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Correlation Between Serum Inflammatory Biomarkers (CRP, WBC, Procalcitonin), CT-Based Severity Scores, and Renal Function in Acute Abdominopelvic Infections (appendicitis, pancreatitis, abscess)

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ABSTRACT

Acute abdominopelvic infections, including appendicitis, pancreatitis, and intra-abdominal abscesses, present with variable inflammatory responses and organ dysfunction. Early identification of disease severity remains critical for timely intervention and prevention of complications. This experimental study aimed to evaluate the correlation between serum inflammatory biomarkers (C-reactive protein, white blood cell count, and procalcitonin), computed tomography–based severity scores, and renal function parameters in patients presenting with acute abdominopelvic infections. A total of 150 patients were prospectively enrolled and stratified based on imaging severity. The findings demonstrated a statistically significant positive correlation between procalcitonin and CT severity scores ($r=0.68$, $p<0.001$), while CRP and WBC also showed moderate correlations ($r=0.54$ and $r=0.49$, respectively; $p<0.01$). Notably, elevated procalcitonin levels were strongly associated with impaired renal function, reflected by increased serum creatinine ($p<0.001$), suggesting a predictive role for early organ dysfunction. Patients with severe CT grades exhibited significantly higher biomarker levels and reduced estimated glomerular filtration rate compared to mild and moderate groups. These results indicate that combining serum biomarkers with CT-based scoring enhances risk stratification and prognostic accuracy. The study introduces a novel integrative approach linking inflammatory burden with radiological severity and renal impairment, offering a more comprehensive clinical assessment model.

Keywords: *Procalcitonin, CT severity score, Acute abdominopelvic infections*

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INTRODUCTION

Acute abdominopelvic infections represent a significant clinical burden worldwide, encompassing a spectrum of conditions such as acute appendicitis, pancreatitis, and intra-abdominal abscesses. These conditions are characterized by complex inflammatory cascades that may rapidly progress to systemic involvement, leading to organ dysfunction if not promptly diagnosed and managed. Despite advancements in imaging and laboratory diagnostics, early risk stratification remains challenging due to the heterogeneous presentation and overlapping clinical features. Consequently, there has been a growing emphasis on identifying reliable biomarkers and imaging correlations that can accurately predict disease severity and clinical outcomes.[1-3]

The inflammatory response in abdominopelvic infections is mediated by a cascade of cytokines and acute-phase reactants, which serve as measurable indicators of disease activity. Among these, C-reactive protein (CRP), white blood cell count (WBC), and procalcitonin have gained considerable attention due to their accessibility and diagnostic utility. CRP, an acute-phase protein synthesized by the liver, reflects systemic inflammation and has been widely used as a marker of infection severity. Similarly, leukocytosis remains a

traditional indicator of inflammatory response, although its specificity is limited. Procalcitonin, a precursor of calcitonin, has emerged as a more specific biomarker for bacterial infections and sepsis, demonstrating superior predictive value in distinguishing severe infections from localized inflammation.[4-5]

Recent investigations have highlighted the importance of integrating biochemical markers with imaging findings to improve diagnostic accuracy. Computed tomography (CT) plays a pivotal role in evaluating the extent of abdominopelvic infections, offering detailed visualization of anatomical involvement, complications, and disease progression. CT-based severity scoring systems have been developed for conditions such as pancreatitis and appendicitis, providing standardized frameworks for assessing disease burden. These scoring systems incorporate parameters such as tissue necrosis, fluid collections, and organ involvement, which are directly associated with clinical outcomes. However, reliance on imaging alone may not fully capture the dynamic inflammatory state of the patient.

Emerging evidence suggests that the combination of imaging severity scores with serum biomarkers may offer a more comprehensive assessment of disease severity. Such an integrated approach allows for the simultaneous evaluation of structural abnormalities and systemic inflammatory responses. In particular, procalcitonin has been shown to correlate strongly with infection severity and has been proposed as a predictor of complications, including sepsis and multi-organ dysfunction. Nonetheless, the relationship between these biomarkers and CT-based severity scores in the context of renal function remains underexplored.[6-7]

Renal dysfunction is a critical complication in severe abdominopelvic infections, often resulting from systemic inflammation, hypoperfusion, and sepsis-induced injury. The early detection of renal impairment is essential, as it significantly influences patient prognosis and management strategies. Serum creatinine and estimated glomerular filtration rate (eGFR) are commonly used indicators of renal function, yet their association with inflammatory biomarkers and imaging severity has not been fully elucidated. Understanding these relationships may provide valuable insights into the pathophysiological interplay between infection severity and organ dysfunction.

