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Original Article

Tracheostomy versus Endotracheal Intubation Prior to Admission to a Respiratory Care Center: A Retrospective Analysis☆

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S U M M A R Y

Background: This study was conducted to examine the hypothesis that a tracheostomy prior to admission to a respiratory care center (RCC) with a specialized weaning setting would improve the outcome of patients transferred from intensive care unit previously maintained on prolonged mechanical ventilation.
Methods: A retrospective review of medical records from intubated adult patients admitted to the Chi-Mei Medical Center, a 16-bed RCC in Southern Taiwan from January 1, 2001 through July 31, 2012, was performed. The outcomes at weaning (without ventilator support within 120 hours), mortality, and expenditure at hospital discharge were compared between the tracheostomy group ($n = 1216$) and the endotracheal tube group ($n = 1187$), and the predictors of weaning in all patients were determined.
Results: The overall weaning rate and the in-hospital mortality rate were 68.2% and 16.4%, respectively. The tracheostomy group showed significantly higher weaning rate and shorter hospital stay (73.5% vs. 62.8% and 57.4 vs. 61.0 days, both $p < 0.01$) compared with the endotracheal tube group. In-hospital mortality, total ventilator days, and cost of hospitalization were comparable between groups. Factors predictive of successful weaning were surgical origin [odds ratio (OR) 2.165], higher albumin (OR 1.937), tracheostomy group (OR 1.543), higher PaO_2/fraction of inspired oxygen (OR 1.345), and lower blood urea nitrogen (OR 0.984).
Conclusion: Tracheostomy creation prior to RCC admission was associated with a significantly higher weaning rate and reduced hospital stays. The provision of assessment of the aforementioned markers may be helpful in the clinical setting to facilitate the optimal management and the accreditation of medical care quality of patients with prolonged mechanical ventilation.

1. Introduction

Mechanical ventilation (MV) offers essential support in the care of critically ill patients during recovery from acute respiratory failure, but prolonged mechanical ventilation (PMV) leading to multiorgan dysfunction is frequently a consequence. The continuous receipt of artificial respiratory support ≥21 days is defined as PMV[1], patients generally suffer from a “chronic critical illness” with significant impairments to metabolism and neuroendocrine and immunologic functions, and they often become ventilator-dependent[2,3]. Up to 40% of patients' total time on MV is spent weaning off the ventilator[4]. The weaning rate may be as high as 90% in selected patients with planned extubation[5]. In Taiwan, the National Health Insurance Bureau (NHIB) designed the respiratory care center (RCC) to help manage PMV patients with attempted weaning and who have been ventilator-dependent for ≥21 days; it also acts as a downstream unit of the intensive care unit (ICU).

Tracheostomies have been used in an effort to shorten the time spent on MV if intubation time is anticipated to last more than

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several weeks[6]. A tracheostomy is performed in approximately 24% of patients in hospital ICUs[7]. The benefits of tracheostomy over translaryngeal intubation includes improved patient comfort, better oral hygiene, less dental damage and tracheal injury, easier and safer nursing care, and lower airway resistance, which may facilitate the weaning process and avoid ventilator-associated pneumonia[8]. However, infrequent complications such as stomal infection, hemorrhage, pneumomediastinum, tracheostenosis, and death may occur[9,10]. Studies evaluating the association of tracheostomy with patient outcomes are conflicting[11–13]. Currently, there is no specific information regarding individual characteristics associated with improved outcomes with either early or late tracheostomy by the heterogeneity of the studies[14]. In the 1980s, a tracheostomy was considered "early" if it was performed prior to 21 days of translaryngeal intubation, and this decision could be made within 7–10 days according to the recent literature[15].

A recent study showed that the type of mechanical ventilation did not appear to be an important determinant of weaning success in an RCC setting[12]. Most studies have been conducted in the ICU. The aim of the present study was to test the hypothesis that a tracheostomy prior to RCC admission improved outcome as weaning and mortality rate at hospital discharge in PMV patients. The secondary endpoints included predictors of successful weaning and hospital mortality.

