Tracheostomy placement in patients with complete cervical spinal cord injuries: American Spinal Injury Association Grade A

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Object. The authors sought to identify variables that predispose patients with acute American Spinal Injury Association (ASIA) Grade A cervical spinal cord injury (SCI) to require tracheostomies for ventilator support or airway protection.

Methods. A retrospective analysis was performed of 178 consecutive patients with a cervical ASIA Grade A SCI who were admitted through the Delaware Valley SCI Center at Thomas Jefferson Hospital during a 6-year period. Exclusion criteria included injury occurring more than 48 hours prior to admission, death within 14 days of admission or nontraumatic SCI. Twenty-two patients were excluded based on these criteria. Parameters evaluated in the remaining population (156 patients) included demographics, cervical vertebral ASIA level, tracheostomy placement, pneumonia, premorbid pulmonary disease, smoking history, evidence of direct thoracic/lung trauma, operative intervention, associated appendicular trauma, and preexisting medical comorbidities.

The ASIA classification of the 156 patients included in this analysis were C-2 (eight), C-3 (11), C-4 (64), C-5 (36), C-6 (20), C-7 (13), and C-8 (four). Tracheostomies were performed in 107 of these 156 patients. Statistical analysis revealed a significant relationship between tracheostomy and patient age (p = 0.0048), preexisting medical conditions (p = 0.0417), premorbid lung disease (p = 0.0177), higher cervical ASIA level (p < 0.0001), and the presence of pneumonia (p < 0.0001). No patient with a C-8 ASIA A injury required tracheostomy, whereas all C-2 and C-3 ASIA A–injured patients underwent tracheostomies. Patients older than 45 years of age with ASIA A levels between C-4 and C-7 more commonly required tracheostomy (p < 0.005) than patients younger than 45 years of age.

Conclusions. Several risk factors were identified that corresponded to the frequent tracheostomy placement in the acute injury phase after complete cervical SCI. Early tracheostomy may be considered in patients with multiple risk factors to reduce duration of stay in the intensive care unit and facilitate ventilatory weaning.

KEY WORDS • cervical spine • tracheostomy • spinal cord injury • respiratory distress

Patients who sustain high cervical SCIs frequently require ventilatory assistance and support during their acute hospitalization and rehabilitation period; however, even patients with lower cervical SCI may require temporary tracheostomy to facilitate weaning from mechanical ventilation and airway protection. Some physicians are reluctant to perform tracheostomies before several attempts at ventilatory weaning and extubation. These attempts can prolong the duration of endotracheal intubation and the patient’s stay in the intensive care unit. In addition, premature endo- or nasotracheal extubation may lead to gradual ventilatory failure, requiring reintubation and “late” tracheostomy. Delayed or late tracheostomies, defined as occurring more than 7 days after intubation, have been associated with increased duration of hospital stay, increased duration of treatment in the intensive care unit, more frequent infectious complications, and a delay in initiating acute rehabilitation.6,12,18,26

The relevant risk factors that influence the requirement for tracheostomy in patients with SCI have not been established. We retrospectively examine a large group of patients with acute complete cervical SCI to ascertain the risk factors that are associated with subsequent tracheostomy. Identification of these risk factors may facilitate earlier tracheostomy to reduce hospital stay and pulmonary complications.

Clinical Material and Methods

During a 6-year period, a total of 3233 consecutive patients with acute spinal cord and spine injuries were evaluated at the Delaware Valley Regional Spinal Cord Injury Center at Thomas Jefferson University Hospital. A subset of 178 consecutive patients with complete cervical SCI (ASIA Grade A) either from penetrating or blunt trauma

Abbreviations used in this paper: ARDS = acute respiratory disease syndrome; ASIA = American Spinal Injury Association; SCI = spinal cord injury.
were identified from the total patient cohort. Patients were excluded from statistical analysis if a tracheostomy was performed while at an outside institution, if there was an associated closed head injury, or if there was evidence of direct airway trauma resulting in airway obstruction. Patients who died within 14 days of admission were also excluded; these patients were critically ill and life support care was withdrawn. Twenty-two patients were excluded from analysis based on these criteria. These included 14 patients who required tracheostomy for management of traumatic head or upper airway injuries (11 closed head injuries [Glasgow Coma Scale score < 10] and three mandible or trachea injuries). In addition, seven patients respiratory and medical care was withdrawn and resulted in death within 2 weeks of the injury. One patient who had undergone a tracheostomy at an outside institution prior to transfer was also excluded. The mean patient age was 38 years (median 33 years), with a range of 13 to 94 years. The mean age of the patients who required tracheostomy was 42 years, which was significantly older than the age of patients who did not require a tracheostomy (mean age 34 years; p = 0.0048).

