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Association between tracheostomy timing and mechanically ventilated patient outcomes in intensive care unit Dr. M. Djamil Hospital Padang

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Abstract
Background: Tracheostomy plays a fundamental role in airway management of mechanically ventilated patient in intensive care units (ICUs). The ideal timing of tracheostomy is still a controversial issue. This study aimed to evaluate the association between the timing of tracheostomy and outcome in patients receiving mechanical ventilation.
Methods: This study was retrospective cohort analysis of adult patients who underwent tracheostomy during their ICUs admission between January 2021 and December 2023. Data were collected from the medical record database. The outcome was mechanical ventilation duration and ventilator associated pneumonia (VAP) scoring. The timing of tracheostomy was grouped by early tracheostomy (ET): ≤ 6 days and late tracheostomy (LT): > 6 days. The association was evaluated using Mann-Whitney analysis.
Results: Among the 143 patients population, 62 patients were included in the analysis: ET (n=37) dan LT (n=25). The mean of post-tracheostomy MV duration in days was 5,19±3, 48 standard deviation (SD) in ET group and 5,48±4,45 in LT group (p=0,983). The mean of total MV duration in days was 10,08±3,35 SD in ET group and 13,64±4,47 SD in LT group (p=0,001). The mean of pre-tracheostomy VAP scoring was 2,43±1,28 SD in ET group and 3,16±1,03 SD in LT group (p=0,024), and post-tracheostomy VAP scoring was 3,05±1,22 SD in ET group and 3,88±1,33 SD in LT group (p=0,014).
Conclusion: Early tracheostomy had a significant impact in shortening the total duration of the MV and reducing the risk of VAP.

Keywords: Tracheostomy timing, intensive care, outcome, mechanical ventilation duration, VAP

Introduction
Mechanical ventilation has a crucial role for critically ill patients diagnosed with acute or chronic respiratory failure1. Approximately 75% of patients treated in the intensive care unit (ICU) require ventilation support and most of these patients experience prolonged mechanical ventilation. Prolonged associated pneumonia (VAP) [9, 10]. Therefore, tracheostomy is preferred by international consensus for patients who are predicted to have prolonged mechanical ventilation [11]. The National American Association of Medical Directors of Respiratory Care indicates tracheostomy for patients requiring mechanical ventilation for more than 14-21 [12] mechanical ventilation is defined as at least 21 consecutive days of mechanical days.
Despite of many advantages in ventilation for > 6 hours/day, which is associated with increased morbidity, mortality, and length of stay in the ICU and hospital, resulting in increased hospital care costs [2-7]. Long duration of mechanical ventilation could cause several complications, named as ventilator-associated events (VAE). Some VAEs that often occur include ventilator associated pneumonia (VAP), pulmonary edema, acute respiratory distress syndrome (ARDS), tracheostomy procedure compared to translaryngeal endotracheal intubation in prolonged mechanical ventilated patients, optimal time to perform tracheostomy is still under debate. The definition of tracheostomy timing varies across studies. Overall, early tracheostomy is performed within a period of 2-10 days after installation of mechanical ventilation, and late tracheostomy is performed within a period of 6-29 days or more after installation of mechanical [13-17] atelectasis, and sepsis. VAE could also ventilation However, other studies increase in patient with comorbidities [8].
Tracheostomy has a fundamental role in airway management. Compared with translaryngeal endotracheal intubation, tracheostomy has the potential to be superior for mechanically

ventilated patients, such as reduced airflow resistance, better patient comfort and mobilization, less invasive weaning, and reduced incidence of ventilator-suggest the appropriate timing of tracheostomy should be based on the patient condition [18, 19].

Studies regarding optimal timing are always related to its relationship with mechanical ventilation complications, length of stay and mortality. The study by Chorath *et al*. (2021) showed that early tracheostomy was associated with a reduction in the incidence of VAP, shortening the duration of mechanical ventilation and length of ICU stay, but not in reduction of mortality [20]. This is similar with the study by Huang *et al*. (2021) which states that early tracheostomy is associated with a reduction in respiratory complications and length of stay [21].

