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ORIGINAL RESEARCH

Assessing the Diagnostic Accuracy of Clinical, Radiological, and Biochemical Findings with Post-operative HPR in Acute Appendicitis Cases

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ABSTRACT

Introduction: Acute appendicitis represents a significant clinical challenge, necessitating accurate and prompt diagnosis to ensure effective treatment. This study aims to correlate clinical, biochemical, and radiological diagnoses with post-operative HPR findings of acute appendicitis patients. **Materials/Patients and Methods:** Prospective observational research was conducted on 168 patients who presented with features suggestive of acute appendicitis to the Department of General Surgery, B.L.D.E. (D.U.), VIJAYAPURA, KARNATAKA, from July 2022 to June 2024. Data were collected on patient demographics, clinical symptoms, physical examination findings, biochemical parameters (e.g., CRP, serum lactate), and radiological findings (Ultrasoundof abdomen and pelvis). Initial clinical, radiological, and biochemical findings were recorded and compared with post-operativehistopathological reports of the appendix. **Results:** The clinical diagnosis of acute appendicitis achieved a sensitivity of 100%, outperforming radiological diagnosis carried out using ultrasound(abdomen and pelvis), which had a sensitivity of 97.06% and CRP with levels ≥10.1 mg/l, which had a sensitivity of 89.71%. The sensitivity of lactate with levels ≥2.2 mmol/l was lower at 47.06%. Further, the results revealed that the clinical, radiological, and CRP levels are highly accurate and reliable, as the accuracy rate was84%, 80.95%, and 83.33%, respectively.However, the accuracy rate of lactate levels (46.43%) was limited. **Conclusion:** The study reaffirms the superior diagnostic accuracy of clinical diagnosis in managing acute appendicitis. While radiological and biomarker assessments provide valuable supplementary information. Elevated CRP and Lactate levels serve as important indicators of disease severity, guiding clinicians in risk stratification and management decisions.

INTRODUCTION

Appendicitis is caused by appendiceal lumen blockage due to appendicoliths, tumours, intestinal parasites, and hypertrophied lymphatic tissues.(1)(2). It is the most common acute surgical disorder of the abdomen, with a complex and multifaceted presentation that often leads to diagnostic challenges in clinical practice. Generally, clinicians rely heavily on clinical evaluation, such as McBurney, psoas, obturator, Dunphy's, and roving signs, sometimesresulting in a negative diagnosis, as patients present with similar symptoms due to gynaecological conditions.(3).Although there are advancements in acute appendicitis diagnosis, to achieve a precise diagnosis, it is essential to use a two-step approach to identify the cases of acute appendicitis and distinguish the cases during complications. No single diagnosis is efficient in diagnosing the complicated case of acute appendicitis. Thus, combining clinical, laboratory, and imaging findings is essential.

Imaging, particularly ultrasound (US) and computed tomography (CT) scanning has revolutionized over the last three decades with better accuracy in diagnosis and assistance in detecting complicated cases.(4). Recently, high-resolution US and CT scanning have emerged as tools for confirming

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clinical diagnoses and the improved outcome was found to be between 72% to 97% (5). Besides imaging, biochemical markers such as lactate and C-reactive protein levels are also been highly used recently(6)(7). These markers make the diagnostic process much more efficient and reduce unnecessary surgeries. This paper addresses the role of clinical, radiological, and biochemical findings for effective diagnosis of acute appendicitis in setting up a definitive approach to acute appendicitis diagnosis and promoting better management practices as well as decreased morbidity in patients.

Study type and ethical approval

Prospective observational research was conducted with 168 patients aged between 8 and 85 years. Patients who visited the Department of General Surgery, Shri B M Patil Medical College Hospital and Research Centre, Vijayapura, Karnataka, India, with acute pain in the abdomen and underwent surgery for acute appendicitis and provided consent lettersfor being included in the research were considered for the study.All the guidelines provided by the local ethical committee were followed and clinical investigations for all selected 168 patients were documented, and approval for the study was obtained on 30.08.2022 from the Institutional Ethical Committee (Ref. No. BLDE(DU)/IEC/669/2022-23)

Duration of Study

The research was conducted for a period of two years, beginning from July 2022 to June 2024, focusing on patients with acute pain in the abdomen.

Sample Size

The sample size for this study was determined to be 168 patients, calculated using G*Power ver. 3.1.9.4 software to achieve a power of 80% for detecting a difference in proportion with a 5% significance level. Ali M. Z. and Maddu V. K(2) outlined this sample size determination in their research, ensuring robust statistical reliability.

Inclusion Criteria

All the patients who presented to the Department of General Surgery with acute pain in the abdomen were included in the study.

