Safety of early tracheostomy in trauma patients after anterior cervical fusion

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BACKGROUND: Cervical spine injuries (CSIs) can have major effects on the respiratory system and carry a high incidence of pulmonary complications. Respiratory failure can be due to spinal cord injuries, concomitant facial fractures or chest injury, airway obstruction, or cognitive impairments. Early tracheostomy (ET) is often indicated in patients with CSI. However, in patients with anterior cervical fusion (ACF), concerns about cross-contamination often delay tracheostomy placement. This study aimed to demonstrate the safety of ET within 4 days of ACF.

METHODS: Retrospective chart review was performed for all trauma patients admitted to our institution between 2001 and 2015 with diagnosis of CSI who required both ACF and tracheostomy, with or without posterior cervical fusion, during the same hospitalization. Thirty-nine study patients with ET (within 4 days of ACF) were compared with 59 control patients with late tracheostomy (5–21 days after ACF). Univariate and logistic regression analyses were performed to compare risk of wound infection, length of intensive care unit and hospital stay, and mortality between both groups during initial hospitalization.

RESULTS: There was no difference in age, sex, preexisting pulmonary or cardiac conditions, Glasgow Coma Scale score, Injury Severity Score, Chest Abbreviated Injury Scale score, American Spinal Injury Association score, cervical spinal cord injury levels, and tracheostomy technique between both groups. There was no statistically significant difference in surgical site infection between both groups. There were no cases of cervical fusion wound infection in the ET group (0%), but there were five cases (8.47%) in the late tracheostomy group ($p = 0.15$). Four involved the posterior cervical fusion wound, and one involved the ACF wound. There was no statistically significant difference in intensive care unit stay ($p = 0.09$), hospital stay ($p = 0.09$), or mortality ($p = 0.06$) between groups.

CONCLUSION: Early tracheostomy within 4 days of ACF is safe without increased risk of infection compared with late tracheostomy. (*J Trauma Acute Care Surg.* 2018;85: 741–746. Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Evidence, level III.

KEY WORDS: Tracheostomy; cervical fusion; surgical site infection.

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Traumatic injuries to the cervical spine with and without spinal cord injury (SCI) can have severe respiratory complications.[1] In particular, SCI can cause devastating effects upon the respiratory system. There are about 12,000 new cases of SCI in the United States each year with an incidence of 40 cases per one million people. Spinal cord injury represents a major economic burden on the health care system with the cost on average ranging between $340,797 and $1,044,197 in the first year after injury.[2] Complete injuries above C5 almost always require intubation and mechanical ventilation because of diaphragmatic and respiratory muscle paralysis and impairment of the ability to clear tracheobronchial secretions[3–5]; 20.6% of patients with cervical SCIs (CSCIs) require tracheostomy and long-term mechanical ventilation.[6]

Patients with injuries to the cervical spine without SCI also suffer from a significant incidence of respiratory failure due to airway obstruction, concomitant facial or thoracic injuries, and cognitive impairment.

In critically ill patients, early tracheostomy (ET) (within 10 days of intubation) has been linked to several benefits, such as decreased rates of pneumonia, decreased sedation requirement, fewer ventilator days, decreased intensive care unit (ICU) and hospital stay, and significant cost savings.[7–10] These benefits also apply to patients with CSCI on prolonged mechanical ventilation.[11,12] There is, however, concern about performing tracheostomies soon after anterior cervical fusion (ACF) because of the anatomic proximity of the surgical sites and the risk of cross-contamination.

In the past, valuable efforts have been made to demonstrate the safety of ET in ACF patients. However, the number of patients in these studies was too low to create a paradigm shift toward ET on patients after ACF. Also, patients could potentially benefit from tracheostomy even earlier after ACF than previously examined. The purpose of our study was to investigate in a larger study population if ET is safe after ACF. We hypothesize that there is no increased risk of infection when performing tracheostomy within 4 days after ACF.

METHODS

After approval from the institutional review board and waiver of the requirement for individual patient consent, we conducted a retrospective study for which clinical data were collected from medical records of patients identified in our hospital trauma database using *International Classification of Diseases, Ninth Revision, Clinical Modification* codes for cervical fusion (81.00–81.02) and tracheostomy procedures (31.1–31.2).

We included all trauma patients admitted from January 2000 to August 2015 to our institution, one of 14 federally sponsored regional SCI centers in the United States, who presented with cervical spine trauma and were treated with ACF and posterior cervical fusion (PCF), in whom tracheostomy was subsequently performed during the same hospitalization. We excluded patients who underwent PCF only or had incomplete data records.

