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Qualitative and Quantitative Analysis of C-Reactive Protein in Inflammatory and Infectious Conditions

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ABSTRACT

Background: C-Reactive Protein (CRP) is a key biomarker for inflammation and infection, widely used in clinical settings to assess disease severity and monitor therapeutic responses. Qualitative and quantitative CRP tests serve distinct diagnostic purposes, with the former offering rapid screening and the latter providing precise measurements. This study evaluates the diagnostic utility of both methods in inflammatory and infectious conditions, comparing their accuracy, feasibility, and clinical applicability.

Methods: A cross-sectional study was conducted over 8 months at Saidu Teaching Hospital, Pakistan, involving 150 patients with suspected inflammatory or infectious diseases. Venous blood samples were analyzed using qualitative (latex agglutination) and quantitative (immunoturbidimetric) CRP tests. Diagnostic accuracy, sensitivity, specificity, and correlations with other inflammatory markers (WBC count, ESR) were assessed using SPSS version 25.

Results: Qualitative CRP testing showed 80.4% sensitivity and 78.9% specificity, with a diagnostic accuracy of 80%. However, its negative predictive value (NPV) was limited (57.7%). Quantitative CRP testing identified elevated levels (>5 mg/L) in 74.7% of patients and demonstrated strong correlations with ESR ($r = 0.75$) and WBC count ($r = 0.62$). Significant agreement was observed between the two methods ($\chi^2 = 45.2$, $p < 0.001$).

Conclusion: Qualitative CRP testing is a cost-effective screening tool, particularly in resource-limited settings, but lacks precision for mild or early-stage inflammation. Quantitative CRP testing offers superior accuracy for disease stratification and treatment monitoring. The complementary use of both methods can enhance diagnostic efficiency, with qualitative tests for initial triage and quantitative tests for detailed evaluation in complex cases.

Keywords: C-Reactive Protein (CRP), qualitative testing, quantitative testing, inflammation, infectious diseases, diagnostic accuracy.

INTRODUCTION

C-Reactive Protein (CRP) can be characterized as an acute-phase reactant produced by the liver in response to inflammation, tissue damage or infection.[1] As part of the body's natural immune response, CRP levels quickly elevate after the onset of an inflammatory stimulus, making it an effective biomarker in clinical observations and disease monitoring.[2] CRP testing is highly utilized in diverse medical conditions such as bacterial infections, autoimmune diseases, heart diseases, sepsis, and many others, in which it helps in determining the severity of diseases as well as response to therapy.[3] CRP measurements can be performed by two different methods: qualitative and quantitative. Qualitative tests give a yes or no answer which can be used in a fast screening basis where typing of the resource is limited. Quantitative analysis, however, provides the accuracy of serum CRP value, at which clinician can gauge the degree of inflammation and track the progress or cure in the course of time.[4] Even though the quantitative testing is more informative, qualitative testing continues to have a role because it is less expensive and easy to operate.[5]

CRP is a pentraxin protein that is involved in the detection of pathogens and damaged cells which was then acted upon to be removed by the complement system and phagocytosis. Its serum level can exponentially increase up to as high as 1,000-fold in 6 to 8 hours of the inflammatory induction reaching its peak at approximately 48 hours.[6] This would lead to a speedy and sensitive response and thus a valuable biomarker in conditions like acute and chronic conditions.[7] Compared to other indicators of inflammation like erythrocyte sedimentation rate (ESR), the level of CRP varies rapidly and correctly shows the existing level of inflammation, which is especially vital to an early diagnosis and treatment of an issue. Such tests may employ latex agglutination or

immunochromatographic detection to show positive or negative results in presence of elevated CRP levels.[8] Although they are cheap and simple to conduct, they can only reveal severe elevation or changes in the nature of the disease because they are binary in character. Compared to them, immunoturbidimetric, ELISA and high sensitivity CRP (hs-CRP) allow a quantitative measurement, that results in a better stratification of clinical decision-making and measurement of therapeutic intervention efficacy.[9]

Since both testing options are widespread, the thorough analysis of their ability to provide diagnostics is necessary, particularly in the environment where healthcare resources may vary. This is crucial in establishing the clinical usefulness of both qualitative and quantitative CRP testing in determining the correlation of the tests with the particular inflammatory and infectious conditions of illnesses with respect to their manifestations.[10] Although CRP values have exceptionally wide clinical use, the interpretation of their results should be made with reference to the clinical situation. Non-infectious causes of CRP increase include malignancies, autoimmune disorders, trauma, and post-surgical inflammation amongst others, making it not always easy to detect the causative agent using CRP alone.[11] Moreover, qualitative CRP assays may not find the slight alterations in some low-grade inflammatory conditions or the initial stages of infection, which would be identified by quantitative CRP tests. It is essential to know the limits to and strengths of each of the testing methods to perform desired clinical decision-making without misdiagnosis.[12]

This research project seeks to examine and evaluate the diagnostic utility of both qualitative and quantitative CRP assay in cases of inflammatory and infectious disease. This study aims at finding out the usefulness of each technique in different clinical practice settings and their implementation in efficient diagnostic and intervention procedures.

