Dysphagia and Associated Respiratory Considerations in Cervical Spinal Cord Injury

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Background: Dysphagia is a relatively common secondary complication that occurs after acute cervical spinal cord injury (SCI). The detrimental consequences of dysphagia in SCI include transient hypoxemia, chemical pneumonitis, atelectasis, bronchospasm, and pneumonia. The expedient diagnosis of dysphagia is imperative to reduce the risk of the development of life-threatening complications. **Objective:** The objective of this study was to identify risk factors for dysphagia after SCI and associated respiratory considerations in acute cervical SCI. **Methods:** Bedside swallow evaluation (BSE) was conducted in 68 individuals with acute cervical SCI who were admitted to an SCI specialty unit. Videofluroscopy swallow study was conducted within 72 hours of BSE when possible. **Results:** This prospective study found dysphagia in 30.9% (21 out of 68) of individuals with acute cervical SCI. Tracheostomy ($P = .028$), ventilator use ($P = .012$), and nasogastric tube ($P = .049$) were found to be significant associated factors for dysphagia. Furthermore, individuals with dysphagia had statistically higher occurrences of pneumonia when compared with persons without dysphagia ($P < .001$). There was also a trend for individuals with dysphagia to have longer length of stay ($P = .087$). **Conclusion:** The role of respiratory care practitioners in the care of individuals with SCI who have dysphagia needs to be recognized. Aggressive respiratory care enables individuals with potential dysphagia to be evaluated by a speech pathologist in a timely manner. Early evaluation and intervention for dysphagia could decrease morbidity and improve overall clinical outcomes. **Key words**: *dysphagia, respiratory complications, spinal cord injuries, tetraplegia*

Dysphagia, swallowing dysfunction, following traumatic cervical spinal cord injury (SCI) is an under-recognized complication that can lead to significant medical complications and morbidity. In a prospective study by Shem et al, the incidence of dysphagia in individuals with tetraplegia was as high as 40%.[1] It is imperative to diagnose dysphagia early to initiate timely evaluation and treatment by speech pathologists and to prevent possible secondary pulmonary complications that can result from aspiration, which is a sequelae of dysphagia. The most common pulmonary complications of dysphagia are airway obstruction, chemical pneumonitis, and pneumonia.[2]

Swallowing serves 2 important roles. It serves an alimentary role for nutrition. A vital, but likely underappreciated, function involves clearing the nasopharynx and oropharynx and the subsequent coordination to close the nasopharynx and larynx to prevent aspiration.[3,4] Aspiration is the entry of material (such as oral secretions, food or drink, or stomach contents) from the oropharynx or gastrointestinal (GI) tract into the respiratory tract. The act of normal swallowing involves the extraordinary coordination and sequencing of more than 25 pairs of muscles in the mouth, pharynx, larynx, and esophagus.[5] As classically described by Logemann et al,[6] there are 3 phases to the swallowing process: oral, pharyngeal, and esophageal. The oral preparatory phase is under voluntary control and involves the formation of an alimentary bolus from the food consumed. The pharyngeal and esophageal phases, once initiated, are involuntary and irreversible. The pharyngeal phase is the shortest but most complex phase of swallowing, with several key events occurring simultaneously. This phase is initiated when the tongue and suprahyoid muscles propel the food bolus from the oral cavity into the pharynx. Soft palate elevation occurs to prevent nasopharyngeal regurgitation. The larynx moves to an elevated position, with an excursion approximately the distance of 1 cervical vertebra and half the length of the jaw. The epiglottis moves to a retroflexed position. The upper esophageal sphincter dilates to receive the food bolus, which transitions to

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the esophageal phase. The food bolus is propelled via peristalsis from cricopharyngeus to lower esophageal sphincter. Upon reflex relaxation of the lower esophageal sphincter, food enters the stomach.