Based on this background, the author is interested to evaluate the relationship between tracheostomy timing and patient outcomes in the intensive care unit at Dr. M Djamil Hospital, Padang.

Metode

This is an analytical study using a retrospective cohort design. The study was conducted at Dr. M. Djamil Hospital Padang in January-February 2024 which included all patients installed on mechanical ventilation who had a tracheostomy and were treated in the ICU at Dr. M. Djamil General Hospital, Padang in January 2021 to December 2023. Inclusion criteria were age above 17 years, admitted to the ICU at Dr. M. Djamil General Hospital in January 2021-December 2023, installed on mechanical ventilation, and had tracheostomy. Patients with unclear or incomplete medical records, or died during treatment were excluded. Demographic data (age and gender), clinical characteristics (primary disease and comorbidities), ventilation duration and complications were extracted. The independent T test was used to compare the outcomes between both groups (early and late tracheostomy). Normality test for numerical data was carried out with Kolmogorov Smirnov. If the data is not normally distributed then the T test cannot be used and an alternative test (the Mann-Whitney test) is carried out.

Result

In this study, 62 samples met the inclusion criteria. Sample selection is shown in Figure 1. There were 37 patients (59.7%) who underwent early tracheostomy and 25 patients (40.3%) underwent late tracheostomy. The average age in the late tracheostomy was higher than the early tracheostomy group (50 vs 47 years). The majority of patients were male (23 [62.2%] in early tracheostomy; 15 [60%] in late tracheostomy), and had neurological disorders (28 (75.7%) in early tracheostomy; 14 (56%) in late tracheostomy).

Based on comorbidities, patients in the early tracheostomy group most often had respiratory disease (43.2%), followed by AKI/CKD (29.7%) and others (shock, electrolyte imbalance, anemia, trauma) (29,7%). Then in the late tracheostomy group, most patients had other comorbidities (36%) and respiratory disease (32%).

Furthermore, the average duration of mechanical ventilation before and after tracheostomy were higher in late tracheostomy group than early tracheostomy ([8.16 vs 4.89 days] and [5.48 vs 5.19 days] respectively). The average total duration of mechanical ventilation also higher in the late tracheostomy group than the early tracheostomy group (13.64 vs 10.08 days). Then based on VAP (Ventilator-Associated-Pneumonia), the average of VAP score before tracheostomy higher in the late tracheostomy group than the early tracheostomy group (3.16 vs 2.43). score after tracheostomy also higher in the late tracheostomy than the early tracheostomy group (3.88 vs 3.05).

Bivariate analysis aims to determine the relationship between tracheostomy timing and outcomes (the duration of mechanical ventilation [post-tracheostomy and total duration of mechanical ventilation) and the incidence of VAP (pre-tracheostomy and post-tracheostomy VAP) in patients in the intensive care unit of Dr. M. Djamil Hospital Padang. For numerical variables, normality test is done first to determine statistical tests. The normality test uses the Kolmogorov Smirnov. The data is considered as normally distributed if the sig value is >0.05. The results of the normality test for each variable could be seen in Table 2. Table 2 shows that all variable data has an abnormal distribution (sig <0.05), so the statistical test used is the non-parametric Mann-Whitney test.

