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Late versus Very Late Tracheostomy Timing for Prolonged Intubated ICU Patients: Implications for Prognosis and Mechanical Ventilator Weaning

ABSTRACT

Objective: To compare late (10–21 days) and very late (>21 days) tracheostomy in adult ICU patients with prolonged intubation in terms of success of mechanical ventilator weaning, ICU and hospital stay, and mortality.

Methods:

Design: Retrospective Cohort Study
Setting: Tertiary Government Training Hospital
Participants: Adult Intensive Care Unit (ICU) patients (≥18 years) from 2016 to 2024 who underwent tracheostomy after ≥10 days of intubation. Patients were divided into late (10-21 days) and very late (>21 days) timing of tracheostomy groups.

Results: A total of 128 patients were included (48 Late, 80 Very Late). No significant differences were found in mechanical ventilator weaning success, ICU discharge rate, 30-day mortality, or overall mortality between groups. Time to weaning, ICU stay, and time to mortality were longer in the very late group but was not statistically significant. Post-tracheostomy hospital stay was significantly longer in the very late group ($M = 25.8 \pm 26.1$ vs. 37.6 ± 40.7 days, $t(125.4) = -2.00$, $p = .048$). Subgroup analyses of pulmonary and neurologic patients showed similar results. Ventilator-associated pneumonia was a common pre-operative comorbidity and was the leading cause of mortality. Older age and prior cerebrovascular disease were associated with decreased odds of weaning success and survival respectively.

Conclusion: The results of our study may challenge the assumption that further delays in tracheostomy timing lead to worse outcomes. Tracheostomy done earlier within 10-21 days of intubation leads to shorter post-operative hospital stay, but was not accompanied by improved odds of ventilator weaning, ICU discharge, or survival. Timing of tracheostomy may not be the primary determinant of prognosis in these patients as much as the confounding co-morbidities, especially ventilator-associated pneumonia.

Keywords: *tracheostomy; intratracheal intubation; critical care; intensive care units, time-to-treatment*

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Prolonged intubation is one of the primary indications for tracheostomy in critically ill ICU patients. The optimal timing for the procedure remains debatable and no single definition exists. Early tracheostomy is defined as done within 7-10 days of intubation while late tracheostomy occurs beyond this time frame.[1,2] Results from several randomized trials and meta-analyses that compared early and late tracheostomy have conflicting results.[2,3,4,5] The majority of studies suggest that early tracheostomy reduces short-term mortality, increases mechanical ventilator weaning success, and shortens ICU and hospital stays.[3,4,5] In contrast, late tracheostomy has been associated with prolonged ICU stays and higher mortality risk. Each day beyond one week of delay has been shown to increase mortality rates by 6% and further decrease chances of weaning and discharge.[2] Delays may arise from clinical factors such as medical instability, recent anticoagulation, as well as non-clinical factors such as OR suite and schedule availability, multidisciplinary coordination, and ongoing attempts at weaning and extubation.[6]

At the *Ospital ng Makati*, a tertiary public training hospital, tracheostomy is often delayed, with many cases referred only after failed extubation. There is no formal definition for "very late" tracheostomy timing in the literature and there is limited data on the clinical outcomes of tracheostomies done after than 21 days of intubation. These patients are often only included within the broad scope of late tracheostomy patients, without exclusive analysis.[3,7,8] In this study, a "very late" timing was defined as tracheostomies done more than 21 days of intubation. This is to distinguish these patients from the commonly reported late timing of beyond 10–14 days,[4,9] with an average of 14 days in prior studies.[10]

The objective of this study is to determine whether tracheostomies done late (10-21 days) and very late (>21 days) have comparable outcomes of post-operative mechanical ventilator weaning success, ICU and hospital length of stay, and mortality.

