The Effectiveness of Early Tracheostomy (within at least 10 Days) in Cervical Spinal Cord Injury Patients

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Objective: This study aimed to determine the optimal time for tracheostomy by evaluating the benefits and safety of early versus late tracheostomy in spinal cord injury (SCI) patients.

Methods: We retrospectively reviewed a total of 254 patients with spinal cord injury. Of them, we selected 21 spinal cord injury patients who required tracheostomy due to long-term mechanical ventilation and analyzed their medical records. The patients were categorized into two groups. Early tracheostomy was performed day 1-10 from intubation in 10 patients and the late tracheostomy was performed after day 10 in 11 cases. We also evaluated the duration of mechanical ventilation, stay in the ICU and complications related to tracheostomy, the injury level of and clinical severity. All data was analyzed using SPSS 18.0/WIN.

Results: The early tracheostomy offered clear advantages for shortening the total ICU stay (20.8 day vs. 38.0 day, \( p = 0.010 \)). There was also statistically significant reduction in the total length of time on mechanical ventilation (5.2 day vs. 29.2 day, \( p = 0.009 \)). However, the reductions in the incidence of pneumonia (40% vs. 82%) and the length of ICU stay post to tracheostomy (6 day vs. 15 day) were found to be statistically not significant. There were also no statistically significant differences in the injury level and clinical severity between the groups.

Conclusion: We concluded that the early tracheostomy (at least 10 days) is beneficial for SCI patients who are likely to require prolonged mechanical ventilation.

Key Words: Tracheostomy · Spinal cord injury.

INTRODUCTION

Traumatic cervical spinal injury is a common cause of severe disability. It is reported that about 11000 patients are admitted to hospitals due to cervical spinal injury annually\(^{15}\) and around 75% of them require intubation and mechanical ventilation due to respiratory problems\(^{21}\). Tracheostomy is required in 11-35% of patients with cervical spinal cord injury to maintain airway and to manage pulmonary complications and pulmonary hygiene\(^{2,15}\) and in 10% of ICU patients for long-term mechanical ventilation (longer than 24 hours)\(^{16}\). Patients with cervical spinal cord injury tend to require mechanical ventilation more often and for a longer period of time to manage frequently occurred respiratory problems and to effectively provide oxygen. This tendency is more prominent in patients with the upper spinal cord injury or severe spinal cord injury. The American Consensus Conference on Artificial Airways states that tracheostomy is preferred if mechanical ventilation is required longer than 21 days\(^{16}\). Tracheostomy has some advantages over endotracheal or nasotracheal intubation. It improves pulmonary toilet and reduces the length of the breathing pathway and airway resistance. Consequently, it reduces effort to breath and weaning of mechanical ventilation becomes easier and less problematic, reducing the length of time on mechanical ventilation. However, the optimal time to perform tracheotomy remains controversial\(^{11}\). This study aimed to determine the optimal timing of tracheostomy and to evaluate the subsequent beneficial effects by comparing early tracheostomy (1-10 days) and late tracheostomy (>10 days) in patients with spinal cord injury.

MATERIALS AND METHODS

This is a retrospective study conducted at neurosurgery department between August, 2003 and March, 2012. Among a to-
tal of 254 patients with spinal cord injury, 21 patients who required tracheostomy and mechanical ventilation were selected. Their medical records and imaging studies were retrospectively analyzed. Patients with traumatic cervical spinal cord injury were only included in this study and patients with degenerative spinal disease, spinal tumors, inflammatory disease such as myelitis were excluded from this study. Spinal surgery was performed if required and the subjects were classified into two groups according the timing of tracheostomy. In most previous studies, early tracheostomy was defined as performed within 7 days and late tracheostomy as any time after the first week. In this study, we defined early tracheostomy as performed within 10 days and late tracheostomy as more than 10 days. Tracheostomy was performed according to the standard surgical technique. There were 10 patients in the early tracheostomy group and 11 patients in the late tracheostomy group. The severity of spinal cord injury was determined according to the classification of American Spinal Injury Association (ASIA). The location of the injury, the total period of ICU stay, the length of time on mechanical ventilation, the period of ICU stay after tracheostomy, the period of hospital stay and tracheostomy complications of each group were compared to analyze the advantages and disadvantages of early tracheostomy and late tracheostomy (Table 1). Variables are expressed as the mean±SD. Data was analyzed using Fisher's exact, Mann-Whitney U-test and binary logistic regression analysis. Significance was determined when p value was less than 0.05. The statistical package SPSS, version 18.0 for Windows (SPSS Inc., Chicago, IL, USA), was used for the analysis.

