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Outcome of Survivors of Acute Stroke Who Require Prolonged Ventilatory Assistance and Tracheostomy

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Key Words
Stroke · Mechanical ventilation · Outcome · Tracheostomy

Abstract
Background and Purpose: Mechanical ventilation after stroke is associated with high mortality. However, little is known about survivors who require prolonged ventilatory assistance and tracheostomy. Our goal was to assess the rate of pulmonary complication, effect of early tracheostomy and prognosis of patients with stroke requiring prolonged ventilatory support. ***Methods:*** Retrospective review of 97 patients with stroke who required ventilatory assistance and tracheostomy admitted to a single teaching hospital between 1976 and 2000. Outcome was defined using the Glasgow Outcome Scale (GOS). ***Results:*** Poor outcome (GOS 1–3) occurred in 74% of patients at 1 year and it was associated with older age ($p = 0.03$), prior history of brain damage ($p = 0.02$), and neurological worsening after intubation ($p < 0.01$). However, long-term functional recovery (GOS 4–5) was possible and more likely after strokes involving the posterior circulation ($p = 0.03$). Pulmonary complications were prevalent and more frequent before tracheostomy (68 vs. 20% after tracheostomy) but did not determine functional outcome. Mean duration of mechanical ventilation was 11 ± 19 days and did not significantly differ between outcome groups. Early tracheostomy correlated with shorter ICU and hospital stays ($p < 0.01$ in both cases). ***Conclusions:*** Surviving patients with stroke who require prolonged ventilatory assistance and tracheostomy can have a better outcome than previously reported. Aggressive care is justified in patients who do not continue to deteriorate neurologically. Pulmonary complications are frequent but treatable. Early tracheostomy can shorten ICU and hospital stays and reduce costs.

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Introduction

Studies suggest that mechanical ventilation after an acute stroke implies improbable survival [1–17]. However, little is known about mechanically ventilated patients with stroke who survive but require prolonged ventilatory support and eventually tracheostomy. This miss-

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ing information to predict outcome is an impediment in conversations with families that turn to us for guidance and are often riddled with doubts about the future consequences of allowing continuation of aggressive care. Particularly, mechanical ventilation is often equated with 'life support' and a cardinal point in most advance directives.

Respiratory complications such as ventilator-associated pneumonia are common in patients who need prolonged mechanical ventilation [18]. However, their true prevalence and severity in patients intubated after a stroke have not been studied. The proper timing of tracheostomy to minimize respiratory complications in patients with stroke has remained indeterminate. A recent study suggested that, in patients with infratentorial lesions, early tracheostomy may help shorten the time on mechanical ventilation and reduce the length of ICU stay [1].

The decision to prolong ventilatory support and place a tracheostomy is not a trivial issue behooving only physicians working in units for chronically ventilated patients. Neurologists can justify continuation of mechanical ventilation after careful assessment of the prognosis and potential for functional recovery. Neurologists can also play an active role in deciding the appropriate indication of tracheostomy after a stroke based, for example, on the presence of bulbar dysfunction or marginal airway protection due to fluctuating level of arousal.

We studied a large series of patients treated with prolonged mechanical ventilation and tracheostomy after a stroke to assess the rate of pulmonary complications, influence of tracheostomy timing on patients' care and long-term prognosis.

Patients and Methods

We reviewed the medical records of all patients admitted to Saint Mary's Hospital at Mayo Medical Center between 1976 and 2000 with primary diagnosis of stroke who required mechanical ventilation and tracheostomy. The design of this retrospective study was approved by our Institutional Review Board. Patients were included in the study if stroke was considered the main reason for the intubation and they subsequently received prolonged ventilatory assistance culminating in tracheostomy. We excluded patients who were intubated prior to stroke onset, such as in perioperative stroke, and patients whose level of care was restricted or withdrawn due to advanced directives (Do Not Intubate) or family request. Patients with head trauma, hemorrhage into a brain tumor, or diffuse anoxic-ischemic brain injury (e.g. cardiac arrest) were also excluded.

