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Early versus Late Percutaneous Tracheostomy in Critically Ill Stroke Patients: A Competing Risk Analysis of Ventilator Liberation and Complications

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A B S T R A C T

Introduction: The optimal timing of percutaneous dilatational tracheostomy (PDT) in critically ill stroke patients remains controversial. The procedure may facilitate ventilator weaning and neurological assessment, but carries inherent risks. This study aimed to determine the impact of early versus late PDT on clinical outcomes in this specific and vulnerable population. **Methods:** This retrospective cohort study was conducted at a single tertiary care center. We included all mechanically ventilated adult stroke patients who underwent PDT between January 2024 and December 2024. Patients were categorized into an Early PDT group (≤7 days of intubation) and a Late PDT group (>7 days). The primary outcome was time to ventilator liberation, with in-hospital death as a competing risk. This was analyzed using a Fine-Gray subdistribution hazard model. Secondary outcomes included ICU and hospital mortality, length of stay (LOS), and ventilator-associated pneumonia (VAP), analyzed with multivariable regression. **Results:** Seventy patients were included (34 Early PDT, 36 Late PDT). After adjusting for age, admission GCS, NIHSS, and stroke type, early PDT remained significantly associated with a higher probability of ventilator liberation (adjusted subdistribution Hazard Ratio [sHR]: 2.48; 95% CI: 1.41–4.36; p=0.002). Early PDT was also independently associated with lower odds of developing VAP (adjusted Odds Ratio [aOR]: 0.31; 95% CI: 0.10–0.94; p=0.038). There were no significant differences in ICU mortality (aOR: 0.82; 95% CI: 0.28–2.41; p=0.721) or hospital mortality (aOR: 0.70; 95% CI: 0.25–1.96; p=0.495). **Conclusion:** In critically ill stroke patients, an early tracheostomy strategy is independently associated with a significantly shorter time to ventilator liberation and lower odds of VAP, after accounting for competing risks and baseline confounders. While not associated with a survival benefit, early PDT should be considered a key strategy to optimize respiratory management and reduce pulmonary complications in this population.

1. Introduction

Stroke, encompassing both ischemic and hemorrhagic cerebrovascular accidents (CVA), is a leading cause of death and long-term disability worldwide, frequently necessitating admission to an Intensive Care Unit (ICU) for advanced monitoring and organ support.[1] A significant proportion of these patients, particularly those with severe neurological deficits, develop respiratory failure requiring invasive mechanical ventilation. This failure can stem from a compromised level of consciousness leading to loss of protective airway reflexes, impaired central respiratory drive, or secondary complications like aspiration pneumonia.[2]

Prolonged endotracheal intubation in this patient population is fraught with challenges. It often requires deep sedation, which can mask crucial changes in neurological status, impede accurate assessment, and delay the recognition of clinical deterioration or improvement.[3] Furthermore, prolonged intubation is

associated with an increased risk of complications, including ventilator-associated pneumonia (VAP), laryngeal injury, and patient discomfort.[4] Consequently, percutaneous dilatational tracheostomy (PDT) has emerged as a common and vital intervention in the management of neurocritical care patients requiring extended ventilatory support.[5] Since its first description, PDT offers a less invasive, bedside alternative to surgical tracheostomy, with studies suggesting lower rates of bleeding and infection.

Despite its widespread adoption, the optimal timing of PDT remains a subject of intense debate within the critical care community. The central controversy lies in balancing the potential benefits of early intervention against the risk of performing an unnecessary procedure on patients who might otherwise be extubated successfully.[6] Proponents of early tracheostomy (typically defined as within the first 7 days of intubation) argue that it can reduce the duration of mechanical ventilation, decrease sedation needs, enhance patient comfort, lower the incidence of VAP, and facilitate earlier participation in physical rehabilitation.[7] Conversely, a strategy of delayed tracheostomy avoids the procedural risks in patients who may recover respiratory function rapidly, but it may prolong ICU stay and exposure to the hazards of translaryngeal intubation in those who ultimately require a tracheostomy.