METHODS

With *Ospital ng Makati* Research Ethics Board approval (2025-8-023), this retrospective cohort study was conducted at *Ospital ng Makati* – a tertiary-level public training hospital in Taguig City, Philippines, from 21 April 2025 to 09 June 2025. Records of adult patients (≥18 years old) admitted to the ICU from 2016 to 2024, who underwent tracheostomy for prolonged intubation of at least 10 days for medical indications were considered for inclusion. Patients were divided into the late timing group (10-21 days of intubation) and very late timing group (>21 days of intubation). Tracheostomies done outside of the ICU were excluded. Patients intubated for COVID-19 pneumonia were also excluded due to the uncertain optimal timing of tracheostomy considering infection exposure and risk prevention, high mortality rates, and potential delays in ICU discharge from isolation protocols.[11] Likewise tracheostomies done for upper airway obstruction from head and neck pathologies were not included, as these patients may have a shorter course of ventilator weaning or may not require ventilator post-operatively once obstruction is bypassed. Percutaneous tracheostomies were not included to maintain procedural consistency and minimize intervention-related variability.

Data was collected through review of both electronic and paper-based medical records. The hospital's surgical census was the reference for tracheostomies done from 2016 to 2024. The primary author extracted the demographic and clinical data using a standardized collection form. All data were anonymized and encoded in Microsoft Excel version 16.78.3 (Microsoft Corporation, Redmond, WA, USA), with patients identified only by their hospital number. Data collected included patient demographics (hospital number, age, sex); primary indications for intubation and ICU admission; pre-operative and discharge diagnoses; key hospitalization dates (admission, intubation, tracheostomy, ICU discharge, hospital discharge or death); and prognostic factors such as comorbidities (e.g., hypertension, diabetes, CKD, neuromuscular or cerebrovascular disease, thyroid disorders, malignancy) and the presence of ventilator-associated pneumonia (pre- and post-operatively).

Figure 1 summarizes the conceptual framework of the study. The primary outcomes assessed were: (1) post-tracheostomy duration of mechanical ventilation, defined as the number of days from tracheostomy to successful weaning—ventilator independence for ≥7 consecutive days or until hospital discharge within 7 days of weaning; (2) post-tracheostomy ICU length of stay, measured from the date of tracheostomy to transfer to a non-ICU ward or direct discharge,

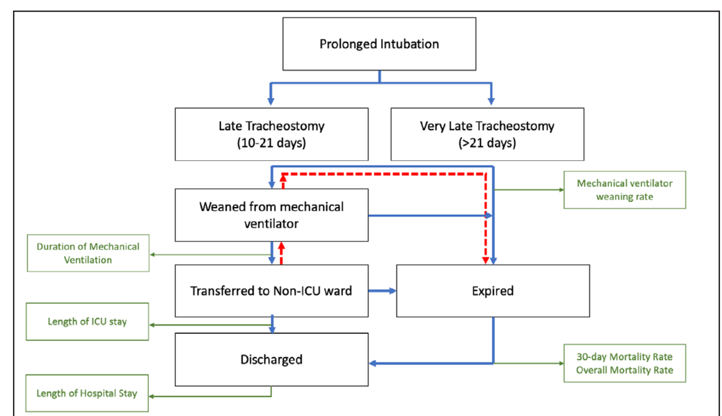

Figure 1. Conceptual Framework. In this study, the independent variable is the timing of tracheostomy done in patients who have had prolonged intubation for medical indications and were admitted to the ICU. The post-tracheostomy patients may or may not be weaned from mechanical ventilation. By hospital protocol, those who were successfully weaned are transferred to non-intensive care wards before discharge (bold solid lines). Unsuccessful weaning from mechanical ventilation includes patient expiration while ventilator dependent or re-initiation of ventilator support within 7 days of weaning, which may or may not lead to eventual mortality (bold broken lines). Dependent variables include outcomes of duration of mechanical ventilation, length of ICU stay, length of hospital stay, mechanical ventilator weaning rate, and mortality rates.

excluding patients who were not weaned; and (3) post-tracheostomy length of hospital stay, measured from the date of tracheostomy until discharge or in-hospital mortality. Secondary outcomes include: (1) 30-day mortality rate, (2) overall mortality rate, (3) weaning success rate, (4) ICU transfer or discharge rate, (5) time to mortality post-tracheostomy. Only patients who were successfully weaned were included in ventilator duration and ICU transfer analyses.

