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Comparison between Tracheostomy and No Tracheostomy on the Incidence of Ventilator-Associated Pneumonia (VAP) Using the Modified Clinical Pulmonary Infection Score (MCPIS): A Prospective Cohort Study

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Abstract

Background: The principal mechanism underlying the development of ventilator-associated pneumonia (VAP) involves the aspiration of microorganisms from colonized oropharyngeal secretions past the endotracheal tube (ETT), followed by bacterial proliferation along the ETT surface. The Modified Clinical Pulmonary Infection Score (MCPIS) is commonly utilised to assist in the diagnosis and clinical evaluation of pneumonia. This instrument assesses various factors, including body temperature, leukocyte count, the volume and characteristics of tracheal secretions, oxygenation status, and results from chest imaging. Airway management through ETT intubation or tracheostomy plays a crucial role in ensuring airway patency, minimizing anatomical dead space, facilitating effective suctioning, and optimizing oxygen delivery.

Methods: This prospective cohort study included individuals diagnosed with non-traumatic brain damage, selected using successive sampling according to established inclusion and exclusion criteria. The sample size was established at a 90% confidence level and a precision of 20%, with statistical significance defined at $p < 0.05$. The research was carried out at Wahidin Sudirohusodo Hospital in Makassar, from March 2024 to April 2025, and involved evaluating the MCPIS both before and after tracheostomy, as well as in patients who did not undergo the procedure. Data analysis was conducted using SPSS version 25, applying the Wilcoxon Signed-Rank test to assess statistical differences.

Results: A total of 50 samples were included (25 with tracheostomy and 25 without). When the average MCPIS scores were analyzed, the tracheostomy group's score dropped from 4.92 to 3.20 (P=0.001), a statistically significant drop. On the other hand, MCPIS scores in the non-tracheostomy group increased from 5.04 to 5.60, although this difference was not statistically significant (P=0.158). Within the tracheostomy cohort, significant improvements were noted in the subcomponents of body temperature (P=0.009), tracheal secretion characteristics (P=0.003), and oxygenation status (P= 0.046). However, no meaningful changes were detected in the parameters of leukocyte count (P=0.564) and chest radiographic findings (P=0.222).

Conclusion: Tracheostomy was associated with improved MCPIS outcomes compared to non-tracheostomy, particularly in the components of temperature, tracheal secretion, and oxygenation.

Keywords: Tracheostomy, modified clinical pulmonary infection score, Ventilator Associated Pneumonia.

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↑What is "already known" in this topic:
Tracheostomy serves as an effective intervention for safeguarding airway patency, alleviating upper airway obstruction, and has the potential to shorten the duration of mechanical ventilator use and patient hospitalization. Additionally, it may reduce the risk of complications associated with prolonged endotracheal intubation. Despite these benefits, intraoperative complications may occur, including bleeding, intraoperative tracheoesophageal fistula, pneumothorax, pneumomediastinum, post-obstructive pulmonary edema, and burns. However, with adequate surgical expertise, these complications can be minimized.

→What this article adds:
MCPIS serves as an alternative for evaluating pulmonary infections in the ICU, particularly in healthcare facilities without access to bacterial culture tests for diagnosing VAP. In developing countries, such tests are sometimes unavailable and often require considerable time to obtain results.

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Introduction

In individuals with intact physiological defenses, the respiratory tract is typically protected from bacterial colonization through mechanisms such as the cough reflex, mucociliary clearance, the presence of epithelial lining fluid and pulmonary surfactants, as well as both cellular and humoral immune responses. Nonetheless, when these protective barriers are breached, the likelihood of pneumonia development significantly escalates (1, 2).

VAP is particularly concerning, as it has been linked to higher mortality rates compared to infections at other anatomical sites. This infection is the second most frequent nosocomial infection in hospitals and the main reason why critically ill people die from nosocomial infections (3).