This debate is particularly complex in the context of acute stroke. Unlike general critically ill populations, the primary determinant of outcome in stroke patients is the extent and location of the initial brain injury. Previous large-scale trials have investigated tracheostomy timing in mixed ICU populations and found no significant mortality benefit with an early approach.[8] However, subgroup analyses focused on patients with acute brain injury have suggested potential benefits, highlighting that a "one-size-fits-all" approach may be inadequate. Specific pilot trials have shown that early PDT in stroke patients is feasible and may impact outcomes.[9]

The novelty of this research stems from its focused analysis within a specific context where local factors may influence both practice patterns and outcomes. In health systems with high patient throughput and potential resource constraints affecting the implementation of comprehensive VAP-prevention bundles or sedation-weaning protocols, the timing of securing a definitive airway may have a more pronounced impact. This study addresses this knowledge gap by providing robust, context-specific evidence.[10] Therefore, the aim of this study was to investigate the impact of early versus late PDT on clinical outcomes in critically ill stroke patients. We hypothesized that early PDT in critically ill stroke patients would be associated with a shorter time to ventilator liberation and a lower incidence of complications compared to late PDT, even after adjusting for baseline disease severity.

2. Methods

This study was a retrospective, observational cohort analysis conducted at the Intensive Care Unit of a single tertiary referral and teaching hospital in Southeast Asia. The study protocol was designed in accordance with the principles of the Declaration of Helsinki. Ethical approval for the study, including a waiver of individual informed consent for the use of anonymized retrospective data, was obtained from the institutional Health Research Ethics Committee.

We included all adult patients (age ≥18 years) admitted to the ICU between January 1st, 2024, and December 31st, 2024, with a primary diagnosis of acute stroke (ischemic or hemorrhagic) who required invasive mechanical ventilation for more than 48 hours and subsequently underwent PDT. The exclusion criteria were: (1) patients under 18 years of age; (2) patients with a tracheostomy placed prior to admission to our ICU; (3) patients who underwent a surgical tracheostomy; (4) patients with incomplete data for key baseline or outcome variables required for multivariable analysis; and (5) patients with a pre-existing condition independently mandating a tracheostomy, such as advanced neuromuscular disease or unstable cervical spine injury.

A standardized data collection form was used to extract information from the hospital's medical records. Subjects were stratified into two groups; Early PDT group: PDT performed within 7 days (≤168 hours) of initial endotracheal intubation; Late PDT group: PDT

performed more than 7 days (>168 hours) after initial endotracheal intubation. Data included age, sex, primary stroke diagnosis (ischemic or hemorrhagic), and key comorbidities. Severity of illness at admission was captured by the Glasgow Coma Scale (GCS) and the National Institutes of Health Stroke Scale (NIHSS). NIHSS scores were reliably collected as they were systematically documented by trained neurology residents or attending physicians as part of the standard admission protocol for all stroke patients. All PDT procedures were performed at the bedside in the ICU by a trained intensivist or anesthesiologist using the Ciaglia Blue Rhino® kit (Cook Medical), often with bronchoscopic guidance. The primary outcome is time to ventilator liberation, defined as the number of days from study enrollment (ICU admission) to the first day of successful discontinuation from mechanical ventilation for at least 48 consecutive hours. In-hospital death before liberation was treated as a competing risk. Secondary outcomes were ICU and hospital length of stay (LOS); ICU and hospital mortality; and incidence of VAP, diagnosed based on clinical criteria (new/progressive infiltrate on chest radiograph, plus at least two of: fever >38°C, leukocytosis/leukopenia, purulent secretions). While microbiological data from tracheal aspirates were often used to guide therapy, they were not required for the case definition to ensure consistency. Procedure-related complications were defined as major bleeding, significant desaturation, or loss of airway.

All data were analyzed using SPSS software, version 22.0. Descriptive statistics were used to summarize patient characteristics. For bivariate comparisons, the Mann-Whitney U test was used for continuous variables and the Chi-square or Fisher's exact test for categorical variables. To address the primary research question while accounting for confounding and competing risks, the following multivariable models were used; A Fine-Gray subdistribution hazard model was used to assess the association between PDT timing and the cumulative incidence of ventilator liberation, with in-hospital death as the competing risk. The model was adjusted for baseline covariates: age, admission GCS, admission NIHSS, and stroke type (hemorrhagic vs. ischemic). Results are presented as adjusted subdistribution Hazard Ratios (sHR) with 95% confidence intervals (CI). Multivariable logistic regression was used to analyze the association between PDT timing and the binary outcomes of VAP and mortality, adjusting for the same set of baseline covariates. Results are presented as adjusted Odds Ratios (aOR) with 95% CIs. A p-value of <0.05 was considered statistically significant.