At admission, patients were independently examined by the SCI team, which consisted of a neurosurgeon, an orthopedic surgeon, and a physiatrist who determined and graded neurological function by using the ASIA classification.1 When appropriate, intravenous methylprednisolone was administered based on the National Acute Spinal Cord Injury Study II protocol.5 Plain radiographs, magnetic resonance imaging, and magnetic resonance angiography were obtained in all patients. All patients were admitted and monitored in a designated SCI intensive care unit. Computerized tomography scanning was performed to define and classify all fractures. Open and/or closed treatment of the cervical spine injuries was performed if indicated. In this large number of patients the decision to proceed to tracheostomy was based independently on the judgment of the attending surgeon caring for that patient. The attending physician was a trauma, neurological, or orthopedic surgeon. There was no detailed protocol or scheme or designation based on which patients were chosen to undergo tracheostomy. Performance and timing of operative procedures was at the discretion of the attending spine surgeon and each attending surgeon based the decision on prior experience in caring for patients with SCI, along with the clinical needs of the patient.

Medical charts, discharge summaries, and imaging studies were individually retrospectively reviewed. Parameters analyzed included patient demographics (age, sex, race), admission ASIA grade of cervical SCI, mechanism of injury, history of tobacco use, the presence of either thoracic/lung trauma or premorbid lung disease (chronic obstructive pulmonary disease, asthma), active pneumonia, ARDS, operative treatment, preexisting medical comorbidities (diabetes mellitus, hypertension, coronary artery disease), and the placement of a tracheostomy. Pneumonia was defined clinically as evidence of increased secretions with positive Gram stain or sputum culture and radiographically demonstrated lung parenchymal consolidation in the presence of a fever (> 101.5°F). Analysis was performed using the Fisher exact, chi-square, and unpaired t-tests with a level of significance designated as a probability value less than 0.05.

Results

One hundred seven (69%) of 156 patients with complete cervical SCI required tracheostomies during acute hospitalization. Other factors identified more commonly in the tracheostomy patients included preexisting medical condition (p = 0.0417), premorbid lung disease (p = 0.0177), rostral ASIA level (p < 0.0001), and pneumonia (p < 0.0001) (Table 1). No significant relationship between tracheostomy and sex, presence of ARDS, history of smoking, direct lung trauma, and operative treatment was observed.

The mean time interval from spine or spinal cord injury to tracheostomy was 7 days, ranging from 2 to 19 days. There was a higher incidence of tracheostomy placement in patients with a more rostral cervical SCI. The majority of the patients (133 of 156) had an ASIA Grade A–classified injury between C-4 and C-7, and 88 of the 107 of the tracheostomies were performed in this group. All patients with C-2 and C-3 ASIA Grade A injuries required tracheostomies, whereas no C-8 ASIA A patient required a tracheostomy. The frequency of tracheostomy procedures stratified by ASIA motor level is detailed in Table 1.

One hundred patients required a surgical decompression and/or stabilization procedure due to the presence of symptomatic cord compression and instability. Thirty-three patients underwent an anterior procedure, 32 underwent a posterior procedure, and 35 underwent both an anterior and posterior spinal procedure. The operative treatment or surgical approach to the spinal fractures and injuries was not found to be a risk factor for placement of a tracheostomy.

Discussion

Approximately 10% of patients who remain ventilator-dependent on a long-term (> 24-hour) basis in the intensive care unit require tracheostomy.15 Long-term ventilator dependence is common in patients with cervical SCI because of frequent respiratory complications as well as the need for enhanced oxygenation to the spinal cord.6,9 Additionally, pulmonary complications are the most common cause of death in patients with acute tetraplegia.5,8 Bellamy, et al.,2 reported that 77% of patients with complete quadriplegia underwent tracheostomy. This correlates with our reported patient population in which 69% of patients with a cervical ASIA Grade A required tracheostomy for pulmonary support and weaning or airway protection. Despite this high rate of tracheostomy place-

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### Table 1

<table>
<thead>
<tr>
<th>ASIA Level</th>
<th>No. of Patients</th>
<th>No. of Tracheostomies (%)</th>
<th>Age &gt;45 Yrs</th>
<th>Pneumonia</th>
<th>Co-morbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-2</td>
<td>11</td>
<td>11 (100)</td>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>C-3</td>
<td>12</td>
<td>11 (100)</td>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>C-4</td>
<td>64</td>
<td>52 (81)</td>
<td>22</td>
<td>40</td>
<td>21</td>
</tr>
<tr>
<td>C-5</td>
<td>36</td>
<td>23 (64)</td>
<td>8</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>C-6</td>
<td>20</td>
<td>9 (45)</td>
<td>7</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>C-7</td>
<td>13</td>
<td>4 (3)</td>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>C-8</td>
<td>4</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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ventilatory support. Kollef, et al., illustrated that decrease the work of breathing and, therefore, shorten the period of ventilation. Tracheostomies have been reported to reduce the distance, thereby facilitating easier weaning from mechanical ventilation. Improved pulmonary toilet and decreased airway resistance also limits patient mobilization because of the presence of an “unsecure” airway, along with the necessity of the accompanying ventilator tubing. Endotracheal or nasotracheal intubation may play a role in delaying emotional recovery from a catastrophic spinal cord injury.