Exclusive Criteria

Patients with co-existing conditions like immunocompromised, steroid therapy, radiotherapy, inflammatory bowel disease, and malignancies were excluded.

Material Used

All the samples were evaluated clinically, and radiological investigations such as Ultrasonography (USG) of the abdomen and pelvis were performed. Biochemical parameters such as CRP and serum lactate were obtained before surgery. The accuracy of clinical, radiological,and biochemical diagnoses was compared with post-operative histopathologically proven acute appendicitis. Routine investigations such as C.B.C, Hb-TC-DC, platelets, renal function tests, random blood glucose, urine – sugar, albumin, electro-cardio-gram, and viral markers (HIV, HBsAg, HCV) were also tested.

Clinical, radiological, and biochemical findings were compared using the Pearson Chi-Square test, and the significance of the test is presented.

RESULTS

Age-wise Distribution of Patients

Figure 1 provides a clear overview of how age correlates with the occurrence of acute appendicitis amongthe study population. The higher percentage (66; 39.3%) of patients were aged between 20 and 29 years, followed by 10 and 19 years (50; 29.8%), while the lowest percentage (2; 1.2%) of patients were aged above 60 years. This distribution reflects the typical age range where acute appendicitis is most frequently observed, with fewer cases in older age groups and tweens.

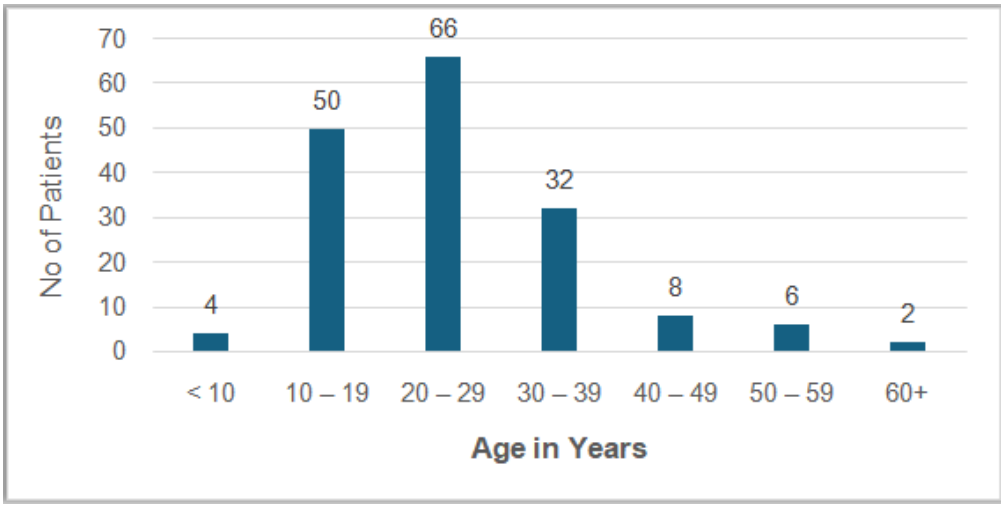

Figure 1: Frequency Distribution of Acute Appendicitis by Age

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Gender-wise Distribution of Patients

Figure 2 briefly summarizes the gender demographics of patients diagnosed with acute appendicitis, highlighting a notable difference in occurrence between males and females. Most patients were male, comprising 67% of the total cases, whereas females account for 33%. This gender disparity indicates a higher prevalence of acute appendicitis among males in the study population.