3. Results

Table 1 provides a detailed comparative summary of the baseline demographic and clinical characteristics for the 70 critically ill stroke patients included in this study, stratified by the timing of their percutaneous dilatational tracheostomy (PDT). The primary purpose of this analysis is to establish the comparability of the Early PDT (n=34) and Late PDT (n=36) groups, which is fundamental to the internal validity of the research. The data robustly demonstrate that the two cohorts were remarkably well-matched across all measured parameters, suggesting that any observed differences in outcomes are less likely to be due to baseline imbalances and more likely associated with the timing of the intervention.

A critical finding is the similarity in the severity of the initial neurological injury. The median admission Glasgow Coma Scale (GCS) score was identical between the groups (7 [IQR: 5-9] for Early vs. 7 [IQR: 5-8] for Late; p=0.880), and the admission National Institutes of Health Stroke Scale (NIHSS) scores were also statistically indistinguishable (median 22 vs. 24; p=0.451). This comparability in initial disease severity is crucial, as it mitigates the potential for confounding by indication, where sicker patients might have systematically received a later intervention.

Furthermore, the demographic profiles were highly similar. The median age was approximately 60 years in both groups (p=0.715), with a slight male predominance that did not differ significantly (p=0.811). The distribution of stroke etiology was also balanced, with a majority of patients in both cohorts having suffered a hemorrhagic stroke (61.8% vs. 58.3%; p=0.753). Finally, the prevalence of major underlying comorbidities, including hypertension, diabetes mellitus, and heart failure, showed no statistically

significant differences between the two groups. In conclusion, the non-significant p-values across all variables confirm that the randomization by clinical practice resulted in two highly comparable groups, providing a strong foundation for the subsequent analysis of the study's primary and secondary outcomes.

Table 1. Baseline demographic and clinical characteristics.

A comparative analysis of critically ill stroke patients undergoing early versus late percutaneous dilatational tracheostomy (PDT).

CHARACTERISTIC	EARLY PDT (N=34)	LATE PDT (N=36)	P-VALUE
Age (years), median [IQR]	60.5 [51 - 68]	59.0 [49 - 67]	0.715
Sex, n (%)			
- Male	20 (58.8%)	22 (61.1%)	0.811
- Female	14 (41.2%)	14 (38.9%)	
Admission Severity Scores			
GCS Score, median [IQR]	7 [5 - 9]	7 [5 - 8]	0.880
NIHSS Score, median [IQR]	22 [18 - 28]	24 [19 - 29]	0.451
Stroke Type, n (%)			
- Ischemic	13 (38.2%)	15 (41.7%)	0.753
- Hemorrhagic	21 (61.8%)	21 (58.3%)	
Comorbidities, n (%)			
Hypertension	25 (73.5%)	28 (77.8%)	0.682
Diabetes Mellitus	12 (35.3%)	14 (38.9%)	0.764
Heart Failure	6 (17.6%)	7 (19.4%)	0.850

Abbreviations: GCS, Glasgow Coma Scale; NIHSS, National Institutes of Health Stroke Scale; IQR, Interquartile Range.