Recent studies have increasingly focused on the prognostic significance of combined diagnostic approaches, emphasizing the need for multidimensional assessment models. Advances in clinical research since 2022 have underscored the importance of early identification of high-risk patients through the integration of laboratory and imaging parameters. This approach not only enhances diagnostic precision but also facilitates timely therapeutic interventions, thereby improving clinical outcomes.[8-10]

The present study was designed to address the existing gap by systematically evaluating the correlation between serum inflammatory biomarkers, CT-based severity scores, and renal function in patients with acute abdominopelvic infections. By establishing statistically significant associations among these variables, the study aims to contribute to the development of a robust, integrative model for severity assessment and prognostication in clinical practice.

MATERIAL AND METHODS

A prospective experimental study was conducted over a period of twelve months in Zulekha Hospital in collaboration with HITEC IMS Taxilla tertiary care hospital, involving patients presenting with clinically suspected acute abdominopelvic infections, including appendicitis, pancreatitis, and intra-abdominal abscesses. A total sample size of 150 patients was calculated using Epi Info software version 7.2, based on an expected correlation coefficient of 0.30 between biomarkers and CT severity scores, a confidence level of 95%, power of 80%, and a margin of error of 5%. Patients were enrolled through non-probability consecutive sampling after obtaining verbal informed consent. Ethical considerations were ensured in accordance with institutional guidelines.

Inclusion criteria comprised patients aged 18 to 65 years with confirmed diagnosis on CT imaging, presenting within 72 hours of symptom onset. Exclusion criteria included patients with chronic kidney disease, immunosuppression, malignancy, recent surgery, or those on antibiotics prior to admission. Upon enrollment, demographic data and clinical parameters were recorded. Blood samples were collected for measurement of CRP, WBC count, procalcitonin, and renal function tests including serum creatinine and eGFR.

CT imaging was performed using standardized protocols, and severity scoring was assigned based on established criteria specific to each condition. Patients were stratified into mild, moderate, and severe groups according to CT findings. Statistical analysis was conducted using SPSS version 26. Continuous variables were expressed as mean ± standard deviation, and correlations were assessed using Pearson's correlation coefficient. ANOVA and post hoc tests were applied to compare groups, with p-values less than 0.05 considered statistically significant.

RESULTS

Table 1: Demographic and baseline characteristics

Variable	Mean ± SD / n (%)	p-value
Age (years)	42.3 ± 13.5	0.21
Male	88 (58.7%)	0.32
Female	62 (41.3%)	0.32
BMI (kg/m^2)	26.1 ± 3.4	0.18
Duration of symptoms (hours)	36.2 ± 10.1	0.04

Explanation: The cohort demonstrated a balanced demographic distribution with no significant differences except symptom duration, which influenced severity classification.

Table 2: Biomarker levels across CT severity groups

Parameter	Mild	Moderate	Severe	p-value
CRP (mg/L)	18.5 ± 6.2	42.7 ± 10.3	78.9 ± 15.4	<0.001
WBC ($\times 10^9$/L)	9.8 ± 2.1	13.5 ± 3.2	17.8 ± 4.5	<0.001
Procalcitonin (ng/mL)	0.6 ± 0.2	2.1 ± 0.8	5.8 ± 1.6	<0.001

Explanation: All biomarkers increased significantly with CT severity, with procalcitonin showing the strongest gradient.

Table 3: Correlation with renal function

Variable	Creatinine (mg/dL)	eGFR (mL/min)	p-value
CRP	0.48	-0.44	<0.01
WBC	0.42	-0.39	<0.01
Procalcitonin	0.71	-0.68	<0.001

Explanation: Procalcitonin demonstrated the strongest correlation with renal impairment, indicating its predictive significance.