The data recorded included control patient demographics (sex and age), preexisting pulmonary and cardiac comorbidities, admission Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), Chest Abbreviated Injury Scale (AIS) score, American Spinal Injury Association (ASIA) score, CSCI levels (high C1–C4, low C5–C7), tracheostomy technique (open vs. percutaneous), and timing as control variables. Response variables included ICU and hospital length of stay, neck and spinal infections with subsequent management (antimicrobial management, surgical interventions), and in-hospital mortality.

The patients were grouped according to tracheostomy timing after anterior cervical stabilization: ET, within 4 days, or late tracheostomy (LT), 5 days or more after ACF during initial hospital stay.

Univariate tests for association with tracheostomy timing were performed using *t* tests for normally distributed continuous variables, Wilcoxon rank sum test for non–normally distributed continuous variables, χ^2 test for categorical variables, and Fisher exact test for categorical variables when appropriate. Kaplan-Meier plots for ET and LT groups are presented with log-rank *p* values. These show hospital and ICU length of stay as response variables, with mortality as a censoring event.

RESULTS

During this 15-year period, a total of 747 trauma patients underwent cervical fusion, of whom 119 received tracheostomies in the initial hospitalization. Fourteen patients identified from the trauma database lacked electronic medical records, and seven patients had incomplete surgical procedure reports and were excluded. The results included data from 98 patients who complied with inclusion criteria. Of these patients, 74 (75.5%) were men, and 24 (24.5%) were women. Their ages ranged from 15 to 90 years, and the mean age was 51.1 years. Seventy-three of the patients had both posterior and ACF. Preexisting pulmonary comorbidities were present in 10 (10.2%) of the patients, whereas 37 (37.8%) suffered preexisting cardiac conditions. The median admission GCS score was 15; 24.5% of the patients suffered a concomitant chest injury, which ranged from minor (AIS score of 1) to severe (AIS score of 4), and the median ISS score was 26. Although all the patients suffered cervical spine injury, 14 (14.3%) had no neurological deficit. Those who suffered SCI were grouped according to the severity of the underlying neurologic injuries based on the ASIA classification system as follows: incomplete (ASIA B, C, and D), 22.4%; and complete (ASIA A), 63.3%. The majority of the patients underwent percutaneous tracheostomy (78.6%). The remainder underwent open tracheostomy (18.4%). Tracheostomy was performed from 0 to 21 days after ACF. Thirty-nine study patients with ET were compared with 59 control patients with LT. In the ET group, tracheostomy was performed an average of 2.4 days after ACF. In the LT group, tracheostomy was performed an average of 9.7 days after ACF. The distribution of tracheostomy postoperative day (POD) after ACF is presented in Figure 1. Additionally, tracheostomy was performed an average of 2.8 days after injury in the ET group and 11.1 days after injury in the LT group. There were no statistically significant differences for the control variables previously discussed. Summary statistics separated by tracheostomy timing (early vs. late) for control variables are presented in Table 1.

There were no cases of cervical fusion surgical site infection in the ET group (0%), but there were five cases (8.47%) in the LT group ($p = 0.15$), four of which involved the PCF. The only patient who developed ACF surgical site infection suffered from an esophageal perforation by cervical fusion hardware and developed an esophagocutaneous fistula. Mean length of ICU stay was 20 days, and the mean length of hospital stay was 31 days. There was no statistically significant difference between groups for these response variables.

Five of our studied patients died during initial hospital stay. The most common cause of death was cardiorespiratory complications: three patients died secondary to multilobar pneumonia and acute respiratory distress syndrome, and two died of bradycardia and hypotension. There was no statistically significant difference in mortality ($p = 0.06$) between groups. The rate of surgical site infection and mortality is presented in Table 1. Details on the patients who suffered surgical site infection are presented in Table 2.

Survival analysis for hospital and ICU length of stay variables did not show a statistically significant association with ET timing. Figure 2 shows the Kaplan-Meier curves for hospital and ICU length of stay for ET and LT and includes censoring due to in-hospital mortality. These plots trend toward longer hospital stay ($p = 0.091$) or ICU stay ($p = 0.093$) with LT.

DISCUSSION

Spinal cord injuries are devastating events that can be life threatening and significantly influence long-term quality of life.

