Section: Orthopedics

Original Research Article

# A PROSPECTIVE STUDY IN ASSESSING THE ROLE OF PROCALCITONIN LEVELS AS A BIOMARKER IN KNEE SEPTIC ARTHRITIS

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ABSTRACT

**Background:** Septic arthritis is a critical orthopaedic emergency requiring rapid diagnosis and intervention. **Objective:** To investigates the diagnostic utility of serum procalcitonin (PCT) levels in differentiating septic from non-septic arthritis. **Materials and Methods:** This prospective observational study was conducted on 30 patients aged 20–50 years presenting with acute arthritis at Narayana Medical College, the study involved clinical, radiological, and laboratory evaluations including PCT, CRP, ESR, and synovial fluid analysis. A PCT threshold of >0.5 ng/mL was considered abnormal. **Results**: demonstrated significantly elevated PCT levels in septic arthritis cases (mean 6.16 ± 1.42 ng/mL) compared to non-septic cases (mean 0.44 ± 0.14 ng/mL), with a sensitivity of 100% and specificity of 78.57%. PCT showed strong positive correlations with WBC count, CRP, and synovial fluid WBC count. **Conclusion:** The study concludes that PCT is a valuable, specific, and rapid biomarker that can enhance the diagnostic accuracy and management of septic arthritis when used alongside conventional methods.

**Keywords:** Septic arthritis, Procalcitonin, Diagnostic biomarker, Synovial fluid, CRP, WBC count, Sensitivity, Specificity.

## INTRODUCTION

Septic arthritis is a severe and potentially life-threatening condition characterized by the infection of a joint space, leading to inflammation and destruction of the joint.[1] The diagnosis of septic arthritis typically involves a combination of clinical evaluation, laboratory tests, imaging studies, and microbiological cultures.[2] Common clinical features include acute joint pain, swelling, warmth, and restricted movement, often accompanied by systemic signs of infection such as fever and elevated white blood cell count.[3]

In recent years, procalcitonin (PCT) has emerged as a promising biomarker for various bacterial infections, including septic arthritis. Procalcitonin is a precursor of the hormone calcitonin, primarily produced by the thyroid gland. Under normal physiological conditions, PCT levels in the blood are very low. However, during bacterial infections, procalcitonin production is significantly upregulated in response to inflammatory cytokines and bacterial endotoxins. This makes PCT a potentially valuable indicator of bacterial infections, differentiating them from viral infections and non-infectious inflammatory conditions.[4,5]

The role of procalcitonin as a biomarker in septic arthritis has garnered increasing attention in the medical community.6 Its utility lies in its ability to provide a rapid and sensitive indication of bacterial infection within the joint space, potentially guiding clinicians in decision-making processes regarding the initiation of antibiotic therapy and other treatments. Moreover, procalcitonin levels can aid in monitoring the response to treatment, helping to determine the duration of antibiotic therapy and the resolution of infection.

**Aim and Objectives**

**Aim:** To study the role of serum Procalcitonin (PCT) as a diagnostic biomarker in patients of suspected septic arthritis

**Objectives:**

1. To evaluate the diagnostic accuracy of serum Procalcitonin (PCT) levels in distinguishing

septic arthritis from non-septic arthritis in patients presenting with joint inflammation.
2. To determine the sensitivity and the specificity of procalcitonin in comparison to the gold standard test (culture and sensitivity and biopsy).

## MATERIALS AND METHODS

**Study Design:** Prospective Observational study
**Sample size:** 30
Based on a previous study, with mean procalcitonin level among septic arthritis was 1.48 ± 2.30 ng/ml Mean ± SD = 1.48 ± 2.30 ng/ml Confidence interval (CI) = 95% Absolute precision (d) = 1% Using the standard formula for proportion = [(Zα/2)2 × SD2] / d2.
The final sample size for the present study was rounded to 30 cases.
**Sample Technique:** Convenient sampling method.
**Inclusion Criteria:**
1. Patients with age in between 20-50 years.
2. Non-specific cases of knee joint effusion.
3. Patients willing to participate and give consent for study.

**Exclusion Criteria:**
1. Patients below 20 years of age and above 50 years of age.
2. Patients with foci of infection elsewhere in the body.
3. Post traumatic joint effusion.
4. Immunocompromised patients.

