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STUDY ROLE OF C-REACTIVE PROTEIN (CRP), ERYTHROCYTE SEDIMENTATION RATE (ESR) AND SERUM AMYLASE IN THE DIAGNOSIS OF ACUTE APPENDICITIS

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ABSTRACT

Background: Acute appendicitis is among the most common surgical emergencies, yet its diagnosis can be challenging due to variable presentations. Laboratory biomarkers such as C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and serum amylase may aid in diagnosis and assessment of severity. **Aim:** This study aims to evaluate the diagnostic accuracy of C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and serum amylase in diagnosing acute appendicitis, as well as their association with the severity of the disease. **Methods:** This prospective study was conducted over 24 months in the Department of General Surgery, Era's Lucknow Medical College & Hospital, including 60 patients aged >18 years presenting with clinically suspected appendicitis. Demographic data, Alvarado score, ultrasonography findings, and laboratory parameters (WBC count, neutrophil count, CRP, ESR, and serum amylase) were recorded. Patients were classified intraoperatively and histopathologically into normal, inflamed, or complicated appendicitis. Data were analyzed using ANOVA, the chi-square test, and ROC analysis. **Results:** Most patients were male (71.7%) with a mean age of 33.50 ± 12.87 years. Peri-appendicular fluid was seen in 76.7% on ultrasonography. Mean ESR was significantly higher in complicated cases (95.0 ± 7.07 mm/hr) compared to inflamed (32.80 ± 14.68 mm/hr) and normal appendix (13.79 ± 2.69 mm/hr) ($p < 0.001$). CRP levels were elevated in appendicitis but did not significantly differ among groups ($p = 0.368$). Serum amylase was markedly elevated in complicated cases ($p < 0.001$). ROC analysis showed ESR ≥18.5 mm/hr had 100% sensitivity and specificity (AUC = 1.00, $p < 0.001$). **Conclusion:** ESR demonstrated excellent diagnostic performance in acute appendicitis, surpassing CRP and serum amylase. Incorporating ESR with clinical assessment may improve diagnostic accuracy and guide timely intervention.

KEYWORDS : Acute Appendicitis, C-reactive Protein, Erythrocyte Sedimentation Rate, Serum Amylase, ROC Analysis

INTRODUCTION

Acute appendicitis remains one of the most common surgical emergencies worldwide, with a lifetime risk of approximately 7–8% in the general population. Untreated vermiform appendix inflammation can cause perforation, peritonitis, abscess formation, and sepsis, increasing morbidity and mortality [1,2]. Anorexia, nausea, vomiting, and low-grade fever are common symptoms of periumbilical or epigastric stomach pain that localizes to McBurney's point in the right iliac fossa [3,4]. However, classical presentation is not universal. Young children, elderly patients, pregnant women, and atypical appendix placements often have variations, which might delay diagnosis and treatment [5].

Traditional diagnosis involves clinical examination, laboratory tests, and imaging. Localized tenderness, rebound tenderness, and specific maneuvers (Rovsing's, psoas, and obturator indications) are helpful but not conclusive [6–8]. Ultrasonography (USG) and computed tomography (CT), the gold standard because of their high sensitivity and specificity, are significant [7]. In resource-limited environments, imaging may delay decision-making, be expensive, and expose younger populations to radiation.

Clinical scoring systems like the Alvarado score stratify patients by symptomatology, physical findings, and test results to facilitate diagnosis. High scorers can go straight to surgery, but intermediate scorers need more imaging [9,10]. However, imaging for intermediate-probability patients may not be viable in rural or low-resource healthcare systems, indicating the importance of simple, quick, and cost-effective diagnostic adjuncts. It is crucial to avoid removing a histologically normal appendix, which occurs in 15–25% of appendicitis cases [11]. Negative appendectomy puts patients at risk and wastes healthcare resources. Inflammatory biomarkers improve diagnostic accuracy, reduce negative appendectomy rates, and predict disease severity. CRP, ESR, and, less often, serum amylase have been studied as markers.

