Archives of Anesthesiology and Critical Care (In Press); x(x): xx-xx.

Available online at http://aacc.tums.ac.ir

Research Article

Correlation Analysis before and after Tracheostomy on Procalcitonin Levels in Intensive Care Unit Patients

Cristian Risky Pirade[1], Sutji Pratiwi Rahardjo[1]*, Rafidawaty Alwi[1], Muh. Fadjar Perkasa[1], Arifin Seweng[2]

[1]*Department of Otorhinolaryngology - Head and Neck Surgery, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia.*

[2]*Department of Biostatistics, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia.*

ARTICLE INFO

Article history:
Received 22 October 2025
Revised 12 November 2025
Accepted 26 November 2025

Keywords:
Procalcitonin;
Tracheostomy;
Inflammation;
Critical care;
Intensive care unit;
Infection biomarker

ABSTRACT

Background: Tracheostomy is a critical procedure for airway management in mechanically ventilated patients, yet its biological impact on systemic inflammation remains unclear. Procalcitonin (PCT), a biomarker of bacterial infection and inflammatory activity, provides valuable insight into infection dynamics in critically ill patients. This study sought to examine fluctuations in serum PCT levels before and after tracheostomy in ICU patients to evaluate inflammatory responses and potential advantages in infection management.

Methods: Between January and July 2025, a prospective cohort study was done in three tertiary ICUs in Makassar, Indonesia. Twenty adult patients need extended mechanical ventilation received tracheostomy. We checked serum PCT levels four times: one day before the tracheostomy (H−1) and on days 3, 5, and 7 after the surgery. We used the Friedman and Least Significant Difference (LSD) tests to look at the data. The cutoff for significance was $p < 0.05$.

Results: The average PCT levels dropped dramatically from 13.52 ± 22.86 ng/mL (H−1) to 6.64 ± 14.13 ng/mL (H+3; $p = 0.048$). They then progressively went back up on days 5 and 7. Younger patients (under 50 years old) and those who were intubated for a shorter duration (7 days or fewer) showed better PCT patterns, which implies that there was less inflammation after early tracheostomy.

Conclusion: Tracheostomy was associated with a transient reduction in systemic inflammation, seen by decreased PCT levels by the third day post-procedure. The later rise in PCT suggests possible secondary infection or inflammatory rebound. Early tracheostomy and serial PCT monitoring are recommended to enhance infection control and optimize ICU outcomes.

Introduction

Tracheostomy is a vital surgical procedure frequently performed in critically ill patients who require prolonged mechanical ventilation or airway protection. It serves to establish a stable airway, facilitate pulmonary hygiene, and decrease respiratory workload by reducing dead space and airway resistance [1-2]. A number of studies have demonstrated that performing a tracheostomy promptly can benefit patients by reducing their duration of mechanical ventilation, the level of sedation required, and their length of stay in the Intensive Care Unit (ICU) [1–3]. Aside from these therapeutic benefits, the biological implications of tracheostomy, especially its effects on systemic inflammation and infection indicators, are still not well characterized in critical care settings. Procalcitonin

The authors declare no conflicts of interest.
*Corresponding author.
E-mail address: sutjipratiwirahardjo@yahoo.com
DOI:

(PCT), a precursor hormone of calcitonin, has emerged as a prominent biomarker for bacterial infections and systemic inflammation. Produced primarily by thyroid C cells and peripheral tissues in response to bacterial endotoxins, PCT concentrations rise proportionally with the severity of infection and organ dysfunction [4-5].

PCT is more specific for bacterial infections compared to other inflammatory markers such as C-reactive protein (CRP), rendering it effective in distinguishing between infectious and non-infectious inflammatory causes [6–7]. High levels of PCT in the blood have been linked to worse clinical outcomes, such as higher death rates, longer stays in the ICU, and slower recovery in septic patients [8].