RESULTS

There were 10 patients in the early tracheostomy group and 11 patients in the late tracheostomy group. Early tracheostomy was performed after 6.7±3.97 days and late tracheostomy was performed after 24±5.66 days. The mean age of the subjects was 50 years (18-88 years). There were 19 male and 2 female patients and the majority of them were between 40 years and 70 years old. There was no statistically significant difference in the demographic characteristics between the groups (p=0.328). The injury occurred at the cervical 1-2nd level in a patient, cervical 3-5th level in 16 patients and cervical 6-7th level in 4 patients. The severity of the injury was determined according to ASIA classification; 8 patients were grade A; 3 patients were grade B; 9 patients were grade C; 1 patient was grade D. There were no statistically significant differences in the location and the severity of the injury between the groups (p=0.781, 0.301) (Table 2). Among dependent variables, the total ICU stay was significantly reduced in the early tracheostomy group comparing with the late tracheostomy group and the reduction was statistically significant (20.8 day vs. 38.0 day, p=0.010). The total length of time on mechanical ventilation was also significantly reduced in the early tracheostomy group comparing with the late tracheostomy group and the reduction was statistically significant (5.2 day

Table 1. Patients data

| Case | Sex | Age | Tracheostomy timing (day) | Hospital duration (day) | Post tracheostomy ICU stay (day) | Pneumonia (post tracheostomy) | Ventilator duration (day) | Severe complication | ICU stay (day) | Level | Grade |
|------|-----|-----|---------------------------|-------------------------|----------------------------------|-----------------------------|---------------------------|---------------------|----------------|--------|-------|
| 1    | M   | 56  | 2                         | 62                      | 5                                | +                           | 3                         | 0                   | 30               | C6.7   | A     |
| 2    | F   | 54  | 10                        | 79                      | 6                                | 0                           | 0                         | 0                   | 18               | C6.7   | B     |
| 3    | M   | 43  | 10                        | 93                      | 4                                | 14                          | 0                         | 19                  | 3               | C3.4.5 | A     |
| 4    | M   | 66  | 1                         | 94                      | 4                                | +                           | 6                         | 0                   | 13               | C3.4.5 | C     |
| 5    | M   | 32  | 10                        | 76                      | 8                                | 0                           | 4                         | 0                   | 20               | C3.4.5 | B     |
| 6    | M   | 59  | 6                         | 83                      | 14                               | +                           | 0                         | 0                   | 28               | C1.2   | C     |
| 7    | M   | 61  | 1                         | 126                     | 5                                | 0                           | 0                         | 0                   | 23               | C3.4.5 | C     |
| 8    | M   | 68  | 7                         | 90                      | 12                               | +                           | 6                         | 0                   | 26               | C3.4.5 | C     |
| 9    | M   | 33  | 10                        | 36                      | 1                                | 0                           | 19                        | 0                   | 19               | C3.4.5 | C     |
| 10   | M   | 72  | 10                        | 33                      | 1                                | 0                           | 18                        | 0                   | 12               | C3.4.5 | C     |
| 11   | M   | 19  | 18                        | 42                      | 2                                | +                           | 20                        | 0                   | 20               | C3.4.5 | C     |
| 12   | M   | 29  | 30                        | 70                      | 0                                | +                           | 14                        | +                   | 20               | C3.4.5 | A     |
| 13   | M   | 51  | 31                        | 84                      | 8                                | 0                           | 35                        | 0                   | 38               | C3.4.5 | B     |
| 14   | M   | 71  | 27                        | 49                      | 22                               | +                           | 49                        | 0                   | 49               | C3.4.5 | D     |
| 15   | M   | 43  | 32                        | 82                      | 44                               | +                           | 76                        | 0                   | 76               | C3.4.5 | C     |
| 16   | M   | 50  | 21                        | 69                      | 13                               | +                           | 27                        | 0                   | 34               | C3.4.5 | A     |
| 17   | M   | 59  | 16                        | 48                      | 11                               | +                           | 47                        | 0                   | 47               | C3.4.5 | A     |
| 18   | M   | 22  | 19                        | 60                      | 3                                | 0                           | 15                        | 0                   | 22               | C3.4.5 | A     |
| 19   | M   | 47  | 20                        | 67                      | 3                                | +                           | 26                        | 0                   | 25               | C3.4.5 | A     |
| 20   | F   | 48  | 24                        | 55                      | 2                                | +                           | 30                        | 0                   | 26               | C6.7   | A     |
| 21   | M   | 63  | 20                        | 237                     | 60                               | +                           | 38                        | 0                   | 61               | C6.7   | C     |
Anterior approach spine surgery performed when surgery was required. There was no infection related to cervical spinal surgery and tracheostomy in both groups.