We tabulated patients' age, sex, and prior illnesses, stroke type (ischemic, intracerebral hemorrhage, or subarachnoid hemorrhage) and location (supratentorial versus infratentorial). Level of responsiveness upon intubation or cannulation (stupor was defined as Glasgow Coma Scale, GCS, sum score below 10), time from stroke onset to initial intubation, neurological deterioration after intubation (defined as a decrease by two points on the GCS score that persisted for at least 24 h and could not be accounted by sedation), time of initial intubation, and timing of tracheostomy in relation to stroke onset were also recorded. Reasons for initial intubation were divided into airway protection, respiratory failure, or neurosurgical intervention. Airway protection was defined as patient's inability to protect airway patency due to decreased level of consciousness or poor handling of respiratory secretions caused by the stroke, in the absence of signs of respiratory failure. Respiratory failure, typically due to stroke-induced aspiration or upper airway collapse, was defined as respiratory arrest or respiratory rate below 5 breathings per minute, hypercapnia (pCO_2 >55 mm Hg), hypoxemia (pO_2 <60 mm Hg), or tachypnea resulting in respiratory alkalosis. Indications for tracheostomy were divided into weaning failure, if continued mechanical ventilatory support was required at the time of tracheostomy, and airway protection, if the endotracheal tube could not be safely removed despite successful weaning from the ventilator.

Pulmonary complications were defined as any respiratory problem that required a therapeutic intervention. The diagnosis of pneumonia required the presence of a radiological infiltrate on chest X-ray plus new or worsening fever, leukocytosis, or need for increased ventilatory support. Atelectasis was tabulated only if there were signs of lobar or segmental collapse on chest X-ray, and mucous plugs were recorded when severe enough to require removal by bronchoscopy. Similarly, pneumothorax and pleural effusion were entered only if chest tube or pleural drainage were necessary. We followed standard diagnostic criteria for acute respiratory distress syndrome [19], and cardiogenic pulmonary edema was defined based on consistent radiological appearance and evidence of low (<40%) left ventricular ejection fraction. A case was considered clinically suspicious for aspiration when the patient developed new respiratory distress or radiological infiltrates after vomiting, starting tube feedings, or when a cuff leak was documented. Failed extubation attempts were defined as need for reintubation within 24 h of extubation. Peritracheostomy complications were defined as those untoward events occurring during or within 12 h of tracheostomy placement. We also collected data on complications occurring after tracheostomy for the duration of the follow-up.

We documented the total duration of ventilatory support (days on intermittent mandatory ventilation or pressure support ventilation exceeding 5 mm Hg of pressure support, even if not continuously), and ICU and hospital stays. Time to airway decannulation and disposition at discharge were also recorded. Outcome was assessed using the Glasgow Outcome Scale (GOS) [20] at discharge and at 1 year or time of last follow-up visit. GOS score of 4–5 was considered good outcome and GOS 1–3 was regarded as poor outcome. Information for the assessment of GOS was derived from review of medical records.

Dichotomous variables were compared using the χ^2 square analysis and the Fisher exact test, and continuous variables using the paired t test. Correlation coefficients between continuous variables were obtained using the JMP statistical software (SAS Institute, Cary, N.C., USA) and then the correlations were subjected to analysis of variance. Level of significance was established at $p < 0.05$.

Table 1. Demographic and clinical information in 97 patients requiring prolonged ventilatory assistance and tracheostomy after an acute stroke according to long-term outcome