Table 2 presents the unadjusted primary and secondary clinical outcomes, offering a direct comparison between the Early and Late PDT cohorts before statistical adjustment for confounders. The most striking finding, and the primary outcome of this study, is the highly significant difference in the time to ventilator liberation. Patients in the Early PDT group were weaned from mechanical ventilation in a median of 6.0 days following their procedure, which is a full three days shorter than the 9.0 days required for the Late PDT group ($p<0.001$). This result strongly suggests that an earlier intervention is associated with a substantially faster return to respiratory autonomy. This finding is not only statistically robust but also clinically profound, as prolonged ventilator dependency is a major driver of ICU-related morbidity. In contrast, the secondary outcomes, while showing interesting trends, did not reach statistical significance. There was a clear numerical advantage for the Early PDT group in terms of length of stay, with a median ICU LOS of 15.0 days compared to 19.5 days in the late group ($p=0.081$) and a hospital LOS of 24.0 days versus 28.5 days ($p=0.112$). Although these differences of 4.5 days are clinically meaningful, the p-values indicate that, in this unadjusted analysis, we cannot rule out the possibility that these findings occurred by chance. Similarly, the mortality rates were high in both groups, reflecting the profound severity of the underlying strokes. While the Early PDT group experienced lower rates of both ICU mortality (35.3% vs. 41.7%) and hospital mortality (50.0% vs. 58.3%), these differences were not statistically significant ($p=0.601$ and $p=0.488$, respectively). This suggests that while early PDT may accelerate respiratory recovery, it does not, on its own, alter the ultimate survival outcome, which is likely dictated by the severity of the primary neurological injury. In summary, this unadjusted analysis reveals a powerful association between early PDT and faster weaning, while the non-significant trends in LOS and mortality highlight the need for multivariable analysis to isolate the true effect of the intervention.

Table 2. Unadjusted primary and secondary clinical outcomes.

A comparison of clinical outcomes between the Early and Late PDT groups before statistical adjustment.

OUTCOME	EARLY PDT (N=34)	LATE PDT (N=36)	P-VALUE
Primary Outcome			
Time from PDT to Liberation (days), median [IQR]	6.0 [4 - 8]	9.0 [7 - 12]	<0.001
Secondary Outcomes - Length of Stay			
ICU LOS (days), median [IQR]	15.0 [11 - 22]	19.5 [14 - 27]	0.081
Hospital LOS (days), median [IQR]	24.0 [17 - 35]	28.5 [20 - 41]	0.112
Secondary Outcomes - Mortality			
ICU Mortality, n (%)	12 (35.3%)	15 (41.7%)	0.601
Hospital Mortality, n (%)	17 (50.0%)	21 (58.3%)	0.488

Abbreviations: ICU, Intensive Care Unit; LOS, Length of Stay; IQR, Interquartile Range.

Table 3 provides a critical analysis of the safety and secondary infectious complications associated with the timing of percutaneous dilatational tracheostomy (PDT), yielding one of the study's most important findings. The data clearly demonstrate a significant benefit to an early intervention strategy in terms of reducing the incidence of ventilator-associated pneumonia (VAP). The VAP rate in the Late PDT group was more than double that of the Early PDT group, with 44.4% of patients in the late cohort developing this serious complication compared to only 20.6% in the early cohort. This difference was statistically significant (p=0.041), strongly suggesting that prolonging the period of endotracheal intubation is a major risk factor for the development of nosocomial pneumonia in this vulnerable stroke population. Conversely, the table also provides crucial reassurance regarding the safety of the procedure itself. When examining immediate, procedure-related complications, the data show that the risks were exceptionally low and did not differ between the groups. The incidence of major bleeding was nearly identical at approximately 2.8-2.9%, and there were no instances of airway loss in either cohort. The rate of significant desaturation during the procedure was also low and comparable (5.9% vs. 5.6%; p>0.999). Collectively, these results paint a compelling picture of the risk-benefit profile. The data indicates that performing an early PDT does not expose patients to any increased procedural harm compared to a later intervention. However, the strategy of delaying the tracheostomy is associated with a significantly higher risk of developing VAP, a complication known to prolong ICU stays, increase healthcare costs, and contribute to morbidity. This finding powerfully supports the argument for an early PDT, as it appears to confer a substantial benefit in complication avoidance without an associated increase in immediate procedural risk.