Dysphagia and Aspiration

Dysphagia increases the risk for aspiration, which is defined as passage of material from the oropharynx into the larynx below the true vocal folds as a result of swallowing dysfunction due to altered anatomic or neurologic states. Aspiration is the primary clinical concern of dysphagia, as it can lead to pulmonary complications. As mentioned previously, the normal process of swallowing prevents aspiration of contents from the oropharynx or GI tract into the respiratory tract. The clinical signs of dysphagia can be identified by clinical history as well as during bedside swallowing evaluation (BSE) and diagnostic swallowing studies. Patients may present with any combination of the following signs and symptoms of aspiration that should increase the index of suspicion for dysphagia: watery eyes during/following meals, runny nose during/following meals, decreased excursion of larynx with either palpitation and/or observation, uncoordinated laryngeal movement with either palpitation and/or observation, audible swallow, wet vocal quality during/following meals, coughing or choking during meals, clearing of throat after completing a swallow, drooling, weight loss as a result of apprehension or aversion to eating, and unexplained, recurrent respiratory tract infections.

Swallowing Dysfunction After SCI

Patients with cervical SCI in the acute period are at very high risk of pulmonary complications, which can occur within hours as a sequela of the neurologic impairment of the muscles of respiration and the autonomic changes that ensue after SCI.[7] Respiratory failure occurs in individuals with SCI despite optimal respiratory care due to these primary neurologic changes and the subsequent cascade of pulmonary events that increases overall work of breathing.[7] Dysphagia and risk for aspiration are increased in patients with cervical SCI. If aspiration occurs, coughing will clear the respiratory tract in physiologically normal, able-bodied individuals. This protective cough reflex is often disrupted by medical conditions and neurologic weakness common to individuals with SCI.[1] The majority of the dyphagia in SCI occurs in the pharyngeal stage of swallowing.

Oftentimes, patients with traumatic cervical SCI undergo operative management in the immediate acute period with anterior spinal surgery, posterior spinal surgery, or both. Spinal surgery, the anterior approach in particular, is a known risk factor for dysphagia.[8,9] Anatomically, the pharynx and esophagus are anterior to the vertebrae. Surgical hardware applied anteriorly occupies a portion of this anatomical space, thereby causing some degree of mechanical compression to the pharynx or esophagus and altering the pressures during the respective phases of swallowing. Additionally, anterior neck muscles involved in swallowing may be manipulated during the surgery, such that they become swollen, stretched, or lose their anatomic position that supported the act of swallowing. Sensation also appears to be impaired, with patients not feeling the food or liquid residuals in the valleculae and pyriform sinuses. The recurrent laryngeal nerve, which innervates all intrinsic neck muscles except the cricothyroid, is at risk of injury during cervical spine surgery, particularly via the anterior approach.[10] Injury to the recurrent laryngeal nerve can present as hoarseness, other voice changes, and/or dysphagia.[11]

Dysphagia Considerations in Respiratory Management

During clinical evaluation of a patient with cervical SCI, it is imperative that there is close communication and coordination of care between the physician, speech-language pathologist (SLP), and respiratory care practitioner (RCP) to optimize outcomes and minimize medical complications. Aspiration precautions are instituted at Santa Clara Valley Medical Center, San Jose, California, for all individuals with cervical SCI whether or not they undergo spinal intervention; specifically,

patients do not receive any oral feeding or cuff deflation prior to a dysphagia evaluation by a licensed SLP. Additionally, all patients are placed on an aggressive pulmonary toileting regimen that consists of a combination of bronchodilators, mucolytics, high tidal volume ventilation, mechanical insufflator-exsufflator (coughalator), intrapulmonary percussive ventilation (IPV), intermittent positive pressure breathing (IPPB), and/or EzPAP (Smiths Medical, Keene, New Hampshire) lung expansion therapy.

Secretion management is a prerequisite for a dysphagia evaluation. Poor secretion management leads to pulmonary congestion, which could progress to atelectasis and subsequently to pneumonia if not managed adequately. As a result, the patient may be too congested to vocalize or swallow as a result of increased work of breathing. Performing a dysphagia evaluation has inherent risks of possible aspiration, whether it be clinically apparent or clinically silent. If a dysphagia evaluation is performed on a patient who has poor secretion management, it would be difficult to discern whether any subsequent pulmonary complications that ensue are a result of an aspiration event or due to a primary pulmonary cause.

