Timing of tracheostomy after anterior cervical spine fixation

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BACKGROUND: Patients with cervical spinal cord injury frequently undergo early anterior cervical spine fixation (ACSF) and tracheostomy procedures to reduce further deterioration, to reduce risk of pulmonary complications, and to improve patient mobilization. However, tracheostomy is often delayed because of the risk of cross contamination as a result of the proximity to the ACSF incision site. Currently, there is a paucity of studies evaluating this outcome to determine the safety of early tracheostomy after ACSF. In this study, we have evaluated the outcomes and complications associated with early tracheostomy placement.

METHODS: We performed a retrospective review of all patients who underwent tracheostomy placement and ACSF during the same hospitalization between 2005 and 2010. A variety of patient and procedural data were collected, including demographics, timing of ACSF and tracheostomy, length of hospitalization, indication for surgery, American Spinal Injuries Association and Glasgow Coma Scale scores on admission, reason for tracheostomy, method of tracheostomy, and complications.

RESULTS: Of the 1,184 patients who underwent an ACSF, 20 (1.7%) required a postfixation tracheostomy. Tracheostomy was performed at mean (SD) of 6.9 (4.2) days after ACSF, ranging from 0 to 17 days. Although nearly half of all patients underwent postfixation tracheostomy within 6 days, no wound or implant infection was seen to occur in any patient. Ten patients (50%) developed ventilator-associated pneumonia, with most cases occurring before tracheostomy (90% vs. 10%, $p < 0.0001$). Univariate analysis only revealed late tracheostomy to significantly increase the risk of complications (odds ratio, 9.33; 95% confidence interval, 1.19–73.0; $p = 0.033$). Analysis of all studies in the literature revealed a 1% cross-infection rate, with no cases involving implant contamination.

CONCLUSION: Our findings suggest that early tracheostomy can be performed safely after cervical spine fixation surgery, with no patients developing incisional or implant infections. As the risk of cross contamination is only 1%, early tracheostomy should be strongly considered because of its potential benefits. (*J Trauma Acute Care Surg*. 2013;74: 961–966. Copyright © 2013 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Therapeutic/care management, level IV.

KEY WORDS: Anterior; cervical spine fixation; complication; infection; tracheostomy.

BACKGROUND

Patients with acute spinal cord injury (SCI) frequently require endotracheal intubation and mechanical ventilation because of respiratory muscle weakness or paralysis, reduced pulmonary vital capacity, and impairment in the clearance of tracheobronchial secretions.[1,2] In addition to supportive care, these patients also often need to undergo spinal fixation soon after presentation to reduce pulmonary complications, to stabilize the spine to facilitate patient mobilization, and to prevent further injury to the spinal cord.[3,4] This decompression and fixation of the spine is often performed through an anterior approach which involves an incision near the cricoid or thyroid cartilage.

Patients with SCI frequently need prolonged mechanical ventilation, occurring in up to 35% of cases.[1,2,5] This increases the risk of respiratory complications, which have been reported to account for 80% of deaths in patients with cervical SCI.[6] To facilitate ventilation weaning and to prevent respiratory complications, a tracheostomy is often performed. It has also been shown to reduce the mortality rate, to prevent the complications of intubation, to reduce the length of sedation, and to facilitate the clearance of secretions in patients with SCI.[7–10]

Tracheostomy is also performed in patients who develop airway obstruction due to wound hematoma after anterior cervical spine fixation (ACSF). This complication occurs in 0.2% to 1.9% of patients after ACSF and may lead to cerebral ischemia and death.[11–14] Often, endotracheal intubation is unsuccessful, requiring emergent open tracheostomy.

Early tracheostomy in SCI patients has been shown to be associated with shorter ICU stay, shorter length of mechanical ventilation, and decreased laryngotracheal complications.[8,10,15,16] Studies have also shown decreased mortality, morbidity, and complications in trauma patients undergoing early tracheostomy.[17,18] However, there is concern for performing tracheostomy soon after ACSF because of the proximity of the incisions, increasing the risk of cross infection.[19] As a result, many surgeons postpone tracheostomy placement until the wound has been adequately healed. Thus far, only three studies have evaluated the timing of tracheostomy, suggesting tracheostomy as early as 4 days after ACSF is associated with minimal complications.[16,20,21]

In this study, we performed a retrospective review of patients who underwent tracheostomy after ACSF to evaluate the outcomes and complications associated with early tracheostomy placement, in particular examining the risk of infection and cross contamination. In addition, we have analyzed all existing studies to provide conclusive evidence regarding the benefits of early tracheostomy.