**Study Procedure:** Patients with complaints of arthritis during the period of study and satisfying the inclusion criteria were selected.
A detailed clinical examination with history of socio demographic factors with age, sex, duration of symptoms and swelling of the joint, movements, tenderness, warmth, restriction of movements is noted.
Radiological investigations - X-ray (anteroposterior/lateral) and ultrasound of involved knee joint were done. In cases with swelling due to collection of fluid, aspiration was done using 18 G needle under adequate anaesthesia. The aspirate was processed immediately with gram staining, culture and sensitivity. Laboratory analyses include CBP, ESR, CRP and procalcitonin.
PCT was measured by an automatic quantitative method [BRAHMS diagnostic, Germany]. This method has a sensitivity of 0.06 ng/ml. Values of PCT levels >0.5 ng/ml were considered abnormal;

**PCT in the Diagnosis of Septic Arthritis**

The relationship between serum PCT and the diagnosis of septic arthritis has been well investigated. According to these research, septic arthritis is linked to higher PCT levels. PCT has also showed promise as a highly sensitive and specific diagnostic biomarker.
**Sensitivity and Specificity:** The sensitivity of PCT in diagnosing septic arthritis varies across studies but is generally high. For instance, a study by Hugle et al,[7] (2007) reported a sensitivity of 100% and a specificity of 75% for PCT in diagnosing septic arthritis. Another study by Maharajan et al,[8] (2013) found that PCT had a sensitivity of 85% and a specificity of 87% at 0.4ng/ml. These findings suggest that PCT is a reliable marker for identifying septic arthritis, although it should be used in conjunction with other diagnostic modalities to improve accuracy.
**Comparison with Other Biomarkers:** Other commonly used biomarkers for diagnosing septic arthritis include C- reactive protein (CRP), erythrocyte sedimentation rate (ESR), and white blood cell (WBC) count. While these markers are useful, they lack specificity and can be elevated in various inflammatory conditions. PCT, on the other hand, has a higher specificity for bacterial infections, making it a more precise indicator of septic arthritis.
For example, a study by Ben-Zvi et al,[9] (2019) compared PCT with CRP and ESR in children with septic arthritis and reported that PCT had superior diagnostic accuracy. The study reported that PCT levels were significantly higher in children with septic arthritis compared to those with viral or inflammatory arthritis, while CRP and ESR levels showed considerable overlap between the groups.

**Advantages of PCT as a Diagnostic Biomarker**

**Rapid Response**

One of the main advantages of PCT is its rapid response to bacterial infection. PCT levels rise within hours of infection onset, providing an early indication of septic arthritis. This rapid increase can be particularly useful in clinical settings where timely diagnosis and treatment are critical to prevent joint damage.[10]

**Specificity for Bacterial Infections**

PCT is more specific for bacterial infections compared to other markers like CRP and ESR, which can be elevated in various inflammatory and infectious conditions. This specificity helps differentiate septic arthritis from other types of arthritis, reducing the likelihood of misdiagnosis and inappropriate treatment.[11] Monitoring Treatment Response PCT levels correlate with the severity of infection and decline rapidly with effective treatment. This makes PCT a valuable tool not only for diagnosis but also for monitoring the response to therapy. Regular measurement of PCT levels can help clinicians assess the effectiveness of antibiotic treatment and make informed decisions about the duration and adjustment of therapy.[12]

**Limitations and Considerations**

**Cost and Availability**

One of the limitations of using PCT as a diagnostic biomarker is the cost and availability of the test. PCT assays can be more expensive than other commonly used inflammatory markers, which may limit their use in resource-limited settings. Additionally, not all healthcare facilities have the

necessary equipment and expertise to perform PCT testing.[12]

**Influence of Non-infectious Conditions**

While PCT is highly specific for bacterial infections, certain non-infectious conditions can also cause elevated PCT levels. These include major surgery, severe trauma, burns, and some malignancies. Therefore, clinicians should consider the patient's overall clinical context and use PCT in conjunction with other diagnostic information to avoid false-positive results.

**Variability in Cut-off Values**

There is variability in the cut-off values for PCT used to diagnose septic arthritis across different studies and clinical settings. This variability can affect the sensitivity and specificity of the test. Establishing standardized cut-off values and incorporating them into clinical guidelines can help improve the consistency and reliability of PCT testing.

