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Original Article

The importance of tracheostomy to the weaning success in patients with conscious disturbance in the respiratory care center

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Abstract

Background: When to extubate the endotracheal tube is controversial in patients with depressed mental status. The use of the Glasgow Coma Scale (GCS) with score 8 or above as a criterion for extubation by many investigators is questionable.
Methods: A total of 133 consecutive patients (M/F: 86/47; age: 71 ± 17 years) admitted to the respiratory care center (RCC) of the hospital were enrolled. The effects of GCS score on the outcomes and weaning rate of the patients were evaluated.
Results: The mortality rate was significantly higher in patients with a GCS score < 7T or derived GCS (dGCS) score < 10 ($p = 0.011$). In patients with a low GCS score (GCS < 7T or dGCS score < 10), the rate of successful ventilator weaning in patients with tracheostomy was significantly higher than that in patients without tracheostomy (GCS and dGCS: 94.4% vs. 38.5%, $p = 0.001$). However, tracheostomy in patients with a high GCS (GCS score ≥ 7T or dGCS score ≥ 10) did not lead to a higher success rate of weaning. In multivariable analysis, tracheostomy was still an independent determinant of successful weaning in patients with low GCS.
Conclusion: Tracheostomy increases the success rate of weaning in patients with low GCS, but not in patients with high GCS. Mental status graded by GCS did affect the outcomes in patients with conscious disturbance in the RCC. The low tracheostomy rate in patients with low GCS affected the rate of successful weaning, which might have contributed to the higher mortality rate in patients with low GCS in the RCC.

Keywords: extubation; Glasgow Coma Scale; respiratory care center; tracheostomy; weaning

1. Introduction

Extubation is a very important issue in the intensive care unit (ICU). Identification of patients suitable for extubation is one of the major challenges in the ICU. However, the timing of extubation is quite controversial in patients with depressed mental status. It has been shown that after adjustment for severity of illness and comorbid conditions, extubation failure had a significant independent association with increased risk of death, prolonged ICU stay, and transfer to a long-term care or rehabilitation facility, and that identifying patients at risk of poor outcome from extubation failure and instituting alternative care practices may reduce mortality, duration of ICU stay, and need for transfer to a long-term care facility.[1] Extubation failure has been reported to be associated with higher

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morbidity and mortality rates in the ICU. Thus, timely identification of patients at elevated risk for extubation failure followed by rapid reestablishment of ventilatory support can improve outcome.[2]

Some studies supporting the safety of extubation in neurologically impaired patients have been reported. For instance, Coplin et al[3] demonstrated that timely extubation of brain-injured patients who met standard weaning criteria appeared to be safe (no increased risk of reintubation or subsequent tracheotomy), potentially beneficial (associated with a lower incidence of pneumonia), and less expensive (shorter length of stay in ICU and lower hospital costs). Prediction of extubation failure is one of the most challenging aspects of critical care medicine. Traditional weaning parameters have been shown to be incapable of predicting extubation failure in neurocritical care patients.[4] By incorporating assessment of mental status, endotracheal secretions, and pre-extubation $PaCO_2$ into the clinical prediction rule, clinicians can predict who will fail extubation despite a successful spontaneous breathing trial.[5] The Glasgow Coma Scale (GCS) seems to be important in the prediction of extubation failure. A GCS score ≤ 10 was found to be significantly associated with extubation failure,[5] whereas a GCS score > 8 at extubation was found to be associated with a success in 75% of cases, versus 33% for a GCS score < 8.[6] However, some investigators have found that it is safe to extubate in neurologically impaired patients without increased risk of extubation failure.[7,8] Thus, the use of a cutoff value of GCS score to favor or be against extubation is questionable, because a lack of verbal component for the GCS score in intubated patients may affect the accuracy of GCS score in the prediction of extubation failure.

Prolonged intubation and direct extubation are not uncommon in patients with conscious disturbance in respiratory care centers (RCCs) in Taiwan. The rate of tracheostomy seems to be relatively low for patients with conscious disturbance in the RCC. The aims of this study were threefold. The first purpose was to determine whether or not the mental status graded by GCS, with or without verbal component, could affect the outcome of patients in the RCC. The second was to determine whether the rate of weaning from mechanical ventilation was different between patients with high a GCS score (GCS score ≥ 7T or dGCS score ≥ 10) and a low GCS score (GCS score < 7T or dGCS score <10) in the RCC. The third one was to determine whether the effect of tracheostomy on the rate of weaning from mechanical ventilation was different between patients with a high and a low GCS score in the RCC.

