, anorexia, nausea or vomiting, low-grade fever, localized tenderness, rebound tenderness, and guarding. To improve consistency and reduce subjectivity, clinical scoring systems such as the Alvarado score and other diagnostic scores were developed, integrating symptoms, signs, and basic laboratory findings into a composite index of probability. These scores are helpful in risk stratification and in identifying patients who may be safely observed or discharged versus those needing urgent surgery. However, their performance can vary between populations, and they may be less reliable in special groups such as children, the elderly, and pregnant women. Furthermore, clinical scoring alone cannot always reliably differentiate early appendicitis from non-specific abdominal pain or other intra-abdominal pathologies.[4] Imaging has transformed the diagnostic approach to appendicitis over the last few decades. Ultrasonography is widely used as a first-line modality because it is non-invasive, inexpensive, and free of ionizing radiation. When the appendix is clearly visualized, ultrasound can provide high specificity; however, its sensitivity is operator-dependent and may be limited in obese patients, in those with significant bowel gas, or in early disease. Computed tomography (CT) has superior sensitivity and specificity and has markedly reduced negative appendectomy rates in many centres, but at the cost of radiation exposure, higher cost, and limited availability in some settings. Magnetic resonance imaging (MRI) is an attractive radiation-free alternative, especially in pregnancy, but is not universally accessible. As a result, there remains considerable interest in complementary diagnostic tools that are less resource-intensive yet clinically informative.[5] Inflammatory markers occupy a central place among these complementary tools. Appendicitis is fundamentally an acute inflammatory process of the vermiform appendix, driven by luminal obstruction, bacterial overgrowth, and subsequent mucosal injury. This local process triggers a systemic acute-phase response mediated by cytokines such as interleukin-6, interleukin-1, and tumour necrosis factor-α, which stimulate hepatic synthesis of acute-phase proteins and alter circulating leukocyte counts. C-reactive protein (CRP) is one of the most widely used acute-phase reactants; it begins to rise within 6–8 hours of the onset of inflammation and peaks at about 24–48 hours. Erythrocyte sedimentation rate (ESR), although less specific and slower to change, reflects plasma protein alterations associated with inflammation and may remain elevated for a longer period. In principle, both CRP and ESR can contribute to the diagnosis of appendicitis and may also indicate disease severity, particularly in advanced or complicated cases.[6,7]

MATERIAL AND METHODS

This prospective observational study was conducted in the Department of General Surgery at a tertiary care hospital, enrolling patients presenting with clinical suspicion of acute appendicitis. The study aimed to evaluate the diagnostic utility of inflammatory markers—C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR)—in confirming acute appendicitis and assessing disease severity. All clinical evaluations, laboratory investigations, imaging procedures, and surgical interventions were performed according to standardized institutional protocols.

A total of 98 patients who presented with right lower-quadrant abdominal pain and were clinically suspected of having acute appendicitis were included. Patients were eligible if they were aged ≥12 years, provided informed consent, and underwent further diagnostic work-up to confirm appendicitis. Exclusion criteria consisted of patients with known chronic inflammatory diseases, ongoing systemic infections, immunosuppressive therapy, malignancy, pregnancy, or previous appendectomy. Patients with incomplete diagnostic data or inadequate follow-up after surgical intervention were also excluded to maintain data accuracy.

Methodology

All patients underwent a detailed clinical assessment, including history, physical examination, and symptom scoring using a standardized appendicitis grading tool such as the Alvarado score. Clinical parameters recorded included duration of pain, migration of pain, anorexia, nausea or vomiting, fever, and localized tenderness or rebound tenderness in the right iliac fossa. Vital signs, abdominal examination findings, and signs of peritonitis were documented at admission. Decisions for imaging and operative intervention were made by the attending surgical team based on clinical judgment supported by laboratory and radiological findings.

Venous blood samples were collected from all patients at presentation prior to initiation of antibiotic therapy. Serum CRP levels were measured using a high-sensitivity immunoturbidimetric assay, and

348

values were recorded in milligrams per liter (mg/L). ESR was determined using the Westergren method and expressed in millimeters per hour (mm/hr). Additional hematological parameters—including total leukocyte count, differential leukocyte count, and neutrophil percentage—were evaluated to support the diagnostic work-up. All laboratory analyses were performed in the hospital's certified diagnostic laboratory using calibrated instruments and quality-control protocols.