The Clinical Pulmonary Infection Score (CPIS) is a frequently used instrument for assessing clinical indicators of lung infection. Despite being reasonably simple to compute, the CPIS relies on microbiological data that may be difficult to collect in acute care settings. To address this limitation, the Modified CPIS (MCPIS) was introduced, enabling clinicians to assess pulmonary infection based on observable clinical parameters (4).

Tracheostomy has demonstrated efficacy in facilitating recovery for patients necessitating extended mechanical ventilation, including advantages such as decreased duration of ventilatory assistance, abbreviated intensive care unit (ICU) admissions, and a diminished occurrence of problems associated with prolonged endotracheal intubation (5, 6).

In light of these considerations, this study was conducted to compare the incidence of VAP between patients undergoing tracheostomy and those managed without the procedure.

Methods

Study Design

A prospective cohort study was conducted involving individuals with non-traumatic brain damage, selected using successive sampling according to established inclusion and exclusion criteria. The research was performed in the ICU of Wahidin Sudirohusodo Hospital, Makassar, from March 2024 to April 2025. The MCPIS was evaluated both before and after tracheostomy, as well as in a non-tracheostomy comparison group. Data analysis was conducted with SPSS version 25, applying the Wilcoxon Signed-Rank test to assess differences within and between groups.

Research Sample

Participants were chosen via consecutive sampling according to established inclusion and exclusion criteria. The sample size was calculated using a 90% confidence level and a margin of error of 20%, leading to a minimum requirement of 20 subjects per group. The threshold for statistical significance was established at a p-value of less than 0.05. The inclusion criteria included ICU patients undergoing mechanical ventilation and having clinical indications for tracheostomy. In the tracheostomy cohort, the criteria for exclusion encompassed: mechanical ventilation lasting more than five days, the existence of coagulation disorders, trauma to the neck, infection at the intended insertion site, thoracic trauma associated with respiratory distress, pre-existing pulmonary conditions prior to intubation, or death/discharge against medical advice within a week following the tracheostomy. Patients in the non-tracheostomy group were excluded from the study if they had chest injuries accompanied by respiratory disorders, a history of pulmonary disease prior to intubation, or if they died or were discharged within nine days of admission to the ICU. The independent variables in this study were tracheostomy and non-tracheostomy procedures. Meanwhile, confounding variables that may have influenced the results included age, comorbid conditions, and patient consciousness level. However, pulmonary comorbidities were excluded from the analysis, and all patients were sedated, thereby minimizing the influence of these confounders on the study outcomes. The dependent variable in this study was the Modified Clinical Pulmonary Infection Score (MCPIS), where a score of more than 6 indicated the presence of ventilator-associated pneumonia (VAP), while a score of 6 or less indicated the absence of VAP. The MCPIS assessment was conducted based on the criteria listed in Table 1.

For patients who underwent tracheostomy, the MCPIS was assessed on the day of the procedure and subsequently

Table 1. MCPIS components

Components		Point
Temperature ^{0}C	≥ 36.5 and ≤ 38.4	0
	≥ 38.5 and ≤ 38.9 or ≥36.1 and ≤36.4	1
	≥ 39.0 and ≤ 36.0	2
Blood Leukocytes (mm^3)	≥ 4.000 and ≤11.000	0
	<4.000 or >11.000 + band forms ≥50%	1
Tracheal Secretion	There isn't any	0
	There is non-purulent tracheal discharge	1
	There is purulent tracheal discharge	2
Oxygenation (PaO_2/FiO_2, mmHg)	>240 or ARDS	0
	<240 and no ARDS	2
Chest X-ray	Partial or diffuse infiltrate	1
	Local infiltrate	2

on the seventh day following the tracheostomy. In contrast, for the non-tracheostomy cohort, MCPIS evaluations were performed on the second and ninth days of their ICU admission. This design ensured that all participants, regardless of group, underwent comparative MCPIS evaluation within a consistent 7-day interval.