If the patient has any risk factors for dysphagia, speech swallowing evaluation would need to be performed before cuff deflation could occur for initiation of speaking valve and/or progressive ventilator-free breathing. However, evaluation of dysphagia cannot be initiated until secretion management has been optimized by the aforementioned pulmonary management measures. Aggressive pulmonary management measures have been shown to improve outcomes in SCI.[12] Stabilization of the patient's respiratory status by appropriate aggressive respiratory care interventions that have been proven effective for the cervical SCI patient allows the SLP the opportunity to perform the dysphagia evaluation. Enabling the ventilated or tracheostomized SCI patient to vocalize early in the rehabilitation course is important for multiple reasons: (1) It minimizes isolation and any frustration that is associated with the patient's inability to communicate, thereby improving overall mood and socialization; and (2) it optimizes the interaction with medical and rehabilitation providers of the interdisciplinary team during the acute rehabilitation course.

Risk Factors and Clinical Management for Dysphagia

As early as 1905, physicians from all specialties have been studying dysphagia and associated risk factors.[13] Over the last 2 decades, there has been an increasing amount of focus placed on the unique factors associated with increased risk of dysphagia after SCI.[14-16] Kirshblum et al reported tracheostomy, mechanical ventilation, anterior cervical spine surgery, and age were significant factors associated with dysphagia. [14] Shem et al reported similar significant risk factors associated with dyphagia and also identified nasogastric (NG) tubes as an additional risk factor. Other reported risk factors that circumstantially place patients with cervical SCI at higher risk of aspiration include the presence of a halo or cervical orthoses, supine position, impaired GI motility, other GI medical conditions that could potentiate nausea/vomiting, and inability to turn head to spit out regurgitated material.

Cervical Spine Surgery

Postoperative dysphagia after anterior cervical spine surgery has been well-established as a significant risk factor.[8,17-21] However, the exact mechanism of how the surgery causes dysphagia is not as clearly defined. Apfelbaum et al[22] postulated that direct surgical trauma, neuropraxia from nerve traction, and postoperative edema lead to postoperative dysphagia. During surgical instrumentation via the anterior approach, there is possible interruption of motor/sensory innervation of the recurrent laryngeal nerve from dissection and retraction of the larynx and pharynx and also alteration of the organization of the muscular structures involved in swallowing. Furthermore, these same patients have also been noted to be at risk for silent aspiration, likely related to the nerve injury described. [8,17-21] There have been various retrospective studies discussing the duration and resolution of postoperative dysphagia. Bazaz et al performed one of the first

prospective studies and noted a trend toward resolution over 2 to 6 months after surgery.[8]

Tracheostomy

Tracheostomy tubes are commonly placed in individuals with cervical SCI to facilitate mechanical ventilation; however, this can adversely affect swallowing function. The causes of aspiration include abnormal anterior-superior movement of the larynx, reduced subglottic pressure, impaired laryngeal closure reflexes, and alterations of the oral, pharyngeal, and esophageal stages of swallowing.[23] Tracheostomy tube cuff should remain inflated until secretion management has been optimized and swallow evaluation by SLP suggests no risk for aspiration. There has been a common misconception that any risk of aspiration is entirely eliminated as long as a tracheostomy cuff is fully inflated; however, it has been identified in the literature that there is still risk for leakage of secretions around an inflated cuff.[24,25] Therefore, it is important to consult the SLP early to evaluate a patient for dysphagia. The type of tracheostomy tube and associated cuff also determine the degree to which an inflated cuff can minimize, not altogether avoid, the risk for aspiration by forming a better seal. Doyle et al report that a low volume, low pressure cuff is more protective in preventing secretion leakage around the cuff than a high volume, low pressure cuff.[26]

Nasogastric Tubes

Nasogastric tubes are often employed in the acute care setting for SCI for GI decompression and have been associated with increased risk for dysphagia.[15] The NG tube itself interferes with the process of swallowing, as it passes through the lumen of the pharynx, while also producing increased oral secretions. There is also the inherent risk that the enteral nutrition delivered by the NG tube can be regurgitated; patients with paralysis and mechanical ventilation are particularly at high risk.[27] Even in able-bodied individuals, NG tubes lead to increased risk of aspiration due to "(1) loss of anatomical integrity of the upper and lower esophageal sphincters, (2) increase in the frequency of transient lower esophageal sphincter relaxations, and (3) desensitization of the pharyngoglottal adduction reflex."[28(p327)] With placement of the tube, proper position needs to be confirmed prior to starting any enteral nutrition as there is risk for perforation, tracheobronchial location, laryngeal ulcerations, and tracheoesophagic fistula.[29] If there is expected prolonged need for nutritional support (greater than a month) in a patient, consideration should be given to a percutaneous endoscopy gastrostomy tube.