Table 4 represents the statistical core of this investigation, presenting the multivariable-adjusted outcomes that control for potential confounding variables and elevate the analysis beyond simple association to a more robust assessment of the intervention's independent effect. This table is pivotal because it answers the critical question: does the benefit of early PDT persist after accounting for baseline differences in patient age, initial neurological severity (GCS and NIHSS), and stroke type? The results are definitive and compelling. The primary outcome, time to ventilator liberation, remains highly significant even after rigorous adjustment. The Fine-Gray competing risk model yields an adjusted subdistribution Hazard Ratio (sHR) of 2.48 (95% CI: 1.41–4.36; p=0.002). This

can be interpreted to mean that patients in the Early PDT group have nearly two and a half times the likelihood of being successfully weaned from the ventilator at any given point in time compared to their counterparts in the Late PDT group, even when accounting for their initial severity of illness and the competing risk of death. The narrow confidence interval and strong p-value underscore the robustness of this finding, solidifying it as the study's primary conclusion. Similarly, the benefit regarding ventilator-associated pneumonia (VAP) also holds true after adjustment. The adjusted Odds Ratio (aOR) of 0.31 (95% CI: 0.10–0.94; p=0.038) indicates that the odds of developing VAP were 69% lower in the Early PDT group. This confirms that the reduced VAP rate seen in the unadjusted data is not merely an artifact of healthier patients being in the early group, but rather a significant, independent association with the timing of the intervention. Conversely, the multivariable analysis confirms the lack of a survival benefit. The adjusted odds ratios for ICU mortality (aOR: 0.82) and hospital mortality (aOR: 0.70) show wide confidence intervals that comfortably cross 1.0, with non-significant p-values. This demonstrates that after controlling for the initial severity of the stroke, the timing of tracheostomy has no discernible impact on the ultimate outcome of survival. In essence, this table powerfully isolates the true effect of early PDT: it is a potent strategy for accelerating respiratory recovery and preventing pulmonary complications, but it does not alter the mortality trajectory dictated by the primary brain injury.

Table 3. Incidence of VAP and procedure-related complications.

A comparison of key complications between the Early and Late PDT groups.

COMPLICATION	EARLY PDT (N=34)	LATE PDT (N=36)	P-VALUE
Ventilator-Associated Pneumonia (VAP), n (%)	7 (20.6%)	16 (44.4%)	**0.041**
Immediate Procedure-Related Complications			
Major Bleeding, n (%)	1 (2.9%)	1 (2.8%)	>0.999
Loss of Airway, n (%)	0 (0.0%)	0 (0.0%)	>0.999
Significant Desaturation, n (%)	2 (5.9%)	2 (5.6%)	>0.999

Abbreviations: VAP, Ventilator-Associated Pneumonia.

Table 4. Multivariable-adjusted analysis of outcomes.

Effect of Early PDT after adjusting for age, admission GCS, admission NIHSS, and stroke type.

OUTCOME	STATISTICAL MODEL	ADJUSTED EFFECT ESTIMATE	95% CI	P-VALUE
Time to Ventilator Liberation	Fine-Gray Competing Risk	**sHR: 2.48**	1.41 – 4.36	**0.002**
Ventilator-Associated Pneumonia	Logistic Regression	**aOR: 0.31**	0.10 – 0.94	**0.038**
ICU Mortality	Logistic Regression	**aOR: 0.82**	0.28 – 2.41	0.721
Hospital Mortality	Logistic Regression	**aOR: 0.70**	0.25 – 1.96	0.495

Abbreviations: sHR, subdistribution Hazard Ratio; aOR, adjusted Odds Ratio; CI, Confidence Interval.

Figure 1 provides a powerful visual representation of the study's primary outcome through a cumulative incidence function (CIF) plot, a sophisticated statistical method designed to accurately model time-to-event data in the presence of competing risks. In this context, the event of interest is ventilator liberation, and the competing risk is in-hospital death. The y-axis represents the cumulative probability that a patient will be successfully liberated from the ventilator, while the x-axis tracks the time elapsed in days since their admission to the ICU. The most immediate and striking feature of the graph is the clear and consistent separation between the two curves. The blue curve, representing the Early PDT group, demonstrates a significantly steeper initial trajectory. This indicates that patients who received a tracheostomy within the first seven days began achieving respiratory autonomy much more quickly and at a higher rate than their counterparts. The curve continues to rise rapidly within the first two weeks, signifying a sustained period of successful weaning events in this cohort. Conversely, the red curve, representing the Late PDT group, shows a more gradual, delayed ascent. This illustrates that the process of ventilator liberation was slower and less frequent in patients whose tracheostomy was deferred. The visual gap between the two curves represents the clinical advantage conferred by the early intervention strategy at any given point in time. Furthermore, the final plateau of each curve is highly informative. The Early PDT curve stabilizes at a higher cumulative incidence of approximately 50%, meaning that by the end of the observation period, half of the patients in this group had been successfully liberated. The Late PDT curve plateaus at a lower level of around 42%, indicating a lower overall proportion of liberated patients. The fact that neither curve reaches 100% is a direct reflection of the competing risk of death; the remaining patients in each cohort either died before liberation or remained ventilator-dependent. This figure compellingly visualizes the study's core finding: early PDT is robustly associated with a higher probability of achieving ventilator liberation over time.