METHODS

We performed a retrospective review of all patients who underwent ACSF between June 2005 and December 2010. All anterior fixation procedures involved the use of instrumentation. Patients underwent ACSF for a variety of conditions, including SCI and degenerative disc disease. We then selected patients who also underwent tracheostomy placement during the same hospitalization. There were no exclusion criteria. The timing of tracheostomy was determined by a multidisciplinary critical care team composed of respiratory therapists, critical care intensivists, and trauma surgeons. No standardized protocol was used to determine tracheostomy timing with each patient being evaluated based on their clinical status, expected outcome, and family wishes. Delays in tracheostomy were due to either the inability to obtain consent for the procedure or unstable clinical condition of the patient.

A variety of patient and procedural data were recorded, including demographics, date of admission, ACSF, and

TABLE 1. Cohort Characteristics of Patients Who Underwent Tracheostomy Placement After Anterior Cervical Fixation Surgery

Variables	
Patient characteristics	
Age (range), y	47 (22–86)
Male, %	90
Caucasian, %	40
African American, %	45
American Indian, %	15
Functional status	
Glasgow Coma Score	12.2 (4.2)
ASIA category, %	
A	55
B	0
C	15
D	15
E	5
NA	10
Injury Severity Score, median	6
Causes of injury	
Traumatic, %	
Motor vehicle accident	50
Collision with motor vehicles	15
Falls	10
All-terrain vehicle accident	10
Crush injury	5
Nontraumatic, %	
Degenerative	10
Indication for ACSF, %	
SCI	90
Degenerative spine disease	10
Indication for tracheostomy, %	
Ventilator dependence	90
Postoperative hematoma	5
Cardiopulmonary arrest	5

tracheostomy, length of hospitalization, indication for surgery, American Spinal Injuries Association (ASIA) and Glasgow Coma Scale (GCS) scores on admission, reason for tracheostomy, and method of tracheostomy. Complications were also recorded if present during the hospitalization or at 90-day follow-up, including the presence of pneumonia, wound breakdown or erythema, osteomyelitis, and positive wound cultures.

Statistical Analysis

Continuous variables were presented using medians, means, and SDs, with categorical variables presented using numbers and percentage values. The Student *t* test was used to compare continuous variables, with the chi-squared test used for categorical variables. Univariate and stepwise multivariate logistic regression was performed to evaluate risk factors for complications. All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC).

RESULTS

Patient Cohort

A total of 1,184 patients underwent an ACSF procedure during the 5-year period, of whom 20 (1.7%) had a tracheostomy performed after cervical spine fixation surgery. The median age of these patients was 47 years, ranging from 22 to 86 years (Table 1). Eighteen patients (90%) were male, with Caucasians, African Americans, and American Indians accounting for 40%, 45%, and 15% of the cases, respectively. The mean (SD) GCS at presentation was 12.2 (4.2), with 50% of patients having a GCS of 15. The severities of the SCI at presentation as determined by the ASIA classification system were as follows: 55% category A, 0% category B, 15% category C, 15% category D, and 5% category E. Two patients were not assigned an ASIA score because of the nontraumatic mechanisms of injury and absence of SCI. The most common cause of injury was motor vehicle accidents, occurring in 50% of cases. Other causes of injury were collisions with motor vehicles (three cases; 15%), falls (two cases; 10%), degenerative causes (two cases; 10%), all-terrain vehicle accidents (two cases; 10%), and a crush injury (one case; 5%). The majority of patients required an ACSF because of the presence of SCI (90%), with the remaining two patients requiring fixation for

TABLE 2. Review of All Studies Evaluating the Timing of Tracheostomy After Cervical Fixation Surgery

Author	No. Patients	Spine Fixation Procedure	Type of Tracheostomy	Timing of Tracheostomy (Mean)	Complications
O'Keeffe et al.[20]	17	ACSF	12 percutaneous	8.8 days	Cellulitis at tracheostomy site (1 patient)
			4 surgical		Pneumonia (14 patients)
Berney et al.[21]	32	ACSF	68 surgical	3.8 days	Infection of tracheostomy and ACSF site (1 patient)
	15	PSF	3 percutaneous	3.1 days	Infection of tracheostomy and PSF site (2 patients)
	24	A&P		4.9 days	Infection of tracheostomy site alone (7 patients); infection of PSF site (7 patients)
Romero-Ganuza et al.[16]	28	ACSF	28 percutaneous	8.3 days	Bleeding at tracheostomy site (1 patient); mild cellulitis at tracheostomy site (1 patient); extensive cellulitis at tracheostomy site (1 patient)
Current study	20	ACSF	16 surgical	6.9 days	Postfixation hematoma (1 patient)
			4 percutaneous		Pneumonia (10 patients)

A&P, anterior and posterior; PSF, posterior spinal fusion.

degenerative spine disease. For trauma patients, the median Injury Severity Score was 6 (mean, 13.8), ranging from 2 to 57. Although all trauma patients had SCI, only one patient also had traumatic brain injury (5.6%). The mean (SD) length of hospital stay was 39 (31) days, ranging from 5 to 155 days.