Variable	All patients (n = 97)	GOS 4–5 (n = 25)	GOS 1–3 (n = 72)
Male gender, n (%)	65 (67)	16 (25)	49 (68)
Mean age, years (range)	62 (20–88)	56 (21–83)	64 (20–88)*
Comorbid conditions, n (%)			
Hypertension	47 (48)	11 (44)	36 (50)
Smoking	32 (33)	7 (28)	25 (35)
Prior brain injury	2 (23)	3 (12)	25 (35)**
Coronary artery disease	22 (23)	3 (12)	19 (26)
Lung disease	18 (19)	3 (12)	15 (21)
Obesity	19 (19)	6 (24)	13 (18)
Diabetes mellitus	4 (14)	4 (16)	10 (14)
Congestive heart failure	12 (12)	1 (4)	11 (15)
Atrial fibrillation	0 (10)	1 (4)	9 (12)
Stroke type, n (%)			
Ischemic	58 (60)	14 (56)	44 (61)
Intracerebral hemorrhage	5 (26)	8 (32)	17 (24)
Subarachnoid hemorrhage	4 (14)	3 (12)	11 (15)
Stroke territory, n (%)			
Supratentorial	30 (31)	4 (16)	26 (36)
Infratentorial	53 (55)	18 (72)	35 (49)*
Subarachnoid hemorrhage	4 (14)	3 (12)	11 (15)
GCS score < 10 upon intubation, n (%)	71 (73)	16 (64)	55 (76)
Neurological decline after intubation[1], n (%)	38 (39)	2 (8)	36 (36)***
Time of initial intubation[2]			
At onset, n (%)	3 (55)	13 (52)	40 (56)
Delayed, n (%)	4 (35)	8 (32)	26 (36)
Reason for initial intubation			
Airway protection, n (%)	60 (62)	15 (68)	45 (73)
Respiratory failure, n (%)	24 (25)	7 (32)	17 (27)
Neurosurgery, n (%)	3 (3)	0 (0)	3 (5)
Mean time ETT to tracheostomy, days (range)	13 (4–29)	12 (6–23)	13 (4–29)
Mean time stroke to tracheostomy, days (range)	14 (4–29)	14 (3–26)	14 (4–29)
Reason for tracheostomy			
Weaning failure, n (%)	20 (21)	7 (28)	13 (18)
Airway protection, n (%)	77 (79)	18 (72)	59 (82)
Pulmonary complications			
Pre-tracheostomy, n (%)	6 (68)	15 (60)	51 (71)
Post-tracheostomy, n (%)	19 (20)	6 (24)	13 (18)
Ventilatory support, days (mean ± SD)	11 ± 19	9 ± 13	12 ± 21
ICU stay, days (mean ± SD)	7 ± 14	7 ± 14	7 ± 14
Hospital stay, days (mean ± SD)	38 ± 27	42 ± 23	37 ± 23

ETT = Endotracheal intubation; ICU = intensive care unit.
* p = 0.03; ** p = 0.02; *** p < 0.01.
1 See text for criteria.
2 Ten patients received tracheostomy early without previous endotracheal intubation.

Results

Ninety-seven surviving patients received prolonged ventilatory support and required a tracheostomy after an acute stroke. Table 1 displays demographic and clinical data of the study population organized by outcome groups.

Outcome was poor (GOS 1–3) in 72 of 97 patients (74%). Patients with better outcome (GOS 4–5) were significantly younger. History of arterial hypertension was

Table 2. Respiratory complications before tracheostomy in 97 patients with acute stroke requiring prolonged ventilatory assistance

Pulmonary complication	Total	GOS 4–5	GOS 1–3[a]
Pneumonia	55 (57%)	13 (52%)	42 (58%)
Suspected aspiration	49 (51%)	12 (48%)	37 (51%)
ARDS	5 (5%)	1 (4%)	4 (6%)
Atelectasis	15 (15%)	3 (12%)	12 (17%)
Mucous plug	16 (16%)	4 (16%)	12 (17%)
Cardiogenic pulmonary edema	3 (3%)	1 (4%)	2 (3%)
Pneumothorax	2 (2%)	1 (4%)	1 (1%)
Pleural effusion	3 (3%)	0 (0%)	3 (4%)
Tracheal bleeding	4 (4%)	0 (0%)	4 (6%)
Pulmonary embolism	1 (1%)	0 (0%)	1 (1%)
Neurogenic pulmonary edema	1 (1%)	0 (0%)	1 (1%)
Accidental extubation	5 (5%)	4 (16%)	1 (1%)
Cuff leak	5 (5%)	3 (12%)	2 (3%)
Upper airway edema	3 (3%)	1 (4%)	2 (3%)
Failed extubation trials	38	9	29

ARDS = Acute respiratory distress syndrome. GOS scores of 4–5 indicate patients who regained functional independence.
[a] None of the differences reached statistical significance.