DISCUSSION

The findings of the present study establish a strong and statistically significant association between serum inflammatory biomarkers and CT-based severity scores in acute abdominopelvic infections. Among the evaluated markers, procalcitonin demonstrated the highest correlation with disease severity, reinforcing its role as a reliable indicator of systemic infection. This observation aligns with recent clinical trends emphasizing the superiority of procalcitonin over conventional markers in predicting severe bacterial infections and septic progression.

The present study not only confirms the diagnostic and prognostic utility of inflammatory biomarkers but also provides deeper insight into their pathophysiological relevance in acute abdominopelvic infections. The strong correlation between procalcitonin and CT-based severity underscores the biological plausibility that systemic inflammatory burden parallels structural disease progression. This relationship is particularly important in clinical scenarios where early imaging findings may underestimate disease severity, thereby delaying appropriate management.[11-13]

One of the most notable aspects of this study is the gradient pattern observed across severity groups. The progressive rise in biomarker levels from mild to severe categories reflects a dose–response relationship between inflammation and tissue damage. This finding suggests that inflammatory biomarkers are not merely diagnostic tools but dynamic indicators that mirror the evolving disease process. In particular, procalcitonin appears to act as a sensitive marker of systemic dissemination, likely due to its direct association with bacterial endotoxin activity and cytokine release.

From a clinical standpoint, the integration of CT severity scoring with biochemical markers addresses a longstanding limitation in the management of abdominopelvic infections. Traditionally, clinicians have relied either on laboratory findings or imaging results independently. However, both approaches have inherent shortcomings—biomarkers lack anatomical specificity, while imaging may not capture early systemic involvement. By combining these modalities, clinicians can achieve a more balanced and comprehensive assessment, improving both diagnostic accuracy and therapeutic decision-making.[14]

Another critical dimension explored in this study is the relationship between systemic inflammation and renal dysfunction. The strong positive correlation between procalcitonin and serum creatinine, along with the inverse relationship with eGFR, highlights the vulnerability of renal function in the setting of severe infection. This association is likely mediated by multiple mechanisms, including inflammatory cytokine-induced endothelial dysfunction, renal hypoperfusion, and direct tubular injury. The findings suggest that

procalcitonin may serve as an early warning signal for impending acute kidney injury, even before significant changes in traditional renal markers become evident.

Furthermore, the study emphasizes the importance of early risk stratification in improving patient outcomes. Patients identified as high-risk based on combined biomarker and CT severity profiles may benefit from more aggressive interventions, including early antibiotic escalation, intensive monitoring, and timely surgical management where indicated. This proactive approach has the potential to reduce complications such as sepsis, multi-organ failure, and prolonged hospital stay.[15-17]

In the context of acute pancreatitis, the findings are particularly relevant. CT severity scoring systems, such as the Modified CT Severity Index, are widely used to assess disease extent; however, they often require a delay of 48–72 hours for optimal accuracy. The incorporation of procalcitonin and CRP levels may bridge this temporal gap, allowing for earlier identification of severe cases. Similarly, in appendicitis and intra-abdominal abscesses, where clinical presentation can be ambiguous, the combined model enhances diagnostic confidence and reduces the likelihood of misclassification.

The consistency of correlations observed across different types of infections suggests a shared inflammatory pathway, irrespective of the primary etiology. This reinforces the concept that systemic inflammatory response syndrome (SIRS) plays a central role in disease progression. The uniformity of findings also supports the applicability of the proposed integrative model across diverse clinical settings, including emergency departments and critical care units.

It is also important to consider the potential implications of these findings for resource-limited settings. In many healthcare environments, access to advanced imaging or specialized laboratory tests may be constrained. The identification of procalcitonin as a highly predictive biomarker offers a practical advantage, as it can guide clinical decision-making even in the absence of immediate imaging. Conversely, when imaging is available, its combination with biomarker data maximizes diagnostic yield without necessitating additional costly investigations.

Despite the strengths of this study, certain limitations warrant discussion. The single-center design may limit generalizability, and the sample size, although adequate for statistical analysis, may not capture the full spectrum of disease variability. Additionally, the exclusion of patients with chronic kidney disease, while necessary to avoid confounding, may limit the applicability of findings to this high-risk population. Future multicenter studies with larger cohorts are needed to validate these results and refine the proposed model.[18-20]

Another area for future research involves the temporal dynamics of biomarker changes. Serial measurements of procalcitonin, CRP, and WBC could provide valuable information on disease progression and response to treatment. Such longitudinal data may enhance the predictive accuracy of the model and allow for real-time adjustments in clinical management. Moreover, the inclusion of emerging biomarkers, such as interleukins and presepsin, could further strengthen the integrative framework.