Data Analysis

Categorical variables (e.g., sex, indication for intubation, presence of co-morbidities, mortality, weaning success, ICU transfer) were presented as frequencies and percentages, and comparison between groups was performed using Chi-square test. Continuous variables were reported as means ± standard deviations. Normality was assessed using the Shapiro-Wilk test. Normally distributed variables (e.g. age, post-tracheostomy hospital stay, days to mortality) were compared using the Student's t-test, while non-normally distributed variables (duration of intubation and post-operative mechanical ventilation, and post-tracheostomy ICU stay) were compared using Mann-Whitney U Test. Statistical tests were performed using Microsoft Excel version 16.78.3 (Microsoft Corporation, Redmond, WA, USA). Binary logistic regression was performed using IBM SPSS Statistics version 31 (IBM Corp., Armonk, NY, USA) to evaluate associations between clinical outcomes and prognostic factors. Subgroup analyses were also conducted for patients with primary pulmonary or neurologic diagnoses. A *p*-value of $<.05$ was considered statistically significant.

RESULTS

A total of 128 patients were included: 48 in the late and 80 in the very late tracheostomy group. Patient characteristics did not differ significantly between groups. Sex distribution was similar, with a slight female majority in both groups. A Student's t-test to compare age between groups showed that the late group had a mean age of M = 65.88 years (SD = 15.16) while the very late group M = 67.94 years (SD = 13.69), without statistically significant difference, $t(126) = -0.78$, p = .438. Neurologic and pulmonary etiologies were the two most common indications for intubation. Neurologic indications were more frequent in the late group (50% vs 35%), although not significantly different $X^2(1, N = 128) = 2.82$, $p = .094$. These included cases of cerebrovascular ischemia and hemorrhage, and a few neuromuscular crises. Pulmonary indications were similarly distributed between groups (40% vs 46%) $X^2(1,N = 128) = 0.54$, $p = .462$, which included pneumonia, COPD, asthma exacerbations, and pulmonary metastases. Cardiac (8% vs 15%) $X^2(1, N = 128) = 1.21$, $p = .270$ and renal causes (2% vs 4%) $X^2(1, N = 128) = 0.28$, $p = .600$ were similarly distributed and uncommon in both groups.

Likewise, distribution of co-morbidities was statistically similar between groups as determined by chi-square test. Hypertension was the most common co-morbidity, present in 32 out of 48 (67%) of the late group and 60 out of 80 (75%) of the very late group, $X^2(1, N = 128) = 1.03$, $p = .310$. This was followed by diabetes mellitus which occurred in 27% and 35%, respectively, $X^2(1, N = 128) = 0.86$, $p = .353$, while prior cerebrovascular or neurologic disease was observed in 23% and 25% of patients $X^2(1, N = 128) = 0.07$, $p = .790$. Less common comorbidities including pulmonary tuberculosis, asthma, COPD, non-pulmonary malignancy, chronic kidney disease, and thyroid disease were similarly distributed between groups, with no statistically significant differences (all $p > .05$).

Shapiro–Wilk results showed non-normal distributions for number of days before weaning success (very late: $W = 0.714$, $p = .003$), and post-tracheostomy ICU length of stay (very late: $W = 0.738$, $p = .006$). Post-tracheostomy hospital stay and number of days before mortality were normally distributed in both the late and very late groups (all $p >$ .05).

There were no significant differences between the late and very late tracheostomy groups in the number of days to successful weaning, ICU stay post-tracheostomy, or time to mortality. Post tracheostomy length of hospital stay was significantly shorter in the late tracheostomy group. *(Table 1)*

Non-normally distributed variables (number of days in the ICU post-tracheostomy and number of days before weaning success) were compared between groups using the Mann–Whitney U test. Median ICU length of stay was shorter in the late group (median = 8 days, n = 38) than the very late group (median = 11 days, n = 27), U = 448.5, Z = −0.860, p = .394, r = 0.11. The number of days before successful weaning was shorter in the late group (median = 8 days, n = 45), than the very late group (median = 9 days, n = 27), U = 537.5, Z = −0.816, p = .419, r = 0.10. None of these results reached statistical significance.

Normally distributed variables (post-tracheostomy length of hospital stay and number of days before mortality) were compared between groups using independent-samples t-tests. Post-tracheostomy length of hospital stay was significantly shorter in the late group (M = 25.8 ± 26.1 days, n = 48) compared to the very late group (M = 37.6 ± 40.7 days, n = 80), t(125.4) = −2.00, p = .048. The number of days before mortality was shorter in the late group (30.0 ± 33.1 days, n = 25) compared to the very late group (38.0 ± 36.3 days, n = 48); however, this difference was not statistically significant, t(52.9) = −0.95, p = .348.