In patients undergoing tracheostomy, fluctuations in PCT levels may reflect the complex interplay between local airway inflammation, infection control, and postoperative recovery. Early tracheostomy has been shown to lower the risk of ventilator-associated pneumonia (VAP) and systemic inflammatory response [9–10]. Conversely, a delayed or complicated tracheostomy may lead to localized infection, tissue injury, or biofilm development, thus elevating PCT levels [11–12].

So, looking at how PCT levels change before and after a tracheostomy will help us learn more about how the patient will do and help us refine timing approaches to attain the greatest clinical results. Numerous research has examined procalcitonin as an indicator of infection and the efficacy of treatment in ICU patients; however, only a limited number have investigated its temporal variations surrounding tracheostomy procedures, particularly among Southeast Asian or Indonesian populations.

Variations in the etiology of infections, antibiotic utilization, and the coexistence of comorbidities among patients may influence the dynamics of biomarkers and their clinical interpretation. So, understanding how tracheostomy and PCT changes are related is important for improving infection monitoring and postoperative care in critical care.

This study aims to investigate the differences in serum procalcitonin levels before and after tracheostomy in ICU patients, thereby providing empirical evidence concerning the inflammatory and infectious response to tracheostomy in a tertiary hospital setting.

Methods

This study employed a prospective cohort design to evaluate changes in serum PCT levels before and after tracheostomy in critically ill patients.

The study took place in the ICUs of three tertiary teaching hospitals in Makassar, Indonesia: Dr. Wahidin Sudirohusodo General Hospital, Universitas Hasanuddin Hospital, and Pelamonia Hospital. Data collection occurred from January 2025 until July 2025.

Study Population

The study population included patients who were severely ill and had to stay in the ICU for a long time because they needed tracheostomy to manage their airways. Adults aged 18 and older who were on mechanical ventilation and had a medical reason for needing a tracheostomy as evaluated by an intensivist or anesthesiologist were eligible to take part. Informed consent was obtained from each patient's legal representative prior to enrollment. Patients were excluded if they presented with coagulopathy or bleeding diathesis, local infection or trauma at the tracheostomy site, thoracic trauma causing respiratory compromise, or a pre-existing chronic pulmonary disease prior to intubation. Individuals who were discharged against medical advice during the study period were also excluded.

Sampling and Sample Size Determination

Using a consecutive sampling method, all eligible ICU patients who had a tracheostomy during the study period were included in the samples. We used a paired mean comparison algorithm to figure out the smallest sample size. With these settings, at least 20 patients were needed to reach 90% confidence with a 20% margin of error.

Tracheostomy

Tracheostomy was defined as a surgical procedure creating an artificial airway through a cervical incision into the trachea.

Procalcitonin level

Procalcitonin level referred to the serum concentration obtained through laboratory quantification before and after the procedure using Human Procalcitonin from BT-Lab Kit catalog no. E0977Hu (Zhejiang, China).

Data Collection Procedures

For each participant, serum procalcitonin levels were measured at four specific time points: one day before tracheostomy (H−1), three days after the procedure (H+3), five days after tracheostomy (H+5), and seven days after tracheostomy (H+7). The hospital's central laboratory used the enzyme-linked immunosorbent assay (ELISA) method to test venous blood samples that were taken in sterile settings. Along with biomarker tests, clinical and demographic data—such as age, sex, primary diagnosis, comorbid conditions, duration of intubation, and vital signs—were gathered from electronic medical records for thorough analysis.

Data Analysis

All data were entered and analyzed using IBM SPSS Statistics version 25.0. Data cleaning and normality testing were performed prior to analysis. Continuous variables were represented as mean ± standard deviation (SD) or median (interquartile range) where suitable. We used the Friedman test to see if there were any variations in PCT levels between the four measurement points.

The Least Significant Difference (LSD) test was used to do post-hoc pairwise comparisons. A P value of less than 0.05 was considered statistically significant.

Ethical Considerations

All study procedures adhered to the principles of the Declaration of Helsinki. Ethical approval for this study was obtained from the Ethics Committee of the Faculty of Medicine, Hasanuddin University (approval number: 262/UN4.6.4.5.31/PP36/2025).

