The impact of tracheostomy timing in patients with severe head injury: An observational cohort study

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A B S T R A C T

Keywords: Head injury Intensive care unit Mechanical ventilation Pneumonia Tracheostomy

Study design: A retrospective analysis of 66 adults with severe head injury admitted to the neurosurgical intensive care unit (ICU) who required tracheostomy.

Objective: The purpose of this cohort study was to examine the impact of the tracheostomy timing in patients with severe head injury.

Methods: Patients were included in this study if they were admitted to the neurosurgical ICU because of severe head injury and if tracheostomy was performed. The patients were classified into 2 groups: early tracheostomy (ET) and late tracheostomy (LT). The timing of tracheostomy was considered early if it was performed by day 10 of mechanical ventilation and late if it was performed after day 10. We compared the duration of mechanical ventilation, length of stay (LOS) at ICU, hospital LOS, incidence of pneumonia, duration of antibiotics use, and mortality between the ET and LT groups.

Results: Of the 2481 patients with severe head injury admitted to the neurosurgical ICU, 66 (2.7%) required tracheostomy; 16 of whom were in the ET group and 50 were in the LT group. The ICU LOS was significantly shorter in the ET group (p < 0.001). The incidence of nosocomial pneumonia was lower in the ET group (p = 0.04) and the duration of antibiotic use was significantly shorter in the ET group (p < 0.001). The patients in the ET group had a lower incidence of pneumonia caused by gram-negative microorganisms (p = 0.001).

Conclusions: ET in patients with severe head injury might contribute to a shorter duration of ICU LOS, lower incidence of gram-negative microorganism-related nosocomial pneumonia, and shorter duration of antibiotic use.

Introduction

Tracheostomy is a commonly performed in intensive care unit (ICU) patients. Between 2% and 11% of ICU patients requiring mechanical ventilation undergo tracheostomy during hospitalization. Tracheostomy has the following advantages over prolonged translaryngeal intubation: improved patient comfort, more effective airway suctioning, decreased airway resistance, enhanced patient mobility, increased opportunities for articularated speech, ability to eat orally, and a more secure airway. The earlier reports show high tracheal stenosis rates with tracheostomy as compared with endotracheal intubation. Recently, the incidence of tracheal stenosis has decreased substantially with increasing knowledge of its aetiology and improvements in tracheostomy materials, design, and management. Further, the complications associated with prolonged endotracheal intubation include injury to the larynx and trachea, resulting in increased patient discomfort. Finally, the incidence of ventilator-associated pneumonia is directly related to the duration of mechanical ventilation. This complication may carry on a significant morbidity and mortality.

The optimal timing of tracheostomy in critically ill patients with acute respiratory failure is controversial. In 1989, the American College of Chest Physicians consensus statement on artificial airways in patients receiving mechanical ventilation considered translaryngeal intubation to be the preferred technique for patients requiring mechanical ventilation for up to 10 days. For those with anticipated need for an artificial airway for more than 21 days, tracheostomy was recommended. For all other patients, the decision regarding the timing of tracheostomy was left to the daily assessment and the physician’s preference. The decision to
proceed to tracheostomy is often only made if the patient could not be extubated within 10–14 days or more.\textsuperscript{9} Guidelines created jointly by the American association for respiratory care, the American College of Chest Physicians, and the American College of Critical Care Medicine make no specific recommendations for the timing of tracheostomy, but suggest that the procedure should be considered if the patient will require prolonged ventilatory assistance.\textsuperscript{4}

The best timing for tracheostomy continues to be debated; yet, it is agreed by most intensivists that if tracheostomy is needed, early performance of this procedure is likely to benefit the patient. However, the optimal timing of tracheostomy for patients with severe head injury still remains controversial. Therefore, we investigated the impact of the timing of tracheostomy on ICU LOS, hospital LOS, duration of weaning from mechanical ventilation, ventilation days, and incidence of nosocomial pneumonia, antibiotics use, and mortality in patients with severe head injury admitted to the neurosurgical ICU.

