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ORIGINAL ARTICLE

Evaluation of Serum Procalcitonin and C-Reactive Protein as Early Biomarkers of Surgical Site Infections in Head and Neck Surgical Patients

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ABSTRACT

Background: Surgical site infections (SSIs) are among the most common postoperative complications following head and neck surgeries and are associated with increased morbidity, prolonged hospital stay, and higher healthcare costs. Early identification of infection is important to improve patient outcomes. Serum biomarkers such as procalcitonin (PCT) and C-reactive protein (CRP) have been proposed as useful indicators for early detection of postoperative infections.

Objective: To evaluate the role of serum procalcitonin and C-reactive protein in predicting surgical site infections in patients undergoing head and neck surgeries.

Methods: This prospective observational study was conducted at the Department of Otorhinolaryngology (ENT), Shahida Islam Medical College and Teaching Hospital, Lodhran, Pakistan, from February 2022 to February 2023. A total of 100 patients undergoing elective head and neck surgeries were included. Serum procalcitonin and C-reactive protein levels were measured preoperatively and postoperatively. Patients were followed for 30 days after surgery for the development of surgical site infections based on clinical assessment and CDC criteria. Statistical analysis was performed using SPSS version 25.

Results: Out of 100 patients, 22% developed surgical site infection during the postoperative follow-up period. Patients with SSI showed significantly higher postoperative levels of procalcitonin and C-reactive protein compared with those without infection ($p < 0.001$). Procalcitonin demonstrated higher specificity (89%) for detecting bacterial infection, whereas CRP showed higher sensitivity (87%) for postoperative inflammatory response.

Conclusion: Serum procalcitonin and C-reactive protein are useful biomarkers for predicting surgical site infections after head and neck surgeries. Monitoring these markers in the postoperative period may facilitate early detection and timely management of infection.

Keywords: Surgical site infection, Procalcitonin, C-reactive protein, Head and neck surgery, Biomarkers, Postoperative infection.

INTRODUCTION

Surgical site infection (SSI) is one of the most common postoperative complications in patients undergoing head and neck surgeries. It represents a significant cause of postoperative morbidity, prolonged hospitalization, delayed wound healing, and increased healthcare costs. The head and neck region contains a complex anatomical structure that is closely associated with the upper aerodigestive tract, which is naturally colonized by a diverse microbial flora. Because of this microbial contamination and the extensive tissue manipulation during surgical procedures, patients undergoing head and neck surgeries are at an increased risk of developing postoperative infections[12]. The reported incidence of surgical site infections in head and neck surgeries ranges from approximately 10% to 30%, depending on the type of procedure, surgical technique, patient comorbidities, and perioperative care[3].

Early detection of postoperative infections is essential to reduce complications and improve patient outcomes. Traditionally, the diagnosis of surgical site infection is based on clinical signs such as erythema, swelling, pain, purulent discharge, fever, and wound dehiscence[4]. However, these clinical manifestations often appear after the infection has already progressed, which may delay appropriate management[5]. Therefore, the identification of reliable biochemical markers that can detect infection at an earlier stage has become an important area of clinical research.

C-reactive protein (CRP) is one of the most widely used inflammatory biomarkers in clinical practice. It is an acute-phase protein synthesized by the liver in response to inflammatory cytokines, particularly interleukin-6[6]. CRP levels increase rapidly following tissue injury, infection, or inflammation and are commonly used as a marker to monitor postoperative inflammatory responses[7]. Although CRP is highly sensitive, it is not specific for bacterial infection because its levels can also rise following surgical trauma, tissue damage, or noninfectious inflammatory conditions[8].

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Procalcitonin (PCT), a precursor peptide of the hormone calcitonin, has recently gained attention as a promising biomarker for bacterial infections. Under normal physiological conditions, procalcitonin is produced in small amounts by the thyroid gland[9]. However, during bacterial infections, procalcitonin production increases significantly in multiple tissues throughout the body[10]. This elevation occurs rapidly within a few hours after bacterial invasion and correlates with the severity of infection[11]. Unlike CRP, procalcitonin is considered more specific for bacterial infections and is less influenced by noninfectious inflammatory processes such as surgical trauma[12].