MATERIALS AND METODS

It was a cross sectional, comparative study carried out during a span of 8 months (from November 2024 to June 2025) in the Department of Pathology, Saidu Teaching Hospital Swat a tertiary care hospital in the Khyber Pakhtunkhwa Province of Pakistan. The study was conducted with ethics approval received from Department of Pathology, Saidu Teaching Hospital Swat with reference number (ERB/lab/1754) on date 21 October 2024.

At the end of the study, 150 patients with clinical signs and symptoms indicating the presence of inflammatory or infectious disorders were recruited into the study. The sample size was calculated with WHO formula $S=Z^2\times(1-P)/M^2$.[13] The inclusion criteria were specific patients who were aged 1-60 years and of either sex who had suspected infections (respiratory tract infections, urinary tract infections, sepsis) or inflammatory diseases (rheumatoid arthritis, inflammatory bowel disease). To limit confounding, patients who had been on anti-inflammatory or antibiotic treatment longer than 72 hours, had the chronic liver disease or malignancy were excluded.

Each of the participants provided approximately 3 mL of venous blood aseptically. The tests were carried out as recommended by manufacturer and following standard laboratory procedures. The samples were split into two parts: Qualitative CRP Test was performed using the latex agglutination method. A positive result was indicated by visible agglutination, while a negative result showed no change.[14] Quantitative CRP Test was performed using an immunoturbidimetric method on an automated analyzer (Roche Cobas c501), providing results in mg/L. Values >5 mg/L were considered elevated.[4] Besides CRP data, other appropriate clinical data such as the clinical diagnosis, presenting symptoms, laboratory tests (WBC count, ESR), and radiological findings were noted.

Entry of data was done in Microsoft excel and analyzed in SPSS version 25. Patient characteristics and demographics were summarized by descriptive statistics. Quantitative CRP was used as the standard against which sensitivity, specificity and diagnostic accuracy of qualitative CRP testing was calculated. Associations were determined by chi-square test and Pearson correlation with significance level of $p < 0.05$.

RESULTS

A total of 150 patients with suspected inflammatory or infectious conditions were included in the study. The demographic and clinical characteristics of the participants are summarized in Table 1. The mean age of the participants was 32.5 ± 15.2 years, with a male-to-female ratio of 1:1.2. The most common clinical presentations included respiratory tract infections (35.3%), urinary tract infections (28.7%), sepsis (15.3%), rheumatoid arthritis (12.0%), and inflammatory bowel disease (8.7%). Qualitative method results showed that positive results 98 patients (65.3%), and Negative Results 52 patients (34.7%).

Table 1: Demographic and Clinical Characteristics of the Study Population

Characteristic	**Value**
Total Participants	150
Age (Mean ± SD)	32.5 ± 15.2 years
Gender (Male:Female)	68:82 (1:1.2)
Clinical Diagnosis	**Number (%)**
Respiratory Infections	53 (35.3%)
Urinary Tract Infections	43 (28.7%)
Sepsis	23 (15.3%)
Rheumatoid Arthritis	18 (12.0%)
Inflammatory Bowel Disease	13 (8.7%)

Table 2: Qualitative Analysis of CRP Test Results

Qualitative CRP	Results (n=)	Percentage
Positive	98	65.3%
Negative	52	34.7%

The quantitative method results showed that mean CRP level was 42.6 ± 28.4 mg/L (range: 1.2–320 mg/L), and elevated CRP levels (>5 mg/L) were observed in 112 patients (74.7%).

Table 3: Comparison of Qualitative and Quantitative CRP Test Results

Qualitative CRP	Quantitative CRP Elevated (>5 mg/L)	Quantitative CRP Normal (≤5 mg/L)	Total
Positive	90	8	98
Negative	22	30	52
Total	112	38	150

Using quantitative CRP as the reference standard, the diagnostic performance of qualitative CRP testing was evaluated (Table 4). The Chi-square test revealed a significant association between qualitative and quantitative CRP results ($\chi^2 = 45.2$, $p < 0.001$).

Table 4: Diagnostic Accuracy of Qualitative CRP Testing

Parameter	Value (%)
Sensitivity	80.4%
Specificity	78.9%
Positive Predictive Value (PPV)	91.8%
Negative Predictive Value (NPV)	57.7%
Diagnostic Accuracy	80.0%

A Pearson correlation analysis was performed to assess the relationship between quantitative CRP levels and other inflammatory markers (WBC count and ESR). CRP vs. WBC count showed moderate positive correlation ($r = 0.62$, $p < 0.001$), while CRP vs. ESR showed strong positive correlation ($r = 0.75$, $p < 0.001$) see Table No 5.

