Tracheostomy after Anterior Cervical Spine Fixation

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Background: Patients with cervical spine injury may require both anterior cervical spine fusion and tracheostomy, particularly in the setting of associated cervical spinal cord injury (SCI). Despite the close proximity of the two surgical incisions, we postulated that tracheostomy could be safely performed after anterior spine fixation. In addition, we postulated that the severity of motor deficits in patients with cervical spine injury would correlate with the need for tracheostomy.

Methods: A retrospective review was undertaken of all adult trauma patients diagnosed with cervical spine fractures or cervical SCI admitted between June 1996 and June 2001 at our university Level I trauma center. Demographic data, severity of neurologic injury based on the classification of the American Spinal Injury Association (ASIA), complications, and use and type of tracheostomy were collected. In the subgroup of patients with unstable cervical spine injury that underwent anterior stabilization and tracheostomy, data regarding timing and technique of these procedures and wound outcomes were also collected. Categorical data were analyzed using χ^2 analysis using Yates correction when appropriate, with $p < 0.05$ considered significant.

Results: During this time period, 275 adult survivors were diagnosed with cervical spinal cord or bony injury. Forty-five percent of patients with SCI (27 of 60) and 14% of patients without SCI (30 of 215) underwent tracheostomy ($p < 0.001$). Moreover, on the basis of the ASIA classification system, 76% of ASIA A and B patients, 38% of ASIA C patients, 23% of ASIA D patients, and 14% of ASIA E patients were treated with tracheostomy ($p < 0.001$). In the subgroup that underwent both anterior spine fixation and tracheostomy (n = 17), the median time interval from spine fixation to airway placement was 7 days (interquartile range, 6–10 days), with 71% of these tracheostomies performed percutaneously. No patient developed a wound infection or nonunion as a consequence of tracheostomy placement, and there were no deaths because of complications of either procedure.

Conclusion: These data support the safety of tracheostomy insertion 6 to 10 days after anterior cervical spine fixation, particularly in the presence of cervical SCI. The presence of severe motor neurologic deficits was strongly associated with the use of tracheostomy in patients with cervical spine injury. Percutaneous tracheostomy, which is our technique of choice, may be advantageous in this setting by virtue of creating only a small wound. The optimal timing and use of tracheostomy in patients with cervical spine injury requires further study.

Key Words: Tracheostomy, Anterior, Cervical spine, Fixation, Spinal cord injury, American Spinal Injury Association (ASIA).

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Patients suffering injuries to the cervical spinal cord, even as isolated injuries, often require endotracheal intubation and positive-pressure ventilation. The ensuing respiratory muscle weakness and impaired ability to clear respiratory secretions can result in a prolonged intensive care unit (ICU) course. Increasingly, early stabilization of the cervical spine is being performed, in part to reduce pulmonary complications, as stabilization can facilitate early patient mobilization.[1,2] Spinal cord decompression and stabilization of the cervical spine is often accomplished by means of an anterior approach that uses a transverse incision at the level of the thyroid or cricoid cartilage.[3–5]

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A significant proportion of patients with cervical spinal cord injury (11–35%) will also require placement of a tracheostomy to facilitate the management of the airway, pulmonary complications, and pulmonary hygiene.[6–8] The proximity of the anterior cervical spine fixation and tracheostomy wounds (Fig. 1) creates a potential risk of cross-contamination, with the danger of deep infection and subsequent nonunion.[9] As reported infection rates for tracheostomy can be as high as 30%,[10–13] concern regarding cross-contamination may cause surgeons to delay or avoid tracheostomy. Additional factors making spinal cord injured trauma patients susceptible to infection include the use of high-dose steroids, multiple trauma, and the immunosuppression caused by the severe injury, including the acute spinal cord injury itself.[14,15] Consequently, the surgeon must consider multiple factors when making airway management decisions for patients with cervical spine injury.