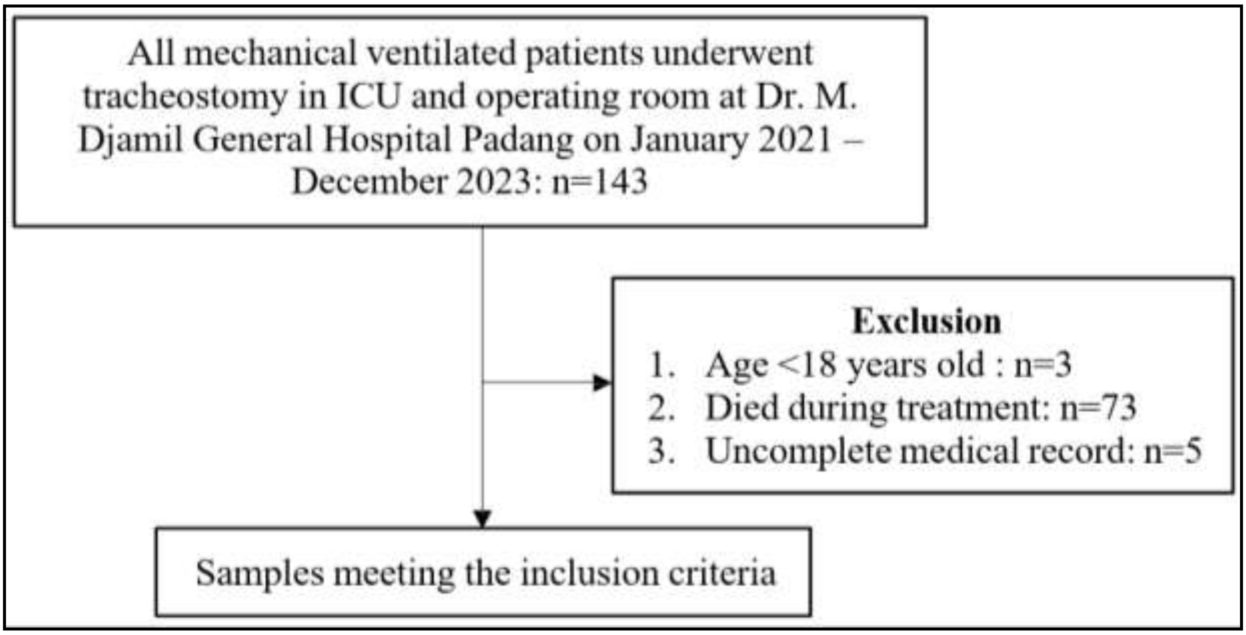

Fig 1: Flowchart of sampling process

Table 1: Demographic and Clinical Characteristics of Patients Based on Tracheostomy Timing in the ICU Treatment Room at RSUP Dr. M. Djamil Padang

Characteristic		n (%)/(mean ± SD; min-max)	
	Total (n)	Early Tracheostomy (n=37)	Late Tracheostomy (n=25)
Age (years)	62	47±15,16; 18-68	50±14,77; 18-70
Gender			
Male	38	23 (62,2	15 (60,0)
Female	24	14 (37,8)	10 (40,0)
Primary diseas			
Neurology	42	28 (75,7	14 (56,0)
Non-neurology	20	9 (24,3)	11 (44,0)
Comorbidities			
Hypertension	9	6 (16,2)	3 (12,0)
Diabetes Mellitus	14	8 (21,6)	6 (24,0)
AKI/CKD	17	11 (29,7)	6 (24,0)
Respiratory Disease	24	16 (43,2)	8 (32,0)
Others	20	11 (29,7)	9 (36,0)
Duration of MV before tracheostomy (days)	62	4,89±1,20; 1-6	8,16±1,18; 7-11
Duration of MV after tracheostomy (days)	62	5,19±3,48; 1-14	5,48±4,45; 1-20
Total Duration of VM (days)	62	10,08±3,35; 3-19	13,64±4,47; 8-29
VAP before tracheostomy	62	2,43±1,28; 0-5	3,16±1,03; 1-5
VAP after tracheostomy	62	3,05±1,22; 1-7	3,88±1,33; 2-7

Table 2: Normality Test

Kolmogorov Smirnov		
Variate	(Sig)	Interpretation
Duration of MV after tracheostomy	0,000	Abnormal distribution
Total Duration of MV	0,002	Abnormal distribution
VAP before tracheostomy	0,000	Abnormal distribution
VA P after tracheostomy	0,000	Abnormal distribution