## RESULTS

**Table 1: Age distribution of the study subjects**

| Age group | Number of cases | % of cases |
|---|---|---|
| 20 – 30 years | 4 | 13.3% |
| 31 – 40 years | 11 | 36.7% |
| 41 – 50 years | 15 | 50% |
| Total | 30 | 100% |
| Mean age = 39.5 ± 6.9 years | | |

**Table 2: Gender distribution of the study population**

| Gender | Number of cases | % of cases |
|---|---|---|
| Male | 18 | 60% |
| Female | 12 | 40% |
| Total | 30 | 100% |

The mean hemoglobin level of study population was 11.9 ± 1.6 g/dL. The mean white blood cell count was 14.2 ± 3.4 x10³/µL. The mean C-reactive protein (CRP) level was 72.7 ± 22.3 mg/L, and the 95% CI ranged from 64.3 to 81.0 mg/L. The mean serum creatinine level was 1.3 ± 0.6 mg/dL. The mean synovial fluid WBC count of 42.5 ± 20.1 x10³/µL. The mean procalcitonin (PCT) level was 3.4 ± 3.0 ng/mL.

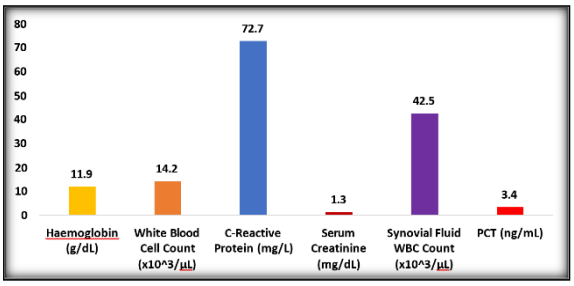


**Figure 1: Bar graph showing laboratory findings**

**Table 3: Distribution of cases based on procalcitonin levels**

| Procalcitonin | Number of cases | % of cases |
|---|---|---|
| ≤0.5 ng/ml | 11 | 36.7% |
| >0.5 ng/ml | 19 | 63.3% |
| Total | 30 | 100% |

In the study population, 63.3% of patients had procalcitonin (PCT) levels greater than 0.5 ng/ml, while 36.7% had PCT levels of 0.5 ng/ml or lower.

**Table 4: Sensitivity and specificity of PCT in diagnosing septic arthritis**

| PCT | Septic arthritis | |
|---|---|---|
| | Yes | No |
| Elevated [>0.5 ng/ml] | 16 [84.2%] | 3 [15.8%] |
| Normal [≤0.5 ng/ml] | Nil | 11 [100%] |
| Total | 16 [53.3%] | 14 [46.7%] |
| $\chi 2 = 19.85$, $p<0.001$ [sig.] | | |

$$\text{Sensitivity} = \frac{TP}{TP+FN} = \frac{16}{16+0} = \frac{16}{16} = 100\%$$

$$\text{Specificity} = \frac{TN}{TN+FP} = \frac{11}{11+3} = \frac{11}{14} = 78.6\%$$

PCT has a sensitivity of 100% (all patients with septic arthritis had elevated PCT levels above 0.5 ng/ml). The specificity of PCT is 78.57%, indicating that 78.57% of patients without septic arthritis had normal PCT levels of 0.5 ng/ml or less.

84.2% of patients with septic arthritis had elevated procalcitonin (PCT) levels (>0.5 ng/ml), while only 15.8% of patients without septic arthritis had elevated PCT levels. Conversely, all patients with normal PCT levels (≤0.5 ng/ml) did not have septic arthritis. The chi-square test statistic indicates a

significant association between elevated PCT levels and the presence of septic arthritis.

**Table 5: Relation between procalcitonin and septic arthritis**

| | Procalcitonin (ng/ml) | | |
|---|---|---|---|
| | **Mean** | **SD** | **p-value [unpaired t-test]** |
| Septic arthritis | 6.16 | 1.42 | < 0.001 (Sig.) |
| Aseptic arthritis | 0.44 | 0.14 | |

Patients with septic arthritis have a significantly higher mean procalcitonin level (6.16 ± 1.42 ng/ml) compared to those with aseptic arthritis (0.44 ± 0.14 ng/ml). The p-value of less than 0.001 indicates this difference is statistically significant.