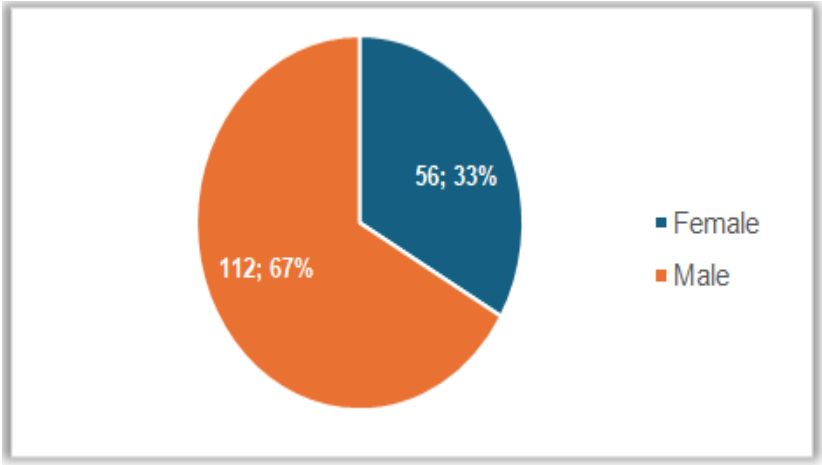

Figure 2: Gender-wise Distribution of Acute Appendicitis Patients

Crosstabulation of Clinical, Radiological, and Biochemical Findings with HPR

Table 1 presents the crosstabulation analysis ofclinical, radiological, and biochemical findings with post-operative histopathologically proven acute appendicitis cases. The clinician diagnosed 168 acute appendicitispositive cases, however,post-operative HPRfindings for acute appendicitis confirmed only 136 positive cases of acute appendicitis. This indicates that clinical diagnosis alone may not be sufficient for a definitive diagnosis. Ultrasound diagnosis of the abdomen and pelvis revealed 160 acute appendicitis-positive cases, while histopathologically proven acute appendicitis cases indicate that 28 cases of USG proven acute appendicitis were histologically negative, and four cases of USG negative for acute appendicitis were HPR proven acute appendicitis. The p-value of 0.106 for the association between USG and HPR findingsindicates a nonsignificant association. This indicates that USG has limitations in confirming acute appendicitis. The CRP (≥10.0 mg/l)levels indicated 136 HPR proven acute appendicitis. However, 14 cases of CRP (<10.0 mg/l)were HPR proven acute appendicitis, and 14 cases of CRP(≥10.0 mg/l)were HPR negative as for acute appendicitis cases. The p-value of 0.000 for the association between elevated CRP (≥10.0 mg/l) and HPR findingsindicatesa significant association. CRP can thus be considered a valuable marker in diagnosing acute appendicitis. The lactate (>=2.1mmol/l)levels indicated 82 cases of HPR proven acute appendicitis. However, 72 cases ofLactate (<2.1mmol/l)were HPR proven acute appendicitis, and 18 cases of Lactate(>=2.1mmol/l)wereHPR negative for acute appendicitis. The p-value for the association between lactate levels and HPR findings is 0.5081,which indicates no statistically significant association between lactate levels and HPR findings. This indicates lactate levels alone are not effective in distinguishing acute appendicitis true positive cases from false negative cases.

Table 1: Crosstabulation Analysis of Clinical, Radiological, and Biochemical Findings with HPR

Method		HPR Positive	HPR Negative	Total	Chi-Square Value	P Value
ClinicalDaignosis	Positive	136	32	168	NA	NA
	Negative	0	0	0		
Ultrasound (abdomen & pelvis)	Positive	132	28	160	2.610	0.106
	Negative	4	4	8		
CRP	>=10.0mg/l	122	14	136	17.74	0.000
	<10.0mg/l	14	18	32		
Lactate	>=2.1mmol/l	64	18	82	0.438	0.508
	<2.1mmol/l	72	14	86		

Diagnostic accuracy in acute appendicitis

Table 2 compares the effectiveness of diagnosis approaches for acute appendicitis with histopathological report (HPR).Clinical diagnosis

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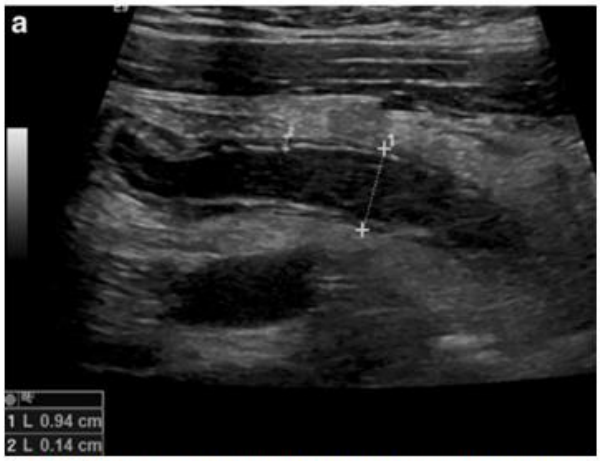
shows 100% sensitivity, 84% Positive Predictive Value (PPV), and 84% accuracy. This confirms the high reliability of clinical diagnosis in confirming acute appendicitispositive cases. Ultrasound (USG) diagnosis showeda high sensitivity of 97.06%, a positive likelihood ratio of 1.11, an accuracy of 80.95%, and a positive predictive value of 82.50%. This confirms the reliability of USG in confirming acute appendicitis positive cases. While USG diagnosis showeda specificity of 12.50%, the negative predictive value is 50.00%, and a negative likelihood ratio of 0.24. This indicates that USG diagnosis has limitations in excluding acute appendicitis-negative cases. CRP levels demonstrated a sensitivity of 89.71%, a positive likelihood ratio of 2.05, a positive predictive value of 89.71%, and an accuracy of 83.33% for acute appendicitis. This indicates that CRP biomarkers are reliable indicators of positive acute appendicitis. WhileCRP levelsshow a specificity of 56.25%, a negative likelihood ratio of 0.18, and a negative predictive value of 56.25%. This indicatesthat CRP levels are a good indicator of acute appendicitis-negative cases. Serum lactate levels exhibiteda lower sensitivity of 47.06%,a positive likelihood ratio of 0.84, a positive predictive value of 78.05%, and an accuracy of 46.43%. This indicates the moderate reliability of lactate levels in confirming acute appendicitis-positive cases. While lactate levels showed a specificity of 43.75%, a negative predictive value of 16.28%,and a negative likelihood ratio of 1.21. This indicates that lactate levels have limitations in excluding acute appendicitis-negative cases.