2. Materials and methods

2.1. Study design and patient selection

A retrospective review of the medical records of all adult patients on MV admitted to the RCC of Chi-Mei Medical Center in Taiwan from January 1, 2002 to July 31, 2012 was performed. This study was approved by the Institutional Review Board of the Chi-Mei Medical Center. The 16-bed RCC, accepting patients >17 years of age, was a part of a program intended for general ICU patients experiencing difficulty in MV weaning. Patients expected to be maintained on MV $\geq$ 3 weeks at the time of RCC admission, and all previous weaning attempts that had failed were included in this study. The patients matched the requirements of the NHIB system in Taiwan: hemodynamic stability, no vasoactive drug infusion prior to transfer, stable oxygen requirements, or the attending physician deemed it beneficial to transfer the patient to the RCC. The RCC staff provided 24-hour patient coverage, and included in-charge respiratory and critical care medicine physicians, fellows, respiratory therapists, clinical nurse specialists, clinical dietitians, and clinical pharmacists. The nurse/patient ratio in the RCC was 1:4, and the respiratory therapist/patient ratio was 1:8. Indications for tracheostomy were based on the clinical consensus of all the physicians. Indications for continued translaryngeal intubation included the expectation of possible extubation in the near future, refusal of tracheostomy by the patient or relative(s), and delayed tracheostomy at RCC. The patients receiving tracheostomy creation prior to RCC admission formed the tracheostomy group, and those who were ventilated with an endotracheal tube comprised the endotracheal group. Overall, 2443 patients were eligible.

Each patient was assessed daily for readiness for weaning via tracheostomy or endotracheal tube using the following criteria: hemodynamic stability and recovery from the precipitating illness; and respiratory criteria consisting of an arterial blood gas with pH > 7.30, PaO_2 > 60 mmHg, minute ventilation <15 L/min, fraction of inspired oxygen (FiO_2) < 60%, positive end-expiratory pressure $\leq$10 cmH_2O, $PaO_2/FiO_2 \geq 200$ mmHg, and rapid shallow breath indices <120 (under continuous positive airway pressure mode with positive end-expiratory pressure 5 cmH_2O for >1 min). Patients were evaluated with these criteria on a daily basis by respiratory therapists. The weaning process was described in a previous study[5]. If there was poor tolerance at any time, MV was reinstituted.

Successful weaning occurred if MV was not required for 120 consecutive hours. Patients were considered to be "ventilator dependent" (including nocturnal MV) if weaning efforts were discontinued after both the interdisciplinary team and the informed patient/family agreed that the efforts should cease.

2.2. Measurements

The following data were collected at RCC admission: (1) demographic and clinical variables, including age, sex, diagnosis of admission (Appendix 1), hemodialysis or not, ventilator duration, and ICU type; (2) severity of patient's condition calculated as Acute Physiology and Chronic Health Evaluation II (APACHE II) score and Glasgow Coma Score; (3) laboratory data, such as blood, biochemistry, and blood gas data; (4) outcomes, including weaning success (without ventilator support $\geq$120 hours), tracheostomy at RCC discharge, RCC ventilator days and RCC stays, total hospital costs (expressed in US currency) and hospital mortality rate. Our primary endpoints were the comparisons of the outcome between the tracheostomy group and the endotracheal group, with a focus on weaning success and hospital mortality. Secondary endpoints were the predictors of successful weaning and hospital mortality.

2.3. Statistical analyses

Mean values, standard deviations, and group sizes were used to summarize the results for continuous variables. The differences between failed and successful weaning or hospital mortality were examined first using univariate analysis with a Student t test or a Chi-square test. A p value < 0.05 was considered statistically significant. Those significantly associated with failed extubation or hospital mortality in univariate analysis ($p < 0.05$) were tested for interaction with multiple logistic regression analysis. Odds ratios (OR) and 95% confidence intervals were calculated. All statistical analyses of the data were performed with SPSS 14.0 for Windows (SPSS, Inc., Chicago, IL, USA).

3. Results

A total of 2403 patients were admitted consecutively to the RCC during the study period. This included 1216 patients who received a tracheostomy (50.6%) and 1187 who received an endotracheal tube (49.4%) at RCC admission. The mean age of all patients was 69.5 years, and most of them were male (59.3%). The patients had a mean APACHE II and Glasgow Coma Score of 16.6 and 9.4, respectively. Surgical ICU origin was about 38%, and hemodialysis was required by 10.1% of patients. The most common cause was lung infection (42.7%), followed by neuromuscular disorder (31.2%), and heart disease (10.4%). The other data are shown in Table 1. The tracheostomy group was younger and had a longer duration of ICU ventilator use. The laboratory data are presented in Table 2; the tracheostomy group had a lower level of phosphate. The overall weaning and in-hospital mortality rates were 68.2% and 16.4%, respectively. The outcome is presented in Table 3; the tracheostomy group had a significantly higher rate of weaning and tracheostomies, shorter RCC ventilator days, RCC and total hospital stays as compared with the endotracheal group. However, in-hospital mortality, total ventilator days, and total cost were comparable between the two groups.

