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Diagnostic Utility of Procalcitonin and C-Reactive Protein in Detection of Bacterial Infection in Patients of Abdominal Sepsis

Dr. Kshiti Mahuli[1], Dr. Chandrashekhar Mahakalkar[2], Dr. Suhas Jajoo[3], Dr. Deepak Patil[4], Dr. Chava Aravind[5], Dr. Cherkula Anil Reddy[6]

[1]Senior Resident Mahadevappa Rampure Medical College and Basaveshwar General Hospital

Email ID: kmahuli@gmail.com

[2]Professor, Dept of General Surgery Jawaharlal Nehru Medical College, Datta Meghe Institute Of Higher Education and Research

Email ID: cmahakalkar@rediffmail.com

[3]Professor Dept of General Surgery Jawaharlal Nehru Medical College Datta Meghe Institute Of Higher Education and Research

Email ID: suhas_jajoo@yahoo.co.in

[4]Junior Resident Dept of General Surgery MRMC & BTGH

Email ID: deepakrpatil639@gmail.com

[5]SR dept of Gen Sur, JNMC, DMIHER

Email ID: chava.aravind@gmail.com

[6]SR dept of general surgery, JNMC, DMIHER

Email ID: anilreddyk36@gmail.com

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ABSTRACT

Background: The diagnostic utility of Procalcitonin (PCT) and C-Reactive Protein (CRP) as biomarkers for bacterial infection in patients with abdominal sepsis is of significant interest due to the critical nature of timely and accurate sepsis diagnosis.

Methods: This cross-sectional study included 120 patients presenting with symptoms of abdominal sepsis. We evaluated the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of PCT and CRP, and analyzed their correlation with the severity of sepsis.

Results: The mean age of the study subjects was 39.47 years, predominantly male (72.50%). PCT demonstrated a sensitivity of 85% and a specificity of 90%, while CRP showed a sensitivity of 80% and a specificity of 85%. The biomarkers correlated strongly with sepsis severity, indicating higher values in more severe cases.

Conclusion: PCT and CRP are valuable biomarkers for diagnosing bacterial infection in abdominal sepsis, with PCT showing slightly higher diagnostic accuracy than CRP.

Keywords: *Procalcitonin, C-Reactive Protein, abdominal sepsis, diagnostic biomarkers, bacterial infection.*

1. INTRODUCTION

Abdominal sepsis represents a severe systemic inflammatory response stemming from bacterial peritonitis, where the spillage of intestinal contents into the peritoneal cavity ignites a hostile reaction. Notably, postoperative bacterial infections after abdominal surgery stand as a primary cause of morbidity, underscoring the clinical gravity and complexity of managing sepsis.[1,2,3] This life-threatening condition, characterized by a dysregulated host response to infection, precipitates organ dysfunction and, without timely intervention, can escalate to multiple organ failure and septic shock. The global health challenge presented by sepsis extends beyond its immediate impact on patient mortality, resonating through the corridors of public health due to its prevalence in hospital settings and its significant contribution to in-hospital deaths.[4,5,6]

Early post-surgical infection detection is imperative, yet it is fraught with challenges due to the often ambiguous clinical signs that can mislead physicians during critical postoperative periods. This scenario underpins the urgent need for rapid and reliable diagnostic tools to preempt the worsening of patient conditions. Traditionally, microbiological culture has served as the cornerstone for diagnosing peritonitis associated with abdominal sepsis, but this method is hampered by slow turnaround times and a notable incidence of false negatives.[7]

In light of these limitations, the medical community has turned its focus towards biomarkers that can offer quicker and more accurate diagnostic capabilities. Among the array of markers explored over the years—including cytokines and various acute-phase proteins—Procalcitonin (PCT) and C-Reactive Protein (CRP) have emerged as particularly promising due to their potential to streamline diagnosis and therapeutic interventions in critically ill patients. PCT, first identified in 1984, is a polypeptide synthesized primarily in the thyroid gland's C-cells, with healthy individuals typically exhibiting levels below 0.1 ng/mL. However, PCT levels can surge to 100 ng/mL in the presence of bacterial infections, driven by an upregulation in various body cells in response to cytokines and bacterial endotoxins. This unique response profile of PCT, not commonly seen in viral infections or other inflammatory states, distinguishes it as a superior marker for bacterial sepsis.[8,9,10]

CRP, on the other hand, is a well-recognized acute-phase protein that escalates within hours of inflammation onset. Its rapid response and equally swift decline post-inflammation make it a useful, albeit nonspecific, indicator of inflammatory states. The diagnostic interplay between elevated PCT and CRP levels in patients can, therefore, provide crucial insights into the presence and severity of bacterial infections, particularly in the ambiguous and critical context of abdominal sepsis.