Statistic	Clinical Diagnosis		Radiological Diagnosis		CRP Levels		Lactate Levels	
	Value	95% CI	Value	95% CI	Value	95% CI	Value	95% CI
Sensitivity	100.00 %	95.70% to 100.00%	97.06%	89.78% to 99.64%	89.71%	79.93% to 95.76%	47.06 %	34.83% to 59.55%
Specificity	0.00%	0.00% to 20.59%	12.50%	1.55% to 38.35%	56.25%	29.88% to 80.25%	43.75 %	19.75% to 70.12%
Positive Likelihood Ratio	1.00	1.00 to 1.00	1.11	0.92 to 1.34	2.05	1.17 to 3.59	0.84	0.51 to 1.38
Negative Likelihood Ratio			0.24	0.04 to 1.55	0.18	0.08 to 0.42	1.21	0.66 to 2.20
Positive Predictive Value (*)	84.00%	84.00% to 84.00%	82.50%	79.59% to 85.07%	89.71%	83.25% to 93.86%	78.05 %	68.31% to 85.43%
Negative Predictive Value (*)			50.00%	13.21% to 86.79%	56.25%	36.06% to 74.56%	16.28 %	9.65% to 26.14%
Accuracy (*)	84.00%	75.32% to 90.57%	80.95%	70.92% to 88.70%	83.33%	73.62% to 90.58%	46.43 %	35.47% to 57.65%

Picture: 1

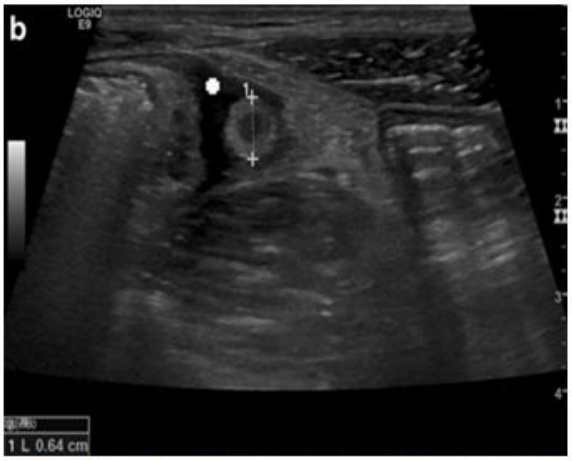
USG of Abdomen& Pelvis



Transverse and Longitudinal view of appendix with wall thickened, diameter>6mm and surrounding free fluid

Picture:2

USG of Abdomen& Pelvis



Cross-section view of an appendix with wall thickened, diameter>6mm and surrounding free fluid

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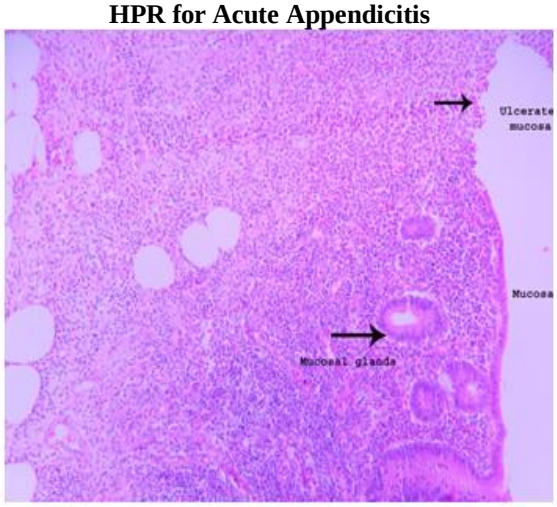
Picture: 3

Intra-operative View of Acute Appendicitis Inflamed appendix with venous congestion

Picture: 4
HPR for Acute Appendicitis



Ulcerated mucosa with lamina propria showing benign glands, mixed inflammatory infiltrate and focal lymphoid aggregates

DISCUSSION

The diagnosis of acute appendicitis poses achallenge despite progress in radiological imaging and biochemical markers. Acute appendicitis is prevalent among patients of age ranging from 10 to 29 years,which confirms the findings of Aboulwafa et al. (8). Additionally, gender distribution, as shown in Table 2, highlights a higher prevalence in males (66.7%) than females (33.3%), confirming similar findings by clinicians.(9)(8)(10)(11).