We therefore decided to perform a retrospective review of all patients undergoing both anterior cervical procedures and tracheostomy. The goals of this review were to characterize the clinical characteristics of this patient cohort and evaluate the safety of this approach as determined

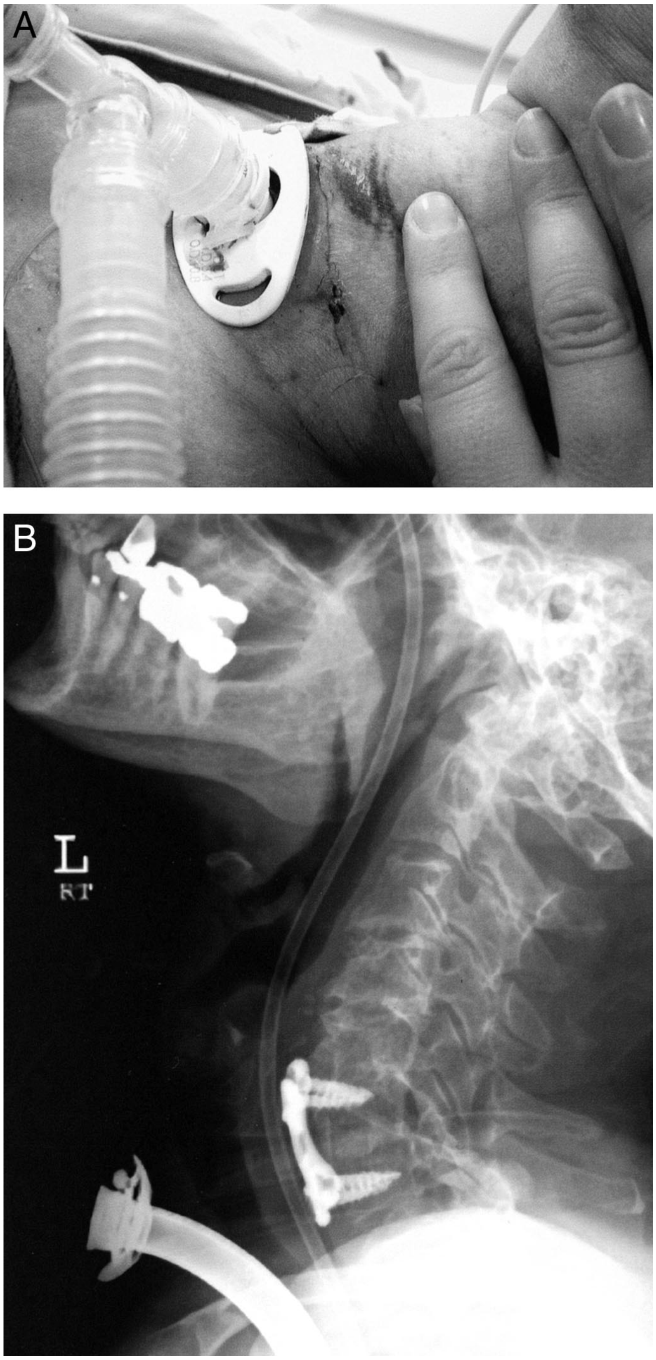

Fig. 1. *Proximity of tracheostomy to anterior spine wound. Photograph and radiograph of a typical patient illustrates the close proximity of the two wounds.*

by the rate of wound complications in these patients. To further assist the surgeon's complex decision regarding tracheostomy for an individual patient, we evaluated the pulmonary and airway complications of this cohort and the association of the severity of the associated neurologic injury and our use of tracheostomy in all patients with cervical spinal cord injury.