Chi-square tests of independence were performed to examine the association between tracheostomy timing (late vs very late) and clinical outcomes. No statistically significant associations were found between tracheostomy timing and ventilator weaning success , $X^2(1, N = 128) = 1.24$, $p = .266$; ICU discharge, $X^2(1, N = 128) = 1.31$, $p = .253$; overall mortality, $X^2(1, N = 128) = 0.35$, $p = .551$; or 30-day mortality, $X^2(1, N = 128) = 1.24$, $p = .266$. *Table 1* shows the actual number and

corresponding percentages of the clinical outcomes between timing groups.

Incidence of all-cause post-tracheostomy mortality did not significantly differ between late and very late groups (52% vs 58%), X^2(1, N = 128) = 1.22, *p* = .270. Ventilator associated pneumonia (VAP) was the leading cause of death and occurred similarly in both groups (27% vs 29% of all patients), X^2(1, N = 128) = 0.04, *p* = .839. This was followed by cardiac causes (15% vs. 13%), X^2(1, N = 128) = 0.11, *p* = .737, non-ventilator-associated pulmonary conditions (2% vs. 9%), X^2(1, N = 128) = 2.28, *p* = .131 and sepsis from non-pulmonary infectious sources (8% vs. 5%), X^2(1, N = 128) = 0.57, *p* = .451.

Ventilator associated pneumonia was prevalent and occurred similarly between groups (69% vs 58%), X^2(1, N = 128) = 1.60, *p* = .205, with the majority occurring preoperatively (48% vs 44%) X^2(1, N = 128) = 0.647, *p* = .21. Chi-square analysis was performed to determine association of ventilator associated pneumonia and mortality. Regardless of tracheostomy timing, all-cause mortality was higher in those with VAP (47 out of 80, 59%) than those who did not developed it (23 out of 48, 48%), however this was not statistically significant, X^2(1, N = 128) = 1.420, *p* = .233. On subgroup analysis based on tracheostomy timing, patients in the late group who had VAP had higher mortality rates (20 out of 33, 60.6%) than those without it (5 out of 15, 33.3%), however did not reach statistical significance X^2(1, N = 128) = 0.070, *p* = .080 . This was also consistent in the very late group wherein 27 out of 47 (57%) with VAP and 18 out of 33 (55%) without VAP died, X^2(1, N = 128) = 0.380, *p* = .797.

Subgroup analysis of pulmonary (n=56) and neurologic (n=52) patients showed no significant differences in weaning success, ICU discharge, overall mortality, or 30-day mortality between late and very late tracheostomy groups. (*Table 2 and 3)*

A stepwise backward binary logistic regression analysis was performed to identify independent predictors of weaning success, ICU discharge, and mortality. Variables entered into the initial model included age, indication for intubation and ICU admission, timing of tracheostomy (late vs very late), co-morbidities, and presence of ventilator associated pneumonia. In the final logistic regression model, increasing age was independently associated with decreased odds of successful weaning (B = –0.033, SE = 0.014, Wald = 5.648, *p* = .017; OR = 0.967, 95% CI 0.941–0.994). Among the variables, only a history of previous cerebrovascular disease was associated with higher mortality (B = 1.170, SE = 0.487, Wald = 5.773, *p* = .016; OR = 3.222, 95% CI 1.241–8.367), and decreased odds of ICU discharge (B = -1.013, SE = 0.484, Wald = 4.373, *p* = .037; OR 0.363, 95% CI 0.140 - 0.938). Timing of tracheostomy or presence of ventilator associated pneumonia were not significant predictors of clinical outcomes in the adjusted models.