Clinical diagnosis: Clinical diagnosis is commonly followed in diagnosing acute appendicitis. This study showed a 100% sensitivity for clinical diagnosis (Table 4),indicating that all true cases were correctly identified during the initial examination. However, the specificity was remarkably low at 0%, suggesting a high rate of false positives. This low specificity could be attributed to the non-specific nature of symptoms, such as dull abdominal pain and diffuse tenderness, which are common in various abdominal conditions.(12). The positive predictive value (PPV) of 84% indicates the accuracy and reliability of the clinical diagnosis. This suggests that though the clinical diagnosis is highly effective in identifying acute appendicitis positive cases, it sometimeshaslimitations in excluding acute appendicitis-negativecases due to non-specific presentation.

Radiological Diagnosis: Ultrasoundexhibited a high sensitivity of 97.06%. The high sensitivity indicates that ultrasound is highly effective in detecting true positive cases of appendicitis. This indicates the suitability of ultrasound for confirming acute appendicitis when a clinical dilemma exists. However, ultrasound diagnosis showed low specificity,suggesting a substantial rate of false positives, which may lead to unnecessary surgical interventions.(13)(14). The positive likelihood ratio of 1.11 indicates a minimal increase in the probability of appendicitis upon a positive ultrasound finding, which reflects the low discriminatory power of ultrasound. Ultrasound can be considered as a source for confirming suspected acute appendicitis. It may not be a highly reliable standalone diagnostic tool, as it shows a substantial numberof false positive cases and lacks a strong correlation with post-operativehistopathologically proven acute appendicitis cases.

Biochemical Diagnosis: Biochemical markers, specifically CRP and lactate levels, are increasingly being used to support the diagnosis of acute appendicitis. CRP levels ≥10.1 mg/l were associated with a sensitivity of 89.71% and a specificity of 56.25%, confirming the study by Sartelli et al.(11). The relatively high specificity of CRP compared to clinical and radiological findings indicates its utility in differentiating acute appendicitis from other abdominal conditions.(6).The positive likelihood ratio of 2.05 suggests that increased CRP enhances the probability of identifying false positive acute appendicitis cases. Moreover, the positive predictive value of 89.71% and the accuracy of 83.33% emphasize the use of CRP as an additional diagnostic tool, especially in adilemma. Lactate levels of ≥2.2 mmol/l exhibited a sensitivity of just 47.06% and a specificity of 43.75%, signifying limited efficiency in diagnosingacute appendicitis. The limited sensitivity and specificity, along with a negative probability ratio of 1.21, indicate that lactate is not a dependable marker for appendicitis. The positive predictive value of 78.05% and accuracy of 46.43% further substantiate its restricted utility in the diagnosis of acute appendicitis. However, lactate enhances predictive values of acute appendicitis.(15) and assists in evaluating disease severity.

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CONCLUSION

The clinical diagnosis is critical in accurately diagnosing acute appendicitis.Additionally, ultrasound imaging assists in further confirming the cases;however,it has limited sensitivity, indicating lesser importance in ruling out false positive conditions. Thus, requires additional confirmatory tests to avoid overdiagnosis. Biomarkers such as CRP and serum lactate assist the clinician in confirming the cases as CRP levels are valuable initial indicators of acute appendicitis,and lactate levels, to an extent, assist in identifying severity. However,lactate may be less reliable as a primary diagnostic marker but has the potential to provide complementary information, particularly in evaluating the severity of acute appendicitis.Thus, it is essential to utilize elevated CRP levels asone of theindicators of acute appendicitis, while lactate levels arean additional marker. The diagnosis of acute appendicitis requires a multifaced approach to achieve high accuracy and avoid unnecessary surgical interventions. The study demonstrated that clinical, radiological, and biochemical diagnosis provides a comprehensive approach to enhance diagnostic accuracyin identifying acute appendicitis-positive cases and reduce the likelihood of false-positive cases.Future research may focus on using better algorithms to enhance the accuracy of identifying true positive and false positive acute appendicitis cases in radiological modalities and biomarkers.

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