Results

Between March 2024 and April 2025, a total of 798 patients required mechanical ventilation in the ICU. Among these, 38 patients underwent a tracheostomy procedure. Following the application of predefined inclusion and exclusion criteria, a final sample of 50 patients was selected, comprising 25 patients who underwent tracheostomy and 25 who did not. The research sample comprised 33 males (66%) and 17 females (34%), with a mean age of 42.7 years.

According to Table 2, the group undergoing tracheostomy exhibited a statistically significant reduction in the average body temperature score (*P* = 0.009), tracheal secretions (*P* = 0.003), and oxygenation levels (*P* = 0.046). In contrast, no significant alterations were observed in the average leukocyte count (*P* = 0.564) or the results of chest radiography (*P* = 0.222). In contrast, within the non-tracheostomy group, the only parameter exhibiting a significant change was the temperature score, which showed a notable increase (*P* = 0.022).

As shown in Table 3, the tracheostomy group experienced a significant decrease in the mean total MCPIS following the procedure, which fell from 4.92 to 3.20 (*P* = 0.001). In contrast, the non-tracheostomy group exhibited an increase in the mean MCPIS during the 7-day period, rising from 5.04 to 5.60; however, this change did not reach statistical significance (*P* = 0.158).

Discussion

The majority of participants in this research were male, representing 66% of the sample, with an average age of 42.7 years. This gender distribution is in close agreement with the findings of Indriasari et al. (2024), who reported that 63.3% of patients diagnosed with VAP were male. Similarly, El-Anwar et al. (2017) observed that males constituted 91.7% of ICU patients who underwent tracheostomy. Supporting this trend, Anindito et al. (2023) also reported a predominance of tracheostomy cases among male patients (7-9).

In contrast, Muhibbut Thibri et al. (2024) discovered that women constituted the predominant group of ICU patients who underwent tracheostomies, making up 54% of their sample. In terms of age, the present study did not find it to be a significant determinant for the development of VAP. However, this finding diverges from several other investigations, including Sutoyo et al. (2025), which highlighted age as a notable contributor to the development of VAP (10, 11).

The inconsistencies noted in these studies may stem from variations in study populations, research techniques, or other contextual factors.

Concerning the temperature parameter, the tracheostomy cohort demonstrated a statistically significant decrease in the mean score (*P* = 0.009), while the non-tracheostomy cohort revealed a significant increase (*P* = 0.022). These findings correspond with the data of Sudadi et al. (2023), who identified variations in patient body temperature

Table 2. Comparison of MCPIS Component Scores between Before and After Action

Group	Components	n	Mean	SD	*P*
Tracheostomy	Pre-Temperature	25	0.68	0.90	0.009
	Post-Temperature	25	0.16	0.47	
	Pre-Leukocytes	25	0.64	0.49	0.564
	Post-Leukocytes	25	0.56	0.51	
	Pre-Tracheal Secretions	25	1.92	0.28	0.003
	Post-Tracheal Secretions	25	1.36	0.70	
	Pre-Oxygenation	25	0.32	0.75	0.046
	Post-Oxygenation	25	0.00	0.00	
	Pre-Chronic X-Ray	25	1.36	0.81	0.222
	Post-Chronic X-Ray	25	1.12	0.88	
Without Tracheostomy	Pre-Temperature	25	0.68	0.80	0.022
	Post-Temperature	25	1.36	0.81	
	Pre-Leukocytes	25	0.88	0.33	0.058
	Post-Leukocytes	25	0.64	0.49	
	Pre-Tracheal Secretions	25	1.92	0.28	0.564
	Post-Tracheal Secretions	25	1.88	0.33	
	Pre-Oxygenation	25	0.48	0.87	1.000
	Post-Oxygenation	25	0.48	0.87	
	Pre-Chronic X-Ray	25	1.08	0.86	0.396
	Post-Chronic X-Ray	25	1.24	0.78	