Table 3. Respiratory complications after tracheostomy in 97 patients with acute stroke requiring prolonged ventilatory assistance

Pulmonary complication	Total	GOS 4–5	GOS 1–3[a]
Pneumonia	14 (14%)	4 (16%)	10 (14%)
Suspected aspiration	15 (15%)	4 (16%)	11 (15%)
Atelectasis	3 (3%)	1 (4%)	2 (3%)
Tracheal bleeding	2 (2%)	0 (0%)	2 (3%)
Pleural effusion	4 (4%)	1 (4%)	3 (4%)
Empyema	1 (1%)	0 (0%)	1 (1%)
Pulmonary embolism	1 (1%)	1 (4%)	0 (0%)
Brief apneas	11 (11%)	6 (24%)	5 (7%)

GOS scores of 4–5 indicate patients who regained functional independence.
[a] None of the differences reached statistical significance.

commonly found but did not correlate with outcome. Prior history of brain damage (mostly from stroke but also form previous neurosurgery, brain abscess or benign brain tumor) was associated with worse outcome (GOS 1–3) ($p = 0.02$), whereas a similar but less pronounced trend was seen in patients with history of lung disease or smoking ($p = 0.16$).

Hemorrhagic strokes were fairly common in this population of mechanically ventilated patients but the type of stroke had no detectable impact on outcome. However, infratentorial strokes (all of which involved the brainstem directly or by compression) were associated with a better outcome than the other categories ($p = 0.03$). When patients with subarachnoid hemorrhage were excluded from the analysis, the results did not change significantly. Most patients were intubated early after the stroke and usually to protect the airway, but neither the timing of nor the reason for the intubation differed between outcome groups. Stupor was more frequently present upon intubation or cannulation among patients with worse outcome. Neurological decline after intubation showed a significant association with poor outcome ($p < 0.01$).

Pulmonary complications were very prevalent before tracheostomy placement and they occurred slightly more often in patients with worse outcome (71% in GOS 1–3 group versus 60% in GOS 4–5 group). Pneumonia was present in over half of all patients and aspiration was frequently suspected. Table 2 displays the prevalence rates of all recorded pulmonary complications. Duration of ventilatory support showed no significant correlation with outcome.

All patients underwent surgical tracheostomy. Transient fevers were the most frequent peritracheostomy complication, occurring after 12% of the procedures. Pulmonary complications after tracheostomy occurred in 20% of patients (table 3) and long-term problems related to tracheostomy were rather infrequent, affecting approximately 5% of the patients (stoma abrasion, tracheal ste-

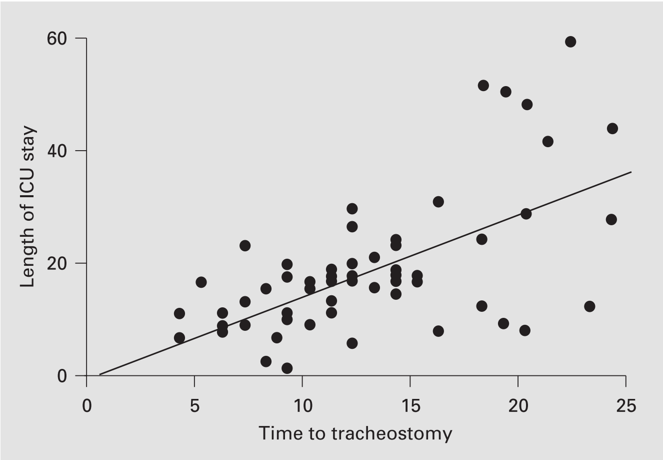

Fig. 1. Correlation between timing of tracheostomy and ICU stay (r = 0.61, p <0.0001) in 97 patients requiring prolonged ventilatory assistance and tracheostomy after an acute stroke. The numbers on both axes represent days.