The relationship between tracheostomy timing and duration of mechanical ventilation (post-tracheostomy and total duration) could be seen in Table 3. Based on Table 3, it is found that the mean duration of mechanical ventilation after tracheostomy was longer in the late tracheostomy group (5.48 days with variations 4.45 days) compared to the early tracheostomy group (5.19 days with a variation of 3.48 days). The results of statistical tests obtained a p-value = 0.983, meaning that there was no difference in the mean duration of mechanical ventilation after tracheostomy between the early and late tracheostomy group.
Furthermore, the results showed that the mean total duration of mechanical ventilation was longer in the late tracheostomy group (13.64 days with a variation of 4.47 days) compared to the early tracheostomy group (10.08 days with a variation of 3.35 days). The statistical test results obtained a p-value = 0.001, meaning that there was a difference in the total mean duration of mechanical ventilation between the early and late tracheostomy group.

Table 3: The Relationship between Tracheostomy Timing and the Duration of Mechanical Ventilation in Patients in the ICU at Dr. M. Djamil Hospital Padang (N=62)

Variable	N	Mean	SD	P-value
Duration of MV after tracheostomy				
Early Tracheostomy	37	5,19	3,48	
Late Tracheostomy	25	5,48	4,45	0,983
Total Duration of MV				
Early Tracheostomy	37	10,08	3,35	
Late Tracheostomy	25	13,64	4,47	0,001

Notes: MV (Mechanical ventilated), SD (Standard Deviation)

The relationship between tracheostomy timing and VAP (before and after tracheostomy) could be seen in Table 4. It shows that the mean pre-tracheostomy VAP score was higher in the late tracheostomy group, (3.16 with a variation of 1.03) compared to the early tracheostomy group, (2.43 with a variation of 1.28). The relationship between tracheostomy timing and VAP was significant (p value = 0.024).
Furthermore, the results showed that the mean post-tracheostomy VAP score was higher in the late tracheostomy group, (3.88 with a variation of 1.33) compared to the early tracheostomy group (3.05 with a variation of 1.22) and p-value = 0.014, so it was concluded that there was a difference in post-tracheostomy VAP score between the early tracheostomy patients and the late tracheostomy patients who were admitted in ICU at Dr. M. Djamil Hospital Padang.

Table 4: The Relationship between Tracheostomy Timing and VAP (Ventilator-Associated-Pneumonia) in the ICU at Dr. M. Djamil Hospital Padang (N=62)

Variable	N	Mean	SD	P-Value
Early Tracheostomy	37	2,43	1,28	0,024
Late Tracheostomy	25	3,16	1,03	
VAP after tracheostomy				
Early Tracheostomy	37	3,05	1,22	
Late Tracheostomy	25	3,88	1,33	

Notes: VAP (Ventilator-Associated-Pneumonia); SD (Standard Deviation)

Discussion

The ideal time to perform tracheostomy is still controversial. There is no consensus regarding the definition of tracheostomy timing, but one study showed that the initial time for early tracheostomy was within 6 days of intubation [22]. There is no official guideline regarding tracheostomy timing at Dr. M. Djamil Hospital. But on average, most tracheostomies are carried out in the time period between the 5th, 6th or 7th day of mechanical ventilation. Therefore, this study determined early tracheostomy within ≤ 6 days and late tracheostomy within > 6 days.
This study found that patients who underwent early tracheostomy had a lower mean age than the late tracheostomy group. This study is similar to findings by Khammas *et al*. in 2018 [23]. Another study by Huang *et al*. in 2020 showed that the average age of the early and late groups was lower because the samples used specifically had infratentorial lesions and the time

cut-off for early and late tracheostomy was different which were 10 days [21]. Most of patients in the early and late tracheostomy groups were males, similar to the study by Zaponi *et al*. in 2019 and Khammas *et al*. in 2018 [23, 24]. However, Huang *et al*. 2020 had different findings where the late tracheostomy patients had larger percentage of women [21].

The average duration of mechanical ventilation in the late tracheostomy group was higher than the early tracheostomy group, both in the duration of mechanical ventilation before and after tracheostomy, and also the total duration. This is similar to several previous studies including different tracheostomy timing groupings [11, 21, 24, 25].