Table 1
Demographic and clinical variables by treatment group at RCC admission.

Items	All (n = 2403)	Tracheostomy group (n = 1216)	Endotracheal group (n = 1187)	p
Age	69.5 ± 14.3 (18−96)	68.1 ± 15.0	71.0 ± 13.3	<0.001
Age >65 y	1691 (69.2%)	799 (65.7%)	892 (75.1%)	<0.001
Male sex	1426 (59.3%)	744 (61.2%)	682 (57.5%)	0.063
APACHE II score	16.6 ± 6.2 (1−54)	16.8 ± 6.2	16.4 ± 6.2	0.161
Glasgow Coma Scale	9.4 ± 3.0 (3−15)	9.2 ± 3.0	9.4 ± 2.9	0.119
Surgical ICU origin	922 (37.9%)	477 (39.2%)	435 (36.6%)	0.240
Hemodialysis at RCC admission	242 (10.1%)	115 (9.5%)	127 (10.7)	0.272
RCC admission diagnosis				0.770
Chronic lung disease	68 (2.8%)	44 (3.6%)	24 (2.0%)	
Lung infection	1041 (43.3%)	537 (44.2%)	504 (42.5%)	
Heart disease	254 (10.6%)	123 (10.1%)	131 (11.1%)	
Neuromuscular disorder	762 (31.7%)	377 (31.0%)	385 (32.4%)	
Nonlung infection	170 (7.1%)	81 (6.7%)	89 (7.5%)	
Gastrointestinal disease	49 (2.0%)	22 (1.8%)	27 (2.3%)	
Others	59 (2.5%)	32 (2.6%)	27 (2.3%)	
ICU ventilator d	19.0 ± 9.6 (14−64)	20.4 ± 10.7	17.6 ± 8.2	<0.001

Values are expressed as mean ± SD (range) or n (%).
APACHE II = Acute Physiology and Chronic Health Evaluation II; BUN = blood urea nitrogen; ICU = intensive care unit; RCC = respiratory care center; SD = standard deviation.

Table 2
Laboratory data at RCC admission.

Items	All (n = 2403)	Tracheostomy group (n = 1216)	Endotracheal group (n = 1187)	p
PaO_2 (mmHg)	91.3 ± 27.0 (22−418)	91.6 ± 24.9	90.8 ± 28.7	0.521
FiO_2 (%)	28.6 ± 6.1 (21−100)	28.5 ± 5.4	28.6 ± 6.5	0.915
PaO_2/FiO_2 (mmHg)	328.0 ± 94.6 (46−649)	331.6 ± 93.7	325.1 ± 95.3	0.729
$PaCO_2$ (mmHg)	39.4 ± 7.8 (13.9−85.5)	39.3 ± 7.5	39.2 ± 7.8	0.940
Blood and biochemistry data				
Hb (g/dL)	10.0 ± 1.4 (5.3−15.4)	10.2 ± 1.4	9.7 ± 1.4	0.354
BUN (mg/dL)	38.6 ± 30.3 (3−201)	33.1 ± 26.7	49.1 ± 40.0	0.831
Cr (mg/dL)	1.5 ± 1.6 (0.3−11)	1.3 ± 1.4	1.9 ± 1.8	0.484
Albumin (g/dL)	2.7 ± 0.5 (1.0−4.0)	2.7 ± 0.5	2.7 ± 0.5	0.710
P (mg/dL)	3.5 ± 1.2 (0.4−15.0)	3.4 ± 1.1	3.6 ± 1.2	0.014

Values are expressed as mean ± SD (range) or n (%).
BUN = blood urea nitrogen; Cr = creatinine; FiO_2 = fraction of inspired oxygen; Hb = hemoglobulin; P = phosphate; PaO_2 = arterial oxygen tension; RCC = respiratory care center; SD = standard deviation.

Using multivariate analyses, the factors that predicted successful weaning were surgical ICU origin (OR 2.165), higher albumin (OR 1.937), tracheostomy group (OR 1.543), higher PaO_2/FiO_2 (OR 1.345), and lower blood urea nitrogen (BUN; OR 0.984). The predictors of hospital mortality were failed weaning (OR 3.650), higher APACHE II score (OR 1.027), higher BUN (OR 1.014), and lower albumin (OR 0.407) (Tables 4 and 5).