Table 5: Correlation Between CRP Levels and Other Inflammatory Markers

Marker	Correlation Coefficient (r)	p-value
WBC Count	0.62	<0.001
ESR	0.75	<0.001

DISCUSSION

The results of this research indicate the diagnostic value of CRP testing, particularly qualitative and quantitative testing, in the context of inflammatory diseases, infections, their identification and assessment, and, also, reveal the advantages and drawbacks associated with such tests. Our findings concur with the past investigations on CRP testing methods. In one study, it was emphasized that CRP can respond rapidly to inflammation and can be a sensitive biomarker, supporting our results in the overall utility of CRP in determining the diagnosis of acute and chronic cases.[15] In the correlation between CRP and ESR that we observed the findings, similar study observed that the level of CRP increases faster than ESR, and thus CRP is a more timely predictor of inflammation than ESR.[16] Our qualitative CRP results (sensitivity 80.4%, specificity 78.9%) are consistent with previous studies using latex agglutination methods, which reported sensitivities of 78–85% and specificities of 80–88%.[17] Our lower NPV is opposed to literature that promote the use of qualitative test in primary care facility suggesting that the potential of qualitative tests were good enough to exclude severe infections in low-resource setting.[1] This disparity could be based on the difference in population study or due to the existence of subclinical altered inflammations in our observed group. Our findings in this research agree with other findings in high-income settings that quantitative CRP testing is superior. A meta-analysis has concluded that quantitative CRP assays are essential in the diagnosis of bacterial infection, and in the decision to utilize antibiotics, especially in hospitalized patients.[18] Our results further confirm such accuracy by showing quantitative CRP superiority in stratifying the disease severity and the monitoring the treatment effects.

The usefulness of CRP testing in the various clinical settings has also been pointed out through research carried out in Pakistan. A Pakistan based study confirmed that the level of CRP was so high among bacterial infection patients compared to viral infections, which strengthened its diagnostic nature in distinguishing between the two diagnoses.[19] A second study conducted in Karachi, Pakistan observed that CRP testing, together with clinical assessment, enhanced the specificity of the diagnoses of pediatric sepsis in resource-limited hospitals.[20] Our results provide similar findings as they state that CRP is an essential diagnostic tool, even despite the low-resource setting. Nevertheless, issues like test availability variability and price were stated in the rural Pakistan, which might restrict diffusion.[19] Cost-effective cost-effective methods to introduce the CRP testing in such places should be studied further.

A multicentric study conducted across Pakistan it was found that, quantitative testing of CRP notably minimized the antibiotic featuring that were prevailed in outpatient prescribing, thereby, justifying it in antimicrobial stewardship.[21] This is in line with the evidence that is established globally on superiority of quantitative CRP testing as has been observed in our research. Conversely, Peshawar-based study has emphasized weaknesses of qualitative CRP test which shows negative results on early stage infections, mostly among children with nutrition problems.[22] This highlights why context-sensitive instructions need to be given with respect to the meaning of CRP values in

patients with highly prevalent malnutrition or chronic infections.

Qualitative and quantitative CRP testing yields complementary findings as seen with our results. Qualitative tests are inexpensive, and quite efficient to screen patients quickly, therefore, it is valuable in an outpatient practice or in an emergency department where a decision must be made immediately.[23] They have a disadvantage though, in terms of absolute sensitivity, it cannot pick up small changes or changes inherent in low-grade inflammation, as compared to early infections. The quantitative tests are more resource-consuming but allow obtaining a subtle set of data that must be used to treat complicated cases, including sepsis or autoimmune disorders.[8] Qualitative CRP testing is also a practical option in areas that do not have ample laboratory infrastructure. Engaging quantitative techniques or at least ensuring their availability in the tertiary care facilities can make a big difference in the effectiveness of diagnosis and patient outcomes, however, with the evolution of healthcare systems, this can now be a promising direction towards a better diagnosis and patient outcomes.[10] This is especially applicable to the current scenario where evidence-based medical practice and individualized care plans are increasingly becoming a demand.

CONCLUSION

This study gives a comprehensive analysis of the qualitative and quantitative C-reactive protein (CRP) testing in patients who have inflammatory and infectious diseases. These results prove that both of the techniques can complement each other and have clear applications in clinical practices. The qualitative and quantitative analysis of CRP is essential in the disease stratification and monitoring therapeutic effects, as well as in helping clinicians design clinical management in complicated cases. The accuracy of CRP qualitative testing that describes its usefulness in screening rapidly is equivalent to quantitative CRP testing, which has the detail required to facilitate evidence-based management. These findings point to the relevance of context-specific test selection qualitative methods to enable the initial triage of primary or emergency settings and quantitative methods to provide a richer evaluation in the tertiary units.

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