2. Methods

2.1. Patients

This was a retrospective controlled study (National Taiwan University Hospital IRB: 201105114RC). Patients intubated and admitted to the RCC because of general trauma, head trauma, postoperative care, or medical illness were included in the study group. In Taiwan, RCC is set up as a step-down unit to care for patients transferred from an ICU who have received mechanical ventilation for > 21 days, or have received mechanical ventilation for > 10 days with expected difficulty in ventilator weaning, and for weaning them from mechanical ventilation. For admission to the RCC, the patients must: (1) be hemodynamically stable: mean arterial blood pressure ≥ 65 mmHg without the use of inotropic agents and no life-threatening arrhythmia; (2) have adequate gas exchange: $SpO_2 \geq 90\%$ or $PaO_2 \geq 60$ mmHg under mechanical ventilator support with inspired oxygen fraction < 60% and positive end-expiratory pressure < 10 cmH_2O; and (3) have no uncontrolled infection. Weaning from mechanical ventilation was done according to an established weaning protocol (Fig. 1).

2.2. Study protocol

The effects of GCS score on the patients' outcomes and weaning rates were evaluated. The outcome measurements included mechanical/ICU/RCC days, ventilator weaning rate, and mortality rate. Discharge from the RCC was defined as ‘survival’. Patients who were not using ventilators for > 5 days were defined as successful weaning from mechanical ventilation. The eye and motor scores published in a previous regression model were used to predict the verbal score:[9]

$$\text{Derived Verbal Score} = -0.3756 + 0.5713\cdot\text{Motor Score} + 0.4233\cdot\text{Eye Score}$$

The effects of traditional and dGCS on mortality and weaning rate were evaluated. In addition, the effects of tracheostomy on weaning rate in high and low GCS score groups

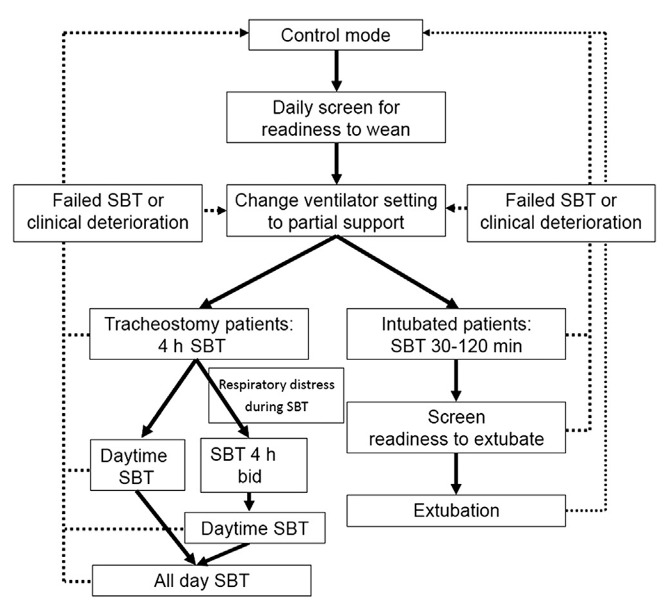

Fig. 1. Weaning protocol in respiratory care center (RCC). SBT = spontaneous breathing trial.

were compared. The mental status graded by GCS was reported as follows:

$$\text{GCS score} = \text{E score} + \text{M score} + \text{“T(Tracheostomy or intubation)”}$$

$$\text{dGCS score} = \text{E score} + \text{M score} + \text{Derived Verbal Score.}$$

A low GCS score group was defined by GCS score < 7T or score < 10, and a high GCS score group was defined by GCS score ≥ 7T or dGCS score ≥ 10.

2.3. Statistical analysis

Data were presented as mean ± standard deviation for continuous variables. Absolute and relative frequencies were determined for discrete variables. Between group comparisons were performed using the Student's *t* test for continuous variables and the Chi-square test for categorical variables. By using multiple logistic regression analysis with stepwise selection, the following variables were examined to determine the independent determinants of successful ventilator weaning: age, sex, tracheostomy or not, and types of organ dysfunctions. Data analysis was performed by using SPSS 16.0 statistical software (SPSS, Inc, Chicago, IL, USA). Statistical significance was assumed for $p < 0.05$.