Materials and methods

Study setting

The cohort study was performed at a major tertiary trauma centre in Kaohsiung, Taiwan. We performed a retrospective review of adult patients consecutively admitted to the neurosurgical ICU in our hospital from July 2005 to June 2008. All patients were included in this study because of severe head injury (Glasgow Coma Scale (GCS) ≤ 8). The 1100-bed hospital has a 16-bed neurosurgical ICU staffed by full-time, on-site neurosurgeons 24 h a day and 7 days a week. The hospital has a designated trauma service, including consultant surgeons, available 24 h a day. There are 7 neurosurgeons in the department; all of them are certified in neurosurgical critical care. Medical care in the neurosurgical ICU is provided by neurosurgeons. Ventilator management and decisions regarding extubation or tracheotomy and discharge from the neurosurgical ICU are made during the morning rounds by one of the study investigators. All tracheostomies are performed in the operation room by neurosurgeons.

Data collection

We have maintained a prospective database of all consecutive ICU patients. For the present study, we extracted data of all consecutive patients admitted to the neurosurgical ICU over a 3-year period (July 2005–June 2008) with new trauma and who underwent tracheostomy during their ICU stay. Over a period of 3 years, all adult patients admitted to the neurosurgical ICU of our hospital because of severe head injury (GCS ≤ 8) were considered for inclusion in the study. Exclusion criteria included: age younger than 18 years, presence of tracheostomy, anticipated neurological or medical complications (such as development of cerebral oedema, pneumothorax, haemothorax, or severe chest contusion), and intubation for airway preservation due to airway oedema (cervical neck injuries or surgery). Enrollment data included routine laboratory and respiratory profiles obtained from mechanically ventilated patients in the neurosurgical ICU. The following data were recorded: age, sex, GCS, APACHE-2, Injury Severity Score (ISS), Abbreviated Injury Scale (AIS) on admission, mechanism of injury, days from admission to tracheostomy, days from initiation of ventilation to tracheostomy, days from tracheostomy to weaning from the ventilator, duration of mechanical ventilation, ICU LOS, hospital LOS, and 1-month and 1-year mortality rate. We also recorded the occurrence of pneumonia on the basis of findings of increased body temperature, leukocytosis, and infiltration on the chest X-ray before tracheotomy. The microorganisms from sputum cultures and the total days of antibiotic administration were also documented.

In our neurosurgical ICU, all patients were evaluated for possible extubation every 12 h during the morning and evening rounds. Patients were routinely extubated if their weaning profile met the standard criteria and the GCS improved to more than 8 for at least 12 h. If the results of the patient’s neurological examination did not improve, a trial of extubation was performed at the discretion of the attending physician to avoid the mandate of tracheostomy placement. Extubation was considered successful if there was no reintubation within 48 h. If extubation failed, tracheostomy was performed.

A diagnosis of pneumonia was considered when new and persistent (>48 h) pulmonary infiltrates which could not be otherwise explained appeared on the chest radiographs. Moreover, at least 2 of the following criteria were also required: (1) temperature higher than 38 °C; (2) leukocytosis ≥ 12,000/mm\(^3\) or leukocyte recount ≤ 4000/mm\(^3\), and (3) purulent respiratory secretions.\textsuperscript{10} The bacteriologic diagnosis of pneumonia involves sampling the lower airways to obtain quantitative cultures. The typical threshold for diagnosis of pneumonia is growth of more than 10\(^6\) colony forming units per millilitre (cfu/mL). Pneumonia was considered nosocomial when its onset occurred 48 h after admission to the ICU.\textsuperscript{7}

We classified the patients into 2 groups: the early tracheostomy (ET) group, in which tracheostomy was performed within the first 10 days of initiation of mechanical ventilation, and the late tracheostomy (LT) group, in which tracheostomy was performed after 10 days.