Figure 1. Cumulative incidence function (CIF) for ventilator liberation.

4. Discussion

This study investigated the impact of tracheostomy timing in a focused cohort of critically ill stroke patients, employing robust statistical methods to account for confounding variables and the competing risk of death. Our principal finding is that an early PDT strategy is independently associated with a significantly higher probability of successful liberation from mechanical ventilation and a lower odds of developing VAP.[11] These respiratory benefits, however, did not translate into a statistically significant reduction in length of stay or mortality.

The finding that early PDT is independently associated with faster weaning is physiologically plausible and supports a proactive approach to airway management in this population.[12] The mechanisms are

likely multifactorial (Figure 2). By creating a direct conduit to the lower airway, a tracheostomy reduces anatomical dead space and airway resistance, thereby decreasing the work of breathing. This is particularly beneficial for stroke patients, whose respiratory muscle function and central drive may be compromised. A potential mechanism for the observed VAP reduction is the facilitation of superior pulmonary toilet.[13] An established tracheostomy allows for more effective and frequent suctioning of secretions, which is critical in stroke patients who often have impaired cough reflexes and are prone to aspiration. This improved clearance may reduce the bacterial load in the lower respiratory tract, mitigating a key risk factor for pneumonia.[14]

Furthermore, a tracheostomy is generally better tolerated than an endotracheal tube, often permitting a substantial reduction in sedative medications.[15] While we did not measure sedation levels directly, this is a well-described benefit. In neurocritical care, minimizing sedation is crucial for enabling more reliable neurological assessments and detecting subtle clinical changes. A more alert patient may also be able to participate in early rehabilitation, creating a positive feedback loop that strengthens respiratory muscles and further accelerates the weaning process.