3. Results

A total of 133 consecutive patients admitted to the RCC for respiratory care were enrolled. Baseline demographics, days of ICU/RCC stay, and prevalence of cerebral and other organ dysfunctions in RCC patients are listed in Table 1. There were no significant differences in age, sex, prevalence of organ dysfunction, and ICU stay between the low GCS score group and the high GCS score group. Patients with lower GCS or dGCS had a higher mortality rate. The mortality rates graded by GCS and dGCS are summarized in Table 2. The mortality rate was significantly higher in patients with a low GCS score than patients with a high GCS score as defined by GCS < 7T or dGCS < 10 for the low GCS group. Therefore, mental status graded by GCS either with or without verbal component could affect the outcome of the patients in the RCC. The shorter duration of RCC stay in patients with a low GCS score may be due to their higher mortality in the RCC.

Table 1
Baseline demographics, days of intensive care unit (ICU)/respiratory care center (RCC) stay, and prevalence of organ dysfunction in the RCC patients.

	Overall ($n = 133$)	Low GCS (< 7T) ($n = 31$)	High GCS (≥ 7T) ($n = 102$)	p
Age (y)	71 ± 17	68 ± 17	71 ± 16	0.72
Sex (M/F)	86/47	18/13	68/34	0.40
Reasons for admission to RCC (dysfunction)				
Cardiovascular (%)	20 (15%)	7 (23%)	14 (13.7%)	0.26
Respiratory (%)	59 (44%)	10 (32%)	49 (48%)	0.15
Renal (%)	15 (11%)	3 (9.7%)	14 (13.7%)	0.76
Neurologic (%)	38 (28.6%)	13 (42%)	25 (24.5%)	0.07
Hepatic (%)	7 (5%)	0 (0%)	7 (6.8%)	0.20
Hematologic (%)	7 (5%)	1 (3%)	7 (6.9%)	0.68
ICU stay (d)	23 ± 12	19 ± 7	25 ± 13	0.10
RCC stay (d)	16 ± 9	15 ± 7	17 ± 10	0.01

GCS = Glasgow Coma Scale; ICU = intensive care unit; RCC = respiratory care center. Organ dysfunction was defined by underlying diseases and comorbidity at RCC admission.

Table 2
Mortality rate graded by traditional Glasgow Coma Scale (GCS) and derived GCS (dGCS) in the respiratory care center (RCC).

	Low GCS	High GCS	p
GCS			
< 8T vs. ≥ 8T	8.5%	1.2%	0.052
< 7T vs. ≥ 7T	12.9%	1.0%	0.011
< 6T vs. ≥ 6T	17.4%	0.9%	0.003
dGCS			
< 11 vs. ≥ 11	8.5%	1.2%	0.052
< 10 vs. ≥ 10	12.9%	1.0%	0.011
< 9 vs. ≥ 9	12.9%	1.0%	0.011

GCS = Glasgow Coma Scale; traditional GCS = E score + M score + “T (Tracheostomy or intubation)”; dGCS = E score + M score + Derived V score; low GCS = GCS < 7T or dGCS < 10; high GCS = GCS ≥ 7T or dGCS ≥ 10.

Table 3 shows that the rate of weaning from mechanical ventilation in patients with a high GCS score (GCS ≥ 7T or dGCS ≥ 10) was similar to that of patients with a low GCS score. More patients with a high GCS score underwent tracheostomy, as compared with those patients with a low GCS score (not significantly different). The time of tracheostomy was performed 14.7 ± 12.2 days after admission in patients with a high GCS score, and 12.9 ± 8.7 days after admission in patients with a low GCS score (p = NS). In patients with a low GCS score (GCS < 7T or dGCS < 10), the rate of successful weaning was significantly higher in patients with tracheostomy than patients without tracheostomy (GCS and dGCS: 94.4% vs. 38.5%, $p = 0.001$). However, in patients with a high GCS score, the tracheostomy did not affect the rate of successful weaning (Fig. 2).