This study found the average VAP (Ventilator-Associated-Pneumonia) score was higher in the late tracheostomy patients than the early groups, in both pre-tracheostomy and post-tracheostomy. This was also found in several other studies which showed that there was a significant reduction in the incidence of VAP in patients who underwent early tracheostomy [11, 23-25].

Primary neurological included in this study were traumatic brain injury and spontaneous intracranial hemorrhage. Meanwhile, non-neurological primary diseases were gastrointestinal diseases such as gastric perforation, ileal perforation and neoplasms, then sepsis due to burns, as well as respiratory failure due to respiratory diseases such as pleural effusion and chronic obstructive pulmonary disease. This study demonstrated a greater percentage of patients with primary neurological disease in both groups. Similar results were also found by Zaponi *et al*. in 2020 [24].

Patients with various acute neurological disorders constitute the majority of all patients who require treatment in the ICU. The increased risk of respiratory disorders in patients with neurological diseases can occur due to damage to the respiratory center in the medulla, posterior cranial nerves which play a role in airway protection, and the reticular activation pathway which affects consciousness through reducing the secondary reflex of airway protection. Therefore, optimizing airway management is essential to improve clinical outcomes in neurological diseases [26].

Based on comorbidities, patients in the early tracheostomy group most often had a history of respiratory disease (43.2%), followed by a history of AKI/CKD (29.7%) and other comorbidities, such as shock, electrolyte imbalance, anemia, and trauma (29.7%). Then in the late tracheostomy group, most patients had comorbidities included in “other” (36%) and respiratory disease (32%). Comorbidities can affect patient’s outcome, duration of mechanical ventilation and mortality, especially those related to respiratory disease [27-29]. Kligerman *et al*. in 2020 showed that tracheostomy infection was the biggest predictor of patient mortality. Diabetes mellitus is associated with increased colonization and infection of the tracheostomy tube and is associated with morbidity and mortality, especially cardiovascular and renal complications [29, 30].

In this study, the mean duration of post-tracheostomy mechanical ventilation was longer in the late tracheostomy group compared to the early tracheostomy group, but showed no significant difference and no relationship between tracheostomy timing and duration of post-tracheostomy mechanical ventilation. However, the results showed that the mean total duration of mechanical ventilation was longer in the late tracheostomy group and there were significant differences and we found relationship between tracheostomy timing and total duration mechanical ventilation.

Several studies have found relationship between tracheostomy timing on the duration of mechanical ventilation and the length of ICU stay, with the duration of mechanical ventilation being shorter in patients with early tracheostomy. Early tracheostomy allows early weaning, which can affect the duration of mechanical ventilation. A randomized study showed that the duration of mechanical ventilation and length of ICU stay were shorter in early tracheostomy patients (<7 days). This was also confirmed by meta-analysis studies [11, 22, 31, 32].

In this study, there was no significant difference in the duration of post-tracheostomy mechanical ventilation but there was a significant difference in the total duration of mechanical ventilation. These results are similar to studies which categorizing tracheostomy timing into 3 groups, very early (1-5 days), early (6-9 days) and late (≥10 days), where they found significant differences in the total duration of mechanical ventilation between the three group but not on duration of post-tracheostomy mechanical ventilation [24].

The results of this study differ from several other studies which showed a significant difference in the duration of mechanical ventilation between early and late tracheostomy. However, these studies have differences in defining tracheostomy timing which consider late tracheostomy after 10 days [1, 32] or categorizing tracheostomy timing in several groups, such as very early (≤4 days), early (4-9 days), late (10-14 days), and very late (>14 days) [11, 32], so there were several conditions when the late category in this study was included in the early category in their studies. Another reason is, some studies only define the duration of mechanical ventilation in the total duration of mechanical ventilation, without distinguishing it from the duration of post-tracheostomy mechanical ventilation, so that the results of the duration of mechanical ventilation can be biased [23, 32].