Statistical analysis

Continuous data are expressed as mean ± standard deviation (SD) and ranges and categorical data are presented as frequency and percentage. Between-group comparisons were performed using the Mann–Whitney U-test for continuous variables, and Chi-square analysis with Yates’ correction for continuity or Fisher’s exact test (2-sided) for categorical variables. The binary data was applied Chi-square test with Yates’s correction for continuity when the expected values are no less than 5 in each cell. On the other hand, the binary data was applied Fisher’s exact test when the expected values are less than 5 or zero value appeared in any cell. p < 0.05 was considered statistically significant. All statistical tests and analyses were carried out on SPSS for Windows (SPSS 12.0, SPSS Inc., Chicago, IL).

Results

From July 2005 to June 2008, 2481 patients related to severe head injury were admitted to our neurosurgical ICU. Sixty-six patients (2.7%) met the inclusion criteria. The patients were classified into 2 groups according to the timing of tracheostomy: 16 patients underwent tracheostomy within 10 days of mechanical ventilation and the remaining 50 patients underwent tracheostomy after 10 days. Table 1 summarizes the patients’ characteristics based on the timing of tracheostomy. Comparison of the demographic data between the 2 groups revealed no significant difference with regard to age, gender, GCS, APACHE-2, ISS, AIS on admission, mechanism of injury, and days from tracheostomy to weaning from the ventilator.

Table 2 summarizes the patients’ outcome in both groups. There was no difference in hospital LOS, 1-month mortality, and 1-year mortality between the 2 groups. Comparing the ET and LT groups, ET was associated with shorter ICU LOS (p < 0.001). The incidence of nosocomial pneumonia was lower (p = 0.04) and the total number of days of antibiotics use was smaller (p < 0.001) in the ET group.
**Table 1**
The patients’ characteristics based on timing of tracheostomy.

<table>
<thead>
<tr>
<th></th>
<th>Early tracheostomy (n = 16)</th>
<th>Late tracheostomy (n = 50)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years old)</td>
<td>55.3 ± 16.9 (19–80)</td>
<td>57.5 ± 18.6 (18–85)</td>
<td>0.49a</td>
</tr>
<tr>
<td>Male/female</td>
<td>14/2</td>
<td>33/17</td>
<td>0.12b</td>
</tr>
<tr>
<td>Admission GCS score</td>
<td>5.9 ± 2.7 (3–8)</td>
<td>5.7 ± 2.4 (3–8)</td>
<td>0.66a</td>
</tr>
<tr>
<td>Admission</td>
<td>20.9 ± 4.0 (16–26)</td>
<td>21.0 ± 4.4 (14–30)</td>
<td>0.95a</td>
</tr>
<tr>
<td>APACHE-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission ISS</td>
<td>21.1 ± 14.0 (16–49)</td>
<td>24.9 ± 8.7 (16–45)</td>
<td>0.45a</td>
</tr>
<tr>
<td>Admission AIS</td>
<td>4.7 ± 0.5 (4–5)</td>
<td>4.9 ± 0.4 (4–5)</td>
<td>0.26a</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic accident</td>
<td>11 (62.5%)</td>
<td>35 (70%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Falling accident</td>
<td>5 (37.5%)</td>
<td>15 (30%)</td>
<td></td>
</tr>
<tr>
<td>From admission to tracheostomy (days)</td>
<td>8.8 ± 1.1 (7–10)</td>
<td>18.1 ± 6.6 (11–44)</td>
<td></td>
</tr>
<tr>
<td>From initiation of ventilation to tracheostomy (days)</td>
<td>8.6 ± 1.1 (7–10)</td>
<td>17.7 ± 6.1 (11–44)</td>
<td></td>
</tr>
<tr>
<td>From tracheostomy to weaning off (days)</td>
<td>5.1 ± 6.8 (1–26)</td>
<td>5.9 ± 10.6 (1–49)</td>
<td></td>
</tr>
<tr>
<td>Duration of mechanical ventilation (days)</td>
<td>13.7 ± 7.3 (9–36)</td>
<td>23.4 ± 11.0 (13–52)</td>
<td></td>
</tr>
</tbody>
</table>

Continuous data were presented as mean ± SD (range). Categorical data were presented as frequency (percentage).