One-way Speaking Valve

A one-way speaking valve, originally designed with the intent to facilitate communication by redirecting airflow through the vocal cords for phonation, has been reported to improve swallowing function in patients with a tracheostomy and thereby decrease the incidence of aspiration.[30,31] The mechanism by which this occurs has been attributed to a change in subglottic pressure that is lost with placement of a tracheostomy. The subglottic airway is a region of the larynx surrounded by the cricoid cartilage. Mechanoreceptors in the subglottic region have been identified and are believed to communicate with centers in the cortex and brainstem, whereby signals are then relayed to stimulate activation of the pharyngeal and laryngeal muscles, which constrict and build up subglottic pressure to facilitate swallowing.[30] It has been the experience at Santa Clara Valley Medical Center that the use of a one-way speaking valve has improved the overall physiology of swallowing, likely explained by restoration of subglottic pressure, which is absent in an open tracheostomy arrangement. To allow greater translaryngeal flow for vocalization, a silicone tracheostomy tube, with an invisible cuff profile when completely deflated, is utilized in our SCI specialty unit. The additive effect of communication, improvement in respiratory physiology, and trend toward normalization of swallowing physiology has improved outcomes in the SCI population with shorter acute care length of stay, earlier communication, and shorter time to tracheostomy decannulation.[32]

Dysphagia Evaluation

When assessing the swallowing capabilities of a ventilator-dependent patient, an RCP and an SLP work together to ensure a safe evaluation. The RCP will administer interventions such as high frequency percussive ventilation therapy, mechanical insufflation–exsufflation treatments, and tracheal suctioning to clear any pulmonary secretions from the airways. The RCP will slowly deflate the tracheostomy cuff and may slowly increase the ventilator tidal volume to compensate for some tidal volume loss with the deflated tracheostomy cuff. Any tracheal secretions that may have occurred above the tracheostomy cuff that may enter the lower airways will be removed by tracheal suctioning by the RCP. The SLP will conduct BSE, which has been described in an article by Shem et al.[33]

BSE should be the preferred diagnostic method for dysphagia in individuals with cervical SCI as it can be performed expediently by an SLP at the patient's bedside. During the BSE, individuals with SCI can be examined on regular beds or in wheelchairs; positioning depends on spine precautions such as halo vest, soft/hard collars, and head of bed no greater than 30° limitations. In addition to interpreting the patient's swallowing ability, the SLP can decide when the patient should be suctioned and when/if the cuff should be deflated during BSE. The SLP and RCP have an option of using a one-way speaking valve (Passy-Muir valve) to determine whether the added back-pressure that the valve provides can help prevent aspiration.

The SLP identifies a patient as having "dysphagia" if the SLP observes overt signs of aspiration such as coughing, choking, or liquid/food present in or around tracheostomy stoma and/or a wet vocal quality after drinking. Other signs of dysphagia that the SLP will look for are runny nose, watery eyes, and limited or uncoordinated laryngeal movement during the BSE. Individuals who have a negative finding with the BSE can be placed on a regular diet. However, if these individuals have positive findings with the BSE, the SLP will place them on modified diets or recommend no oral nutrition. The RCP will monitor oxygen saturations and peak airway pressures on the ventilator and will provide tracheal suction as needed throughout the entire swallow evaluation procedure. Upon completion of the evaluation, the RCP will reset the ventilator settings the patient was on prior to the evaluation and reinflate the tracheostomy cuff. Breath sounds will be evaluated to determine whether there are any changes in contrast to the patient's breath sounds prior to the swallow evaluation procedure.