This study aims to rigorously evaluate the diagnostic utility of Procalcitonin and C-Reactive Protein in detecting bacterial infections among patients with abdominal sepsis, aiming to substantiate their role in improving clinical outcomes through enhanced diagnostic accuracy and timely therapeutic intervention.

2. MATERIALS AND METHODS

Study Setting: This study was carried out in the Department of Surgery at J.N.M.C and Acharya Vinoba Bhave Rural Hospital, Sawangi (Meghe), Wardha, affiliated with DMIMS (DU).

Study Population: The study population comprised patients presenting with acute abdominal conditions at AVBRH, managed either surgically or non-surgically.

Inclusion Criteria: Patients included in the study were those with:

- Non-surgical abdominal conditions such as:
    - Small bowel obstruction
    - Large bowel obstruction
    - Acute Pancreatitis
- Surgical abdominal conditions including:
    - Gastric perforation
    - Small intestinal perforation
    - Large intestinal perforation
    - Gall bladder perforation
    - Gastric outlet obstruction
    - Appendicular perforation

Exclusion Criteria: Patients were excluded based on the following criteria:

- Pregnancy or puerperium
- Known cases of Diabetes mellitus
- Malignancies
- Current immunosuppressive therapy
- Infection with hepatitis B, hepatitis C, or HIV
- Suspected extra-abdominal source of infection

Study Design: A cross-sectional analytical observational design was employed.

Sample Size: Based on the study by Yan Zhang et al., which reported the highest diagnostic accuracy for combined detection

of PCT and CRP in bloodstream infections with a prevalence of E.coli at 17.91%, a minimum sample size of 120 was calculated to achieve 90% power and a 5% level of significance, allowing for a margin of error reduction.

Duration of Study: The study was conducted over a period of two years.

Methodology: Eligibility for participation was determined using the above criteria, with all patients admitted for acute abdomen considered. Consent was obtained prior to enrollment. Participants underwent a comprehensive intake including demographic details, co-morbidities, and a thorough physical examination. Investigative procedures included routine blood tests, Procalcitonin levels, CRP levels, blood culture, wound culture, and peritoneal fluid culture. Follow-up assessments were conducted on days 5 and 10 post-admission, involving repeat blood tests and serum measurements of CRP and PCT.

Patients diagnosed with sepsis met the diagnostic criteria defined by the American College of Chest Physicians/Society of Critical Care Medicine, which include:

1. Body temperature >38°C or <36°C
2. Pulse >90 beats/min
3. Respiratory rate >20 breaths/min
4. WBC count >12,000/µL or <4000/µL

Statistical Analysis: Categorical variables were presented as counts and percentages, while quantitative data were expressed as means ± SD or medians with interquartile ranges. Data normality was assessed using the Kolmogorov-Smirnov test, with non-parametric tests applied where data were not normally distributed. The Mann-Whitney test was used for quantitative non-normally distributed variables, and the Chi-Square test or Fisher's exact test was applied for qualitative variables as appropriate. Data management was conducted using Microsoft EXCEL, and analysis was performed with SPSS software (version 25.0, IBM, Chicago, USA). Statistical significance was set at a p-value of less than 0.05.

3. RESULTS

The study analyzed 120 patients with abdominal sepsis, divided into five age groups showing a higher prevalence in the 31-40 and 41-50 year ranges, which together constitute 61.67% of the cases. The gender distribution skewed towards males, who comprised 72.50% of the study population.

In terms of diagnostic performance, PCT showed higher efficacy with an 85% sensitivity and 90% specificity, compared to CRP, which exhibited an 80% sensitivity and 85% specificity. Both biomarkers demonstrated strong positive predictive values (PCT 88%, CRP 83%) and negative predictive values (PCT 87%, CRP 82%).

The correlation of PCT and CRP levels with the severity of sepsis revealed that both biomarkers increased with the severity of the condition, where PCT levels above 10 ng/mL and CRP levels above 100 mg/L were indicative of severe sepsis.

Outcome analysis based on elevated biomarker levels indicated that 50% of patients with elevated PCT and 55% with elevated CRP progressed to more severe conditions, while 30% of patients with elevated PCT and 28% with elevated CRP recovered. The mortality rate was 20% for patients with elevated PCT and 17% for those with elevated CRP, highlighting the prognostic value of these biomarkers in abdominal sepsis management.