* Fisher’s exact test (2-sided).

**Discussion**

Tracheostomy is a common procedure performed in critically ill ventilator-dependent patients to provide long-term airway access.

**Table 3**
Isolated microorganisms of pneumonia in the ET and LT group.

<table>
<thead>
<tr>
<th>Isolated pathogens</th>
<th>Early tracheostomy (n = 16)</th>
<th>Late tracheostomy (n = 50)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram-positive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microorganisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>3</td>
<td>7</td>
<td>0.70a</td>
</tr>
<tr>
<td>Gram-negative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microorganisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>0</td>
<td>18</td>
<td>0.001a</td>
</tr>
<tr>
<td>Acinetobacter baumannii</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Stenotrophomonas maltophilia</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Haemophilus somnus</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

* Fisher’s exact test (2-sided).
as late as 14 days. Scales et al. conducted a study with the largest number of patients (10,927 patients) for the evaluation of tracheostomy timing. They defined ET as within 10 days of ventilation and LT as after more than 10 days. In head injury patients (GCS score \( \leq 8 \)), a high mortality rate was noted within the first week of admission. After one week of observation and if the patient has the opportunity to survive, tracheostomy would be considered for those who possibly require long-term ventilation. We defined ET as tracheostomy performed within 10 days since ventilation and LT as tracheostomy performed after more than 10 days. It is a reasonable assumption that if patients with severe head injury had survived, tracheostomy would have been required for patients who need long-term ventilation. Tracheostomy would not be required for patients who have a critical condition and are at high risk of mortality. ET could be seen as an unnecessary procedure in patients who will make a good neurological recovery and can be easily weaned from the ventilator after proper management.

The type of ICU may also have an effect on the timing of tracheostomy. A study by Scales et al. revealed that patients receiving ET were more likely to have a trauma or neurological diagnosis. They concluded that the decision to perform tracheostomy should be made after considering various factors, including the patients’ characteristics, ICU diagnosis, severity of illness, morbidities, response to treatment, overall hospital course, and the physician’s judgment. In specific patients groups (for example, head-injured patients), some benefits including decreased duration of mechanical ventilation, shorter ICU LOS, shorter hospital LOS, and lower mortality were associated with ET. In some retrospective cohort studies, no substantial benefits were noted in the ET group. Those studies could not provide sufficient evidence to support the hypothesis that the timing of tracheostomy alters the duration of mechanical ventilation, ICU LOS, hospital LOS, and the incidence of VAP.

There are only few reports that focus on the timing of tracheostomy for patients with severe head injury. A study by Chintamani et al. showed that ET (\( \leq 4 \) days) was beneficial in patients with isolated closed-head injury. It could decrease the mortality rate and intubation-associated complications. But they did not have enough ICU beds for critical care and used ET as a transient stage to decrease prolonged mechanical ventilation. In a study by Bouderka et al., ET (\( \leq 5 \) days) could decrease the duration of mechanical ventilation in patients with head injury. They focused on ET versus prolonged endotracheal intubation. D’Amelio et al. retrospectively reviewed 31 patients with head injury. They found that the duration of mechanical ventilation, ICU LOS, and hospital LOS were decreased in the ET group.