DISCUSSION
Endotracheal or nasotracheal intubation is often performed when patients with cervical spinal cord injury present with respiratory problems. However, the optimal time to perform tracheostomy after intubation remains controversial. Previous studies, both animal experiments and clinical trials, reported that prolonged endotracheal intubation (longer than 7 days) resulted in severe laryngeal trauma and repeatedly injured posterior endolarynx, inducing tracheal stenosis. vs. 29.2 day, p=0.009). This shows that there were correlation between early tracheostomy (within 10 days) and the length of time on mechanical ventilation and ICU stay [odds ratio (OR 1.134). The length of ICU stay after tracheostomy was shorter in the early tracheostomy group comparing with the late tracheostomy group (6 days vs. 15 days) but without statistical significance (p=0.597), and there was no statistically significant difference in the total length of hospital stay (p=0.291) (Table 3). With respect to post-tracheostomy complications, the incidence of pneumonia was 40% in the early tracheostomy group and 82% in the late tracheostomy group but the difference was statistically not significant (p=0.283) (Table 4). Tracheal stenosis was reported in a case of late tracheostomy but the difference between the group was statistically not significant (p=0.999) (Fig. 1). Anterior approach spine surgery performed when surgery was required. There was no infection related to cervical spinal surgery and tracheostomy in both groups.

Endotracheal or nasotracheal intubation is often performed when patients with cervical spinal cord injury present with respiratory problems. However, the optimal time to perform tracheostomy after intubation remains controversial. Previous studies, both animal experiments and clinical trials, reported that prolonged endotracheal intubation (longer than 7 days) resulted in severe laryngeal trauma. The long-term intubation repeatedly injured posterior endolarynx, inducing tracheal stenosis.