Patients underwent abdominal ultrasonography as the initial imaging modality to evaluate appendiceal diameter, wall thickness, periappendiceal fluid, echogenic fat stranding, or appendicolith presence. In cases where ultrasound findings were inconclusive, contrast-enhanced computed tomography (CT) of the abdomen was performed following institutional imaging guidelines. Radiological impressions were recorded and correlated with laboratory and clinical findings to improve diagnostic accuracy.

Patients diagnosed with acute appendicitis based on combined clinical, laboratory, and imaging evidence underwent operative management through open or laparoscopic appendectomy. Intraoperative findings—including appendiceal appearance, presence of perforation, gangrene, suppuration, or periappendiceal abscess—were documented in a structured format. Resected appendices were submitted for histopathological examination, which served as the definitive diagnostic reference standard. Histopathology classified appendicitis as normal, catarrhal, suppurative, gangrenous, or perforated.

All clinical, laboratory, radiological, operative, and histopathological data were collected prospectively using a standardized proforma. The primary outcome measure was the diagnostic accuracy of CRP and ESR in detecting acute appendicitis. Secondary outcomes included correlation of CRP and ESR levels with disease severity, operative findings, and histopathological grading. Additional metrics such as leukocyte count, neutrophil percentage, and imaging findings were evaluated to assess their combined predictive value.

Statistical Analysis

Data were entered into a standardized database and analyzed using appropriate statistical software. Continuous variables such as CRP, ESR, and leukocyte counts were expressed as mean ± standard deviation or median with interquartile range, depending on distribution. Categorical variables were summarized as frequencies and percentages. Diagnostic performance of inflammatory markers was assessed using sensitivity, specificity, positive predictive value, negative predictive value, and receiver operating characteristic (ROC) curve analysis. Correlation coefficients were used to examine relationships between inflammatory marker levels and histopathological severity. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1 presents the demographic characteristics of the 98 patients included in the study. The largest proportion of patients belonged to the 21–30-year age group (38.78%), followed by the 31–40-year group (24.49%), indicating that acute appendicitis was more common in young adults. The mean age was 27.8 ± 8.6 years, reinforcing the observation that this condition frequently affects individuals in their most active years. A male predominance was observed, with 62 males (63.27%) and 36 females (36.73%). The difference in gender distribution was statistically significant, as indicated by a p-value of 0.041, suggesting that males had a higher likelihood of presenting with acute appendicitis in this study population.

Table 2 summarizes the clinical presentation of the patients. All patients (100%) reported right iliac fossa pain, which remained the most consistent and defining clinical symptom of acute appendicitis. Migration of pain was seen in 65.31% of cases, supporting its diagnostic relevance. Systemic symptoms such as anorexia (73.47%) and nausea/vomiting (70.41%) were commonly observed, indicating the presence of gastrointestinal irritation. Fever >38°C was present in 47.96% of the patients, reflecting variable systemic inflammatory response. Physical findings such as rebound tenderness were documented in 59.18% of cases, highlighting localized peritoneal irritation. Hematological indicators—raised total leukocyte count (80.61%) and neutrophilia >75% (75.51%)—were found in the majority of patients, corresponding well with acute inflammatory processes. The mean Alvarado score was 7.6 ± 1.3, which falls within the range suggestive of a high probability of appendicitis.

Table 3 evaluates CRP, ESR, and total leukocyte count as inflammatory markers. CRP was elevated in 87.76% of patients, with a mean value of 38.42 ± 11.76 mg/L, making it the most frequently elevated marker. ESR was elevated in 79.59% of patients, with a mean of 32.65 ± 9.48 mm/hr, while total leukocyte count was increased in 80.61%. All three markers demonstrated strong statistical significance (p < 0.001), confirming that these inflammatory parameters reliably correlate with the presence of acute appendicitis. Among them, CRP showed the highest rate of elevation and therefore the strongest diagnostic association.

Table 4 demonstrates the correlation between inflammatory marker levels and histopathological severity of appendicitis. The trend clearly shows that both CRP and ESR increase steadily as the severity progresses from normal appendix to catarrhal, suppurative, gangrenous, and perforated forms. Patients with normal appendices had mean CRP and ESR values of only 8.67 mg/L and 12.50 mm/hr, respectively, whereas the perforated group exhibited markedly elevated values averaging 64.92 mg/L for CRP and 49.75 mm/hr for ESR. All pathological categories beyond the normal group showed

349

statistically significant p-values (<0.001), indicating that both markers strongly correlate with severity. This suggests that CRP and ESR not only aid in diagnosis but may also help predict complications and advanced disease.