Multiple logistic regression analysis with stepwise selection was performed to assess the independent determinants of successful ventilator weaning. Multivariate analysis revealed that tracheostomy was an independent determinant of successful

Table 3
The rate of successful weaning and rate of tracheostomy graded by traditional Glasgow Coma Scale (GCS) and derived GCS in the respiratory care center (RCC).

	Low GCS	High GCS	p
Rate of successful weaning			
GCS < 7T vs. ≥ 7T	71.0%	71.6%	> 0.99
dGCS < 10 vs. ≥ 10	71.0%	71.6%	> 0.99
Rate of tracheostomy			
GCS < 7T vs. ≥ 7T	58.1%	70.6%	0.197
dGCS < 10 vs. ≥ 10	58.1%	70.6%	0.197

GCS = Glasgow Coma Scale; traditional GCS = E score + M score + “T (Tracheostomy or intubation)”; dGCS = E score + M score + Derived V score; low GCS = GCS < 7T or dGCS < 10; high GCS = GCS ≥ 7T or dGCS ≥ 10.

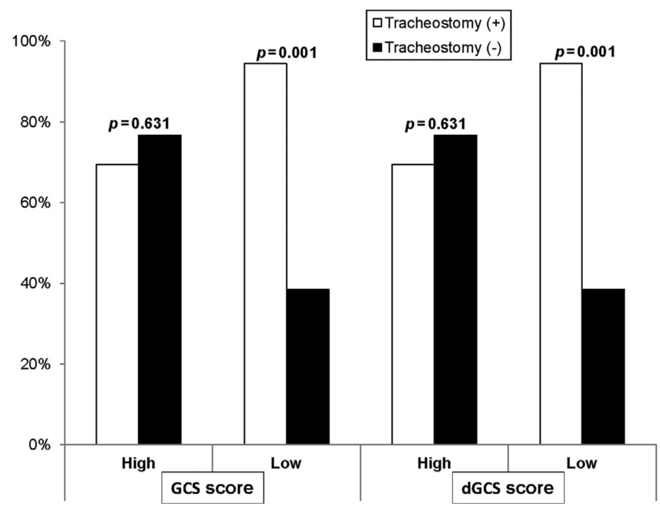

Fig. 2. Impact of tracheostomy on the rate of weaning success in patients with a low or high traditional Glasgow Coma Scale (GCS) and derived GCS (dGCS) in the respiratory care center (RCC). Low GCS group was defined by GCS < 7T or dGCS < 10, and high GCS group was defined by GCS ≥ 7T or dGCS ≥ 10.

ventilator weaning in patients with a low GCS score, but not in patients with a high GCS score (Table 4). Age, sex, and types of organ dysfunctions did not affect the weaning success rate in multivariate analysis.

4. Discussion

Our study showed that the mortality rate was significantly higher in patients with a low GCS score, both GCS score and dGCS score, in the RCC. Despite the rate of weaning from mechanical ventilation being similar between patients with high and low GCS scores, the rate of successful weaning in patients with tracheostomy was significantly higher than that in patients without tracheostomy in patients with a low GCS score. Furthermore, tracheostomy did not affect the rate of successful weaning in patients with a high GCS score.

4.1. Low GCS score and mortality

Although mechanical ventilation provides essential life support, no consensus has been reached about the appropriate ventilatory management in critically ill neurologic patients. It is believed that outcomes of critically ill neurologic patients are mainly driven by the underlying neurologic pathology;[8] the influence of extracerebral organ dysfunction and ventilatory management on outcomes in this group of patients has not been well established.[9,10] A multicenter, prospective, observational study showed that, compared with non-neurologic patients requiring mechanical ventilation, those with neurologic diseases were characterized by a longer duration of mechanical ventilation and a higher mortality rate, despite a lower incidence of extracerebral organ dysfunction.[11] Mascia et al[12] showed that GCS and the presence of nontraumatic brain injury were independently associated with a higher risk of death in neurologic patients in the ICU. Our observations also support that GCS score did affect the mortality rate of patients requiring mechanical ventilation.

Table 4
Tracheostomy and successful ventilator weaning as assessed by multiple logistic regression analysis.

	Estimate	OR	95% CI	*p*
Overall patients				
tracheostomy	0.595	1.81	0.71–4.61	0.211
Patients with low GCS				
tracheostomy	3.963	52.6	2.4–1145	0.012
Patients with high GCS				
tracheostomy	−0.177	0.84	0.25–2.86	0.780

GCS = Glasgow Coma Scale; low GCS = GCS < 7T; high GCS = GCS ≥ 7T; OR = odds ratio; CI = confidence interval.