Methods

To determine the incidence and risk factors of dysphagia and assess associated respiratory considerations in SCI, we conducted BSE in individuals with acute SCI who were admitted to our SCI specialty unit. Videofluroscopy swallow study (VFSS) was conducted within 72 hours of BSE when possible. Individuals with acute SCI, admitted to the acute inpatient rehabilitation program at our facility, were recruited consecutively. The inclusion criteria were individuals at least 18 years old with tetraplegia who were medically stable to participate in BSE initially and expected to be able to participate in VFSS subsequently and who signed an informed consent and Health Insurance Portability and Accountability Act of 1996 (HIPAA) privacy documents. Individuals who were excluded were orally or nasally intubated and/or had known preinjury swallowing dysfunction.

Demographic data of the subjects included the level of injury based on International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI); age; premorbid diagnosis such as osteophytes, gastroesophageal reflux disease, and lung diseases; presence of and type of cervical collar; intubation at admission; tracheostomy; approach for surgical spine fusion; and use of halo vest or other cervical orthosis. In this study, every individual with acute SCI who was admitted to our SCI rehabilitation unit underwent a BSE as soon as he or she became capable of participating in BSE.

Results

Sixty-eight individuals with tetraplegia (57 males and 11 females) were enrolled in the study. Average age of the subjects was 43 years old (*SD* 17.2). Their ethnicities were Caucasian (n=42; 61.8%), Hispanic (n=11; 16.2%), Asian (n=9; 13.2%), African American (n=3; 4.4%), Indian (n=2; 2.9%), and other (n=1; 1.5%). Forty-nine (72%) had high cervical tetraplegia (C4 or higher) and 19 (28%) had lower cervical tetraplegia. Twenty-eight subjects had a complete injury and 40 patients were identified as incomplete. The numbers of SCI level of injuries were as follows: C1 complete (n=2), C2 complete (n=6), C3 complete (n=14), C4 complete (n=6), C4 incomplete (n=21), C5 incomplete (n=10), C6 incomplete (n=4), C7 incomplete (n=3), and C8 incomplete (n=2). Etiologies of SCI were motor vehicle accident (n=18; 26.5%), fall (n=13; 19.1%), diving (n=9; 13.2%), bicycle accident (n=5; 7.4%), gunshot wound (n=5; 7.4%), motorcycle accident (n=4; 5.9%), medical (n=4; 5.9%), myelopathy (n=4; 5.9%), trauma (n=4; 5.9%), and other (n=2; 2.9%). In terms of cervical spine surgery, 25 subjects (36.8%) had anterior surgery only, 15 (22.1%) had posterior spine surgery only, 18 (26.5%) had both anterior and posterior spine surgeries, and 10 subjects (14.7%) had no spine surgery. Three subjects had a halo vest immobilization. The average number of days to admission was 25 days (*SD* 35.9). A tracheostomy tube was present in 35 (51.5%) patients, and 33 (48.5%) subjects were on mechanical ventilation with one additional subject being on noninvasive positive pressure ventilation (Bi-PAP). Among the individuals who had a tracheostomy tube, 15 subjects (42.9%) were using Shiley tubes, 18 subjects (51.4%) were using Bivona tubes, and 2 (5.7%) were using a Portex tube. Four subjects had NG tubes. The subjects were at our facility on average 41.4 days (range, 7-98 days; *SD* 18.7) prior to being discharged to home. Comorbid conditions noted at the time of SCI were brain injury (n=24; 35.3%), diabetes mellitus (n=5; 7.4%), gastroesophageal reflux disease (n=5; 7.4%), and osteoarthritis (n= 4; 5.9%). None of the subjects had other comorbid conditions that could be potential risk factors for dysphagia such as prior history of esophageal dilation and prior radiation treatment to the neck area. At the time of admission, subjects were 25 days from their date of injury on average (*SD* 35.9).

All 68 subjects underwent BSE, but 35 (51.5%) subjects did not complete the VFSS due to refusal (n = 34; 97.1%) or intolerance (n = 1; 2.9%). The average number of days from the date of injury to BSE was 31.8 days (range, 3-275 days; *SD* 37.8). VFSS was conducted on average 1.39 days (*SD* 1.17) after the initial BSE. Twenty-one subjects (30.9%) were diagnosed as having dysphagia based on the BSE results. Among the subjects who completed the VFSS, 14 (42.4%) were diagnosed with dysphagia and 4 subjects (12.1%) were diagnosed with aspiration. Of the 21 subjects who completed the VFSS, 3 subjects were diagnosed as not having dysphagia when dysphagia was diagnosed by the BSE. None of the subjects who were diagnosed as not having dyphagia by the BSE were diagnosed as having dysphagia by the VFSS.