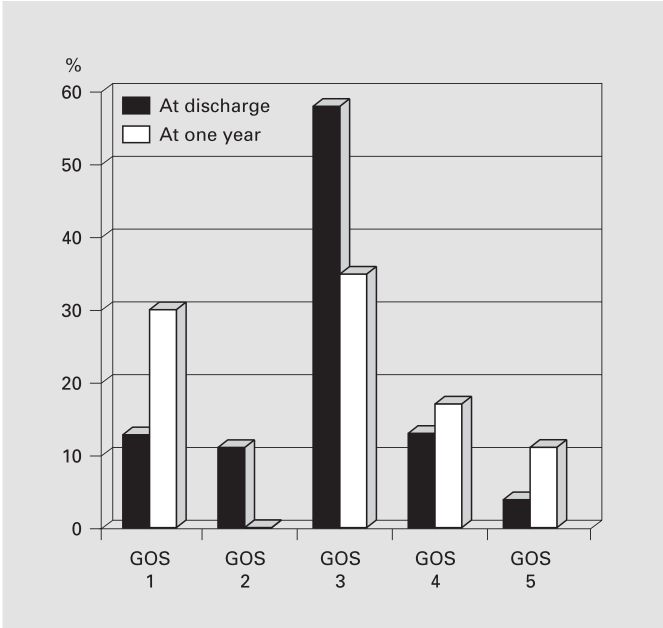

Fig. 2. Outcome data at hospital discharge and at 1 year in patients requiring prolonged ventilatory assistance and tracheostomy after an acute stroke.

nosis, vocal cord paralysis, and dystrophic scar in 3 cases each, tracheocutaneous fistula and stoma infection in 2 cases each, and dislodgement of the cannula and failure of stoma closure in 1 case each). Airway decannulation was possible in nearly half of the survivors, including 80% of patients who regained independence (GOS 4–5). Median time to decannulation was 32 days (range 8 days to 48 months). Earlier tracheostomy significantly correlated with shorter ICU ($r = 0.61$, $p < 001$; fig. 1) and hospital stays ($r = 0.42$, $p < 0.01$) despite the lack of association between timing of tracheostomy and functional outcome.

Outcome data at hospital discharge and at 1 year is depicted in figure 2. Eighteen percent of patients had regained functional independence at the time of hospital discharge, whereas 13% died in the hospital. Twenty percent of all patients were discharged home after extensive in-hospital rehabilitation, 48% went to nursing homes, 20% to local hospitals, 7% to other rehabilitation facilities and 7% to hospice. Follow-up data after discharge was available in 74% of the patients. At 1 year (or at 6 months in 8 patients who were followed for less than 1 year), the mortality rate had increased to 30%, and 26% of patients were functionally independent. Eighty-four percent of patients lost to follow-up had been discharged in poor functional status (GOS 2–3). Forty-one percent of deaths were due to neurological worsening, 24% to documented systemic complications, and the cause remained undetermined in the rest of the cases (35%). Patients treated over the last 10-year time epoch achieved meaningful functional recovery more often than patients treated in earlier decades (GOS 4–5, 35 versus 23%), although the difference did not achieve statistical significance ($p = 0.38$).

Discussion

It is a widely held assumption that prolonged mechanical ventilation and tracheostomy are only palliative measures after an acute devastating stroke. Our study, arguably one of the largest to date, suggests that a considerable number of patients with stroke may greatly benefit from such aggressive medical interventions. Despite often long and complicated ICU and hospital stays, over a fourth of patients with stroke who required a tracheostomy – for prolonged ventilatory failure or persistent inability to protect the airway – regained functional independence. Advanced age, prior history of brain damage, neurological decline after intubation, and supratentorial location were significantly associated with worse outcome. Pulmonary complications occurred in a majority of these patients and were frequently severe but did not affect long-term functional outcome. Surgical tracheostomy was safe and early tracheostomy timing correlated with shorter ICU and hospital stays.

Several studies have assessed the prognosis of patients with stroke who need intubation and mechanical ventilation [1–17]. Reported mortality rates have been consistently high, ranging between 50 and over 90%. Low GCS at presentation or before intubation, loss of brainstem reflexes, and evidence of neurological deterioration have consistently predicted fatal outcome.

Functional outcome in survivors was good or fair in most [2, 7, 8, 12, 15, 17], but not all [9] series – although the conclusions were limited by the small number of surviving patients. A better outcome was seen in patients intubated for respiratory compromise, as opposed to neurological decline [11, 14, 17], and those with higher GCS score at the time of intubation [12]. When assessed, there was no correlation between outcome and duration of ventilatory support [7, 8]. These findings indicate that respiratory complications can be successfully treated and that final outcome depends mainly on the degree of irreversible brain damage.

Our study population differs from those included in prior cohorts in that we only included surviving patients with stroke who had prolonged mechanical ventilation and required a tracheostomy. Therefore, we excluded patients who were intubated after presenting with a stroke but died before a tracheostomy could be performed. These moribund patients predominated in previous series and determined high in-hospital mortality rates.