4.2. Extubation in patients with a low GCS score

Although neurologic patients are younger and have less comorbidity, they develop extracerebral organ failure, including respiratory failure, more frequently than non-neurologic patients.[11,12] In prior studies, respiratory failure was the most frequent extracerebral complication, followed by cardiovascular dysfunction in neurologic patients.[11–13] These data suggested that the lung may represent a specific therapeutic target in patients with depressed mental status. Slow recovery from neurologic dysfunction was associated with higher rates of impairments to respiratory muscle power, cough, clearing secretions, and swallowing. All of these make the timing of extubation quite controversial in patients with a low level of consciousness. Clinical study showed that in the presence of a low GCS score, physicians tended to delay extubation even when standard extubation criteria were reached.[11] While it is clear that prolonged intubation is associated with increased morbidity and mortality, the medical literature also demonstrates harm from extubation failure and reintubation.[1,14] Extubation failure appears to lengthen hospital stays, worsen functional outcomes, and increase mortality. Moreover, multivariate analyses have shown that premorbid health status, severity of illness, and complications directly associated with reintubation do not fully explain the increased mortality associated with extubation failure.[15] Patients who failed extubation had an increased mortality rate compared with patients who were successfully extubated on the first attempt or patients who failed their first breathing trial but were not extubated.[1,16] This result suggested that extubation failure itself independently increased mortality. A direct correlation between increased time to reintubation and mortality has led some researchers to suggest that clinical deterioration prior to reinstitution of mechanical ventilation is responsible for the increased mortality associated with extubation failure.[16] Tracheostomy is likely to benefit from balancing the risks between prolonged intubation and extubation failure in patients with depressed mental status.

4.3. Benefits of tracheostomy in patients with a low GCS score

There are many purported advantages of tracheostomy in patients undergoing mechanical ventilation, such as improved patient comfort, less need for sedation, lower work of breathing, improved patient safety, improved oral hygiene, better long-term laryngeal function, lower risk of ventilator-associated pneumonia, faster weaning from mechanical ventilator, and shorter ICU and hospital stay.[14,17] Rizk et al[18] reported that early tracheostomy was more likely to be functionally independent at discharge and have a shorter length of hospital stay in patients with a GCS score < 8. Early tracheostomy is also feasible, and safe, and can presumably reduce sedation in ventilated intensive care stroke patients.[19] They also found that tracheostomy had benefit in ICU mortality in ventilated stroke patients.[19] In general, studies have suggested a higher incidence of positive outcomes in patients with tracheostomy, but this is by no means universal. In meta-analysis studies, early tracheostomy was found to reduce the duration of artificial ventilation as well as ICU length of stay, but had no effect on mortality.[17,20] Bouderka et al[21] showed that early tracheostomy in head injury decreased both total days of mechanical ventilation and mechanical ventilation time after the development of pneumonia; however, the overall rates of pneumonia and mortality were not different between patients with and without tracheostomy. By contrast, in a small prospective study, Chintamani et al[22] found fewer intubation-associated complications and improved mortality in patients receiving early tracheostomy, as compared to prolonged mechanical ventilation. Patients with depressed mental status might be a specific subpopulation having a survival benefit from early tracheostomy. In our study, tracheostomy affected the successful rate of ventilator weaning only in patients with a low GCS score, but not in patients with a high GCS score. The low tracheostomy rate in patients with a low GCS affected their weaning rate, which might contribute to the higher mortality in patients in the RCC. However, the study of Schauer et al[23] suggested that patients with a high probability of survival were more likely to benefit from early tracheostomy. Thus, tracheostomy should be considered earlier in those low GCS score patients with an acceptable procedure-related risk and a relatively high chance of survival.

In conclusion, mental status graded by GCS either with or without verbal component was associated with the mortality rate in the RCC patients. Tracheostomy could affect the rate of successful weaning in patients with a low GCS score (< 7T), but not in patients with a high GCS score (≥ 7T). The low tracheostomy rate in patients with a low GCS score affected the weaning rate, which might have contributed to their higher mortality rate by increasing the risk of extubation failure in the RCC patients.

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