Written informed consent was provided by the patient's legal representative prior to inclusion. All patient data were anonymized to ensure confidentiality and privacy throughout the research process.

Results

Patient Characteristics

A total of 20 patients who met the inclusion criteria were enrolled in this study. The majority were male (n = 14; 70%) and aged below 50 years (n = 11; 55%). The mean duration of intubation prior to tracheostomy was 11 ± 6 days (range: 5–22 days). Based on duration, 7 patients (35%) were intubated for ≤7 days, 7 patients (35%) for 8–15 days, and 6 patients (30%) for >15 days.

Changes in Procalcitonin Levels Before and After Tracheostomy

(Table 1) summarizes serum procalcitonin (PCT) levels at four different time points: one day before tracheostomy (H−1) and on days 3, 5, and 7 after the procedure. The Friedman test revealed a significant difference in PCT levels across the four time points ($p < 0.05$). The mean PCT level dropped a much, from 13.52 ng/mL (H−1) to 6.64 ng/mL (H+3). It then slowly went back up to 8.88 ng/mL (H+5) and 17.22 ng/mL (H+7).

On day 3 after the tracheostomy, the mean value was the lowest. A post-hoc LSD analysis showed that PCT was significantly lower between H−1 and H+3 ($p = 0.048$). However, no significant differences were observed among the subsequent post-tracheostomy measurements (H+3 vs. H+5 vs. H+7; $p > 0.05$). This finding suggests a transient suppression of systemic inflammation following tracheostomy, followed by variable recovery or secondary inflammatory responses at later time points.

Procalcitonin Levels by Age Group

A comparison of PCT kinetics between age groups (<50 years and ≥50 years) is presented in (Table 2). For patients under 50 years old, the highest PCT level was seen before the tracheostomy (H−1), and then it dropped significantly on day 3 (H+3).

Conversely, older patients (≥50 years) exhibited lower baseline PCT levels, which increased progressively by day 7 (H+7). Both age groups exhibited statistically significant differences over time ($p < 0.05$), with the younger cohort showing a greater amplitude of change. These results imply that younger patients may exhibit a more pronounced inflammatory response that normalizes more rapidly after tracheostomy.

Procalcitonin Concentrations Relative to Intubation Duration

The dynamics of PCT also changed according on how long the patient had been intubated before the tracheostomy (Table 3). Patients intubated for ≤7 days showed a significant drop in PCT levels by day 3, which then slowly rose by day 7.

Table 1- Mean Serum Procalcitonin Levels at Each Time Point (n = 20)

Time of Measurement	Minimum (ng/mL)	Maximum (ng/mL)	Mean ± SD (ng/mL)	P value
H−1 (Pre-tracheostomy)	0.22	74.12	13.52 ± 22.86	0.001
H+3	0.04	60.76	6.64 ± 14.13	
H+5	0.03	67.60	8.88 ± 16.51	
H+7	0.02	95.42	17.22 ± 31.01	

Note: Friedman test

Table 2- Mean Procalcitonin Levels by Age Group

Age Group (years)	Measurement Time	Mean ± SD (ng/mL)	P value
<50 (n=11)	H−1	21.98 ± 28.46	0.014
	H+3	10.26 ± 18.52	
	H+5	11.25 ± 20.59	
	H+7	20.21 ± 32.30	
≥50 years (n=9)	H−1	3.19 ± 3.22	0.008
	H+3	2.22 ± 2.39	
	H+5	5.97 ± 10.02	