PATIENTS AND METHODS

Using the trauma registry and patient record, a retrospective review of patients admitted to our Level I trauma center from July 1996 to July 2001 was performed. The Oregon Health & Science University Investigation Review Board approved this study. Patients with cervical spine fractures, dislocations, and/or cervical spinal cord injury (SCI) were identified. The data recorded included patient demographics, mechanism of injury, Injury Severity Score, Abbreviated Injury Scale score, steroid therapy, neurologic status at presentation as classified by the American Spinal Injury Association (ASIA),[16] and the occurrence of any operation on the cervical spine or trachea. The ASIA scale includes the following injury categories: A, complete, with no motor or sensory function; B, incomplete with preservation of sensory function below the level of injury, but motor function is not preserved; C, incomplete with preservation of motor function below the level of neurologic injury, but at least 50% of this function is muscle grade less than 3; D, incomplete with preservation of motor function below the level of neurologic injury with at least 50% of this function being muscle grade 3 or greater; and E, normal motor and sensory function.

Additional data in the subgroup that underwent tracheostomy after anterior spine fusion included the technique, timing, and complications of tracheostomy and cervical spine operations, and the occurrence of any pulmonary complications. Follow-up for patients receiving anterior spine fixation and tracheostomy was determined by a combination of outpatient office visits, responses to a brief postal questionnaire, or telephone interview. Fusion of the cervical spine was assessed on follow-up radiographs at a minimum of 3 months. Results were analyzed using the χ^2 test with Yates correction when appropriate. Statistical significance was set at $p < 0.05$. Nonparametric data were reported as median with interquartile range as the measure of dispersion.

RESULTS

During this 5-year period, 275 adult patients, 3% of all injured patients, were treated for cervical spine fractures, subluxations, dislocations, or injury to the cervical spinal cord. There were 60 patients (22%) with cervical SCI and 215 patients without SCI. Patients with cervical SCI (27 of 60 [45%]) received tracheostomy significantly more frequently than patients who had cervical spine injury without SCI (30 of 215 [14%]) ($p < 0.001$, χ^2). The impact of motor deficits was further analyzed by stratifying patients on the basis of the severity of their neurologic injury using the ASIA classification method (Table 1). Patients with severe neurologic deficits (i.e., ASIA scores A, B, and C) received tracheostomy in 62% of cases (21 of 34). Seventy-five percent of complete quadriplegics (ASIA A) were treated with tracheostomy. In summary, 76% of ASIA A and B patients, 38% of ASIA C patients, 23% of ASIA D patients, and 14% of ASIA E patients were treated with tracheostomy ($p < 0.001$, χ^2 with Yates correction).

Table 1 Influence of ASIA Score on Need for Tracheostomy

	Tracheostomy	No Tracheostomy
ASIA A	15	5
ASIA B	1	0
ASIA C	5	8
ASIA D	6	20
ASIA E	30	185
Total	57	218

Forty-seven of the 60 patients with SCI injury underwent an anterior cervical spinal fixation procedure, and 16 of these 60 patients underwent tracheostomy after their spine fixation. No patient underwent tracheostomy before anterior cervical fusion. A seventeenth patient, who did not have a spinal cord injury, underwent tracheostomy after his anterior spine stabilization procedure.

This subgroup of 17 patients consisted of 5 women and 12 men. Their age ranged from 17 to 85 years, with a median of 43 years. Demographic data are summarized in Table 2. The median Injury Severity Score was 26 (range, 16–48) and the median Abbreviated Injury Scale score for the head and neck region was 4 (range, 3–5). Nine of these 17 patients had significant associated injuries; the other 8 had isolated cervical spine injuries. One patient was neurologically intact; the remaining 16 had varying degrees of cervical SCI. These 16 patients received high-dose methylprednisolone for a minimum of 24 hours. Two patients were lost to long-term follow-up because of death after discharge from the hospital. Median follow-up for the remaining 15 patients was 11 months (range, 3–42 months).

Surgical airways included 12 percutaneous tracheostomies, 4 open tracheostomies, and 1 open cricothyroidotomy.