Wilcoxon Signed Rank test

Table 3. Comparison of Total MCPIS Scores by Group

Group	Dependent variables	n	Mean	SD	*P*
Tracheostomy	MCPIS Pre Score	25	4.92	1.93	0.001
	MCPIS Post Score	25	3.20	1.58	
Without Tracheostomy	MCPIS Pre Score	25	5.04	1.57	0.158
	MCPIS Post Score	25	5.60	1.87	

Wilcoxon Signed Rank test

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during mechanical breathing, including feverish episodes that improved subsequent to therapeutic modifications and treatments such as tracheostomy (12). Correspondingly, Achaiah (2023) indicated that most fever cases in the ICU were due to infections, with ventilator-associated pneumonia recognised as a common underlying cause (13).

The findings from the aforementioned studies provide robust evidence that changes in body temperature represent a physiological reaction to infection, as frequently found in patients with VAP.

The mean leukocyte count did not show a significant difference in either the tracheostomy group ($P = 0.564$) or the non-tracheostomy group ($P = 0.058$). Bima (2022) discovered various factors contributing to high leukocyte counts, including infections, malignancies, severe haemorrhage, acute haemolysis, intoxications, and other stress-related disorders such as significant trauma. Supporting this, Viner (2023) demonstrated that infections predominantly accounted for leukocyte counts ranging from 35 to 50 × 10^9 leukocytes/L, whereas malignancies were more commonly associated with counts exceeding 50 × 10^9 leukocytes/L. Among infectious causes, pneumonia remains one of the most prevalent. Notably, neither risk factors nor causative pathogens were found to correlate significantly with leukocyte levels (14, 15). The results of this research correspond with earlier studies that suggest leukocyte counts are affected by various causes, which consequently restricts their effectiveness as a conclusive element within the MCPIS components. Following tracheostomy, a notable reduction in the average tracheal secretion score was observed ($P = 0.003$), whereas in the group that did not undergo tracheostomy, no significant alterations were detected ($P = 0.564$). ETT placement interferes with the natural function of the upper airway in filtering and warming inhaled air. In addition, intubation damages the function of the cilia in the respiratory tract mucosa, creating conditions that support bacterial colonization in the trachea, which then leads to increased secretion production. The accumulation of secretions serves as a medium for bacterial growth. Supporting this, Buston (2020) reported that 79.3% of study participants exhibited copious tracheal secretions and developed VAP, with a significant correlation between secretion volume and VAP incidence (16). These findings underscore the clinical objectives of tracheostomy, which encompass decreasing bacterial colonisation associated with endotracheal tube use and improving pulmonary hygiene, therefore minimising the accumulation of tracheal secretions.

A notable decrease in the mean oxygenation score was recorded post-tracheostomy ($P = 0.046$), while the non-tracheostomy group showed no significant variation ($P = 1.00$). A reduction in the PaO_2/FiO_2 ratio indicates compromised oxygen exchange in patients with VAP. Supporting this, Mark Le Pape et al. (2022) indicated that persons with acute respiratory distress syndrome (ARDS) worsened by VAP had a significant reduction in this ratio, implying that although VAP negatively impacts oxygenation, this impairment may be reversible with appropriate care (17). Conversely, Ferrer et al. (2019) found that incorporating a PaO_2/FiO_2 threshold of ≤ 240 into clinical assessments did not significantly enhance the accuracy of VAP diagnosis. Moreover, a ratio exceeding 240 did not exclude the presence of infection, indicating that reliance on this cutoff may lead to underestimation or misclassification of VAP cases (18). Despite variations among studies, the PaO_2/FiO_2 ratio remains a potential sign of compromised oxygenation in patients with VAP.