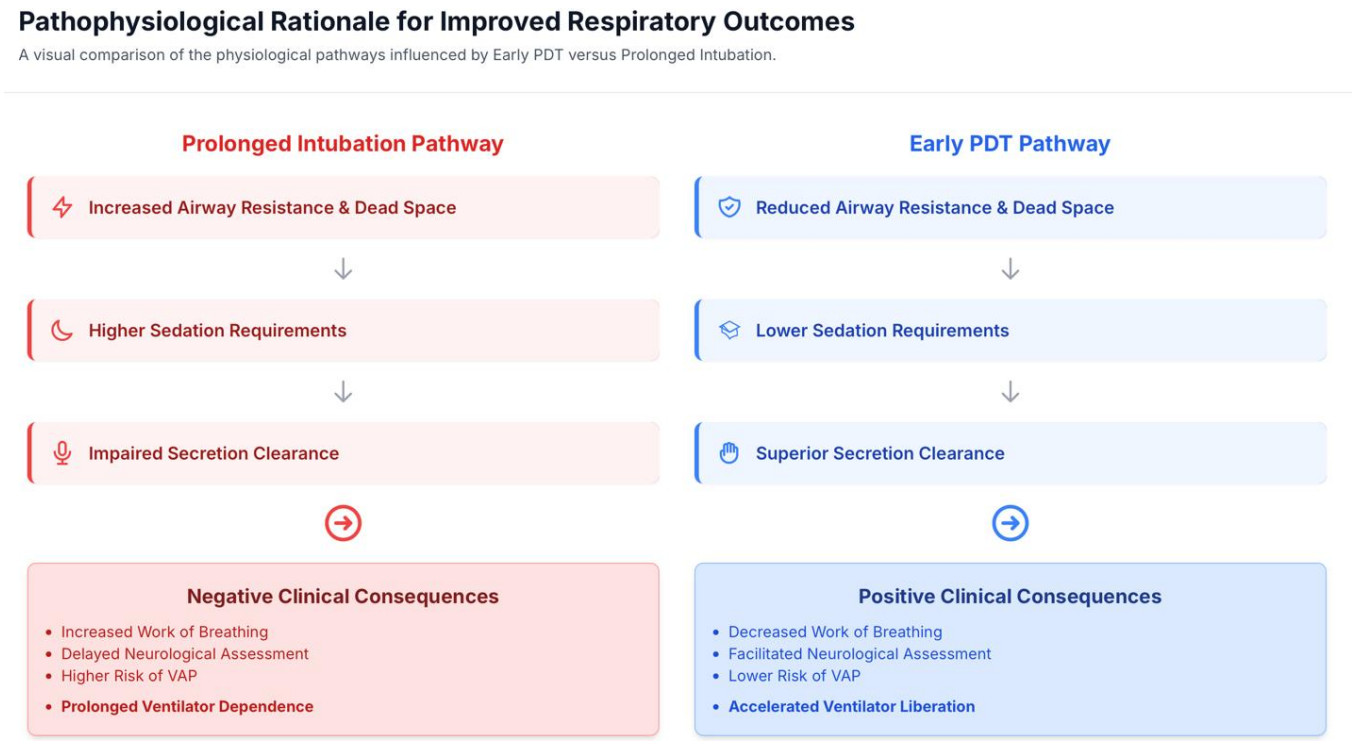

Figure 2. Pathophysiological rationale for improved respiratory outcomes.

A key finding of this study is the persistence of high mortality rates irrespective of PDT timing, even after adjusting for baseline severity. This apparent disconnect between improved respiratory outcomes and unchanged survival is a central tenet in understanding neurocritical care. The primary determinant of mortality in severe stroke is the extent of the initial, irreversible brain injury and its subsequent cascades, such as cerebral edema and herniation.[16] While supportive care interventions like PDT can effectively manage secondary organ dysfunction and prevent further insults, they cannot reverse the primary neurological catastrophe.

Our results support the hypothesis that for patients with a devastating brain injury, the clinical trajectory towards death is established early and is unlikely to be altered by the timing of airway management. The role of early PDT, therefore, should not be framed as a life-saving intervention but as a strategy to improve the quality of care and mitigate morbidity among those with

the potential to survive. By hastening ventilator liberation, early PDT can reduce the duration of exposure to the risks of invasive ventilation and life in the ICU, including delirium, ICU-acquired weakness, and discomfort.[17]

This study has several important limitations that must be acknowledged. First, its retrospective design makes it susceptible to selection bias and unmeasured confounding. Although we used multivariable models to adjust for key baseline variables, it is possible that the clinicians' decision to perform early PDT was influenced by subtle, unrecorded prognostic factors related to a patient's perceived recovery trajectory.[18] Second, this is a single-center study, and our findings, particularly regarding VAP rates and practice patterns, may not be generalizable to other healthcare settings with different patient populations or resource levels. Third, the sample size was modest, which means the study may have been underpowered to detect small but clinically relevant differences in mortality or length of stay. The non-significant trends towards better outcomes in the early group for these measures warrant investigation in larger cohorts.[19]

Fourth, the diagnosis of VAP relied on clinical criteria, which can be non-specific in neurocritical care patients. The observed difference in VAP rates should be interpreted with this diagnostic uncertainty in mind. Finally, our study did not collect data on long-term functional or neurological outcomes, which are arguably the most important endpoints for this patient population.[20] Future prospective studies should focus on these outcomes to fully elucidate the downstream benefits of accelerated ventilator liberation.

5. Conclusion

In this robustly analyzed cohort of critically ill stroke patients, an early percutaneous dilatational tracheostomy strategy (≤7 days post-intubation) was independently associated with a significantly higher probability of successful liberation from mechanical ventilation and a lower incidence of ventilator-associated pneumonia. These benefits, however, did not translate into a statistically significant reduction in ICU/hospital length of stay or mortality. Clinicians should consider early PDT a key intervention to facilitate recovery and rehabilitation in stroke patients projected to require long-term airway support.

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