The liver produces acute-phase reactant CRP in response to pro-inflammatory cytokines such as interleukin-6. It rises within 6–12 hours of inflammation and can detect appendicitis and predict complications such as perforation or gangrene when levels are elevated, especially with leukocytosis and neutrophilia [12,13]. High CRP levels (>1 mg/dL) are common in appendicitis, whereas normal levels after 24 hours have a 97–100% negative predictive value [14-16]. ESR, a less specific test, indicates systemic inflammation and may aid diagnosis when combined with other parameters [17]. ESR may correlate with inflammation duration and help diagnose complex appendicitis, although its slower rise than CRP limits its early use.

Serum amylase, usually high in pancreatitis, may be slightly elevated in appendicitis, especially in complex cases with peritonitis or intestinal inflammation. Although nonspecific, its inclusion in a diagnostic panel may help distinguish appendicitis from other acute abdominal diseases. One laboratory measure cannot identify appendicitis [18], but CRP, ESR, and serum amylase interpretation in conjunction with clinical symptoms may improve diagnostic precision, reduce negative appendectomy rates, and guide timely surgical intervention. They are especially useful when sophisticated imaging is unavailable or delayed.

Given the high frequency of appendicitis, its heterogeneous presentation, and the need for prompt detection, it is important to test these indicators across diverse populations. The North Indian population's demographics and healthcare access issues make such a study relevant. Thus, this study examined the diagnostic accuracy of CRP, ESR, and serum amylase in suspected acute appendicitis cases to determine their individual and combined diagnostic roles and their ability to predict disease severity and complications.

METHODS

The present research study was a prospective observational study that took place in the Department of General Surgery at Era's Lucknow

Medical College & Hospital (ELMCH) in Lucknow, with help from the Department of Radiology. The hospital is a tertiary care center that offers surgical and diagnostic services to people in both cities and rural areas. The study lasted for twenty-four months, which was enough time to recruit and follow up with patients.

Patients over 18 years old who were admitted to the Department of General Surgery with a diagnosis of acute appendicitis and were going to have surgery were included in the study. The study recruited individuals from both the emergency department and the outpatient department (OPD). Patients who were known or thought to have cancer were not allowed to take part in the study. The Department of Social and Preventive Medicine at ELMCH used the formula for estimating proportions to figure out the sample size. To achieve 80% study power, the minimum sample size needed was calculated to be 60 patients using p = 61.6% (the percentage of acute appendicitis cases with a positive CRP level, as reported by Omraninava et al. [19]), q = 100 – p, α = 5% (95% confidence level), and a margin of error (L) equal to 20% of p.

The Institutional Ethical Committee of Era's Lucknow Medical College & Hospital, Lucknow, looked over and approved the study plan. Before they could join, all participants had to submit their written consent. If the patient's condition made it impossible for them to express direct consent, the attendant or legal guardian who was with them did. All procedures adhered to the ethical principles of the Declaration of Helsinki.

Eligible patients had a full clinical examination and a history taken, which included any previous abdominal surgery. The lab tests included the number of white blood cells (WBC), the number of neutrophils, the level of C-reactive protein (CRP), the rate of erythrocyte sedimentation (ESR), and the level of serum amylase. Radiological tests were done when they were needed. A standard form was used to record demographic information, clinical presentation, and investigation results. They noted the surgery's risks, events, and any issues that arose.

Statistical Analysis

We used version 21.0 of SPSS (Statistical Package for Social Sciences) to do the statistical analysis. Mean ± standard deviation (SD) was used to show continuous variables, and numbers and percentages were used to show categorical variables. We used the chi-square test to compare proportions between groups and the one-way analysis of variance (ANOVA) to compare mean values. A p-value of less than 0.05 was thought to be statistically significant.

RESULTS

Table 1 shows the study's patients' ages and genders. Most patients were 18–30 years old (n = 32, 53.3%), followed by 31–40 years (n = 14, 23.3%). Age distribution: 51-60 years (n = 10, 16.7%), 41-50 years (5.0%, n = 3), and ≥61 years (one patient, 1.7%). The study population had a mean age of 33.50 ± 12.87 years, ranging from 18 to 62 years. Most cases were male (n = 43, 71.7%), while females made up 28.3% (n = 17).