Table 2. General patients characteristics and homogeneity

| Characteristics          | Classification | Early (≤10 day) (M±SD 6.7±39.7) | Late (>11 day) (M±SD 24±5.66) | \(\chi^2\) | \(p\) |
|-------------------------|----------------|---------------------------------|--------------------------------|----------|------|
| Sex                     | M              | 9 (90)                          | 10 (91)                         | 0.005    | 1.000*|
|                         | F              | 1 (10)                          | 1 (9)                           |          |      |
| Age                     | -20            | 0 (0)                           | 1 (9.1)                         | 7.228    | 0.328*|
|                         | 21-30          | 0 (0)                           | 2 (18.2)                        |          |      |
|                         | 31-40          | 2 (20)                          | 0 (0)                           |          |      |
|                         | 41-50          | 1 (10)                          | 4 (36.4)                        |          |      |
|                         | 51-60          | 3 (30)                          | 2 (18.2)                        |          |      |
|                         | 61-70          | 3 (30)                          | 1 (9.1)                         |          |      |
|                         | 71+            | 1 (10)                          | 1 (9.1)                         |          |      |
| Level of spine lesion   | C1, 2          | 1 (10)                          | 0 (0)                           | 1.261    | 0.781*|
|                         | C3, 4, 5       | 7 (70)                          | 9 (81.8)                        |          |      |
|                         | C6, 7          | 2 (20)                          | 2 (18.2)                        |          |      |
| Clinical grade          | A              | 2 (20)                          | 6 (54.5)                        | 4.145    | 0.310*|
|                         | B              | 2 (20)                          | 1 (9.1)                         |          |      |
|                         | C              | 6 (60)                          | 3 (27.3)                        |          |      |
|                         | D              | 0 (0)                           | 1 (9.1)                         |          |      |

*Statistical significance test was done by Fisher’s Exact Test

Table 3. Comparison of dependent variables between early and late tracheostomy

| Group variable (days) | Early (n=10) M±SD | Late (n=11) M±SD | U   | \(p^*\) | OR (95% CI) | \(p^1\) |
|-----------------------|-------------------|------------------|-----|--------|-------------|--------|
| Total ICU stay        | 20.8±6.0          | 38±18.5          | 18.5| 0.010* | 1.176 (0.994-1.392) | 0.058  |
| Total duration of ventilator care | 5.2±6.5 | 29.2±22.9 | 18.5 | 0.009* | 1.134 (1.011-1.272) | 0.032  |
| Post tracheostomy ICU stay | 6±4.3 | 15.3±19.6 | 47.5 | 0.597 | 1.071 (0.957-1.199) | 0.234  |
| Hospital stay         | 77.2±27.9         | 78.5±54.3        | 40.0| 0.291 | 1.001 (0.980-1.022) | 0.945  |

*Statistical significance test was done by Mann-Whitney U-test. *Binary logistic regression analysis. OR : odds ratio, CI : confidence interval

Table 4. Tracheostomy complication

| Group Variable                | Early (n=10) | Late (n=11) | OR (95%CI) | \(p^*\) |
|------------------------------|--------------|-------------|------------|--------|
| Pneumonia after tracheostomy | 4 (40)       | 9 (82)      | 2.625 (0.45-15.3) | 0.283  |
| Complication                 | 0 (0)        | 1 (9)       | 1.61 (0.0-) | 0.999  |

*Statistical significance test was done by Binary Logistic Regression Analysis. OR : odds ratio, CI : confidence interval
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In addition, activity is restricted in endotracheally or nasotracheally intubated patients due to ventilator tubing, which may compromise the emotional recovery of the patients.