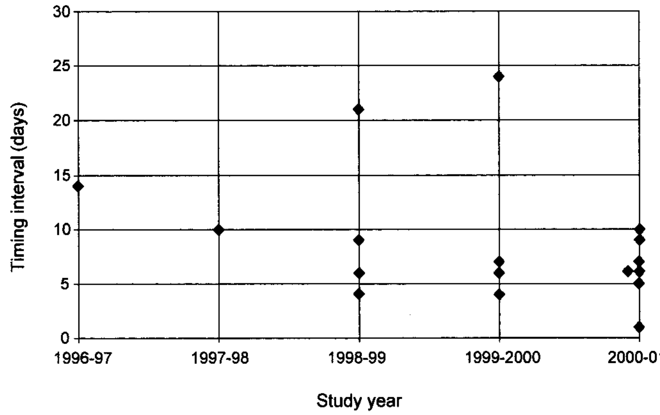

Fig. 2. *Timing interval between anterior spine fusion and tracheostomy. The timing between operative procedures for each patient is illustrated as a function of study year. The median interval was 7 days (interquartile range, 6–10 days).*

All airway procedures were elective, including the cricothyroidotomy.[17] Members of the trauma and surgical critical care service performed 14 of the 17 tracheostomies. Three tracheostomies were performed in the operating room and 14 were inserted at the bedside in the ICU. The median time from anterior cervical fusion to tracheostomy was 7 days (interquartile range, 6–10 days). Tracheostomy was delayed in one patient because of a superficial infection of the anterior cervical fusion wound. As the study period progressed, there was a tendency toward a reduction in the time interval between anterior cervical surgery and tracheostomy, although this was not statistically significant (Fig. 2).

A standard left or right anterior cervical spine operative approach was used in all patients.[18] Autogenous iliac crest bone graft was used in 14 of 17 cases (82%). Four patients

Table 2 Patient Demographics and Associated Injuries[a]

Patient	Age (yr)	Sex	Mechanism of Injury	ISS	AIS Head/Neck	Associated Injuries
1	24	M	Diving	25	5	—
2	85	M	Bicycle struck by car	19	3	Acetabular and pubic rami fractures, facial lacerations, abrasions
3	28	F	MVC	25	5	Bilateral vertebral artery dissection
4	26	M	Fall from bull	29	5	Thoracic 1–2 disc herniation
5	41	F	MVC	25	4	Femur fracture
6	70	M	Ground level fall	16	4	—
7	57	M	Bicycle struck by car	25	5	—
8	40	M	MVC	16	4	Closed head injury-minor
9	40	F	Fall from horse	17	4	Left sixth rib fracture
10	17	M	Diving	16	4	—
11	17	M	Football injury	25	5	—
12	59	M	Industrial accident	30	5	Right CCA and ICA artery injury with stroke, mandibular fracture
13	41	M	MVC	48	4	SAH, spinal epidural hematoma, bilateral ptx, bladder rupture
14	72	F	MVC	29	3	Spleen, liver, rib fractures, transected aorta, pelvic fracture
15	27	M	MVC	26	5	—
16	24	F	Diving	16	4	—
17	70	M	MVC	75	6	—

CCA, common carotid artery; ICA, internal carotid artery; SAH, subarachnoid hemorrhage; ptx, pneumothorax; ISS, Injury Severity Score; AIS, Abbreviated Injury Scale; MVC, motor vehicle crash.

[a] Demographic data for individual patients are provided.

Table 3 Anterior Cervical Spine Procedures and Complications[a]