The difference in the duration of post-tracheostomy mechanical ventilation between early and late tracheostomy, which was not significant in this study, could be influenced by several things, including initial diagnosis, age, comorbidities, and complications of mechanical ventilation [27, 33]. In this study, the majority of patients had a primary diagnosis of neurological disease, and most of these neurological diseases were traumatic brain injury. Patients with traumatic brain injury have a high degree of post-traumatic pulmonary insufficiency [34], besides that neurological conditions can result in failure of coordination between the central nervous system and respiratory muscles, which can cause hypoxemia [27]. Therefore, clinically these conditions require more adequate airway management which results in high dependence on ventilators, resulting in prolonged mechanical ventilation.

Another factor that influences the duration of mechanical ventilation is comorbidity. Patient comorbidities such as diabetes mellitus, congestive heart failure,

AKI, chronic liver disease, COPD, myocardial infarction and neoplasms could prolong the duration of mechanical ventilation for up to 28 days [33]. In this study, the most common comorbidity experienced by patients overall was respiratory disease (24 out of 62 patients), including those in the early tracheostomy group, 43% of patients had respiratory comorbidities. According to Lim in 2022, respiratory comorbidities such as COPD, asthma and bronchitis could prolong the duration of mechanical ventilation. Meanwhile, non-respiratory comorbidities do not have a significant effect on the duration of mechanical ventilation [28].

In this study, there was a significant relationship between the duration of tracheostomy and the incidence of VAP where the pre-tracheostomy CPIS score was lower in the early tracheostomy patients compared to the late tracheostomy patients. VAP is a nosocomial pneumonia associated with mechanical ventilation [33]. VAP is believed to develop through aspiration of contaminated oropharyngeal secretions into the lungs over the tracheal tube. In addition, the tracheal tube could act as a reservoir for microorganisms to form bacterial biofilms. 14 Based on this mechanism, aspiration of contaminated secretions supports bacterial colonization and finally causes lung infections.

The mechanism for reducing VAP in early tracheostomy is based on the tracheostomy action which releave the vocal cords thereby reducing the risk of aspiration of oropharyngeal secretions. Tracheostomy also provide airway clearance and help weaning of mechanical ventilation thereby reducing the duration of mechanical ventilation [14].

In patients who are intubated, endotracheal tubes could hinder access for adequate dental care procedures. Nurses are also often reluctant to provide dental care to patients because of worries in endotracheal tube dislodged. Those dental plaque could be a reservoir for respiratory pathogens, which has an impact on the incidence of VAP [35].

Another possible factor in the incidence of VAP in endotracheal-intubated patients is the position of the orotracheal tube. Placement of an orotracheal tube allows the mouth to remain open, which can predispose to xerostomia. An open mouth could dried-up the oral cavity because of reduction in saliva production. Decreased saliva production lowering the ability in self-cleaning through non-pathogenic bacteria, enzymes and minerals in saliva, so this situation contributes to poor oral hygiene [35].

Another explanation for the role of tracheostomy in reducing VAP is due to decreased use of sedation after tracheostomy. Several studies show a relationship between sedation and VAP. Sedation could lead to micro aspiration, impaired gastrointestinal motility and microcirculatory effects can favor infection in patients [26].

This study has several limitations. First, we used observational study design, so there is high risk of misinterpretation, such as in chest radiograph evaluation which pulmonary infiltrates could be progressive over time so it could lead to wrong scoring in CPIS. Second, the duration of mechanical ventilation was recorded in days while the duration is more valid when it was recorded in hours then converted to total hours into days. Third, this study did not evaluate the severity of the primary disease (GCS) and comorbidities (severity of related comorbid diseases). So, this could be a bias in determining patient outcomes. Finally, this study was single-centered with limited sample size.

Conclusion

In this study, it was found that there was a relationship between tracheostomy timing and the total duration of mechanical ventilation and the incidence of pre-tracheostomy VAP and post-tracheostomy VAP. Because this is a single-centered study, multi-centered study needs to be carried out involving a larger number of samples. Further research is also needed to assess the effect of tracheostomy timing in homogeneous primary disease so direct effect of complication in the primary disease could be avoided as a confounder factor.

Conflict of Interest

Not available

Financial Support

Not available

Reference

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