Table 5 analyses the diagnostic accuracy of CRP, ESR, and total leukocyte count. CRP exhibited the highest sensitivity (91.40%), specificity (75.00%), and positive predictive value (95.55%) among the three markers. ESR demonstrated slightly lower sensitivity (84.00%) and specificity (68.75%), while total leukocyte count showed moderate accuracy with sensitivity of 87.80% and specificity of 62.50%. Negative predictive values for all markers were relatively lower, with CRP being the highest at 60.00%. All markers showed statistically significant p-values, establishing their usefulness in diagnosing acute appendicitis. Overall, CRP emerged as the single most reliable marker in terms of diagnostic performance.

Table 1: Distribution of Patients by Demographic Characteristics (n = 98)

Variable	Category	Number (%)
Age Group (years)	12–20	22 (22.45%)
	21–30	38 (38.78%)
	31–40	24 (24.49%)
	>40	14 (14.29%)
Mean Age ± SD	—	27.8 ± 8.6 years
Sex	Male	62 (63.27%)
	Female	36 (36.73%)
p-value (Male vs Female)	—	0.041

Table 2: Clinical Presentation Among Patients (n = 98)

Clinical Feature	Number (%)
Pain in Right Iliac Fossa	98 (100.00%)
Migration of Pain	64 (65.31%)
Anorexia	72 (73.47%)
Nausea/Vomiting	69 (70.41%)
Fever (>38°C)	47 (47.96%)
Rebound Tenderness	58 (59.18%)
Raised Total Leukocyte Count	79 (80.61%)
Neutrophilia (>75%)	74 (75.51%)
Mean Alvarado Score ± SD	7.6 ± 1.3

Table 3: Distribution of CRP and ESR Levels in Confirmed Acute Appendicitis

Marker	Mean ± SD	Elevated n (%)	p-value
CRP (mg/L)	38.42 ± 11.76	86 (87.76%)	<0.001
ESR (mm/hr)	32.65 ± 9.48	78 (79.59%)	<0.001
Total Leukocyte Count	13,420 ± 2,860	79 (80.61%)	<0.001

Table 4: Correlation of CRP and ESR with Histopathological Severity (n = 98)

HPE Category	n (%)	Mean CRP (mg/L)	Mean ESR (mm/hr)	p-value (CRP)	p-value (ESR)
Normal Appendix	6 (6.12%)	8.67	12.50	—	—
Catarrhal	18 (18.37%)	22.14	24.11	<0.001	<0.001
Suppurative	46 (46.94%)	40.85	33.67	<0.001	<0.001
Gangrenous	16 (16.33%)	52.44	41.56	<0.001	<0.001
Perforated	12 (12.24%)	64.92	49.75	<0.001	<0.001

Table 5: Diagnostic Accuracy of CRP, ESR, and TLC in Predicting Acute Appendicitis

Parameter	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	p-value
CRP (>10 mg/L)	91.40%	75.00%	95.55%	60.00%	<0.001
ESR (>20 mm/hr)	84.00%	68.75%	92.86%	48.00%	0.002
Total Leukocyte Count (>11,000)	87.80%	62.50%	93.67%	44.44%	0.003

DISCUSSION

In the present study, acute appendicitis predominantly affected young adults, with a mean age of 27.8 ± 8.6 years and the highest proportion of patients in the 21–30-year age group (38.78%). Males constituted 63.27% of the cohort, and this male predominance was statistically significant (p = 0.041). These findings are comparable to those of Yildirim et al (2006), who reported a mean age of 31.8 years and a male predominance of 72.9% (62/85) among patients operated on for suspected appendicitis, reinforcing the observation that acute appendicitis is primarily a disease of young adults with a slight to moderate male predominance.[8]

The clinical profile in this series was typical of acute appendicitis, with all patients presenting with right iliac fossa pain (100.00%), and a high frequency of migration of pain (65.31%), anorexia (73.47%), nausea/vomiting (70.41%), and rebound tenderness (59.18%). These observations align well with the meta-analysis by Andersson et al (2004), who demonstrated that migration of pain, signs of peritoneal irritation (rebound tenderness, guarding, rigidity), and inflammatory markers such as raised white cell count and C-reactive protein had the strongest discriminatory value in suspected appendicitis, with receiver operating characteristic (ROC) areas ranging from 0.78 to 0.68 for these variables and up to 0.85–0.87 for inflammatory markers in perforated appendicitis.[9]

Leukocytosis and neutrophilia were prominent features in our patients, with raised total leukocyte count in 80.61% and neutrophilia (>75%) in 75.51% of cases. These findings are comparable to those of Lee et al (2004), who evaluated the diagnostic value of laboratory tests in acute appendicitis and reported sensitivities of 68.5% for WBC >10,000/mm³, 85.1% for neutrophil count >70% or >7,000/mm³, and 74.0% for CRP >12 mg/L, with corresponding specificities of 86.0%, 73.3%, and 80.0%, respectively.[10] Our slightly higher proportion of leukocytosis may reflect the inclusion of a substantial number of patients with suppurative (46.94%), gangrenous (16.33%), and perforated (12.24%) appendicitis, in whom the inflammatory response is expected to be more pronounced.