Table 1: Age and Gender Distribution of Study Participants

		n	%
Age (years)	18-30 years	32	53.3
	31-40 years	14	23.3
	41-50 years	3	5.0
	51-60 years	10	16.7
	≥61 years	1	1.7
	Mean±SD (Range)	33.50±12.87 (18-62) years	
Gender	Female	17	28.3
	Male	43	71.7

Table 2 shows study participants' USG and Alvarado scores. All 46 patients (76.7%) exhibited peri-appendicular fluid, a lumen width higher than 7 mm, and a wall thickness greater than 2 mm, indicating acute appendicitis. The remaining 14 patients (23.3%) were deemed normal on USG due to no peri-appendicular fluid, lumen diameter ≤7 mm, and wall thickness ≤2 mm. Appendix lumen diameters ranged from 2 to 15 mm, with a mean ± SD of 8.5 ± 3.7 mm. The wall thickness ranged between 1-10 mm, with a mean ± SD of 5.1 ± 2.6 mm. Patients' Alvarado scores varied from 2 to 10, with a mean ± SD of 7.5 ± 2.7, indicating moderate to high chance of acute appendicitis.

Table 2: Ultrasonography (USG) Findings and Alvarado Score in Study Participants

		n		%	
USG findings and Alvarado Score	Peri-appendicular Fluid Present	46		76.7	
	Presence of Peri-appendicular Fluid/ Lumen diameter >7 mm & Wall thickness >2mm	Acute Appendicitis		46	
	No peri-appendicular fluid, Lumen diameter ≤7mm & Wall thickness ≤2mm	Normal		14	
		Min.	Max.	Mean	SD
	Diameter of Lumen	2	15	8.5	3.7
	Wall Thickness	1	10	5.1	2.6
	Alvarado Score	2	10	7.5	2.7

Table 3a compares mean ESR, CRP, and serum amylase levels in normal, inflamed, and complicated appendicitis patients, as assessed by ANOVA. Complex cases had a considerably higher mean ESR (95.00 ± 7.07 mm/hr) compared to inflamed (32.80 ± 14.68 mm/hr) and normal (13.79 ± 2.69 mm/hr) cases (F = 37.757, p < 0.001). Complex appendicitis had the highest mean CRP levels (90.00 mg/L), followed by inflamed (61.78 ± 34.83 mg/L) and normal cases (55.36 ± 25.00 mg/L), although the differences were not significant (F = 1.017, p = 0.368 Serum amylase levels significantly increased in complex appendicitis (15,000 ± 7,071 U/L) compared to inflamed (79.36 ± 39.58 U/L) and normal (70.71 ± 16.66 U/L) cases (F = 245.054, p < 0.001).

Table 3a: Comparison of Mean ESR, CRP, and Serum Amylase Levels According to Severity of Appendicitis (ANOVA)

	Normal (n=14)		Inflamed (n=44)		Complicated (n=2)		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	F	'p'
ESR (mm/hr)	13.79	2.69	32.80	14.68	95.00	7.07	37.757	<0.001
CRP (mg/L)	55.36	25.00	61.78	34.83	90.00	0.00	1.017	0.368
Amylase	70.71	16.66	79.36	39.58	15000	7071	245.054	<0.001

Post hoc Tukey HSD analysis for between-group differences is in Table 3b. Significant variations in ESR were seen between normal and inflamed (mean difference 19.01 mm/hr, p < 0.001), normal and complex (81.21 mm/hr, p < 0.001), and inflamed and complicated (62.21 mm/hr, p < 0.001). No group had significant CRP differences (all p > 0.05). Compared to normal and inflamed instances, complicated cases had considerably higher serum amylase levels (mean difference 14,929 U/L, p < 0.001), while the difference between normal and inflamed cases was not significant (p = 0.999).