Recent studies have suggested that measurement of procalcitonin levels in the postoperative period may help in the early identification of infectious complications in surgical patients[13]. Monitoring postoperative inflammatory markers such as CRP and procalcitonin may therefore assist clinicians in differentiating normal postoperative inflammatory responses from early infectious processes[14]. This distinction is particularly important in head and neck surgeries, where early recognition of infection can prevent serious complications, including wound breakdown, flap failure, fistula formation, and systemic infection[15].

Despite the increasing use of inflammatory biomarkers in clinical practice, limited studies have specifically evaluated the combined role of serum procalcitonin and C-reactive protein in predicting surgical site infections following head and neck surgeries[16]. Understanding the diagnostic value of these biomarkers may improve postoperative monitoring and enable earlier intervention in patients at risk of infection[17].

Therefore, the present study aims to evaluate the role of serum procalcitonin and C-reactive protein levels in predicting surgical site infections in patients undergoing head and neck surgeries and to determine their usefulness as early diagnostic markers in the postoperative period[18].

MATERIALS AND METHODS

Study Design: This study was conducted as a prospective observational study to evaluate the role of serum procalcitonin and C-reactive protein in predicting surgical site infections after head and neck surgeries. The study aimed to determine whether postoperative levels of these inflammatory biomarkers could be used as early indicators of infection in patients undergoing surgical procedures in the head and neck region.

Place of Study: The research was carried out in the Department of Otorhinolaryngology (ENT) at Shahida Islam Medical College and Teaching Hospital, Lodhran, Pakistan. This institution is a tertiary care teaching hospital where a large number of head and neck surgical procedures are routinely performed, providing an appropriate clinical setting for the evaluation of postoperative infectious complications.

Study Duration: The duration of the study was one year, and it was conducted from February 2022 to February 2023. During this period, patients undergoing head and neck surgeries were recruited and followed for postoperative outcomes, particularly the development of surgical site infections.

Sample Size: A total of 100 patients who underwent elective head and neck surgical procedures during the study period were included in the study. The sample size was selected to ensure adequate representation of patients and to allow proper evaluation of the relationship between inflammatory biomarkers and postoperative infections.

Study Population: The study population consisted of adult patients undergoing various elective head and neck surgical procedures at Shahida Islam Medical College and Teaching Hospital. Patients were enrolled after meeting the inclusion criteria and providing written informed consent to participate in the study.

Inclusion Criteria: Patients aged 18 years or older, undergoing elective head and neck surgeries, and willing to participate in the study by providing informed consent were included. These patients were considered suitable for evaluating postoperative inflammatory biomarkers and their association with surgical site infections.

Exclusion Criteria: Patients with preexisting systemic infections, those receiving long-term immunosuppressive therapy, and individuals with autoimmune or chronic inflammatory diseases were excluded from the study. In addition, patients with severe systemic illnesses or those who did not complete the postoperative follow-up period were also excluded to avoid potential confounding factors that could influence biomarker levels.

Data Collection Procedure: After obtaining informed consent, detailed clinical history and demographic information were recorded for each patient, including age, gender, comorbid conditions, and the type of surgical procedure performed. All patients underwent a comprehensive preoperative clinical examination along with routine laboratory investigations as part of the standard surgical evaluation.

Blood samples were collected for the measurement of serum procalcitonin (PCT) and C-reactive protein (CRP) levels. Baseline blood samples were obtained before surgery, and postoperative samples were collected at 24 hours, 72 hours, and on the fifth postoperative day. These measurements were used to monitor changes in inflammatory marker levels following surgery.

All surgical procedures were performed under standard aseptic conditions by experienced surgeons. Patients received routine perioperative antibiotic prophylaxis and standard postoperative care according to hospital protocols. Postoperative monitoring included regular wound examinations and clinical assessment.

Assessment of Surgical Site Infection: Patients were followed for 30 days after surgery to monitor for the development of surgical site infection. Clinical evaluation of the surgical wound was performed during postoperative visits. Surgical site infection was diagnosed according to the Centers for Disease Control and Prevention (CDC) criteria, which include the presence of purulent discharge from the wound, localized swelling, redness, warmth, pain at the surgical site, wound dehiscence, or a positive microbial culture obtained from the wound.

Outcome Measures: The primary outcome of the study was the occurrence of surgical site infection following head and neck surgery. Secondary outcomes included evaluation of the association between postoperative serum procalcitonin and C-reactive protein levels and the development of surgical site infection, as well as comparison of biomarker levels between infected and non-infected patients.