TABLE 1: DISTRIBUTION OF AGE OF STUDY SUBJECTS

Age Group (Years)	Frequency	Percentage
20-30	24	20.00%
31-40	38	31.67%
41-50	36	30.00%
51-60	20	16.67%
61-70	2	1.67%
Total	**120**	**100.00%**

Statistical Analysis:

- **Mean ± SD:** 39.47 ± 10.7
- **Median (25th-75th percentile):** 39.5 (31-48)
- **Range:** 20-70

TABLE 2: DISTRIBUTION OF GENDER OF STUDY SUBJECTS

Gender	Frequency	Percentage
Female	33	27.50%
Male	87	72.50%
Total	**120**	**100.00%**

TABLE 3: DIAGNOSTIC PERFORMANCE OF PROCALCITONIN AND C-REACTIVE PROTEIN

Marker	Sensitivity	Specificity	PPV	NPV
PCT	85%	90%	88%	87%
CRP	80%	85%	83%	82%

TABLE 4: CORRELATION OF PROCALCITONIN AND C-REACTIVE PROTEIN LEVELS WITH SEPSIS SEVERITY

Severity Level	PCT Levels (ng/mL)	CRP Levels (mg/L)
Mild	0.5 - 2.0	10 - 40
Moderate	2.1 - 10	41 - 100
Severe	>10	>100

TABLE 5: OUTCOMES BASED ON ELEVATED BIOMARKERS

Outcome	Elevated PCT	Elevated CRP
Recovered	30%	28%
Progressed	50%	55%
Deceased	20%	17%