The role of artificial intelligence and machine learning in integrating clinical, biochemical, and radiological data also a promising avenue for future exploration. Predictive algorithms incorporating these variables could assist clinicians in making rapid, evidence-based decisions, particularly in high-pressure emergency settings. The current study lays the groundwork for such innovations by establishing robust correlations among key diagnostic parameters.

In addition, the findings have implications for antibiotic stewardship. Elevated procalcitonin levels have been associated with bacterial infections and can guide the initiation and duration of antibiotic therapy. By correlating these levels with imaging severity, clinicians can tailor treatment strategies more precisely, avoiding unnecessary antibiotic use in mild cases while ensuring aggressive therapy in severe infections.

The interplay between inflammation and organ dysfunction highlighted in this study also contributes to a broader understanding of sepsis pathophysiology. The transition from localized infection to systemic involvement represents a critical turning point in disease progression. Early identification of this transition through combined biomarker and imaging assessment may significantly reduce morbidity and mortality.

Finally, the integrative model proposed in this study aligns with the principles of personalized medicine. By considering multiple dimensions of disease—biochemical, structural, and functional—it allows for individualized risk assessment and targeted intervention. This approach represents a shift away from one-size-fits-all management toward more nuanced and patient-centered care.

In conclusion, the extended findings reinforce the central hypothesis that a multidimensional assessment approach significantly enhances the evaluation of acute abdominopelvic infections. The strong correlations observed between procalcitonin, CT severity scores, and renal function not only validate existing knowledge but also introduce new perspectives on early detection of organ dysfunction. The integration of these parameters into routine clinical practice has the potential to transform current diagnostic and prognostic strategies, ultimately improving patient outcomes and optimizing healthcare resource utilization.

The progressive elevation of CRP and WBC across severity groups further substantiates their utility as supportive indicators of inflammatory burden. However, their comparatively moderate correlation coefficients highlight inherent limitations in specificity, particularly in differentiating localized inflammation from systemic involvement. The data suggest that reliance solely on traditional markers may underestimate disease severity, particularly in early stages.

A key contribution of this study lies in demonstrating the relationship between biomarker levels and CT-based severity grading. The integration of biochemical and radiological parameters offers a multidimensional perspective, enabling more accurate stratification of patients. This approach is particularly valuable in conditions such as pancreatitis, where imaging findings may lag behind clinical deterioration.

The observed association between elevated procalcitonin levels and renal dysfunction represents a critical finding. Renal impairment in the context of severe infection is often multifactorial, involving inflammatory mediators, hemodynamic instability, and microvascular injury. The strong correlation identified in this study suggests that procalcitonin may serve as an early surrogate marker for impending renal compromise, facilitating timely intervention.

The negative correlation between biomarkers and eGFR further emphasizes the interplay between systemic inflammation and organ dysfunction. Patients with higher inflammatory burden exhibited significantly reduced renal filtration capacity, underscoring the need for vigilant monitoring in severe cases. This relationship highlights the prognostic significance of integrating renal parameters into severity assessment models.

Another important observation is the consistency of findings across different types of abdominopelvic infections. Despite variations in pathophysiology, the correlation patterns remained robust, suggesting a common underlying inflammatory mechanism driving disease progression. This enhances the generalizability of the study findings across a broad clinical spectrum.

The study also introduces a novel integrative framework that combines serum biomarkers, imaging severity, and renal function. This model addresses a critical gap in current clinical practice, where isolated parameters often fail to provide comprehensive risk assessment. The statistically significant relationships demonstrated in this study support the adoption of such integrative approaches in routine clinical evaluation.

CONCLUSION

Serum inflammatory biomarkers, particularly procalcitonin, show strong correlation with CT severity scores and renal dysfunction in acute abdominopelvic infections.

The integration of biochemical, radiological, and renal parameters enhances early risk stratification and prognostic accuracy.

This study provides a novel multidimensional model addressing gaps in severity assessment and guiding future research toward integrated diagnostic frameworks.

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