Table 3b: Post Hoc Tukey HSD Analysis of Between-Group Differences in ESR, CRP, and Serum Amylase Levels

	Normal vs. Inflammed			Normal vs. Complicated			Inflammed vs. Complicated		
	Mean	SE	'p'	Mean	SE	'p'	Mean	SE	'p'
ESR	19.01	3.94	<0.001	81.21	9.71	<0.001	62.21	9.29	<0.001
CRP	6.42	9.98	0.797	34.65	24.58	0.343	28.23	23.51	0.458
Amylase	9.51	287.58	0.999	14929	708	<0.001	14919	678	<0.001

Table 4 shows how Alvarado score affects appendicitis severity. Normal appendix patients exhibited a considerably lower mean Alvarado score (2.86 ± 0.36) compared to inflamed (8.80 ± 0.98) and complex (10.00 ± 0.00) appendicitis patients. Higher Alvarado scores were significantly linked with greater disease severity across groups (p < 0.001).

Table 4: Association of Severity of Appendicitis with Alvarado Score

	N	Mean score	SD	p-Value
Normal	14	2.86	0.36	<0.001
Inflamed	44	8.80	0.98	
Complicated	2	10.00	0.00	

Table 5 shows the ESR, CRP, and serum amylase ROC analyses for the prediction of acute appendicitis. ESR showed the highest diagnostic accuracy, using a cut-off value of ≥18.5 mm/hr with 100% sensitivity and specificity (AUC = 1.00, $p < 0.001$), demonstrating strong discriminatory ability. At a cut-off of ≥62.55 mg/L, CRP had reasonable diagnostic performance (58.7% sensitivity, 78.6% specificity, AUC = 0.532, p = 0.720). With a cut-off of ≥68 U/L, serum amylase had 65.2% sensitivity, 64.3% specificity, and an AUC of 0.593 (p = 0.294), indicating lower diagnostic value than ESR.

Table 5: Receiver Operating Characteristic (ROC) Analysis of ESR, CRP, and Serum Amylase in Predicting Acute Appendicitis

Parameter	Cut-off	Sensitivity	Specificity	AUC	SE	'p'
ESR	≥18.5	100.0%	100.0%	1.00	0.00	<0.001
CRP	≥62.55	58.7%	78.6%	0.532	0.083	0.720
Amylase	≥68	65.2%	64.3%	0.593	0.077	0.294

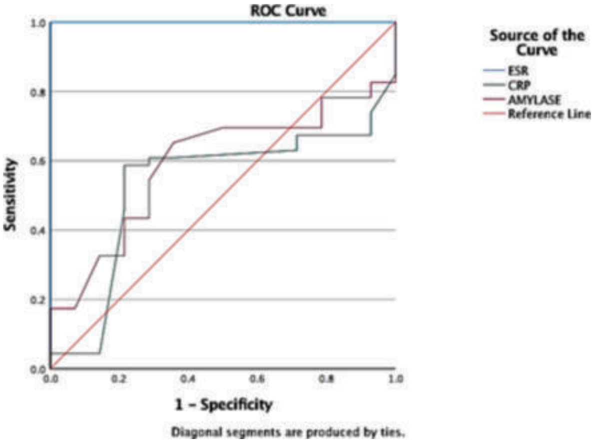

Fig. 1: ROC Curves for ESR, CRP, and Serum Amylase in the Diagnosis of Acute Appendicitis

DISCUSSION

Acute appendicitis is one of the most commonly encountered surgical emergencies across all age demographics [1,2]. Traditionally, it manifests as periumbilical stomach pain that subsequently localizes to the right lower quadrant, frequently accompanied by nausea, vomiting, anorexia, and low-grade fever [3, 4]. The fundamental pathophysiology usually commences with the obstruction of the appendiceal lumen, often resulting from lymphoid hyperplasia, fecaliths, foreign bodies, or infections, which subsequently causes elevated intraluminal pressure, bacterial growth, inflammation, and ischemia. In the absence of prompt intervention, this process may advance to gangrene and perforation within 36–72 hours, potentially leading to peritonitis or intra-abdominal abscesses [5].