4. Discussion

We demonstrated that the RCC setting offers appropriately selected patients an improved rate of weaning success (68.2%) and in-hospital mortality (16.4%) from PMV. These results are comparable with those of other studies reported in Taiwan[12,16]. Because the NHIB established a policy of gradual care reduction for these patients, as demonstrated by their transfer from the ICU after 21 days to an RCC and then to a respiratory care ward (RCW) after 42 days in the RCC, the outcome of patients with PMV became favorable as compared with recent studies[17−19]. As for results from other countries, Rose and Fraser[17] reported moderate weaning success (53%) in a specialized PMV weaning center in Canada, which was similar to a report by Scheinhorn et al[18] in the United States (54.1%). In addition, Kojicic et al[19] and Scheinhorn et al[18] reported a higher in-hospital mortality (>25%) and longer MV days (>24 days) than

Table 3
Outcome of the different groups.

Items	All (n = 2403)	Tracheostomy group (n = 1216)	Endotracheal group (n = 1187)	p
Successful weaning[a]	1639 (68.2%)	894 (73.5%)	745 (62.8%)	<0.001
Tracheostomy at RCC discharge	1664 (69.2%)	1201 (98.8%)	463 (39.0%)	<0.001
In-hospital mortality	394 (16.4%)	196 (16.1%)	198 (16.7%)	0.897
RCC ventilator d	16.4 ± 10.5 (1−42)	15.2 ± 10.3	17.6 ± 10.6	<0.001
In-hospital ventilator d	35.4 ± 14.8 (21−161)	35.7 ± 15.7	35.3 ± 13.9	0.585
RCC stay (d)	20.1 ± 9.4 (1−42)	19.2 ± 9.3	21.2 ± 9.4	<0.001
Total hospital stay (d)	59.0 ± 32.9 (3−510)	57.4 ± 28.0	61.0 ± 37.4	<0.001
Cost of hospitalization (× 1000 US$)	22.6 ± 13.3 (3.1−249.5)	23.1 ± 13.2	22.2 ± 13.5	0.136

Expressed as mean ± SD (range) or n (%).
RCC = respiratory care center; SD = standard deviation.
[a] Presented as without ventilator support within 120 hours.

Table 4
Predictors for successful weaning using multivariate analyses.

Item	Odds ratio	95% CI	p
Surgical ICU origin	2.165	1.618–2.899	<0.001
Albumin (g/dL)	1.937	1.460–2.569	<0.001
Tracheostomy group	1.543	1.179–2.020	<0.001
PaO_2/FiO_2 (mmHg)	1.345	1.164–1.553	<0.001
BUN (mg/dL)	0.984	0.979–0.988	<0.001

BUN = blood urea nitrogen; CI = confidence interval; ICU = intensive care unit.

currently reported[18,19]. The admitted patients in the current study were elderly with comparable ages among each groups.

In spite of the advancements in specialized care from the weaning center, there was some variability in the administration and timing of tracheotomy on outcomes. In the present study, those who received a tracheotomy prior to RCC for PMV had improved outcomes as an increased rate of ventilator discontinuation, shorter RCC ventilator days, shorter RCC and total hospital stays, and a trend for reduced in-hospital mortality, as compared with the endotracheal group. The total ventilator days are not different owing to delayed transferral to the RCC on the tracheostomy group, maybe for the preparation for tracheostomy creation. Others showed that a tracheotomy did not lead to increased weaning success or in-hospital mortality, but reduced RCC stay in a specialized RCC in Tiawan[12]. The data from Frutos-Vivar et al[11] and Clec'h et al[13] also showed that tracheostomy does not reduce mortality when performed in unselected patients, and a longer stay did not affect these variables. In contrast, Combes et al[20] showed that a tracheostomy performed in patients with PMV was associated with reduced in-hospital mortality, but it was not associated with ventilator duration. However, a recent meta-analysis showed there was no specific information about any subgroup characteristics associated with improved outcomes with either early or late tracheostomy[14]. Other studies showed that early tracheotomy was associated with either a higher weaning success rate, a shorter stay, and/or lower mortality[21–23]. In the current study, which had relatively high criteria for inclusion, focused care administered by experienced providers with early tracheostomy creation prior to admission to a specialized weaning center may be more important for facilitating weaning success in patients with PMV.