Patient	Initial Operation	Type of Bone Graft	Complications	Reoperation Required?	Follow-Up Length (mo)	Follow-Up Radiographs
1	C, AF	ICBG	—	No	8	Solid fusion
2	Cannulated screw	None	—	Yes (nonunion; PF)	10 and 5	Solid fusion
3	D, AF, and PF	ICBG	—	No	13	Solid fusion
4	C, AF	ICBG	—	No	3	Solid fusion
5	D, AF and PF	ICBG and allograft	—	No	42	Solid fusion
6	C, AF	Autologous and allograft	—	No	Not available; patient died	Not available
7	C, AF	Allograft	—	Yes (graft displaced; PF)	6 and 3	Solid fusion
8	D, AF	ICBG	—	No	12	Solid fusion
9	D, AF	ICBG	Esophageal erosion	Yes; foraminotomy and laminectomy	11	Solid fusion
10	C, AF, and PF	ICBG	—	No	Not available; patient died	Not available
11	C, AF	ICBG	—	No	24	Solid fusion
12	D, AF	ICBG	—	No	21	Solid fusion
13	C, AF	ICBG	Vocal cord paralysis	No	20	Solid fusion
14	D, AF	ICBG	—	No	9	Solid fusion
15	D, AF	ICBG	—	Yes (nonunion, PF)	5	Solid fusion
16	C, AF	ICBG	—	Yes (nonunion, PF)	10	Solid fusion
17	D, AF, and PF	ICBG	—	No	15	Solid fusion

C, corpectomy; D, discectomy; AF, anterior fusion; PF, posterior fusion; ICBG, iliac crest bone graft.

[a] Data regarding cervical spine operations for each patient are provided. The use of tracheostomy for patients with cervical spine injury has been stratified on the basis of ASIA score. The use of tracheostomy was significantly associated with the presence of neurologic deficits ($p < 0.001$).

had a simultaneous posterior fusion performed, and an additional four patients underwent subsequent delayed posterior fusion because of nonunion or impending nonunion. Neurologic deterioration after spine fixation or tracheostomy was not observed. At final follow-up (median, 11 months), radiographs demonstrated satisfactory fusion in all patients (Table 3).

In addition to fracture healing outcomes, we observed similarly favorable outcomes regarding infection rates. No patient developed an infection at the site of anterior cervical fusion after placement of a tracheostomy. Cellulitis at the tracheostomy site occurred in one patient (6%), after percutaneous tracheostomy. This superficial infection resolved with antibiotic treatment.

In contrast, pulmonary complications in this patient cohort were common. Fourteen patients (82%) had culture-proven pneumonia. Eight of seventeen (47%) patients required reintubation after their anterior cervical spine procedure and four patients were readmitted to the ICU with airway problems, before undergoing tracheostomy. There were no deaths directly related to airway difficulties.

One patient died soon after discharge to a nursing facility from an unknown cause, and one further patient died of unrelated causes 2 years after his injury. All other patients remain alive at the time of their last follow-up.

DISCUSSION

From our review, we found that tracheostomy, which was most commonly percutaneous in our series, performed 6 to 10 days after anterior cervical spine fixation did not result in clinically detectable cross-contamination. No patient developed a wound or hardware infection at the anterior spine fixation site after tracheostomy; and as further evidence of satisfactory wound healing, we did not observe late nonunion during follow-up. Our data suggest that cross-contamination from tracheostomy to anterior spinal fixation wounds may not be as prevalent as imagined.

The other major finding of this review was that stratifying patients with cervical spine injury by the ASIA classification system resulted in an association between degree of neurologic injury and the frequency of tracheostomy. We also found that patients with cervical SCI were three times more likely to be managed with tracheostomy than patients without SCI; 45% versus 14%, respectively. To further illustrate this association, in our subgroup of 17 patients, 94% had an associated cervical SCI, with 65% having the more severe ASIA A or B injuries. We observed a strong association between the ASIA classification and the need for tracheostomy. In a study of patients with isolated cervical spine injury treated at a specialized spinal cord unit, Winslow et al. also found that tracheostomy was required more frequently in patients with motor deficits (28%) versus patients without neurologic deficits (3%).[19]