Possible risk factors for dysphagia such as surgery, collar, mechanical ventilation, and tracheostomy were evaluated (**Table 1**). There was no statistical significance with regard to gender ($P = .32$), presence of head injury ($P = .38$), high versus low tetraplegia ($P = .27$), complete injury or not ($P = .38$), presence of a halo ($P = .17$), anterior spine surgery ($P = .35$), or presence of collar ($P = .87$) as risk factors for dysphagia. Dysphagia was diagnosed in 15 out of 33 of subjects (45%) on the ventilator versus 6 out of 35 subjects (17.1%) not on the ventilator, which proved to be statistically significant ($P = .012$). The presence of tracheostomy was a statistically significant risk factor for dysphagia ($P = .028$), with 15 out 35 subjects (42.9%) with tracheostomy tubes having dysphagia versus only 6 out of 33 subjects (18.2%) without tracheostomy tubes having had dysphagia. Three out of the 4 subjects who had NG tubes were diagnosed with dyphagia ($P = .049$). There was a statistical trend associated between dysphagia and age ($P = .081$).

The effect of dysphagia on medical complications was also examined. Individuals with dysphagia had statistically higher occurrences of pneumonia (56%) compared with those without dysphagia (16.7%; $P < .001$). There was no significant

Table 1. Summary of individuals with and without dysphagia

	With dysphagia	Without dysphagia	*P*
Total number of subjects	21	47	
Age	48.6±18.4	40.2±16.2	.081
Male	15	38	
Female	2	9	
Length of stay, days	47.9±20.8	38.7±17.0	.087
Days to BSE	28.9±17.6	33.1±44.1	.569
Subjects with pneumonia	14	11	<.001
Subjects with bronchosocopy	4	4	.225
Subjects with reintubation	3	2	.143
Subjects on mechanical ventilation	15	18	.012
Subjects with tracheostomy	15	20	.028
Subjects with nasogastric tube	3	1	.049
Subjects with halo vest	2	1	.17
Subjects with high tetraplegia	17	32	.275
Subjects with complete injury	7	21	.38
Subjects with brain injury	9	15	.383
Subjects with collar	12	30	.876

Note: BSE = bedside swallow evaluation.

difference in those with or without dysphagia on need to undergo bronchoscopy ($P = .23$) or the rate of re-intubation ($P = .14$). There was a trend for individuals with dysphagia to have a longer length of stay (47.9 days ± 20.8 days vs 38.7 days ±17.0 days; $P = .087$).

Discussion

The incidence of dysphagia in acute cervical SCI is relatively high at around 40% to 30% in this study.[1,15] The Consortium of Spinal Cord Medicine has published recommendations for assessment of dysphagia after acute SCI in the Clinical Practice Guidelines on Respiratory Management Following Spinal Cord Injury.[34] Following are the risk factors for dysphagia that were identified in the guidelines: spine position, spinal shock, gastric reflux, gastroparesis, anterior cervical spinal surgery, presence of a tracheostomy, medications that cause gastric motility and/or cause nausea/vomiting, and advanced age. Associated risk factors of dysphagia that were identified in this study are tracheostomy, ventilator dependence, and NG tube. We cannot confirm causal relationship between dysphagia and tracheostomy, ventilator dependence, and NG tube; the individuals with SCI who have one of these factors may be "sicker" patients who required these interventions. However, the individuals who had dysphagia were at a much higher risk of pneumonia (56% vs 17%) and tended to stay longer in the hospital compared with those without dysphagia (48 days vs 39 days). Therefore, pulmonary management in individuals with SCI with dysphagia is of paramount importance to prevent morbidity.