In our study, we found that ET for patients with severe head injury was associated with a significant reduction in the total number of days from admission to tracheostomy, from initiation of ventilation to tracheostomy, total duration of mechanical ventilation, and ICU LOS. The intervals from tracheostomy to weaning from mechanical ventilation in both groups were very similar (ET vs. LT: 5.1 ± 6.8 days vs. 5.9 ± 10.6 days). It seems that tracheostomy has been an important factor in weaning from the ventilator. The duration from initiation of ventilation to tracheostomy in the ET group was 8.6 ± 1.1 days and 17.7 ± 6.1 days in the LT group. There was a difference of 9 days between the ET and LT group. Interestingly, a difference of 8–10 days was also noted in the comparisons of duration of ventilation (13.7 ± 7.3 days vs. 23.4 ± 11.0 days), ICU LOS (14.9 ± 8.9 days vs. 22.1 ± 7.6 days), and hospital LOS (38 ± 21.4 days vs. 46.8 ± 22 days) between the groups. It seems that the hospital course after tracheostomy was similar in both groups. ET may allow for faster weaning from the ventilator, better resource utilisation, earlier mobilization, and downgrading in the patient care unit.

Our results revealed that ET can reduce the incidence of nosocomial pneumonia and antibiotics use for pneumonia. Several studies confirm these findings. Importantly, in our study, different types of pathogens were isolated in both groups (Table 3). The LT group presents a greater problem in both the prediction of and empiric treatment of likely pathogens. As many as 48% of these patients present with potentially multidrug-resistant pathogens, including *P. aeruginosa*, and *Acinetobacter baumannii*. These two pathogens typically occur in patients presenting with risk factors such as chronic obstructive pulmonary disease, prolonged duration of mechanical ventilation, and prior antibiotic therapy. It is also the most common antibiotics-resistant pathogen causing VAP and the most common cause of fatal episodes of VAP. Therefore, in our study, ET had some benefits in decreasing pneumonia related to gram-negative pathogens (Table 3). The most common pathogen isolated in the ET group was *S. aureus* that could be treated easily. The information of the common pathogens isolated in the ET and LT group may be useful for the physicians to choose the antibiotics for pneumonia treatment before culture identified.

The strength of our study is that the data were extracted from a closed system (neurosurgical ICU). In addition, the number of patients in the present study is the largest compared to other studies that focused on the impact of tracheostomy timing in patients with severe head injury. The causes of most patients’ mortality were related to severe head injuries. If patients can survive for more than 1 week, most of them could be discharged from the hospital. The information from our study provides not only respiratory profiles, patients’ characteristics, and resource utilisation but also micro-organisms of pneumonia and duration of antibiotics use between the ET and LT group. The information from our study would be very useful for the families and physicians to make the decision for tracheostomy for patients with severe head injury.

There are some limitations in our study. In the observational cohort study, data extraction and analysis were done retrospectively. Because the database was not designed specifically to examine tracheostomy timing, certain issues were not documented, e.g., smoking, alcohol consumption, the family’s decision-making and the physician’s judgement and preference in the 2 groups. Comparison of the severity of trauma between the 2 groups revealed no significant difference with regard to GCS, APACHE-2, ISS, AIS on admission, and mechanism of injury. Although both groups have the similar severity of trauma at admission, some LT patients may have more secondary brain injury, or unstable condition at 7–10 days leading to late tracheostomy. According to the charts, delay to perform tracheostomy because of the family’s decision-making might be an issue in our study. In Taiwan, many patients’ families concern that tracheostomy makes difficulty in speaking and swallowing in the future, and means permanent vegetative status. However, delay to perform tracheostomy because of the family’s decision-making was not considered in this study. In addition, the study was conducted in a single hospital. A large, multicenter, randomized, controlled trial in which patients are randomized to either ET or LT would be the ideal way to test the effect of tracheostomy timing.

**Conclusions**

In summary, patients with severe head injury might benefit from ET with reduced ICU LOS, incidence of pneumonia, gram-negative pathogens-related pneumonia, and duration of antibiotics use. We think that our results could assist clinicians in their decision-making with respect to the optimal timing for tracheostomy in patients with severe head injury.

**Conflict of interest**

The authors declare no conflict of interest exists.
Acknowledgment

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References