Table 1. Comparison of Clinical Outcomes

Clinical Outcomes	Late (N=48)		Very Late (N=80)		
	Days	SD	Days	SD	*P*-value
Days intubated	16.90	3.26	36.41	15.46	<.001
Days before successful weaning	11.96	13.10	21.38	31.49	.410
Post-tracheostomy ICU stay (days)	14.89	15.98	15.71	19.61	.390
Days before Mortality	29.96	33.11	38.02	36.32	.348
Post-tracheostomy hospital stay (days)	25.75	26.06	37.55	40.65	.048
	N	%	N	%	*P*-value
Successfully Weaned and Extubated	27	56	45	56	.266
Transferred from ICU or Directly Discharged from ICU	29	60	40	50	.252
Overall Mortality	25	52	46	58	.551
30-day Mortality	19	40	24	30	.266

*SD: Standard Deviation

Table 2. Subgroup analysis of pulmonary patients

Clinical Outcomes	Late (N=19)		Very Late (N=37)		
	Days	SD	Days	SD	*P*-value
Days intubated	17.40	3.27	37.37	16.41	<.001
Days before successfully weaned	12.33	17.56	19.35	27.57	.787
Post-tracheostomy ICU stay (days)	15.08	25.35	16.50	21.96	.688
Days before Mortality	27.35	34.96	37.56	41.94	.127
Post-tracheostomy hospital stay (days)	24.37	30.87	36.40	41.81	.203
	N	%	N	%	P-value
Days before successfully weaned	9	47	18	49	.928
Days before Transferred from or Discharged from ICU	9	47	16	43	.769
Overall Mortality	13	68	23	62	.898
30-day Mortality	9	47	8	22	.047

*SD: Standard Deviation

DISCUSSION

In this study, post-tracheostomy length of hospital stay was significantly shorter in the late tracheostomy group. Otherwise, there was no statistically significant differences between the late and very late groups in terms of post-tracheostomy duration of mechanical ventilation, weaning success, ICU length of stay, and

Table 3. Subgroup analysis of neurologic patients

Clinical Outcomes	Late (N=24)		Very Late (N=28)		
	Days	SD	Days	SD	*P*-value
Days intubated	17.20	2.98	35.54	13.46	<.001
Days before successfully weaned	12.38	7.56	15.08	39.65	.195
Post-tracheostomy ICU stay (days)	15.08	8.20	15.71	19.22	.620
Days before Mortality	26.46	20.98	38.02	20.06	.565
Post-tracheostomy hospital stay (days)	24.17	15.08	36.19	44.97	.065
	N	%	N	%	P-value
Days before successfully weaned	15	63	17	61	.999
Days before Transferred from or Discharged from ICU	17	71	18	64	.616
Overall Mortality	9	38	13	46	.981
30-day Mortality	8	33	8	29	.711

*SD: Standard Deviation

mortality. This remains consistent among the subgroup of neurologic and pulmonary patients, who were thought to physiologically benefit from improved airway clearance and weaning brought by tracheostomy.[12]

There are limited studies in which patients who have had tracheostomies more than 21 days have been studied specifically. A randomized study showed no significant differences in the length of ventilator support, mortality rate, and pneumonia incidence between tracheostomies done before 8 days (mean 7.62 days) and after 28 days (mean 35.4 days).[13] While the late group in the randomized study aligns with the "very late" tracheostomy group in our study, their findings were based on a trauma patient population, which may limit comparability to our medical ICU cohort.[13] A retrospective study explored clinical outcomes after different durations of intubation.[14] Results of their study show significantly higher ICU mortality rates, failure of mechanical ventilator weaning, and pneumonia incidence when tracheostomies are done beyond 21 days of intubation.[14] Similarly, a multi-center retrospective cohort study showed higher mortality rates and longer ICU and hospital stays at tracheostomies done more than 7 days of intubation, and progressively worsens when done beyond 14 days of intubation.[15] The longer the duration of intubation, the higher risk of complications from patient co-morbidities and risk for developing ventilator associated pneumonia which may ultimately translate into failure of weaning and mortality.[16,17] Each two-day delay beyond one week post-intubation in traumatic brain injury patients increased mortality by 6% and prolonged ICU and hospital stays.[2]

Post-tracheostomy hospital stay was significantly shorter in the late tracheostomy group by a mean difference of 12 days. Weaning success and ICU discharge rates however were similar between groups, suggesting that post-tracheostomy length of hospitalization may be independent of immediate weaning outcomes. While co-morbidities between groups were comparable, differences in disease severity were not measured. Patients in the very late group may have had more severe or chronic underlying conditions requiring a more prolonged post-operative management and rehabilitation prior to discharge.