Statistical Analysis: All collected data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Continuous variables such as biomarker levels were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using independent t-tests and chi-square tests. Receiver operating characteristic (ROC) curve analysis was also performed to determine the diagnostic accuracy of serum procalcitonin and C-reactive protein in predicting surgical site infections. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics of the Study Population: A total of 100 patients undergoing head and neck surgical procedures were included in this study. The age of the patients ranged from 18 to 70 years, with a mean age of 44.6 ± 12.3 years. Among the participants, 62 (62%) were male and 38 (38%) were female, indicating a higher proportion of male patients undergoing head and neck surgeries during the study period. Various surgical procedures were performed, including thyroid surgery, parotid surgery, neck dissection, and other ENT-related procedures. The baseline demographic characteristics of the study population are presented in Table 1.

Table 1: Demographic Characteristics of the Study Population (n = 100)

Variable	Frequency	Percentage
Age Group (years)		
18–30	18	18%
31–45	34	34%
46–60	32	32%
>60	16	16%
Gender		
Male	62	62%
Female	38	38%

As shown in Table 1, the majority of patients were between 31 and 45 years of age, representing the largest age group in the study population.

Incidence of Surgical Site Infection: During the postoperative follow-up period of 30 days, 22 patients (22%) developed surgical site infection, while 78 patients (78%) did not develop any postoperative infection. The incidence of SSI observed in this study reflects the potential risk associated with head and neck surgical procedures due to the anatomical complexity and microbial exposure in this region. The distribution of surgical site infections among the study participants is presented in Table 2.

Table 2: Incidence of Surgical Site Infection (SSI)

Outcome	Frequency	Percentage
Surgical Site Infection Present	22	22%
No Surgical Site Infection	78	78%
Total	100	100%

As illustrated in Table 2, the majority of patients did not develop postoperative infection, while a smaller proportion experienced surgical site infection during the follow-up period.

Comparison of Serum Procalcitonin and C-Reactive Protein Levels: Postoperative levels of serum procalcitonin (PCT) and C-reactive protein (CRP) were compared between patients who developed surgical site infection and those who did not. Patients who developed SSI demonstrated significantly higher levels of both biomarkers in the postoperative period. The mean postoperative

serum procalcitonin level in patients with SSI was 1.74 ± 0.52 ng/mL, whereas patients without infection had a mean level of 0.38 ± 0.19 ng/mL. Similarly, the mean CRP level in the infected group was 72.6 ± 16.4 mg/L, compared with 24.8 ± 11.2 mg/L in patients without infection. These findings indicate a strong association between elevated inflammatory markers and the development of postoperative infection. The comparison of biomarker levels is summarized in Table 3.

Table 3: Comparison of Serum Biomarker Levels in Patients With and Without SSI

Biomarker	SSI Present (n=22) Mean ± SD	No SSI (n=78) Mean ± SD	p-value
Procalcitonin (ng/mL)	1.74 ± 0.52	0.38 ± 0.19	<0.001
C-Reactive Protein (mg/L)	72.6 ± 16.4	24.8 ± 11.2	<0.001

As shown in Table 3, both serum procalcitonin and C-reactive protein levels were significantly higher in patients who developed surgical site infections compared with those who did not.

Diagnostic Performance of Biomarkers: Receiver operating characteristic (ROC) curve analysis was performed to determine the diagnostic performance of serum procalcitonin and C-reactive protein in predicting surgical site infections. Procalcitonin demonstrated a sensitivity of 84% and specificity of 89%, indicating strong predictive value for postoperative infection. On the other hand, C-reactive protein showed a sensitivity of 87% but a lower specificity of 72%, suggesting that while CRP is sensitive for detecting inflammation, it is less specific for bacterial infection compared to procalcitonin. The diagnostic performance of both biomarkers is summarized in Table 4.

Table 4: Diagnostic Performance of Procalcitonin and CRP in Predicting SSI

Biomarker	Sensitivity	Specificity	Diagnostic Accuracy
Procalcitonin	84%	89%	87%
C-Reactive Protein	87%	72%	79%

The findings presented in Table 4 suggest that procalcitonin may serve as a more specific marker for postoperative bacterial infection, while CRP may function as an early sensitive marker for postoperative inflammatory responses.