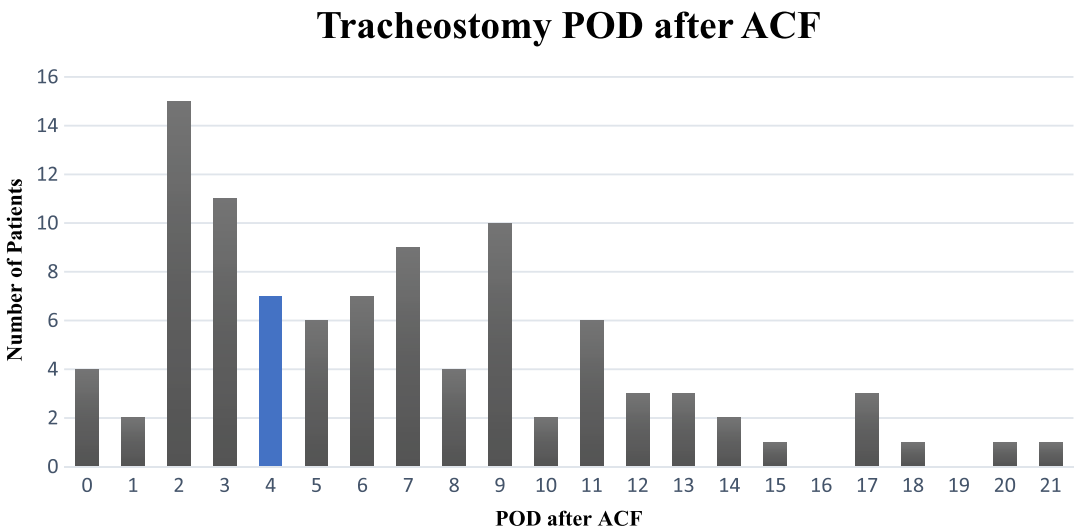

Figure 1. Distribution of the number of patients for each POD tracheostomy was performed after ACF. The cutoff day between the ET (0–4 days) and LT (>4 days) is highlighted in blue.

TABLE 1. Summary Statistics and Univariate Association Tests for Control and Response Variables

		Tracheotomy POD		
		Early (0–4)	Late (5–21)	*p*
Variable		n = 39	n = 59	
Age, y	Mean (IQR)	50.2 (25.8–74.6)	51.8 (29–74.6)	0.75
Sex				0.83
Female	n (%)	10 (25.6)	14 (23.7)	
ISS	Median (IQR)	26.00 (25–34)	26.00 (18–30)	0.16
Chest AIS score		30 (76.9)	44 (74.6)	0.65
0	n (%)			
1	n (%)	1 (2.6)	1 (1.7)	
2	n (%)	1 (2.6)	5 (8.5)	
3	n (%)	4 (10.3)	3 (5.1)	
4	n (%)	3 (7.7)	6 (10.2)	
Admit GCS score	Median (IQR)	14 (3–15)	15 (10–15)	0.28
Preexisting pulmonary condition				0.5
Yes	n (%)	3 (7.7)	7 (11.9)	
Preexisting cardiac condition				0.11
Yes	n (%)	11 (28.2)	26 (44.1)	
SCI level				0.72
None	n (%)	6 (15.4)	8 (13.6)	
High (C1–C4)	n (%)	14 (35.9)	26 (44.1)	
Low (C5–C7)	n (%)	19 (48.7)	25 (42.4)	
ASIA score				0.39
No SCI	n (%)	6 (15.4)	8 (13.6)	
ASIA B, C, D	n (%)	6 (15.4)	16 (27.1)	
ASIA A	n (%)	27 (69.2)	35 (59.3)	
Fixation level				0.43
High (1–4)	n (%)	19 (48.7)	24 (40.7)	
Low (5–7)	n (%)	20 (51.3)	35 (59.3)	
Percutaneous or open tracheostomy				0.24
Percutaneous	n (%)	33 (86.8)	44 (77.2)	
Open	n (%)	5 (13.2)	13 (22.8)	
Mortality				
Yes	n (%)	4 (10.3)	1 (1.7)	0.059
Cervical fusion surgical site infection				
Yes	n (%)	0 (0)	5 (8.5)	0.15*

*Fisher exact test used.
IQR indicates interquartile range.