Notwithstanding progress in diagnostic imaging and the implementation of scoring systems like the Alvarado score [9], diagnosis remains difficult, especially in youngsters, elderly individuals, and pregnant women [5,6]. Atypical presentations and symptom overlap with other abdominal conditions may require supplementary diagnostic methods. Recent years have witnessed an increasing interest in laboratory biomarkers, including C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and serum amylase, for early detection and severity evaluation.

C-reactive protein (CRP) is an acute-phase reactant produced by the liver in response to pro-inflammatory cytokines, including interleukin-6. It ascends within 6–12 hours of the initiation of inflammation and reaches its zenith within 24–48 hours, rendering it a significant indicator of disease development. Increased CRP levels have been linked to more severe phases, including gangrenous or perforated appendicitis [17, 18]. Nonetheless, CRP exhibits a lack of illness specificity and is most efficacious when utilized alongside white blood cell (WBC) count, neutrophil percentage, and imaging results [12]. It is more sensitive in complex appendicitis than in first, uncomplicated instances.

The erythrocyte sedimentation rate (ESR) is a nonspecific inflammatory test indicative of red blood cell aggregation resulting from alterations in plasma proteins [13]. It ascends more gradually than CRP and persists at elevated levels for an extended duration, thereby constraining its effectiveness in the early diagnosis of disease. Nonetheless, it may prove beneficial in recognizing subacute or complex manifestations.

Serum amylase, traditionally linked to pancreatic disorders, has also been observed to elevate in certain cases of appendicitis, especially those that are perforated [20, 21]. This increase is presumed to result from inflammatory dissemination to neighboring structures or a systemic inflammatory response. Due to its limited sensitivity and specificity, amylase is not advised as a standalone diagnostic test for appendicitis.

This study assessed these biomarkers in conjunction with ultrasonography and the Alvarado rating in 60 adult patients. The average age was 33.50 ± 12.87 years, with a male majority of 71.7%, yielding a male-to-female ratio of around 2.5:1. Previous studies indicated more even gender proportions [20, 22]. While certain data indicates that inflammatory responses may differ by sex, no significant gender-specific performance disparities in these biomarkers have been consistently documented.

In our study, merely 4.35% exhibited complex appendicitis, whereas 95.65% presented with an inflamed appendix. This proportion is inferior to that shown in studies by previous studies [20, 23], where complex cases constituted 10–30%. The diminished incidence of complex patients in our study certainly affected biomarker efficacy, especially CRP and amylase, which often elevate in advanced illness stages.

Ultrasonography demonstrated peri-appendiceal fluid in 76.7% of instances, corroborating acute appendicitis. Our dependence on ultrasonography for diagnosis contrasts with other studies that consider CT scanning the gold standard [24], which may influence diagnostic classification and, subsequently, biomarker precision.

ESR was identified as the most precise biomarker in our investigation, with a cut-off of ≥18.5 mm/hr demonstrating 100% sensitivity and 100% specificity (AUC = 1.00, $p < 0.001$). ESR levels increased steadily with illness severity: 13.79 ± 2.69 mm/hr in normal appendices, 32.80 ± 14.68 mm/hr in inflamed appendices, and 95.00 ± 7.07 mm/hr in complex cases. These data indicate that ESR may serve as a dependable independent marker within our community. This nearly flawless performance stands in stark contrast to [11], who reported a sensitivity of 71.9% and a specificity of 39%, and another previous study determined an AUC of 0.767 [24]. The gap may arise from our reduced sample size, the overrepresentation of unequivocal situations, and the restricted number of complex cases, which can inflate performance estimates. Furthermore, the delayed increase of ESR indicates that early presenters may have lower values, a variable not thoroughly considered in our work.