DISCUSSION

Surgical site infections remain a significant cause of postoperative morbidity in patients undergoing head and neck surgeries[12]. These infections can delay wound healing, prolong hospital stay, increase treatment costs, and negatively affect surgical outcomes[3]. Early identification of postoperative infection is therefore essential for timely management and prevention of complications[4]. In recent years, inflammatory biomarkers such as serum procalcitonin (PCT) and C-reactive protein (CRP) have gained attention as potential tools for early detection of surgical infections[56]. The present study evaluated the role of these biomarkers in predicting surgical site infections following head and neck surgeries.

In this study, the overall incidence of surgical site infection was 22%, which is comparable to previously reported infection rates in head and neck surgical procedures[7]. The relatively higher infection rate in these surgeries may be attributed to the proximity of the surgical field to the upper aerodigestive tract, which harbors a large number of microorganisms[8]. In addition, factors such as prolonged surgical duration, tissue handling, presence of comorbidities, and postoperative wound contamination may also contribute to the development of infection[9].

The findings of this study demonstrated that patients who developed surgical site infection had significantly higher postoperative levels of serum procalcitonin and C-reactive protein compared with patients who did not develop infection[10]. This indicates that inflammatory biomarkers can be useful indicators of postoperative infection. Procalcitonin levels were markedly elevated in infected patients, supporting the role of PCT as a specific biomarker for bacterial infection[11]. Procalcitonin is produced in response to bacterial endotoxins and inflammatory cytokines and increases rapidly during systemic or localized bacterial infections[12].

Previous studies have also reported that procalcitonin is a reliable biomarker for detecting bacterial infections and postoperative complications[13]. Because procalcitonin levels are less affected by noninfectious inflammation such as surgical trauma, they provide better specificity for infection compared with other inflammatory markers[14]. In the present study, procalcitonin showed higher specificity in predicting surgical site infection, indicating its potential usefulness as a diagnostic marker in postoperative monitoring.

C-reactive protein, on the other hand, showed high sensitivity for detecting inflammatory responses after surgery[15]. CRP is an acute phase protein produced by the liver in response to inflammatory cytokines such as interleukin-6[16]. Its levels rise within hours after tissue injury or infection[17]. Although CRP is a sensitive marker of inflammation, it lacks specificity because its levels may also increase following surgical trauma, tissue damage, or other inflammatory conditions[18]. In this study, CRP levels were significantly higher in patients who developed surgical site infections, indicating that CRP remains a useful indicator for early inflammatory changes following surgery.

The diagnostic performance analysis in this study demonstrated that procalcitonin had higher specificity, whereas CRP showed higher sensitivity for predicting surgical site infection[19]. These findings suggest that using both biomarkers together may improve the early detection of postoperative infections. The combined assessment of PCT and CRP can help clinicians distinguish between normal postoperative inflammatory responses and true bacterial infections[20].

Early detection of infection through laboratory biomarkers can facilitate prompt clinical intervention, including appropriate antibiotic therapy and wound management. This may help reduce complications, shorten hospital stay, and improve patient outcomes after head and neck surgery[7-11].

Despite these findings, certain limitations should be considered. The study was conducted at a single center with a limited sample size, which may affect the generalizability of the results[18]. Additionally, variations in surgical procedures and patient-related factors such as comorbidities may influence postoperative biomarker levels. Future multicenter studies with larger sample sizes are recommended to further validate the role of these biomarkers in predicting surgical site infections[19,20].

CONCLUSION

The present study demonstrates that serum procalcitonin and C-reactive protein are valuable biomarkers for predicting surgical site infections after head and neck surgeries. Patients who developed postoperative infection showed significantly higher levels of both biomarkers compared with patients without infection.

Procalcitonin demonstrated greater specificity for bacterial infection, while C-reactive protein showed higher sensitivity as an inflammatory marker. The combined use of these biomarkers may provide a more accurate and reliable method for early detection of surgical site infections.

Routine monitoring of serum procalcitonin and C-reactive protein levels in the postoperative period may assist clinicians in identifying infections at an early stage and initiating timely treatment. Early diagnosis and management of surgical site infections can ultimately improve patient outcomes and reduce postoperative complications following head and neck surgeries.

Availability of Data and Materials: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Competing Interests: The authors declare that they have no competing interests.

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Authors' Contributions:

M.F.B. conceptualized the study and supervised the research work.
I. contributed to data collection and methodology.
M.F. performed statistical analysis and data interpretation.
A.H.P. assisted in manuscript writing and literature review.

H.U. contributed to data management and clinical assessment.
S.S. assisted in manuscript editing and final approval.
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