Our study revealed many factors that predicted weaning success in patients with PMV, including surgical origin, higher albumin and $Pa{O_2}/Fi{O_2}$, tracheostomy group, and lower BUN. In addition, failed weaning, higher APACHE II score, higher BUN, and lower albumin also contributed to hospital mortality. These finding are supported by previously reported studies[5,12,16,21,24,25]. Higher serum albumin level has been demonstrated to be a proxy indicator of better nutrition status, and higher weaning success in PMV patients[12,24,25]. In general, the risk for weaning failure is greatest for medical patients, with the possible correlation of various comorbidities in these patients[5]. The current results demonstrated that after the surgery, patients had a greater chance to be weaned, although comorbidities were not recorded. Moreover, elevated BUN levels may be indicative of impaired renal function, the possibility of multiple comorbidities, metabolic dysfunction, and higher risk of subsequent chronic kidney disease development, all of which are consistent with weaning failure and poor outcomes in a post-ICU setting[12,16,25]. Furthermore, the APACHE II scoring system was originally designed to assess the severity of a disease/relative morbidity in ICU, hence providing a guide for treatment intervention and a predictor of weaning success[5,12,24]. Specifically, we found that patients with lower BUN levels (indicating adequate metabolic functioning), higher albumin concentrations (indicating adequate nutritional status), and lower APACHE II scores (indicating the severity of disease) were significantly more likely to be successfully weaned from mechanical ventilation and survive, as reported in the literature[12]. On confirmation of these findings, the provision of assessment of the aforementioned markers may be helpful to facilitate the optimal management of PMV patients. In addition, lower $Pa{O_2}/Fi{O_2}$ ratio, indicative of the severity of respiratory failure, were noted in the failure-to-wean group[21]. A similar finding in the current study was that higher $Pa{O_2}/Fi{O_2}$ correlated with weaning success. Furthermore, it has been reported in the literature that a higher mortality rate ensued after failure of ventilator liberation, which is consistent with the current results[5,21]. This may be attributed to complications from reintubation, clinical deterioration between the time of extubation and reintubation, or the adverse effects of PMV.

There are several important limitations in this study. First, this was a retrospective review of all patients transferred to a single unit over a 10-year period, and some data were missing, such as associated comorbidities and weaning parameters prior to weaning. Second, data were collected upon RCC admission in a patient population at risk for complications and with significant comorbidity—trending of variables might better identify factors associated with successful weaning or in-hospital mortality. Third, we did not perform a cost-effectiveness evaluation of outcomes of patients after discharge, thus limiting the comparability of our results with previous findings. Long-term outcomes, such as 1-year survival, may be more meaningful and helpful in providing patients and families with realistic expectations. Furthermore, we did not assess the patients who were reintubated after a successful weaning in both groups, although the percentage was not high and they may be readmitted to the ICU for further intensive care. Finally, there are no data on drugs used by the cohort, although such drugs may influence the outcome and could be one of the confounding factors.

Table 5
Predictors for hospital mortality using multivariate analyses.

Item	Odds ratio	95% CI	p
Failed weaning	3.650	2.703–4.926	<0.001
APACHE II scores	1.027	1.002–1.053	0.037
BUN (mg/dL)	1.014	1.009–1.019	<0.001
Albumin (g/dL)	0.407	0.297–0.558	<0.001

APACHE II = Acute Physiology and Chronic Health Evaluation II; BUN = blood urea nitrogen; CI = confidence interval.

5. Conclusion

In summary, within a specialized weaning center with focused care by experienced providers, those who received a tracheostomy prior to RCC admission had a significantly higher weaning rate, but had similar in-hospital mortality, total ventilator days, and hospital cost compared with those who received an endotracheal tube, although these two groups exhibited several differences at baseline. After multivariate analyses, the factors that predicted weaning success included surgical origin, higher albumin and $Pa{O_2}/Fi{O_2}$, tracheostomy group, and lower BUN. Failed weaning, higher APACHE II score, higher BUN level, and lower albumin contributed to hospital mortality. Based on these findings, it may be better to consider tracheostomy creation prior to RCC admission, and the provision of assessment of the aforementioned markers may be helpful in the optimal management and the accreditation of medical care quality of PMV patients.

Appendix 1. Respiratory care center (RCC) admission diagnosis.

Chronic lung disease	Chronic obstructive pulmonary disease, restrictive lung disease, acute respiratory distress syndrome in fibroproliferative phase
Lung infection	Pneumonia, aspiration pneumonitis, lung abscess, empyema
Heart disease	Congestive heart failure, primary cardiomyopathy, acute myocardial infarction
Neuromuscular disorder	Status epilepticus, cerebral vascular accident, intracranial hemorrhage, convulsion/seizure disorder
Nonlung infection	Urinary tract infection, intra-abdominal infection, blood stream infection, meningoencephalitis, pericarditis, bacterial endocarditis
Gastrointestinal disease	Upper/lower gastrointestinal bleeding, liver failure
Others	Drug overdose, diabetic ketoacidosis, blood transfusion reaction, upper airway obstruction

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