There were no significant changes in the average chest radiography scores for both the tracheostomy group ($P = 0.222$) and the non-tracheostomy group ($P = 0.396$). Chest X-ray serves as a crucial diagnostic tool for assessing patients diagnosed with VAP. Numerous studies have indicated a robust correlation between radiological enhancement and clinical recovery. Shokouhi et al. (2017) noted that the majority of patients who successfully navigated the acute phase of VAP exhibited a resolution of infiltrates on chest X-rays, accompanied by a more rapid process of radiological improvement. The results indicate that conducting repeat chest X-rays after clinical improvement may provide minimal incremental diagnostic benefit, warranting a reevaluation of their routine application. Consequently, while chest radiographs are indispensable for early VAP detection, their role in continued patient monitoring should be carefully weighed against the patient's overall clinical status (19).

The cohort of patients who underwent tracheostomy exhibited a statistically significant reduction in the overall MCPIS average score following the procedure, decreasing from 4.92 to 3.20 ($P = 0.001$). Conversely, the cohort without tracheostomy experienced an increase in the average MCPIS score over the seven-day assessment period, rising from 5.04 to 5.60; however, this alteration did not achieve statistical significance ($P = 0.158$). These findings align with prior research, including studies by Hayoung Seong et al. (2025), which indicated that the implementation of tracheostomy in patients suffering from severe pneumonia necessitating prolonged mechanical ventilation significantly lowered the 90-day mortality rate. Moreover, the prompt execution of tracheostomy has been linked to enhanced management of hospital resources. This evidence underscores the critical role of timely tracheostomy intervention in enhancing patient prognosis while optimizing healthcare delivery (20). Santos Kumar Swain (2021) illustrated that conducting an early tracheostomy in patients who need extended mechanical ventilation notably reduced the incidence of VAP and, in comparison to delayed or non-existent tracheostomy, enhanced both patient comfort and the effectiveness of care provision (21).

In their 2022 study, Tolga Besci and colleagues established a correlation between the date of tracheostomy and the incidence of VAP. Nevertheless, they emphasized the need for additional prospective research to clarify the causal links between delayed tracheostomy and morbidity in the ICU (22).

Although early tracheostomy has been associated with a decreased likelihood of ventilator-associated pneumonia (VAP), the evidence is still not definitive. A meta-analysis conducted by Moore et al. (2024) revealed no statistically significant differences in mortality rates or the incidence of

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pneumonia when comparing early tracheostomy to late tracheostomy. This lack of definitive results may be attributed to heterogeneity in study populations and inconsistent criteria defining early tracheostomy across studies (23). In a comparable study, Boni A. et al. (2025) performed a systematic review and meta-analysis of randomized clinical trials (RCTs) to evaluate the results of early tracheostomy in comparison to late tracheostomy. Their findings indicated that current evidence remains inadequate to definitively support the advantages of early tracheostomy in reducing VAP incidence and mortality rates (24).

Hui-Hsuan Lai et al. (2021) determined that the choice to undergo tracheostomy had no substantial effect on long-term survival rates or yearly medical expenses for patients undergoing prolonged mechanical ventilation (PMV). This finding underscores the necessity of tailoring treatment strategies on a case-by-case basis to effectively minimize both mortality and medical expenditures (25).

Although tracheostomy provides certain benefits, intraoperative complications may occur, including bleeding, intraoperative tracheoesophageal fistula, pneumothorax, pneumomediastinum, post-obstructive pulmonary edema, and burns (26).

Conclusion

Tracheostomy was associated with improved MCPIS outcomes compared to non-tracheostomy, particularly in the components of temperature, tracheal secretion, and oxygenation.

Authors' Contributions

All authors conceived and designed the study, collected and analyzed the data, and wrote, read, refined, and approved the final version of the manuscript.

Ethical Considerations

Ethics Commission for Biomedical Research on Humans, Faculty of Medicine, Hasanuddin University, with protocol number 523/UN4.6.4.5.31/PP36/2024.

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None.

Conflict of Interests

The authors declare that they have no competing interests.

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