Tracheostomies offer several advantages over either naso- or endotracheal intubation. There is a physically reduced respiratory circuit length because of the bypass of the oro- and nasopharynx. Tracheostomy provides for improved pulmonary toilet and decreased airway resistance, thereby facilitating easier weaning from mechanical ventilation. Tracheostomies have been reported to reduce the work of breathing and, therefore, shorten the period of ventilatory support. Endotracheal or nasotracheal intubation also limits patient mobilization because of the presence of an “unsecure” airway, along with the necessity of the accompanying ventilator tubing. Endotracheal or nasotracheal intubation may play a role in delaying emotional recovery from a catastrophic spinal cord injury.

Tracheostomy also provides a psychological advantage for the patient because it enables the patient to mouth words and allows for phonation when converted to a fenestrated tracheostomy. In patients with neurologic injuries, tracheostomies placed prior to Day 4 of intubation were shown to have improved both medical and emotional outcomes and conditions. Early tracheostomy has also been shown to decrease the incidence of pneumonia. Increased mobility afforded by the tracheostomy improves the rate of transfer from an intensive care setting to an intermediate care facility and eventually a rehabilitation center. Although there are great advantages with the placement of a tracheostomy, it is an invasive surgical procedure and these advantages have to be weighed against potential morbidities. Meade reviewed 212 cases and illustrated multiple morbidities such as subcutaneous emphysema, pneumothorax, hemorrhage, and difficulty with cannula placement.

As a patient ages the baseline pulmonary vital capacity, compliance, and protective respiratory reflexes are diminished. Increasing age alone has been associated with reduced long-term survival in spinal cord–injured patients, along with a greater than twofold increase in the incidence of pneumonia. The combination of compromised pulmonary reserve with aging and the loss of the accessory muscles of respiration (thoracic muscles) after severe cervical SCI makes weaning the patient from the ventilator more difficult. This was highlighted in our analysis in which patients older than age 45 years had a greater likelihood of undergoing tracheostomy (p = 0.0048). Similarly, Ross, et al., identified age as a predictor for required mechanical ventilation in their retrospective analysis of trauma patients.

As a result of a complete cervical SCI, patients lose motor innervation to the thoracic muscles that regulate pulmonary inspiration and expiration. The diaphragm therefore becomes the main respiratory muscle as it is innervated by the phrenic nerve, which is composed of the C3–5 ventral nerve roots. Patients with a more rostral cervical SCI (C3–5) have some degree of compromise to diaphragmatic function due to diminished phrenic nerve motor efferent supply. Overall, a cephalad complete SCI level (above C-5) results in a decreased tidal volume and inability to clear secretions. Therefore, a more rostral cervical SCI is associated with a greater frequency of need for tracheostomy for pulmonary support. In this series, all C-2 or C-3 ASIA Grade A–injured patients required tracheostomy, whereas no patient with a C-8 ASIA Grade A injury underwent tracheostomy during the hospital course. Overall, a higher cervical SCI was associated with an increased frequency of tracheostomy placement (p < 0.0001). Similarly, Claxton, et al., also showed that a neurological level at C-5 or above was an independent predictor for the requirement of mechanical ventilation.

Although tracheostomy reduces respiratory circuit length and improves suctioning effectiveness, it does not alter underlying pulmonary parenchyma dysfunction or disease. Patients with preexisting lung disease such as chronic obstructive pulmonary disease or asthma required tracheostomies more frequently than patients without pulmonary dysfunction (p = 0.018). Interestingly, however, there was not an association between tracheostomy and ARDS, tobacco use, or direct lung trauma.

Cervical SCI or other neurological dysfunction has been associated with an increased risk of early onset pneumonia, possibly due to an inability to clear secretions and protect the airway. For example, pneumonia, defined as a pulmonary infiltrate demonstrated on radiographs and associated with fever, secretions, and a positive respiratory culture, strongly correlated with placement of tracheostomy in this analysis (p < 0.0001). Most likely, an active respiratory infection limits the reserve capacity of the injured pulmonary system, which has already been acutely impaired by severe SCI. These patients with pneumonia also have impaired strength of coughing, resulting in difficulty clearing secretions and difficulty with ventilator weaning.

In summary, all patients with C-2 and C-3 ASIA Grade A SCI required tracheostomy, whereas no patient with a C-8 ASIA A injury underwent a tracheostomy. It is more difficult to predict the necessity of tracheostomy in patients with ASIA Grade A injuries between C-4 and C-7.
Tracheostomy and cervical SCI

C-8 ASIA A injury underwent a tracheostomy. It is more difficult to predict the necessity of tracheostomy in patients with ASIA Grade A injuries between C-4 and C-7. Identified risk factors predisposing to the need for tracheostomy in patients with complete cervical SCIs include, patients older than 45 years of age, a previous pulmonary impairment or preexisting comorbid medical problems (diabetes mellitus, hypertension, coronary artery disease), and active pneumonia. Early tracheostomy should be considered in these high-risk patients, because it may facilitate pulmonary care and ventilatory weaning in patients predisposed to prolonged endotracheal intubation.

References


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