In this study, CRP was elevated in 87.76% of patients with a mean value of 38.42 ± 11.76 mg/L, and demonstrated the highest diagnostic performance with sensitivity of 91.40%, specificity of 75.00%, and positive predictive value of 95.55% at a cut-off >10 mg/L. Hallan and Asberg (1997), in a systematic review of 22 studies involving 3,436 patients, reported pooled sensitivity and specificity values for CRP of 0.62 and 0.66, respectively, concluding that CRP is a test of medium diagnostic accuracy and slightly inferior to total leukocyte count for diagnosing appendicitis.[11]

When CRP and ESR were analyzed together, our study showed ESR elevation in 79.59% of patients (mean 32.65 ± 9.48 mm/hr), with diagnostic sensitivity of 84.00% and specificity of 68.75% for ESR >20 mm/hr, compared with CRP sensitivity of 91.40% and specificity of 75.00%. Dahmardehei et al (2013), in a cohort of 426 patients with suspected appendicitis, reported leukocytosis in 81%, and found that CRP had a sensitivity of 85.0% and specificity of 57.0%, while ESR had a sensitivity of 71.9% and specificity of 39.0%; positive predictive values for CRP and ESR were 89% and 83%, respectively.[12]

A key observation in our study was the stepwise increase in mean CRP and ESR levels with rising histopathological severity: CRP rose from 8.67 mg/L in normal appendices to 22.14 mg/L in catarrhal, 40.85 mg/L in suppurative, 52.44 mg/L in gangrenous, and 64.92 mg/L in perforated appendicitis; ESR showed a corresponding rise from 12.50 mm/hr to 24.11, 33.67, 41.56, and 49.75 mm/hr, respectively. Rodriguez-Sanjuan et al (1999) demonstrated a similar pattern in children, reporting mean CRP values of 4.3 mg/dL in histologically confirmed appendicitis versus 1.2 mg/dL in patients with normal appendices, with CRP levels increasing in parallel with the severity of inflammation and achieving a sensitivity of 58% and specificity of 80% at a cut-off of 1.7 mg/dL.[13]

Our perforated and gangrenous appendicitis subgroups showed particularly high inflammatory marker levels, with mean CRP values of 52.44 mg/L and 64.92 mg/L and ESR values of 41.56 mm/hr and 49.75 mm/hr, respectively, indicating that markedly elevated CRP and ESR are associated with complicated disease. Peltola et al (1986) studied 162 children with acute abdominal symptoms and found that when symptoms had been present for at least 12 hours, CRP >10 mg/L was seen in 72% of histologically proven appendicitis, compared with leukocytosis in 58% and elevated ESR in 51%; in gangrenous appendicitis, CRP alone identified 83% of cases and the combination of raised CRP and leukocytosis identified at least 96% of gangrenous or perforated appendicitis.[14]

Finally, the overall diagnostic performance of inflammatory markers in our study—CRP sensitivity 91.40% and specificity 75.00%, ESR sensitivity 84.00% and specificity 68.75%, and TLC sensitivity 87.80% and specificity 62.50%—is comparable to results reported in paediatric populations where combined markers were evaluated. Siddique et al (2011) observed that in 204 children undergoing appendectomy, WCC had higher diagnostic accuracy and sensitivity than CRP for simple appendicitis, but that combining WCC and CRP increased sensitivity to 95% for simple appendicitis and 100% for perforated appendicitis.[15]

CONCLUSION

In this prospective study of 98 patients with suspected acute appendicitis, CRP and ESR were found to be reliable inflammatory markers, with CRP

demonstrating the highest diagnostic accuracy. Elevated CRP and ESR levels showed a clear, stepwise correlation with histopathological severity, particularly in suppurative, gangrenous, and perforated appendicitis. Combining CRP and ESR with total leukocyte count and clinical assessment improved diagnostic confidence and helped identify patients at risk of complicated disease. These findings support the routine use of CRP, and to a lesser extent ESR, as valuable adjuncts in the evaluation and management of acute appendicitis in tertiary care settings.