Cervical SCI impairs respiratory function and frequently requires prolonged mechanical ventilation and tracheostomy. In critically ill patients, ET (within 10 days) has been shown to facilitate airway care, decrease sedation requirement, shorten time to liberation from mechanical ventilation, decrease ICU and hospital stay, and result in significant cost-savings.[10,13]

A large retrospective study of 5,265 patients with CSCI using the National Trauma Data Bank determined factors predicting the need for tracheostomy. These factors include ISS score of 16 or greater, GCS score on admission of 8 or less, complete CSCI above C5, facial fracture, thoracic injuries, and intubation at the scene of injury or in the emergency room.[6] A retrospective review of 163 patients with CSCI found that 100% of patients with complete injuries at level C2–C4 required mechanical ventilation for more than 48 hours. This percentage drops to 91% for C5, 79% for C6, and 80% for C7.[14] Other recent retrospective studies have confirmed these risk factors and developed a decision tree model for tracheostomy.[15–18]

Another retrospective review of 66 patients with CSCI examined factors predicting the need for prolonged (>7 days) mechanical ventilation and concluded that ISS of greater than 32, complete SCI, and PaO_2/FiO_2 ratio of less than 300 at 3 days after initiation of mechanical ventilation predicted prolonged ventilator dependence. Patients with all three risk factors had a 97% chance of requiring mechanical ventilation for longer than 7 days.[19]

Given the benefits of ET and the known predictors of tracheostomy and prolonged mechanical ventilation, ET placement in select patients with cervical spinal injuries is a desirable approach. However, in patients with ACF, tracheostomy placement has often been delayed because of the anatomic proximity of both surgical sites and the risk of cross-contamination.

Several previous studies have sought to characterize this risk. A review of the literature found that six retrospective studies have been performed on this topic including a cumulative 210 patients, two of which reported infection of the ACF surgical site, in a total of three patients.[3,20–24] The largest and most recent of these studies reported 55 total patients with a mean separation of ACF and tracheostomy of 6 days and one infection of the tracheostomy. There were no infections of the ACF site and two infections of the PCF sites.[24] These studies are summarized in Table 3.

There is significant variation among researchers regarding the definition of "early" tracheostomy. A systematic review of 12 randomized controlled trials found a wide range, with 2 to 10 days used as the early cutoff and 6 to 28 days used as the late cutoff.[25] In studies that examined tracheostomy after ACF, most

TABLE 2. Details on the Five Patients Who Suffered Surgical Site Infections

Age	Sex	Tracheostomy POD	ICU Length of Stay	Ventilator Days*	Hospital Length of Stay	Surgical Approach	Tracheostomy Technique	Management
67	Male	11	36	42	65	Posterior	Percutaneous	Incision and debridement
16	Male	17	31	22	37	Posterior	Percutaneous	Antibiotics
60	Female	9	32	18	18	Posterior	Percutaneous	Incision and debridement
37	Male	13	48	69	80	Anterior	Percutaneous	Surgery (esophagocutaneous fistula)
45	Female	5	30	52	52	Posterior	Percutaneous	Incision and debridement

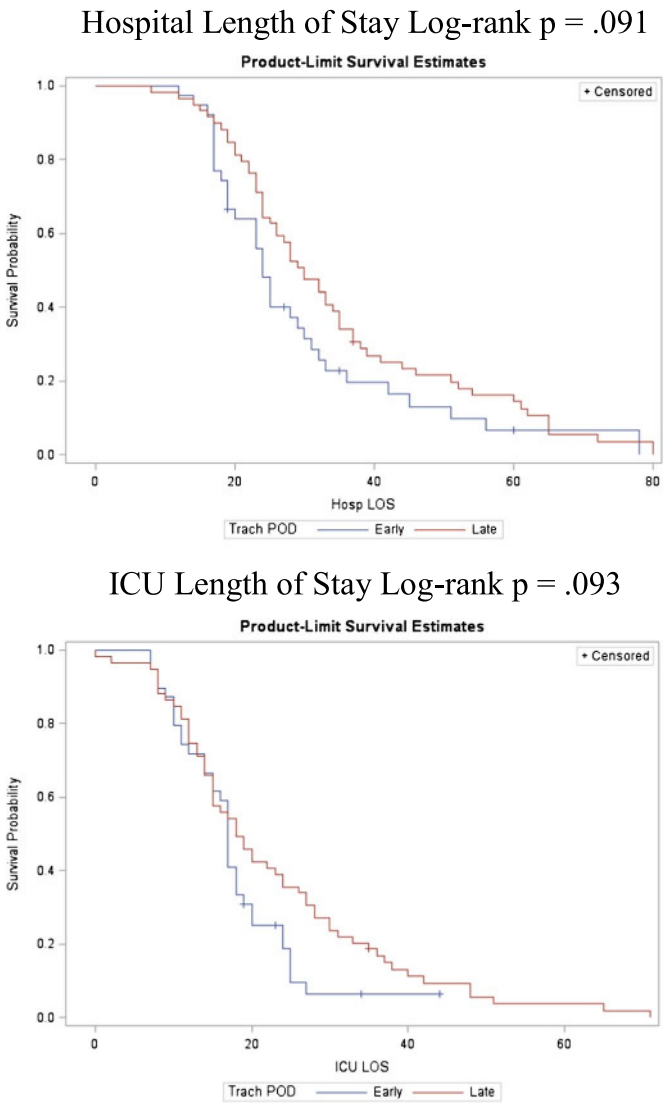

Figure 2. Kaplan-Meier survival curves for hospital and ICU length of stay. Mortality was used as a censoring event and is indicated by a vertical dash on the curve.