Weaning success, ICU discharge, and mortality rates were similar regardless of tracheostomy timing. A plausible explanation is that comorbidities and VAP may exert significant impact as early as 10 days into intubation, such that timing of tracheostomy has less impact in clinical outcomes. In our study, 55% of all patients developed VAP either pre-operatively or post-operatively and VAP was the leading cause of mortality in these patients regardless of tracheostomy timing. Mortality rates among those with VAP was higher than those without it, suggesting the possible association of VAP with weaning failure, and ultimately survival. Prior cerebrovascular disease, and older age were also identified to decrease the odds of weaning success and survival, further supporting the idea that ICU outcomes are multifactorial, brought about by the complex interaction of multiple co-morbidities. Pulmonary and neurologic patients are especially vulnerable to the confounding effects of VAP due to the burden of pulmonary disease and impaired airway protection respectively.[18] The subgroup analysis of these patients showed VAP related complications as the primary reason for mortality.

VAP is a consequence of impaired pulmonary barrier and bacterial colonization from prolonged intubation wherein weaning success and survival in ICU patients significantly decreases when tracheostomy is done after 21 days of intubation.[14] In contrast, tracheostomy has been associated with improved survival in patients with ventilator-associated pneumonia (VAP), irrespective of timing.[18] Tracheostomy may reduce VAP risk by shortening endotracheal intubation duration and allowing for more effective pulmonary toilette.[19,20] Evidence remains inconclusive with several meta-analyses reporting no significant improvement in outcomes.[4,5 21]

The clinical implications of our study results allow for tracheostomies after 21 days of intubation to be done without significant compromise in clinical outcomes. This may allow delays in tracheostomy for hemodynamic stabilization and control of co-morbidities, providing flexibility in management. This also provides the opportunity for potential extubation, especially in patients with reversible medical conditions, avoiding unnecessary surgical risks. Although outcomes between late and very late tracheostomy were similar, this should not justify indefinite delay. In patients with multiple co-morbidities, earlier tracheostomy may be a sound strategy to prevent the risk of developing VAP and its complications. In those developing VAP, early detection

and aggressive management are recommended to help maximize the potential physiologic benefits of tracheostomy.

This study was a retrospective single-center study with inherent limitations. There was potential for selection bias due to the non-randomized nature of the study. Incomplete documentation in medical records may have led to the omission of some patients. Additionally, follow-up for 30-day mortality may be incomplete. Patient readmissions within 30 days were reviewed to supplement outcome data. However, the possibility of patients who did not return for follow-up would not be accounted for, potentially underestimating mortality. Although ideally an additional control group composed of early tracheostomies (done less than 10 days of intubation) may strengthen the analysis, it was not included due to limited available cases in the institution.

Several confounding factors were addressed to improve internal validity of results. Binary logistic regression of confounding factors such as indication for intubation, pre-existing medical co-morbidities, and development of ventilator-associated pneumonia (VAP) was done. Subgroup analysis of pulmonary and neurologic patients was attempted despite the small subgroup population, and VAP- Mortality outcomes were individually analyzed. Despite these efforts, the study acknowledges the limitation of a retrospective study to control for several other key confounders such as baseline severity of illness, variability in weaning protocols, differences in clinical criteria used for diagnosing VAP, and heterogeneity in ICU management of comorbidities. Due to the complex interaction of possible confounders, the applicability of the results of the study remains limited to the general medical ICU population. Future prospective studies with standardized severity scoring, VAP criteria, and ICU protocols are recommended to minimize the effects of confounding factors. In addition, the sample size of the study may not be sufficient to identify predictors of clinical outcomes accurately. The limited sample size paired with the number of variables tested have the potential for overfitting of the multivariate logistic model. Therefore, the identified predictors should be interpreted cautiously and validated in a larger, independent cohort.

In conclusion, the results of our study may challenge the assumption that further delays in tracheostomy timing lead to worse outcomes. Tracheostomy done earlier within 10-21 days of intubation leads to shorter post-operative hospital stay, but was not accompanied by improved odds of ventilator weaning, ICU discharge, or survival. Timing of tracheostomy may not be a primary determinant of prognosis in these patients as much as the confounding co-morbidities, especially ventilator-associated pneumonia.

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