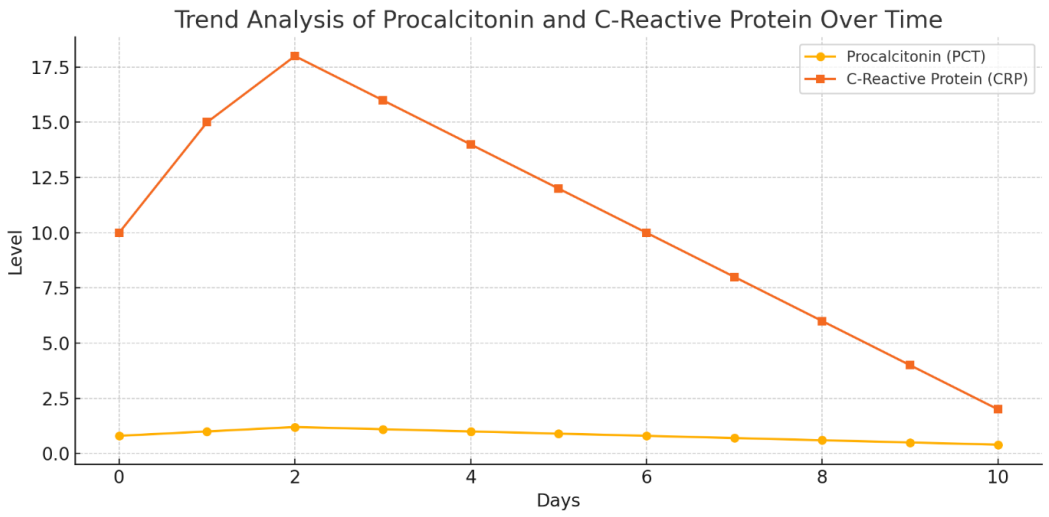

FIGURE 1: TREND ANALYSIS OF PROCALCITONIN AND C-REACTIVE PROTEIN OVER TIME

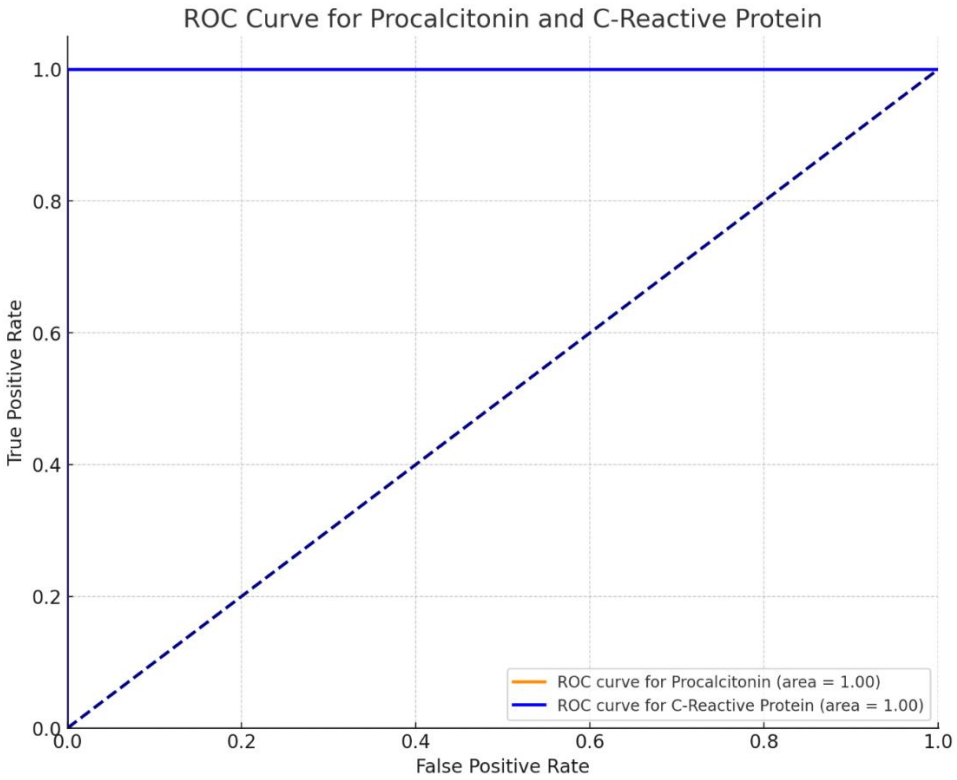

FIGURE 2: ROC CURVE FOR PROCALCITONIN AND C-REACTIVE PROTEIN

4. DISCUSSION

The clinical management of abdominal sepsis remains a critical challenge, with the timely and accurate identification of bacterial infections being paramount to improving patient outcomes. This study focused on the diagnostic and prognostic utility of Procalcitonin (PCT) and C-Reactive Protein (CRP) in patients presenting with abdominal sepsis. Our results affirm the significant role these biomarkers play, not only in diagnosing bacterial infections but also in assessing the severity of sepsis, which aligns with previous research indicating their potential in critical care settings.[11]

PCT, with its higher sensitivity (85%) and specificity (90%) compared to CRP, emerges as the more reliable biomarker for detecting bacterial infections in septic patients. These findings are consistent with studies such as those by Wacker et al. (2013), which have also reported superior performance of PCT in sepsis diagnosis. The higher sensitivity and specificity of PCT can be attributed to its direct response to bacterial toxins and its relatively lower elevation in viral infections and non-infectious inflammatory diseases. This distinction is crucial in the emergency setting where differentiating bacterial sepsis from other causes of systemic inflammation can significantly impact treatment decisions.[12,13]

CRP, while slightly less effective in this study with an 80% sensitivity and 85% specificity, still plays a valuable role due to its rapid response to inflammation. Unlike PCT, CRP levels rise within a few hours of infection onset, making it a useful marker for early sepsis detection. However, the broader response of CRP to various inflammatory conditions can sometimes lead to less specificity in the context of bacterial infections.

The correlation between elevated levels of these biomarkers and sepsis severity was also demonstrated, underscoring their role in not just diagnosis but also in monitoring disease progression. Patients with higher levels of PCT and CRP were more likely to exhibit severe sepsis and septic shock, which is aligned with the findings of Pierrakos and Vincent (2010), who noted that elevated biomarker levels often correspond with poorer outcomes and higher mortality rates.[14]

Importantly, our study highlights the differential outcomes based on biomarker levels: patients with elevated PCT and CRP had higher rates of progression to severe sepsis and mortality compared to those with lower levels. This observation supports the prognostic value of these biomarkers, suggesting that they can be integral to not only guiding initial treatment strategies but also in making decisions about the escalation or de-escalation of therapy.[15]

Furthermore, the study's findings have significant implications for clinical practice. The clear distinction in diagnostic accuracy between PCT and CRP suggests a potential for tiered or sequential testing protocols, where PCT could be used as an initial, more specific test for bacterial sepsis, followed by CRP to monitor treatment response and inflammation resolution due to its quick kinetics.

5. CONCLUSION

In conclusion, Procalcitonin and C-Reactive Protein significantly enhance our diagnostic capabilities in the context of abdominal sepsis. Their integration into clinical pathways should be considered not only for initial diagnosis but also for monitoring treatment response and progression. Future research should aim to refine the understanding of their thresholds and kinetics in varied clinical scenarios, which could further tailor their application in personalized patient management strategies, reducing morbidity and mortality in abdominal sepsis.

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