

Clinical Article

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

Hoi Jung Choi, M.D., Sung Hwa Paeng, M.D., Ph.D., Sung Tae Kim, M.D., Kun Su Lee, M.D., Moo Sung Kim, M.D., Yong Tae Jung, M.D.

Department of Neurosurgery, School of Medicine, Inje University, Busan Paik Hospital, Busan, Korea

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 annually¹⁵ and around 75% of them require intubation and mechanical ventilation due to respiratory problems²¹. Tracheostomy is required in 11-35% of patients with cervical spinal cord injury to maintain airway and to manage pulmonary complications and pulmonary hygiene^{1,2,13} and in 10% of ICU patients for long-term mechanical ventilation (longer than 24 hours)⁸. 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 days¹⁸. 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 tracheostomy remains controversial¹¹. 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-

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• Address for reprints : Sung Hwa Paeng, M.D., Ph.D.

Department of Neurosurgery, College of Medicine, Inje University, Busan Paik Hospital, 75 Bokji-ro, Busanjin-gu, Busan 614-735, Korea
Tel : +82-51-890-6144, Fax : +82-51-898-4244, E-mail : shpaeng@empas.com

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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 to 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 week¹⁴). 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	Trachemos- tomy timing (day)	Hospital duration (day)	Post tracheos- tomy ICU stay (day)	Pneumonia (post trache- ostomy)	Ventilator duration (day)	Severe complica- tion	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	0	14	0	19	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

Table 2. General patients characteristics and homogeneity

Characteristics	Classification	Early (≤10 day)	Late (>11 day)	χ ²	p
		(M±SD 6.7±39.7)	(M±SD 24±5.66)		
		n=10 (%)	n=11 (%)		
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)		
	M±SD	54.4±14.1	45.6±16.5		
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)	Late (n=11)	U	p*	OR (95% CI)	p [†]
	M±SD	M±SD				
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	Late	OR (95%CI)	p*
	n=10 (%)	n=11 (%)		
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

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.

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^{4,19,22}. The long-term intubation repeatedly injured posterior endolarynx, inducing tracheal stenosis.

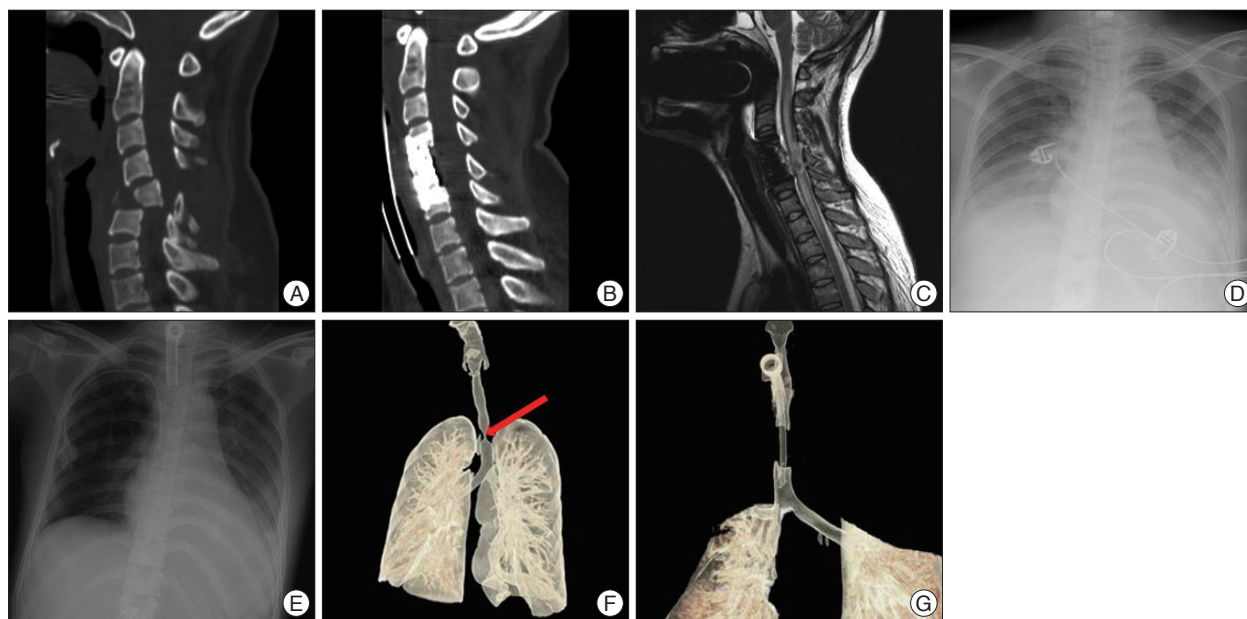


Fig. 1. A 37-year-old female who sustained quadriplegia after a four-meter fall (muscle strength of arms and legs were 3/5 and 1/5, and there was anesthesia below nipples). A : Cervical CT showing compressed fracture and dislocation at the level of C5. B : CT showing corpectomy and mesh cage implantation at the level of C5 and anterior cervical plate fixation at the level of C4 and C6. C : MRI showing cervical spinal cord injury. D : Chest X-ray showing haziness (2 weeks after the injury). E : Improvement on chest X-ray after tracheostomy. F : Chest 3-D CT showing tracheal stenosis after a month (red arrow). G : Chest 3-D CT image after treating the tracheal stenotic lesion.

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 hygiene²¹. 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 C5¹⁷. 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 be an independent predictor for immediate mechanical ventilation⁵. 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^{6,7}. It is reported that early tracheostomy reduces the incidence of pneumonia in traumatic spinal cord injury¹². However, tracheostomy is an invasive procedure causing fractures of cartilaginous rings, posterior tracheal wall injury, hemorrhage, pneumothorax, subcutaneous emphysema, mediastinitis, wound infection¹⁰ 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.²⁰ reported that early tracheostomy was advantageous reducing the

length of time on mechanical ventilation, the length of ICU stay and complications such as tracheal granulemas 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 injury¹⁶). 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 stay³). 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 mortality¹⁰). Early tracheostomy in spinal cord injury patients decreased hospital acquired pneumonia. Furthermore, tracheostomy after anterior cervical discectomy 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 infection⁹). 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 comparing 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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