In our study, CRP levels did not exhibit a significant difference between groups (p = 0.368) and showed suboptimal diagnostic ability (AUC = 0.532). Despite being increased (>10 mg/L) in all cases, its sensitivity (58.7%) and specificity (78.6%) at a threshold of ≥62.55 mg/L were inadequate. Conversely, a study indicated that a CRP level beyond 40 mg/L signifies suppurative appendicitis, while a level surpassing 100 mg/L predicts gangrenous or perforated illness [23]. Another study determined that a CRP level beyond 6.15 mg/L exhibited 100% sensitivity for complex cases [25], while a study indicated a sensitivity of 94% at a CRP level greater than 6 mg/L [26]. The diminished discriminatory capacity seen in our study may be attributed to the early presentation of several patients prior to the peak of CRP levels, in addition to methodological variations in the CRP assessment.

Serum amylase exhibited a significant rise in complex cases (15,000 ± 7,071 IU/L) relative to inflamed (79.36 ± 39.58 IU/L) and normal appendixes (70.71 ± 16.66 IU/L); however, the overall diagnostic accuracy remained low (AUC = 0.593). A study indicated that amylase levels over 46 mg/dL exhibited 89% sensitivity and 100% specificity for perforated appendicitis [20], while another study noted a 90.3% positive predictive value when increased; nonetheless, our results imply restricted independent applicability [21]. The severe outlier values in our two complex cases may have distorted results, and variations in units and test methodologies between research further confound comparisons.

The average Alvarado score in our sample was 7.5 ± 2.7, showing a positive correlation with illness severity ($p < 0.001$). This corresponds with the findings of Shogilev et al. [16], who deemed the score beneficial for risk stratification, and another study documented an AUC of 0.824, with 86.4% sensitivity and 63.2% specificity [27]. Nonetheless, similar to other investigations, the Alvarado score alone proved inadequate for a conclusive diagnosis, necessitating the use of imaging.

We did not evaluate biomarker combinations; nevertheless, some researchers have shown improved accuracy with multimarker approaches. A study shows a positive predictive value of 99.55% through the integration of WBC, CRP, and amylase [28]. Similarly, a study determined that no singular biomarker suffices; nonetheless, combinations enhance diagnostic accuracy and diminish negative appendectomy rates [16].

The constraints of our study encompass a limited sample size, an exclusively adult population, and inadequate representation of severe appendicitis, all of which restrict generalizability. The dependence on USG instead of CT as the diagnostic gold standard may have resulted in misdiagnosis. Furthermore, the timing of biomarker assessment in relation to symptom onset was not uniform, which may have influenced the results, especially for CRP.

CONCLUSION

Our study indicates that ESR is a highly sensitive and specific biomarker for acute appendicitis in our group, with values substantially associated with disease severity. CRP was raised in the majority of instances but lacked the ability to differentiate illness severity, while serum amylase exhibited a significant rise in difficult cases but had restricted overall diagnostic utility. Although ESR has shown remarkable efficacy in our dataset, the prevailing literature advocates for its application solely as an auxiliary rather than a primary diagnostic instrument. Subsequent investigations should concentrate on bigger, more heterogeneous cohorts, consistent timing for biomarker assessment, and the amalgamation of multimarker panels with imaging to enhance diagnostic precision, minimize unwarranted procedures, and optimize patient outcomes.