	H+7	13.56 ± 30.86

Note: Friedman test

Table 3- Serum Procalcitonin Levels by Duration of Intubation

Duration of Intubation	Measurement Time	Mean ± SD (ng/mL)	P value (Friedman Test)
≤7 (n=7)	H−1	7.20 ± 6.82	0.007
	H+3	2.97 ± 2.56	
	H+5	5.06 ± 4.90	
	H+7	16.96 ± 31.07	
8–15 days (n=7)	H−1	21.28 ± 30.71	0.004
	H+3	14.44 ± 22.65	
	H+5	14.90 ± 25.36	
	H+7	17.64 ± 29.10	
>15 days (n=6)	H−1	11.86 ± 25.59	0.642
	H+3	1.83 ± 1.98	
	H+5	6.31 ± 12.52	
	H+7	17.02 ± 38.46	

Those with 8–15 days of intubation showed persistently elevated PCT levels across all time points, indicating sustained inflammatory activity. Meanwhile, patients intubated for more than 15 days showed wide variability and no statistically significant difference across time ($p > 0.05$). These results indicate that prolonged pre-tracheostomy intubation may diminish the anti-inflammatory advantages usually seen post-procedure.

Discussion

This study looked at the link between tracheostomy and serum PCT levels in very ill patients who were being treated in the ICU. The results showed that PCT levels were much lower on day three after the tracheostomy than they were before the treatment. They then slowly rose on days five and seven. These results suggest that tracheostomy may temporarily alleviate systemic inflammation and infection load, with subsequent variations indicating inconsistent clinical recovery or the possibility of secondary infection.

The noted decrease in PCT following tracheostomy corresponds with other research indicating that tracheostomy can enhance airway clearance, reduce ventilator-induced stress, and alleviate inflammatory reactions [9,12]. Early airway stabilization diminishes alveolar strain and secretion retention, both recognized as catalysts of cytokine-mediated inflammation [2]. PCT is a biomarker for bacterial infection and systemic inflammation, and it is sensitive to changes in the amount of microbes and inflammatory mediators that are released [4-5]. So, the early drop in PCT after tracheostomy probably means that the breathing got better and the bacteria didn't grow as much because of better secretion management and less irritation of the endotracheal tube. However, the following increase in PCT levels by day seven indicates that inflammatory processes may resurface, potentially due to new infections, biofilm development at the tracheostomy site, or ongoing systemic inflammation [11]. Accumulation of biofilm on tracheostomy tubes has been recognized as a possible origin of chronic infection and microbial persistence in ICU patients [8]. Moreover, extended mechanical ventilation, comorbidities, and patterns of antibiotic resistance may impede the timely normalization of PCT. These findings show how important it is to keep an eye on infections and change antibiotic therapy as soon as possible following a tracheostomy. Most of the people who took part in this study were men and under 50 years old. The mean period of intubation prior to tracheostomy was roughly 11 days, with the majority of patients intubated for under 15 days. These demographic trends were in line with earlier research that showed that middle-aged to older men who need long-term mechanical ventilation are more likely to have a tracheostomy [13–14].

This study also showed that PCT kinetics changed with age. Younger patients (<50 years) had elevated baseline PCT levels and a more significant reduction post-tracheostomy in comparison to older patients. Younger people may have more systemic immune activation and recover more quickly, which could explain this trend [15–16]. On the other hand, elderly patients had lower baseline PCT and took longer to return to normal. This could be because their immune systems were weaker, their cytokine regulation was off, and they were more likely to get sick [17–19]. These results show that the age of the patient could be a confounding factor when looking at inflammatory biomarker responses in people in critical care.

The length of time a person was intubated before having a tracheostomy also seemed to affect PCT dynamics. Patients who were intubated for less than seven days had the best biomarker trend, with PCT levels dropping quickly after the surgery. Conversely, individuals subjected to prolonged intubation (8–15 days