A study has demonstrated the effectiveness of high tidal ventilation, high frequency percussive ventilation therapy, mechanical insufflation–exsufflation treatments, and lung expansion interventions in the respiratory management in cervical SCI.[35] If the pulmonary status of the patient is not stabilized and a swallow evaluation is performed, this could clinically confuse the assessment. Is the pulmonary inflammation and congestion due to the neurological weakness/paralysis of the protective properties of the respiratory muscles, suboptimal respiratory management of individuals with cervical SCI, or dysphagia? The specialized respiratory management that is administered in our SCI specialty unit has demonstrated improvement in patient's respiratory status as quickly as within 1 week after admission. This respiratory

stabilization allows for a swallow evaluation to be performed expediently. With early detection of dysphagia, proper airway protection measures are implemented. Protection of the airway protocol is used while the patient is moved forward in their rehabilitation goals.

Conclusions

The identification and treatment of dysphagia should be coordinated concomitantly and closely in the context of the pulmonary management. The interdisciplinary team, consisting of an RCP and an SLP preferably certified in the area of swallowing disorders, plays a key role in the overall success and outcomes of individuals with SCI with high respiratory needs. There is a complex interplay, often underappreciated, between the pulmonary management and dysphagia management of an individual with SCI. Critical clinical decisions, such as when and what to feed a patient with acute SCI, should be made carefully on the basis of whether there is any dysphagia.

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REFERENCES

1. Shem K, Castillo K, Wong S, Chang J. Dysphagia in individuals with tetraplegia: incidence and risk factors. *J Spinal Cord Med.* 2011;34:85-92.
2. Palmer JB, Drennan JC, Baba M. Evaluation and treatment of swallowing impairments. *Am Fam Physician.* 2000;61(8):2453-2462.
3. Jean A. Brain stem control of swallowing: neuronal network and cellular mechanisms. *Physiol Rev.* 2001;81:929-969.
4. Matsuo K, Palmer JB. Anatomy and physiology of feeding and swallowing: normal and abnormal. *Phys Med Rehabil Clin N Am.* 2008;19(4):691-707.
5. Cunningham ET Jr, Donner MW, Jones B, Point SM. Anatomical and physiological overview. In: Jones B, Donner MW, eds. *Normal and Abnormal Swallowing. Imaging in Diagnosis and Therapy.* Berlin: Springer-Verlag; 1991:7-32.
6. Dodds WJ, Stewart ET, Logemann JA. Physiology and radiology of the normal oral and pharyngeal phases of swallowing. *Am J Roentgenol.* 1990;154(5):953-963.
7. Berlly M, Shem S. Respiratory management during the first five days after spinal cord injury. *J Spinal Cord Med.* 2007;30(4):309-318.
8. Bazaz R, Lee MJ, Yoo JU. Incidence of dysphagia after anterior cervical spine surgery: a prospective study. *Spine.* 2002;27:2453-2458.
9. Smith-Hammond CA, New KC, Pietrobon R, Curtis DJ, Scharver CH, Turner DA. Prospective analysis of incidence and risk factors of dypshagia in spine surgery patients: Comparison of anterior cervical, posterior cervical, and lumbar procedures. *Spine.* 2004;29(13):1441-1446.
10. Hollinshead WH. *Anatomy for Surgeons. 3rd ed. Vol 1: The Head and Neck.* Philadelphia: Lippincott; 1982:443-440.
11. Ebraheim NA, Lu J, Skie M, et al. Vulnerability of the recurrent laryngeal nerve in the anterior approach to the lower cervical spine. *Spine.* 1997;22:2664-2667.
12. Wallbom A, Naran B, Thomas E. Acute ventilator management and weaning in individuals with high tetraplegia. *Top Spinal Inj Rehabil.* 2005;10:3:1-7.
13. Mosher HP. Exostosis of the cervical vertebrae as a cause for difficulty in swallowing. *Laryngoscope.* 1926;36:181-182.
14. Kirshblum S, Johnston MV, Brown J, O'Connor KC, Jarosz P. Predictors of dysphagia after spinal cord injury. *Arch Phys Med Rehabil.* 1999;80(9):1101-1105.
15. Shem K, Castillo K, Wong SL, Chang J, Kolakowsky-Hayner S. Dysphagia and respiratory care in individuals with tetraplegia: incidence, associated factors, and preventable complications. *Top Spinal Cord Inj Rehabil.* 2012;18(1):15-22.
16. Wolf C, Meiners TH. Dysphagia in patients with acute cervical spinal cord injury. *Spinal Cord.* 2003;41(6):347-353.
17. Brown JA, Havel P, Ebraheim N, Greenblatt SH, Jackson WT. Cervical stabilization by plate and bone fusion. *Spine.* 1998;13(3):236-240.
18. Frempong -Boadu A, Houton JK, el al. Swallowing and speech dysfunction in patients undergoing anterior cervical discectomy and fusion: a prospective, objective preoperative and postoperative assessment. *J Spinal Disord Tech.* 2002;15(5):362-368.