REFERENCES

1. Addiss DG, Shaffer N, Fowler BS, Tauxe RV. The epidemiology of appendicitis and appendectomy in the United States. Am J Epidemiol. 1990;132(5):910–25. Available from: https://pubmed.ncbi.nlm.nih.gov/2239906PubMed+2OUP Academic+2

2. Shogilev DJ, Duus N, Odom SR, Shapiro NI. Diagnosing appendicitis: evidence-based review of the diagnostic approach in 2014. West J Emerg Med. 2014;15(7):859–71. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4251237 PMC+2PubMed+2

3. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med. 1986;15(5):557–64. Available from: https://pubmed.ncbi.nlm.nih.gov/3963537PubMed+1

4. Ohmann C, Yang Q, Franke C; The Abdominal Pain Study Group. Diagnostic score for acute appendicitis. Eur J Surg. 1995;161(4):273–81. Available from: https://pubmed.ncbi.nlm.nih.gov/7612771PubMed+2PubMed+2

5. Grönroos JM, Grönroos P. Leucocyte count and C-reactive protein in the diagnosis of acute appendicitis. Br J Surg. 1999;86(4):501–4. Available from: https://pubmed.ncbi.nlm.nih.gov/10215824PubMed+2bjssjournals.onlinelibrary.wiley.com+2

6. Mohammed AA, Daghman NA, Aboud SM, Oshibi HO. The diagnostic value of C-reactive protein, white blood cell count and neutrophil percentage in childhood appendicitis. Saudi Med J. 2004;25(9):1212–5. Available from: https://pubmed.ncbi.nlm.nih.gov/15448768PubMed+2PubMed+2

7. Amalesh T, Shankar M, Shankar R. CRP in acute appendicitis — is it a necessary investigation? Int J Surg. 2004;2(2):88–9. Available from: https://www.sciencedirect.com/science/article/pii/S1743919106600502ScienceDirect+2journals.lww.

8. Yildirim O, Solak C, Koçer B, Unal B, Karabeyoğlu M, Bozkurt B, et al. The role of serum inflammatory markers in acute appendicitis and their success in preventing negative laparotomy. J Invest Surg. 2006;19(6):345–52. doi:10.1080/08941930600985686. Available from: https://pubmed.ncbi.nlm.nih.gov/17101603PubMed

9. Andersson REB. Meta-analysis of the clinical and laboratory diagnosis of appendicitis. Br J Surg. 2004;91(1):28–37. doi:10.1002/bjs.4464. Available from: https://pubmed.ncbi.nlm.nih.gov/14716790PubMed

10. Lee IK, Sung JY. The Diagnostic Value of Laboratory Tests in Acute Appendicitis. Ann Surg Treat Res (Korean Surgical Society). 2004;66(1):42–45. Available from: https://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE01901086DBpia+1

11. Hallan S, Asberg A. The accuracy of C-reactive protein in diagnosing acute appendicitis. Scand J Clin Lab Invest. 1997;57(5):373–80. Available from: https://www.ncbi.nlm.nih.gov/books/NBK66955/NCBI

12. Dahmardehei M, Khazaeia A, Vahab M, Sargazimoghadam M. Diagnostic Value of Leukocytosis, ESR and CRP in Patients with Suspected Acute Appendicitis. Zahedan J Res Med Sci. 2013;15(7):e92915. Available from: https://brieflands.com/articles/92915 Brieflands

13. Rodríguez-Sanjuán JC, Martín-Parra JI, Seco I, García-Castrillo L, Naranjo A. C-reactive protein and leukocyte count in the diagnosis of acute appendicitis in children. Dis Colon Rectum. 1999;42(10):1325–9. doi:10.1007/BF02234223. Available from: https://link.springer.com/article/10.1007/BF02234223SpringerLink

14. Peltola H, Ahlqvist J, Rapola J, Räsänen J, Louhimo I, Saarinen M, et al. C-reactive protein compared with white blood cell count and erythrocyte sedimentation rate in the diagnosis of acute appendicitis in children. Acta Chir Scand. 1986;152:55–8. Available from: https://pubmed.ncbi.nlm.nih.gov/3953219PubMed

15. Siddique K, Baruah P, Bhandari S, Mirza S, Harinath G. Diagnostic accuracy of white cell count and C-reactive protein for assessing the severity of paediatric appendicitis. JRSM Short Rep. 2011;2(7):59. doi:10.1258/shorts.2011.011025. Available from: https://pubmed.ncbi.nlm.nih.gov/21847441PubMed