ACSF and Tracheostomy Characteristics

All ACSF procedures were performed by experienced orthopedic or neurological surgeons. The most common locations for cervical constructs were C4 to C6 (four cases; 20%) and C6 to C7 (four cases; 20%). The mean number of surgical levels was 1.8, with the longest constructs involving 4 levels (C3–C7). Tracheostomy was most often performed surgically (80%), with the remaining being performed percutaneously (20%). Two patients required emergent surgical tracheostomy because of postoperative hematoma collection and cardiopulmonary arrest.

Timing of ACSF and Tracheostomy

The mean (SD) time from hospital presentation to ACSF was 2.8 (5.6) days, ranging from 0 to 24 days. Half of all patients received surgery on the day of admission, with 65% of all patients undergoing ACSF within 1 day of presentation. Tracheostomy was performed at mean (SD) of 6.9 (4.2) days after ACSF, ranging from 0 to 17 days (interquartile range, 4–8 days). This was required because of ventilator dependence as a result of respiratory failure (90%), postoperative hematoma (5%), and cardiopulmonary arrest (5%). Patients most commonly underwent tracheostomy placement in the operating room (85%), with the remaining being inserted at the bedside (15%). All bedside tracheostomies were inserted percutaneously. Tracheostomy procedures were performed by trauma surgeons (80%) and head and neck surgeons (20%). Nine patients (45%) underwent postfixation tracheostomy within 6 days or less (early), with another 45% undergoing tracheostomy 7 to 12 days after ACSF (late). Those who underwent an early tracheostomy had a shorter hospitalization, staying 26.7 (15) days compared with 49 (37.4) days for those received a tracheostomy later ($p = 0.11$).

Complications

No intraoperative complications occurred during ACSF or tracheostomy in any patient. The only postoperative complication was an expanding hematoma in one patient after ACSF, requiring an emergent surgical tracheostomy. This patient fully recovered after hematoma evacuation and reinitiation of respiratory access. No wound or implant infection was present during the initial hospitalization or at the 90-day follow-up in any patient. Also, no neurological deterioration, tracheoesophageal fistulas, or tracheal ring fractures were observed. Ten patients (50%) developed ventilator-associated pneumonia during their hospital course. Nine cases (90%) of pneumonia occurred before tracheostomy, with the remaining case occurring 1 day after tracheostomy placement ($p < 0.0001$). Two patients died during the initial hospital stay due to sepsis and anoxic injury due to cardiopulmonary arrest, both of which were unrelated to ACSF or tracheostomy placement. Univariate analysis for complications only revealed late tracheostomy to be significantly associated with an increased risk of complications (odds ratio [OR], 9.33; 95% confidence interval [CI], 1.19–73.0; $p = 0.033$). Age, ASIA score, GCS on arrival, Injury Severity Score, and time of ACSF from admission did not significantly affect this risk. Stepwise multivariate logistic regression also demonstrated late tracheostomy to be associated with an increased the risk of complications, with this effect approaching significance (OR, 10.9; 95% CI, 0.85–139.9; $p = 0.066$). Of all the patients, 7 (35%) were dead at a median follow-up of 12.5 months.

DISCUSSION

Prolonged mechanical ventilation is frequently required in patients with cervical SCI due to impairments in respiration. Respiratory failure is common in these patients, occurring in up to 63% of cervical SCI cases.[22] Other pulmonary complications include atelectasis, bronchospasm, bronchial hypersecretion, pneumonia, pulmonary edema, and thromboembolism. As a result, tracheostomy is frequently performed to facilitate weaning from mechanical ventilation, for tracheobronchial clearance, to improve comfort, and to decrease the risk of pulmonary complications.[4,23,24] A study by Como et al.[10] showed all patients with complete SCI at C5 and above require a tracheostomy, with 50% of those with complete injury at or below C6 also undergoing tracheostomy. Although the timing of tracheostomy in trauma patients is controversial, studies have shown early tracheostomy to reduce the time of mechanical ventilation, complication rates, length of intensive care unit and hospital stay, and hospitalization costs.[4,9,15,25–28]

Anterior cervical spine stabilization after SCI is frequently performed shortly after presentation, with studies demonstrating surgery within 72 hours of injury to improve neurological recovery, decreasing the incidence of pneumonia, hospitalization time, ventilator days, and hospital charges.[3,29] A systematic review of the literature, however, did not observe consistent benefit with early surgery, although there was strong evidence demonstrating no increased risk of complications associated with early surgical intervention.[30] Despite inconclusive evidence, a panel of experts recommended surgical decompression within 24 hours due to the potential clinical, neurological, and functional benefits.