19. Winslow CP, Winslow TJ, Wax MK. Dysphonia and dysphagia following the anterior approach to the cervical spine. *Arch Otolaryngol Head Neck Surg.* 2001;127:51-55.
20. Stewart M, Johnston RA, Stewart I, Wilson JA. Swallowing performance following anterior cervical spine surgery. *Br J Neurosurg.* 1995;9:605-609.
21. Vanderveldt HS, Young MF. The evaluation of dysphagia after anterior cervical spine surgery: a case report. *Dysphagia.* 2003;18(4):301-304.
22. Apfelbaum RI, Kriskovich MD, Haller JR. On the incidence, cause, and prevention of recurrent laryngeal nerve palsies during anterior cervical spine surgery. *Spine.* 2000;25:2906-2912.
23. Eibling DE, Gross RD. Subglottic air pressure: a key component of swallowing efficiency. *Ann Otol Rhinol Laryngol.* 1996;105(4):253-258.
24. Pavlin EG, Van Nimwegan D, Hornbein TF. Failure of a high-compliance low-pressure cuff to prevent aspiration. *Anesthesiology.* 1975;42:216-219.
25. Young PJ, Pakeerathan S, Blunt MC, Subramanya S. A low-volume, low-pressure tracheal tube cuff reduces pulmonary aspiration. *Crit Care Med.* 2006;34(3):632-639.
26. Doyle A, Santhirapala R, Crowe M, Blunt M, Young P. The pressure exerted on the tracheal wall by two endotracheal tube cuffs: a prospective observational bench-top, clinical and radiological study. *BMC Anesthesiol.* 2010;10:21.
27. Bastow, MD. Complications of enteral nutrition. *Gut.* 1986;27(SI):51-55.
28. Gomes GF, Pisani JC, Macedo ED, Campos AC. The nasogastric feeding tube as a risk factor for aspiration and aspiration pneumonia. *Curr Opin Clin Nutr Metab Care.* 2003;6(3):327-333.
29. Gomes Jr CAR, Lustosa SAS, Matos D, Andriolo RB, Waisberg DR, Waisberg J. Percutaneous endoscopic gastrostomy versus nasogastric tube feeding for adults with swallowing disturbances. *Cochrane Database Syst Rev.* 2012:3.
30. Gross RD, Mahlmann J, Grayhack JP. Physiologic effects of open and closed tracheostomy tubes on the pharyngeal swallow. *Ann Otol Rhinol Laryngol.* 2003;112(2):143-152.
31. Elpern EH, Borkgren Okonek M, Bacon M, Gerstung C, Skrzynski M. Effect of the Passy-Muir tracheostomy speaking valve on pulmonary aspiration in adults. *Heart Lung.* 2000;29(4):287-293.
32. Cameron TS, McKinstry A, Burt SK, et al. Outcomes of patients with spinal cord injury before and after introduction of an interdisciplinary tracheostomy team. *Crit Care Resusc.* 2009;11(1):14-19.
33. Shem KL, Castillo K, Wong SL, Chang J, Kao MC, Kolakowsky-Hayner SA. Diagnostic accuracy of bedside swallow evaluation versus videofluoroscopy to assess dysphagia in individuals with tetraplegia. *Phys Med Rehabil.* 2012;4(4):283-289.
34. Consortium for Spinal Cord Medicine. Respiratory management following spinal cord injury: a clinical practice guideline for health-care professionals. *J Spinal Cord Med.* 2005;28:259-293.
35. Peterson WP, Barbalata L, Brooks CA, Gerhart KA, Mellick DC, Whiteneck GG. The effect of tidal volumes on the time to wean persons with high tetraplegia from ventilators. *Spinal Cord.* 1999;37(4):284-288.