In addition to motor neurologic deficits, further contributing factors producing pulmonary failure in spinal cord injured patients include the level of spinal cord injury, the severity of the acute catabolic illness, associated injuries, and the preexisting condition of the patient. Difficulty clearing bronchial secretions; development of secondary pulmonary or airway infections; and associated brain, thoracic, abdominal, and pulmonary injuries also play a role.[6,7,20] Because of these factors, many patients fail attempts at weaning from mechanical ventilation or extubation. If the patient fails extubation, reintubation can be difficult because of airway edema, distorted cervical anatomy, pharyngeal secretions, and an inability to place the patient in the "sniffing" position.[21–23] Reintubation, often performed urgently, can result in significant morbidity.[24–26] In addition to providing a secure airway, tracheostomy facilitates clearance of bronchial secretions and the weaning of patients from positive-pressure ventilation and improves patient comfort. These multiple factors suggest that airway decisions in these trauma patients are complex and that evidence-based standards or guidelines are lacking.[27–29] Although tracheostomy use in trauma patients has morbidity and is controversial, it may provide distinct benefit for patients with the more severe ASIA A and B cervical spinal cord injuries; these patients are more predisposed to pulmonary complications.[19]

Although major complications and death have been reported subsequent to tracheostomy,[30,31] there were no significant tracheostomy-related sequelae in this series. However, there was notable pulmonary morbidity, which was manifested as high extubation failure (47%) and pneumonia rates (80%) in our subgroup of 17 patients. We believe the combination of this pulmonary morbidity in the setting of motor deficits from cervical SCI justify that the surgeon consider tracheostomy in this selected group.

Although the satisfactory wound outcomes in our cohort of 17 patients does not prove the safety of this approach, to the author's knowledge, there are only two clinical series and a case report that address the issue of potential wound cross-contamination by tracheostomy. Northrup et al. reported outcomes of anterior cervical fusion performed after tracheostomy.[9] Northrup et al. concluded that a previous tracheostomy was not a contraindication for anterior cervical spine operation, because in their series of 11 patients, they did not observe any subsequent cervical wound infections. In a second report, Hubner et al. found that percutaneous tracheostomy inserted a median of 6 days after median sternotomy in their series of 45 patients did not increase sternal wound infection rates.[32] Mazzon et al.[33] reported on a single case of percutaneous tracheostomy performed after anterior cervical spine surgery. The patient's recovery was uneventful. The series in this report is the largest and most comprehensive evaluation of wound outcomes in patients managed by tracheostomy performed after anterior spinal fusion.

As reflected in this and other series, early anterior cervical spine stabilization for patients with motor deficits from spinal cord injury is gaining prominence.[1,2] Other studies have also demonstrated that significant proportions of patients with spinal cord injury will require tracheostomy.[7,34] These reports and our series suggest that this clinical situation, tracheostomy after anterior cervical spine operation, will increase.

Limitations of this study include the small cohort size, the potential for patient selection bias that conceals implicit technical and judgment issues, and its retrospective design. However, because the infection rate after anterior spine fixation is under 1%,[35–37] a single-institution study of adequate power to evaluate the outcomes of tracheostomy after anterior spine fixation would be impractical. Another limitation includes our nonstandardized technical approach to tracheostomy. Because studies have shown reduced infection rates and fewer wound problems for the percutaneous as compared with the open technique,[38–40] the percutaneous approach may offer an additional advantage in patients requiring tracheostomy after recent anterior cervical spine fixation. Despite these limitations, when a surgeon decides tracheostomy is indicated in a patient that has undergone prior anterior spine stabilization, our data support careful performance of percutaneous tracheostomy 6 to 10 days after the anterior spine operation.

CONCLUSION

Patients with cervical spine injury increasingly undergo early anterior decompression and stabilization to improve mobilization and to reduce the risk of pulmonary complications. In this series, we did not observe infection or impaired wound healing of the anterior cervical spine fusion site as a consequence of cross-contamination from the subsequently placed tracheostomy. Most of our patients underwent percutaneous tracheostomy 6 to 10 days after anterior spine fixation. The percutaneous technique of tracheostomy, because it is performed using a small incision and minimal tissue dissection, may be advantageous in this setting. In summary, although the decision to perform tracheostomy in these patients depends on multiple clinical and technical factors, our data support the belief that tracheostomy can be safely performed after anterior cervical spine procedures.

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