or more) exhibited consistently increased or variable PCT readings. Prolonged intubation is known to increase the risk of ventilator-associated pneumonia and systemic inflammation due to microaspiration and mucosal trauma [20-21]. The findings of this study thus support the concept of early tracheostomy, which has been shown to reduce mechanical ventilation duration, antibiotic exposure, and ICU stay [1,22]. These results have important clinical implications. Serial monitoring of PCT offers a pragmatic and objective method to evaluate the inflammatory condition of tracheostomized patients and to inform antimicrobial treatment. Several studies have shown that PCT-guided antibiotic stewardship can safely shorten the length of time antibiotics are given without hurting patient outcomes [23–25]. In this context, the temporary decrease in PCT after tracheostomy could help make decisions about lowering the dose of antibiotics. On the other hand, a later rise in PCT could make doctors rethink the possibility of a secondary infection or problems with the procedure. Nonetheless, the study possesses numerous drawbacks. The limited sample size (n = 20) and brief observation period (7 days post-tracheostomy) constrain the generalizability of the results. The lack of microbiological culture data hinders the correlation of PCT alterations with particular pathogens or infection sources. Also, differences in patients' comorbidities, antibiotic regimens, and mechanical ventilator settings may have affected how biomarkers responded. Subsequent multicenter investigations with bigger cohorts, extended follow-up periods, and comprehensive microbiological evaluations are necessary to corroborate these findings and develop uniform monitoring techniques.

Conclusion

Tracheostomy was linked to a big drop in serum procalcitonin levels on the third day following the procedure. This shows that inflammation and infection in the body were lessened. The subsequent increase in PCT by day seven indicates a potential secondary infection or inflammatory rebound. Younger patients and those who underwent early tracheostomy showed more favorable biomarker responses. These findings highlight the importance of early tracheostomy and continuous PCT monitoring to optimize infection control and clinical outcomes in critically ill patients.

Authorship contribution

CRP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

SPR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

RA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

MFP: Conceptualization, Investigation, Methodology, Resources, Software, Validation, Writing – original draft, Writing – review & editing.

AS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing.

References

[1] Adly A, Youssef TA, El-Begermy MM, Younis HM. Timing of tracheostomy in patients with prolonged endotracheal intubation: a systematic review. Eur Arch Otorhinolaryngol. 2018; 275(3):679-690.

[2] Schroeder T, Nee J, Kamel S, Storm C, Hinrichs C, Marcy F, et al. Characteristics and outcome of critical care patients undergoing tracheostomy in a medical intensive care setting: a retrospective single center analysis of 1570 procedures in 12 years. Trends Anaesth Crit Care. 2025; 101519.

[3] Karnina R, Sugiarto A, Sedono R, Aditianingsih D, Manggala SK, Purwaamidjaja DB. Decision for early tracheostomy in respiratory failure of a paralyzed myasthenia gravis patient with sepsis-induced pneumonia: A case report. Int J Surg Case Rep. 2024; 117:109514.

[4] Assicot M, Gendrel D, Carsin H, Raymond J, Guilbaud J, Bohuon C. High serum procalcitonin concentrations in patients with sepsis and infection. Lancet. 1993; 341(8844):515-8.

[5] Yunus I, Fasih A, Wang Y. The use of procalcitonin in the determination of severity of sepsis, patient outcomes and infection characteristics. PLoS One. 2018; 13(11):e0206527.

[6] Arif SK, Suyata MP, Gaus S, Ahmad MR. Procalcitonin and C-reactive protein as a predictor of organ dysfunction and outcome of sepsis and septic shock patients in Intensive Care Unit. Glob J Health Sci. 2017; 9(12):169.

[7] Khan AA, Singh R, Singh PK. Diagnostic and prognostic significance of procalcitonin in septicemia. Int J Adv Med. 2017; 4(3):630–634.

[8] Bourika V, Rekoumi EA, Giamarellos-Bourboulis EJ. Biomarkers to guide sepsis management. Ann Intensive Care. 2025; 15(1):103.

[9] Masoudifar M, Aghadavoudi O, Nasrollahi L. Correlation between timing of tracheostomy and duration of mechanical ventilation in patients with potentially normal lungs admitted to intensive care unit. Adv Biomed Res. 2012; 1(1):25.