Tracheostomy is required in 11-35% of patients with cervical spinal cord injury for the management of pulmonary complications and pulmonary hygiene. In case of cervical spinal cord injury, motor innervation to the chest muscle involved in inspiration and expiration is damaged. The diaphragm is innervated by the phrenic nerve which is formed from the cervical nerves C3, C4, and C5. Therefore, injuries at these levels reduce motor impulses via the phrenic nerve and impair diaphragmatic function. Spinal cord injury above the level of C5 also reduces the tidal volume and compromises the ability to clear respiratory secretions. In these patients, tracheostomy is necessary. Spinal cord injury above the level of C5 is reported to the independent predictor for immediate mechanical ventilation. Tracheostomy reduces the length of breathing circuits, improves pulmonary toilet and reduces airway resistance. As a result, breathing and weaning of mechanical ventilation become easier and the length of time on mechanical ventilation becomes shorter. It is reported that early tracheostomy reduces the incidence of pneumonia in traumatic spinal cord injury. However, tracheostomy is an invasive procedure causing fractures of cartilaginous rings, posterior tracheal wall injury, hemorrhage, pneumothorax, subcutaneous emphysema, mediastinitis, wound infection and the colonization around the tracheostomy. In a study analyzing 152 patients who underwent early tracheostomy within 7 days after spinal cord injury, Javier Romero et al. reported that early tracheostomy was advantageous reducing the length of time on mechanical ventilation, the length of ICU stay and complications such as tracheal granulomas and concentric tracheal stenosis. Nonetheless, early tracheostomy failed to reduce the risk of pneumonia related to mechanical ventilation and mortality. We retrospectively analyzed cases of prolonged intubation related to the use of steroids or anti-inflammatory agents due to various factors (medication, severe wound, hemorrhage) and cases of prolonged intubation due to pulmonary complications although extubation was attempted several times. The results showed that early tracheostomy performed within 10 days after intubation was still advantageous. Although the 10-day-period is not absolutely long enough, we retrospectively reviewed the patients with spinal cord injury. In case of the patients whose tracheostomy was delayed due to the patient's condition or situation, we reviewed the dates that fit into 10 days and checked statistically. Statistically, there were some beneficial effects from tracheostomy performed within 10 days, even if we have small number of patients. Although several previous studies reported that beneficial effects came out within 7 days, comparable advantages are still expected even if tracheostomy is slightly delayed due to the unavoidable reasons according to the results (<10 days) of this study. This study demonstrated that early tracheostomy performed within 10 days after intubation significantly reduced the total ICU stay (20.8 day vs. 38.0 day, p=0.010) and the length of time on mechanical ventilation (5.2 day vs. 29.2 day, p=0.009). The ICU stay after tracheostomy was reduced more than a week (6 day vs. 15 day). A previous study conducted with patient who underwent anterior cervical spine fixation reported that there were no complica-
tions related to early tracheostomy performed within 6-10 days such as wound infection, and the need for tracheostomy increased 3 times more in patients with spinal cord injury comparing to patients without spinal cord injury\(^3\). In our study, all patients underwent spinal surgery, and tracheostomy was determined afterwards depending on the clinical condition of the subjects. Surgical outcomes of the patients who had early tracheostomy (within 10 days) were satisfactory. Another study conducted with patients with severe traumatic head injury also reported that early tracheostomy (<7 days) reduced the length of time on mechanical ventilation, the incidence of pneumonia and the length of ICU stay\(^5\). A recent meta-analysis reported that early tracheostomy reduced the length of time on mechanical ventilation and ICU stay but there was no significant difference in the incidence of pneumonia and mortality\(^6\). Early tracheostomy in spinal cord injury patients decreased hospital acquired pneumonia. Furthermore, tracheostomy after anterior cervical disectomy and fusion did not increase the postoperative infection rate. We dichotomized between the early (1-10 days) and the late (after 10 days) tracheostomy group. There was no significant difference whether it was treated surgically or medically. Complications that can occur after tracheostomy are pneumonia, cartilaginous ring fracture, pneumothorax, subcutaneous emphysema, tracheal stenosis and infection\(^9\). In our study, pneumonia was the most prevalent complication and the incidence of pneumonia was reduced more than 2 times in the early tracheostomy group compared to the late tracheostomy group (40% vs. 82%), but there was no statistical significance (\(p=0.283\)). A case of tracheal stenosis was reported in the late tracheostomy group and the management of the patients in the late tracheostomy group was more challenging than the patients in the early tracheostomy group. Despite some variations, the findings of this study were consistent to those of previous studies.

There are two limitations that need to be acknowledged and addressed. This study was a single-center retrospective study and selection bias might have possibly occurred during the selection of the subjects. Despite of these limitations, we believe that early tracheostomy performed within at least 10 days is beneficial to patients with spinal cord injury.

**CONCLUSION**

We suggest early tracheostomy (within at least 10 days) since it has beneficial effects on the management of patients with cervical spinal cord injury requiring long-term mechanical ventilation by facilitating mechanical ventilation and reducing the length of ICU stay and complications related to intubation.