Prognosis in our patients was mostly related to the severity of initial brain injury and the presence of subsequent neurological deterioration and not to the occurrence of systemic complications. Additionally, we found that older age and preexisting brain damage, while not predictive of death in most prior series, led to worse functional outcome after 1 year. Reduced cerebral plasticity and inability to participate in demanding rehabilitation programs can potentially explain this finding. Pulmonary complications were more frequent and duration of mechanical ventilation tended to be longer in the poor outcome group. However, these differences were not significant and patients with severe respiratory problems requiring prolonged ventilatory support were able to recover meaningful function over time. This implies that aggressive treatment of systemic complications is often justified in mechanically ventilated patients who survive a severe stroke.

In our series, patients with brainstem or cerebellar stroke had better prognosis for functional recovery. The absence of this association in previous studies [3, 4] could have resulted from the inclusion of the most severe cerebellar and brainstem strokes that were rapidly fatal and hence excluded from our population. While patients with large hemispheric strokes only need endotracheal intubation when the infarcted region is large, patients with relatively smaller areas of infarction in the brainstem may require intubation due to damage to lower cranial nerve nuclei – involved in the generation of protective airway reflexes – or respiratory drive centers.

The patients in this series were collected from a database covering admissions to our hospital over the last 25 years. Improvement in stroke care, mechanical ventilation techniques, and other ICU interventions throughout these years has been substantial. However, it has been suggested that with current aggressive treatments we may be improving survival but at the expense of compromising quality of life [9]. It is therefore reassuring that, in our population, the chances to regain functional independence were slightly greater for patients treated over the last decade. Nevertheless, the differences in outcome were not significant over time, justifying the inclusion of patients over such a long study period.

Ventilator-associated pneumonia is a major cause of nosocomial morbidity and mortality [18, 21, 22]. Early-onset ventilator-associated pneumonia occurs within 48 or 72 h after endotracheal intubation and often results from aspiration before or at the time of intubation, or after failed extubation trials. Both aspiration and failed extubation attempts were very prevalent in our patients who frequently had impaired lower brainstem reflexes. In addition, late-onset ventilator-associated pneumonia becomes a common problem after several days of intubation, condition met by all of our patients. Therefore, it is not surprising that our population had a very high prevalence of pneumonia, especially before tracheostomy was performed.

Timing of tracheostomy has been debated for years [23]. A recent systematic review of the literature concluded that available studies provide insufficient evidence to support that early tracheostomy alters the duration of mechanical ventilation or the extent of airway injury in critically ill patients [24]. However, there is no prior information on patients who need tracheostomy after a stroke. These patients are markedly different from those reported in previous series because they less commonly have preexistent respiratory disease and often require prolonged intubation for long-term airway protection instead of protracted ventilatory failure. It has been recently suggested that early conversion to tracheostomy in patients with infratentorial lesions – mostly, but not necessarily, caused by a stroke – might facilitate weaning and shorten the length of stay in the ICU [1]. In our study, earlier tracheostomy correlated with shorter ICU and hospital stays. It is unlikely that differences in patients' severity could account for our findings since timing of tracheostomy did not correlate with patients' outcome. The cost savings resulting from timely transfer out of the ICU and earlier dismissal from the hospital could be substantial.

Certain caveats and limitations need to be taken into consideration when interpreting our study results. As in any observational study, therapeutic interventions were not standardized and resulted from the best clinical judgment of the treating physicians. Although we chose to adopt fairly strict criteria for the diagnosis of pneumonia, radiological infiltrates are very commonly reported on chest X-ray films of intubated patients in the ICU, which may have arguably resulted in an overestimation of the frequency of cases of pneumonia. Our study population was graded using the GOS and we acknowledge the existence of better handicap scales. However, our study was initiated to reassess the preconceived notion that prolonged ventilatory assistance and tracheostomy after a severe stroke leave only crippled survivors. More detailed functional scales may provide further information on the spectrum of functional independence. This would require long-term follow-up with thorough rehabilitation assessment.

We conclude that surviving patients with stroke who require prolonged ventilatory assistance and tracheostomy can have a better long-term outcome than previously reported. Aggressive care should be offered and continued, especially in patients who do not deteriorate neurologically. Pulmonary complications are common, and they need to be anticipated and prevented. Early tracheostomy could reduce the length of ICU and hospital stays.

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