did not separate analysis into early and late groups. Two did and used 6 days or less versus more than 6 days as their cutoff. Because the majority of tracheostomies in our series were performed before 10 days (79%) and because we wanted to demonstrate the safety of tracheostomy as soon as possible after ACF, we decided to use 4 days or less versus more than 4 days as our cutoff. Our study demonstrates that tracheostomy within 4 days of ACF is safe, which is earlier than previously described. Further, the mean POD after ACF that tracheostomy was performed in the ET group is actually 2.8 days, suggesting that tracheostomy may be safe even earlier than studied. Additional studies are required to determine if this is true.

This study represents the largest series of ET following ACF. We found no increase in cervical surgical site infection or mortality in patients with ET when compared with LT cases. Moreover, we found a higher incidence of posterior cervical surgical site infection in the LT group. One explanation might be the longer need for sedation as a result of prolonged endotracheal intubation in LT and longer time to mobilization. Previous authors have suggested that the routine use of Philadelphia collars, which place pressure over the PCF surgical site, may be the cause of the relatively high rate of infection.[3,26] The relationship between delayed tracheostomy and increased risk of PCF infections merits further study.

The current study adds to the evidence of the safety of ET after ACF. Despite including more patients than previous studies, our study is still limited by the sample size and retrospective design. Because postoperative ACF infection is relatively rare, our series is insufficiently powered to conclusively assess the association between ET and infection. While every attempt was made to identify confounding variables, the effect of severity of injury on timing of tracheostomy may not have been fully accounted for by ISS and GCS score. Because of the long time period over which our review occurred, changes in care are possible, particularly with regard to the routine administration of steroids for SCI. Our review also includes patients with and without spinal cord injuries, which may be a confounder. However, we felt that the inclusion of these patients was relevant to the primary outcome. This study represents Level III evidence. Further research, involving prospective randomized studies, is

TABLE 3. Review of Literature on Tracheostomy After Cervical Fusion

References	Year	No. Patients	Spinal Fixation Procedure	Mean Timing of Tracheostomy	Early/Late Cutoff (≤d)	Surgical Site Infections (No. Patients)
O'Keeffe et al.[20]	2004	17	ACF	8.8	None	Cellulitis at tracheostomy site[1]
Berney et al.[3]	2008	32	ACF	3.8	None	Infection of tracheostomy and ACF site[1]
		15	PCF	3.1		
		24	ACF and PCF	4.9		Infection of tracheostomy and PCF[2] Infection of PCF site[7] Infection of tracheostomy site[7]
Romero-Ganuza et al.[21]	2011	28	ACF	8.3	6	Cellulitis at tracheostomy site[2]
Babu et al.[22]	2013	20	ACF	6.9	6	Hematoma of ACF site[1]
Binder et al.[23]	2015	30	ACF	15	None	Infection of ACF site[2]
		8	ACF and PCF			
Kaczmarek et al.[24]	2017	40	ACF	6	None	Infection of tracheostomy site[1]
		11	ACF and PCF			Infection of PCF site[2]
Current study	2018	25	ACF	6.8	4	Infection of PCF site[4]
		73	ACF and PCF			Esophagocutaneous fistula[1]

needed to determine more definitive guidelines for tracheostomy after ACF.

We conclude that tracheostomy placement within 4 days after ACF is safe with no increase in anterior cervical surgical site infections or mortality compared with those with LT placement.

AUTHORSHIP

M.S.W., C.P.L.G., M.J.C., J.A.M., and J.S.J. conceived and designed the study. K.A.C. and C.P.L.G. acquired the data. C.P.L.G., M.S.W., M.J.C., J.A.M., J.S.J., and K.A.C. analyzed and interpreted the data. C.P.L.G. and K.A.C. drafted the manuscript. C.P.L.G., M.S.W., M.J.C., J.A.M., J.S.J., and K.A.C. critically revised the manuscript.

DISCLOSURE

The authors declare no conflicts of interest.

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