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**References**

1. Ball PA : Critical care of spinal cord injury. *Spine (Phila Pa 1976)* 26 (24 Suppl) : S27-S30, 2001
2. Biering-Sørensen M, Biering-Sørensen F : Tracheostomy in spinal cord injured : frequency and follow up. *Paraplegia* 30 : 656-660, 1992
3. Bouderka MA, Fakhir B, Bouaggad A, Hmannouchi B, Hamoudi D, Harti A : Early tracheostomy versus prolonged endotracheal intubation in severe head injury. *J Trauma* 57 : 251-254, 2004
4. Bryce DP, Briant TD, Pearson FG : Laryngeal and tracheal complications of intubation. *Ann Otol Rhinol Laryngol* 77 : 442-461, 1968
5. Claxton AR, Wong DT, Chung F, Fehlings MG : Predictors of hospital mortality and mechanical ventilation in patients with cervical spinal cord injury. *Can J Anaesth* 45 : 144-149, 1998
6. Davis K Jr, Campbell RS, Johannigman JA, Valente JF, Branson RD : Changes in respiratory mechanics after tracheostomy. *Arch Surg* 134 : 59-62, 1999
7. Diehl JL, El Atrous S, Touchard D, Lemaire F, Brochard L : Changes in the work of breathing induced by tracheostomy in ventilator-dependent patients. *Am J Respir Crit Care Med* 159 : 383-388, 1999
8. Fischer L, Erhart S, Kieger GR, Frutiger A : Prevalence of tracheostomy in ICU patients. A nation-wide survey in Switzerland. *Intensive Care Med* 26 : 1428-1433, 2000
9. Goldenberg D, Ari EG, Golz A, Danino J, Netzer A, Joachims HZ : Tracheostomy complications : a retrospective study of 1130 cases. *Otolaryngol Head Neck Surg* 123 : 495-500, 2000
10. Griffiths J, Barber VS, Morgan L, Young JD : Systematic review and meta-analysis of studies of the timing of tracheostomy in adult patients undergoing artificial ventilation. *BMJ* 330 : 1243, 2005
11. Harrop JS, Sharan AD, Scheid EH Jr, Vaccaro AR, Przybylski GJ : Tracheostomy placement in patients with complete cervical spinal cord injuries : American Spinal Injury Association Grade A. *J Neurosurg* 100 (1 Suppl Spine) : 20-23, 2004
12. Kluger Y, Paul DB, Lucke J, Cox P, Colella JJ, Townsend RN, et al. : Early tracheostomy in trauma patients. *Eur J Emerg Med* 3 : 95-101, 1996
13. Mansel JK, Norman JR : Respiratory complications and management of spinal cord injuries. *Am J Phys Med Rehabil* 83 : 319-324, 2004
14. Mellinger LB, Salem LL, Davenport TA, Baccari R, Cox DH : Postoperative tracheostomy nursing care. *Am J Crit Care* 3 : 383-388, 1994
15. Plummer AL, Gracey DR : Consensus conference on artificial airways in patients receiving mechanical ventilation. *Crit Care Med* 24 : 655-660, 1996
16. Rodriguez JL, Steinberg SM, Luchetti FA, Gibbons KJ, Taheri PA, Flint LM : Early tracheostomy for primary airway management in the surgical intensive care unit. *Am J Surg* 189 : 293-296, 2005
17. Southwick OW, Fritsch R, Simchen A, Wadhwa S, Anandasabapathy S, et al. : Long-term complications following cervical surgery. *J Neurosurg* 105 (5 Suppl) : 1-6, 2006
18. Warner AM, Townley SM : Tracheostomy in spinal cord injury. *Cochrane Database Syst Rev* : CD000212, 2004
19. Whited RE : A prospective study of laryngotracheal sequelae in long-term intubation. *Laryngoscope* 94 : 367-377, 1984