[10] Qureshi KH, Rasheed A, Saleem MZ, Zafar J, Shah SA, Ahmad B. Frequency of Ventilator Associated Pneumonia with Closed Tracheal Suction versus Open Tracheal Suction. Pak Armed Forces Med J. 2025; 75.
[11] Khammas AH, Dawood MR. Timing of tracheostomy in intensive care unit patients. Int Arch Otorhinolaryngol. 2018; 22(04):437-42.
[12] Vargas M, Buonanno P, Giorgiano L, Sorriento G, Iacovazzo C, Servillo G. Comparison between surgical and percutaneous tracheostomy effects on procalcitonin kinetics in critically ill patients. Crit Care. 2018; 22(1):297.
[13] Nazario LC, Magajewski FR, Pizzol ND, Saloti MH, Medeiros LK. Temporal trend of tracheostomy in patients hospitalized in the Brazilian National Unified Health System from 2011 to 2020. Rev Col Bras Cir. 2022; 49:e20223373.
[14] Mizuno K, Kishimoto Y, Takeuchi M, Omori K, Kawakami K. Demographic and Clinical Trends in Adult Tracheostomy: Analysis of a Japanese Inpatient Database. Laryngoscope. 2025.
[15] Feng T, James A, Doumlele K, White S, Twardzik W, Zahid K, et al. Procalcitonin levels in COVID-19 patients are strongly associated with mortality and ICU acceptance in an underserved, inner city population. Medicina (Kaunas). 2021; 57(10):1070.
[16] Aydin M, Şaylan B, Ekiz İşcanlı İG. Factors associated with mortality in younger and older (≥ 75 years) hospitalized patients with community-acquired pneumonia. Ann Saudi Med. 2022; 42(1):45-51.
[17] Liang SY. Sepsis and other infectious disease emergencies in the elderly. Emerg Med Clin North Am. 2016; 34(3):501.
[18] Cheng Q, Liao Y, Lin Y, Tao L, Wang H, Li M, et al. Clinical characteristics and prognostic factors in elderly patients with COVID-19. In Review. Preprint posted online December 11, 2020. doi:10.21203/rs.3.rs-31123/v3
[19] Ticinesi A, Nouvenne A, Prati B, Guida L, Parise A, Cerundolo N, et al. The Clinical Significance of Procalcitonin Elevation in Patients over 75 Years Old Admitted for COVID-19 Pneumonia. Mediators Inflamm. 2021; 2021:5593806.
[20] Wu D, Wu C, Zhang S, Zhong Y. Risk Factors of Ventilator-Associated Pneumonia in Critically Ill Patients. Front Pharmacol. 2019; 10:482.
[21] Zhang R, Liu J, Wei J, Li X, Deng X, Wang Y. Study on the application value of “micro-aspiration” in prevention and control of ventilator-related pneumonia in severely ill patients: A randomized controlled trial. AIP Adv. 2025; 15(2):025039.
[22] Samiei Nasr D, Khoundabi B, Monshizadeh Azar G, Malekmohammad M, Jamaati H, Hashemian SM. Beneficial Outcomes of Early Tracheostomy in Patients Requiring Prolonged Mechanical Ventilation. Tanaffos. 2020; 19(4):350-355.
[23] Soni NJ, Samson DJ, Galaydick JL, Vats V, Huang ES, Aronson N, et al. Procalcitonin-guided antibiotic therapy: a systematic review and meta-analysis. J Hosp Med. 2013; 8(9):530-40.
[24] Zhang T, Wang Y, Yang Q, Dong Y. Procalcitonin-guided antibiotic therapy in critically ill adults: a meta-analysis. BMC Infect Dis. 2017; 17(1):514. Erratum in: BMC Infect Dis. 2019; 19(1):1077.
[25] Nazer LH, Awad W, Thawabieh H, Abusara A, Abdelrahman D, Addassi A, et al. Procalcitonin-Guided Management and Duration of Antibiotic Therapy in Critically Ill Cancer Patients With Sepsis (Pro-Can Study): A Randomized Controlled Trial. Crit Care Explor. 2024; 6(10):e1173.