Because of the benefits of early spinal fixation and tracheostomy, both procedures may ideally be performed in close temporal proximity. However, the incision for the tracheostomy is made close to the ACSF site, potentially resulting in cross contamination. This may cause osteomyelitis, implant contamination, and subsequent nonunion. As a result, many delay the tracheostomy until the fixation wound is healed, typically around postoperative day 6. To address this concern, few studies have been performed, evaluating the timing of tracheostomy after cervical fixation surgery. The largest study involved 32 patients, with tracheostomy being performed at a mean of 3.8 days after ACSF.[21] In this study, only one patient developed an infection of both the tracheostomy and the anterior stabilization site. However, treatment with antibiotics resulted in resolution, with no deep infection requiring further surgical intervention. No other studies had an infection involving the ACSF site. Therefore, analysis of all studies in the literature revealed a 1% (1 of 97 patients) infection rate of

both tracheostomy and ACSF sites, with tracheostomy being performed at a weighted mean of 6.6 days after ACSF (Table 2). Of all patients receiving cervical fixation surgery, 12 (8.8%) developed an infection at the tracheostomy site.

In our study, nearly half of all patients underwent tracheostomy placement 6 days or earlier after cervical fixation surgery, with 20% having this procedure at postfixation day 3 or earlier. In our series, we did not have any cases of wound infection, even in instances in which tracheostomy occurred emergently or shortly after cervical fixation surgery. This suggests that early tracheostomy can be performed safely, with minimal risk for cross contamination with the ACSF site. The only complications present in this study were a postoperative hematoma collection and ventilator-associated pneumonia. Pneumonia was present in 50% of all patients, with a significantly higher percentage of infections occurring before tracheostomy placement (90% vs. 10%, $p < 0.0001$). These data suggest a reduction in pulmonary complications after tracheostomy, further supporting the use this procedure shortly after cervical fixation surgery. In addition, late tracheostomy after ACSF was associated with a significantly increased risk of complications (OR, 9.33; 95% CI, 1.19–73.0; $p = 0.033$), with this affect approaching significance on multivariate analysis.

This study has several limitations. Because of its retrospective nature and small cohort size, there is a potential for bias. We have also included nontrauma patients and those who underwent emergent tracheostomy, potentially affecting the risks of complications such as pneumonia. However, these patients were included as they typically undergo tracheostomy shortly after ACSF procedures and under nonideal conditions, making them more susceptible to infection and cross contamination. Also, because of the rarity of cross contamination, a single-institution study is inadequately powered to assess this risk and to make conclusive statements regarding the correlation between early tracheostomy and infection risk. This is further compounded by the low rate of deep infections (0.76%) in all patients who underwent ACSF procedures at our institution. However, we have analyzed the literature, reducing bias and allowing for more definitive data. These data support the use of early tracheostomy after ACSF because of the minimal risk of cross infection and reduced risk of complications such as pneumonia.

In summary, patients with cervical SCI frequently undergo early spinal fixation and tracheostomy procedures to reduce further deterioration, risk of pulmonary complications, and length of mechanical ventilation and hospital stay and to improve patient mobilization. However, tracheostomy is often delayed because of the risk of cross contamination due to the proximity of the incision sites. Most of our patients underwent tracheostomy within 8 days after spinal fixation, with no cases of wound infection. Of all cases in the literature, there is only a 1% risk of cross infection, with no cases having implant contamination. As delayed tracheostomy was the only risk factor for increased complications, early tracheostomy should be increasingly considered in patients who are likely to be ventilator dependent and should not be delayed after cervical fixation surgery because of the minimal risk of infection. Further studies with larger cohort sizes are needed to provide more definitive guidelines.

AUTHORSHIP

C.A.B. designed this study. T.R.O., I.O.K., and B.H.G. conducted the literature search. J.R.M. contributed administrative support. R.B. and J.R.M. collected the data, which R.B. and S.T. analyzed. R.B. and C.A.B. performed data interpretation. R.B. and T.R.O. prepared the manuscript, which S.T., I.O.K., B.H.G., S.P.L., and C.A.B. critically revised.

DISCLOSURE

The authors declare no conflict of interest. No external funding was used for this study.

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