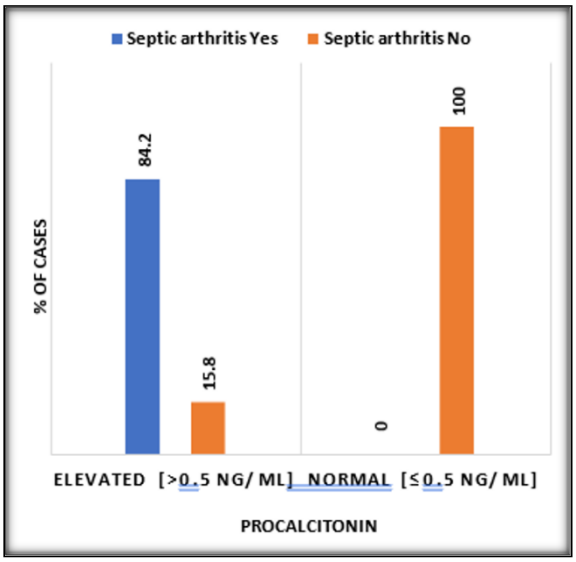


**Figure 2: Bar graph showing association between PCT and septic arthritis**

## DISCUSSION

A Prospective Observational study was conducted among 30 acute arthritis cases for a period of 18 months in the department of orthopaedics at a Narayana medical College, Nellore with an aim to study the role of serum Procalcitonin (PCT) as a diagnostic biomarker in patients of suspected septic arthritis.

- The mean age of the patients is 39.5±6.9 years.
- 60% of the patients are male and 40% are female
- All patients (100%) had pain at the joint. Swelling of the joint is observed in 93.3%, limited movements was in 60% and redness is seen in 30% cases.
- 46.7% and 40% of patients experienced symptoms for 6-10 days and ≤5 days, while 13.3% had symptoms for more than 10 days.
- 23.3% of patients had diabetes mellitus, and 16.7% had hypertension.
- The mean white blood cell count, C-reactive protein (CRP), synovial fluid WBC count was 14.2 ± 3.4 x10³/µL, 72.7 ± 22.3 mg/L and 42.5 ± 20.1 x10³/µL. respectively.
- The mean procalcitonin (PCT) level was 3.4 ± 3.0 ng/mL
- 63.3% of patients had procalcitonin (PCT) levels greater than 0.5 ng/ml, while 36.7% had PCT levels of 0.5 ng/ml or lower.
- The joint aspiration findings for cases reveal that 53.3% of patients had a high white blood cell (WBC) count in the synovial fluid, while 26.7% had a moderate WBC count, and 20% had a low WBC count
- The X-ray findings in patients showed that 40% of cases exhibited joint effusion and erosion, while 13.3% displayed joint effusion and osteolysis.
- The ultrasound findings of cases revealed that 46.6% had moderate effusion, while 26.7% had mild effusion and another 26.7% had significant effusion.
- The culture and sensitivity results for cases showed that 53.3% of patients had positive cultures, indicating septic arthritis.
- Majority of septic arthritis cases (75%) occurred in the 41 – 50 year age group.
- 68.8% of patients with septic arthritis were male, while 31.2% were female.
- Patients with septic arthritis have a significantly higher mean procalcitonin level (6.16 ± 1.42 ng/ml) compared to those with aseptic arthritis (0.44 ± 0.14 ng/ml).
- 84.2% of patients with septic arthritis had elevated procalcitonin (PCT) levels (>0.5 ng/ml), while only 15.8% of patients without septic arthritis had elevated procalcitonin levels.
- Procalcitonin has a sensitivity of 100% and specificity of 78.57% in diagnosing septic arthritis.
- Significant mean differences are observed in WBC (white blood cell count), CRP (C-reactive protein), and synovial fluid WBC, with septic arthritis patients showing much higher values in these markers (WBC: 16.7 ± 2.6 vs. 11.3 ± 1.0, CRP: 90.5 ± 11.6 vs. 52.3 ± 10.6, Synovial fluid WBC: 59.5 ± 9.4 vs. 23.1 ± 6.5).
- There is strong, statistically significant positive correlations between procalcitonin and WBC ($r = 0.926$, $p = 0.000$), CRP ($r = 0.920$, $p = 0.000$), and synovial fluid WBC ($r = 0.973$, $p = 0.000$).

## CONCLUSION

In conclusion, procalcitonin demonstrates significant promise as a biomarker in the diagnosis and management of septic arthritis. Its high sensitivity and correlation with established markers of infection underscore its utility in clinical practice.

Integrating PCT measurement into diagnostic algorithms for suspected septic arthritis can enhance diagnostic accuracy, optimize antimicrobial stewardship, and improve patient outcomes by facilitating timely intervention. Further research is warranted to elucidate its role in guiding therapeutic decisions and its long-term prognostic implications.

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