REFERENCES

1. D'Souza N, Nugent K. Appendicitis. BMJ Clin Evid. 2014;2014:0408.
2. Lotfollahzadeh S, Lopez RA, Deppen JG. Appendicitis. [Updated 2024 Feb 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. Available from: https://www.ncbi.nlm.nih.gov/books/NBK493193/#
3. Moris D, Paulson EK, Pappas TN. Diagnosis and Management of Acute Appendicitis in Adults: A Review. JAMA. 2021;326(22):2299-311.
4. Echevarria S, Rauf F, Hussain N, Zaka H, Farwa UE, Ahsan N, et al. Typical and Atypical Presentations of Appendicitis and Their Implications for Diagnosis and Treatment: A Literature Review. Cureus. 2023;15(4):e37024.
5. Almaramhy HH. Acute appendicitis in young children less than 5 years: review article. Ital J Pediatr. 2017;43(1):15.
6. Prosenz J, Hirtler L. Rovsing sign revisited—effects of an erroneous translation on medical teaching and research. J Surg Educ. 2014;71(5):738-42.
7. Yale SH, Tekiner H, Yale ES. Signs and syndromes in acute appendicitis: A pathophysiologic approach. World J Gastrointest Surg. 2022;14(7):727-30.
8. Guthy E. Zur Klinik und Diagnose der akuten Appendizitis [Clinical signs and diagnosis of acute appendicitis]. Zentralbl Chir. 1999;124(6):554-5.
9. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med. 1986;15(5):557-64.
10. Terasawa T, Blackmore CC, Bent S, Kohlwes RJ. Systematic review: computed tomography and ultrasonography to detect acute appendicitis in adults and adolescents. Ann Intern Med. 2004;141(7):537-46.
11. Dahmardehei M, Khazaei 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):59-63.
12. Baghi I. Association rate of leukocytosis, increased CRP and ESR with acute appendicitis. J Guilan Univ Med Sci. 2006;15(57):54-8.
13. Lawrence WW, Doherth G, Gerard M. Current surgical diagnosis and treatment. 11th ed. New York: McGraw Hill; 2003. p. 668-74.
14. National Surgical Research Collaborative. Multicentre observational study of performance variation in provision and outcome of emergency appendicectomy. Br J Surg. 2013;100(9):1240-52.
15. Cole MA, Maldonado N. Evidence-based management of suspected appendicitis in the emergency department. Emerg Med Pract. 2011;13(10):1-29.
16. 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.
17. Kim HC, Yang DM, Lee CM, Jin W, Nam DH, Song JY, et al. Acute appendicitis: relationships between CT-determined severities and serum white blood cell counts and C-reactive protein levels. Br J Radiol. 2011;84(1008):1115-20.
18. Zinner MJ, Ashley SW. Maingot's abdominal operations. 11th ed. New York: McGraw-Hill; 2007. p. 589-611.
19. Omraninava M, Javan S, Mahmodi G. Precision of C-reactive protein in the diagnosis of acute appendicitis. Soc Determin Health. 2022;8:1-6.
20. Amanollahi O, Tat S. The study of diagnostic value of elevation of serum amylase as a predictive factor for appendiceal perforation in children with acute appendicitis. Int J Pediatr. 2018;6(2):7213-7.
21. Javed MA, Ahmad S, Raza VF, Khan KJ. Positive predictive value of serum amylase in predicting acute appendicitis taking histopathology as gold standard. PJMHS. 2021;15(9):2485-7.
22. Sharma PC, Jain A. Study of predictive value of serum C-reactive protein in diagnosis of acute appendicitis. MedPulse Int J Surg. 2021;19(1):31-4.
23. Rajaa MH, Elshaikha E, Williamsa L, Ahmed MH. The value of C-reactive protein in enhancing diagnosis of acute appendicitis. J Curr Surg. 2017;7(1-2):7-10.
24. Nazik S, Avci V, Kiraz KZ. Ischemia-modified albumin and other inflammatory markers in the diagnosis of appendicitis in children. Ulus Travma Acil Cerrahi Derg. 2017;23(4):317-21.
25. Choudhary SK, Yadav BL, Gupta S, Kumar N, Bansal S, Verma PK. Diagnostic value of C-reactive protein as a predictor of complicated appendicitis like perforated/gangrenous appendicitis. Int Surg J. 2019;6(5):1761-6.
26. Gowda VSS, Ananda BB, Kumar PS, Bharathiraja T. Role of C-reactive protein in acute appendicitis: A diagnostic approach. Int J Health Sci. 2022;6(S6):1887-92.
27. Talabi AO, Adedeji TA, Sowande OA, Adejuyigbe O. Predictive values of Alvarado score, serum C-reactive protein, and white blood cell count in the diagnosis of acute appendicitis: a prospective study. Ann Pediatr Surg. 2021;17:8.
28. Salih IK, Al-Dabbagh AJ, Hassan QA. The value of inflammatory markers in acute appendicitis: a diagnostic accuracy study. Pak J Med Health Sci. 2018;11(4):1-4.