Dysphagia and Respiratory Care in Individuals with Tetraplegia: Incidence, Associated Factors, and Preventable Complications

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Dysphagia occurs in a significant number of individuals with spinal cord injury (SCI) presenting to acute care and inpatient rehabilitation. This prospective study has found dysphagia in nearly 40% of individuals with tetraplegia. Tracheostomy, mechanical ventilation, nasogastric tube, and age are significant risk factors. The detrimental complications of dysphagia in SCI can cause significant morbidity and delays in rehabilitation. Thus, early and accurate diagnosis of dysphagia is imperative to reduce the risk of developing life-threatening complications. Incidence and risk factors of dysphagia and the use of the bedside swallow evaluation (BSE) and videofluoroscopy swallow study (VFSS) to diagnose dysphagia are presented. The often underappreciated role of respiratory therapists, including assist cough, high tidal volume ventilation, and the use of Passy-Muir valve, in the care of individuals with SCI who have dysphagia is discussed. Improved secretion management and respiratory stabilization enable the individuals with dysphagia to be evaluated sooner and safely by a speech pathologist. Early evaluation and intervention could improve upon morbidity and delayed rehabilitation, thus improving overall clinical outcomes. **Key words:** *aspiration, dysphagia, intubation, mechanical ventilation, pneumonia, spinal cord injury, swallowing, tetraplegia, tracheostomy*

Dysphagia is a significant issue for individuals with cervical spinal cord injury (SCI) presenting to acute care and rehabilitation.[1-3] The most recent estimate of dysphagia incidence within one month is 40%.[4] The detrimental consequences of dysphagia in SCI include primarily pulmonary with transient hypoxemia, chemical pneumonitis, mechanical obstruction, atelectasis, bronchospasm, and pneumonia.[1] Therefore, early and accurate diagnosis is imperative to reduce the risk of developing life-threatening complications.[2,5]

There are 3 phases to the swallowing process: oral, pharyngeal, and esophageal. The larynx is positioned to prevent respiration and aspiration during swallowing. If aspiration occurs, coughing will clear the respiratory tract in physiologically normal individuals. This protective cough reflex is often disrupted by medical conditions common to individuals with SCI, thus placing this patient population at a higher risk for silent aspirations.[1] The majority of the dyphagia in SCI may occur in the pharyngeal stage of the swallow, with poor laryngeal elevation and prevertebral swelling in the pharynx preventing the epiglottis from inverting. Sensation also appears to be impaired with patients not feeling the food or liquid residuals in the valleculae and pyriform sinuses. For the individuals with SCI to be evaluated for dysphagia promptly, respiratory status must be stabilized first.

Respiratory Care Considerations

Aggressive respiratory care with secretion management and respiratory stabilization enable the individuals with dysphagia to be evaluated expediently and safely by a speech pathologist.

Respiratory complications

Respiratory complications are the most common cause of morbidity and mortality in acute SCI with an incidence of 36% to 83%, and they contribute significantly to economic burden.[6-11] Ventilatory

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failure can last an average of 5 weeks, and the number of respiratory complications prolongs the length of hospitalization.[12] The level and severity of the SCI are directly related to development of respiratory complications. Individuals with complete injuries experience more frequent and more severe respiratory difficulties.[9] Other factors that are associated with pulmonary complications are age, preexisting medical illnesses (especially pulmonary), smoking, and associated major traumatic injuries.[9,13]

Respiratory pathophysiologies seen in cervical SCI are atelectasis, decreased pulmonary compliance, respiratory muscle fatigue, poor cough, decreased surfactant production, bronchial hypersecretion, bronchospasms, mucus plugs, and pulmonary edema. Atelectasis leads to impaired aeration and pneumonia. Therefore, the prevention of atelectasis becomes the cornerstone of respiratory management. In addition, air swallowing and regurgitation of gastric contents can cause aspiration pneumonia.[14,15] In individuals with a past medical history of diabetes, there may be preexisting gastric paresis. The use of a nasogastric (NG) tube for decompression has become standard of care in individuals with acute SCI, and our study showed the NG tube to be associated with dysphagia. Once the feedings are started, gastric residual volumes need to be monitored.[10] Tracheostomy tubes (TT) are commonly used in individuals with cervical SCI to facilitate ventilation, and many individuals with cervical SCI remain with the TT for a prolonged period of weeks to months. However, tracheostomy places these individuals at high risk for aspiration, dysphagia, and pneumonia.

Respiratory assessment

The initial assessment of individuals with acute SCI should include a complete history such as prior lung disease and smoking history, physical, and neurological examination.[5] Knowing the level of neurological injury will assist in the assessment of the patient's respiratory dysfunction. Guidelines have been written for interdisciplinary respiratory assessment and treatment for different levels of SCI.[10,16] Strength of cough, the patient's height, vital capacity, and respiratory rate need to be determined expediently.[10] Consortium guidelines on respiratory management recommend the initial laboratory assessment to include arterial blood gas (ABG), complete blood count, chemistry panel, and toxicology screen, chest x-ray, and electrocardiogram (EKG).[5]

Atelectasis and secretion management

Aggressive management of atelectasis and secretions, initiated immediately post injury by specialized SCI trained respiratory therapists, has been shown to significantly decrease the risk of pneumonia and the need for bronchoscopy.[17] Emphasis should be on lung expansion and loosening and expelling secretions to prevent mucus plugs. Intermittent positive pressure breathing (IPPB) is a lung expansion treatment that is usually used with a bronchodilator. It is a mechanical device that delivers a positive pressure breath when triggered by the patient's inspiratory effort.[5] Bronchospasm necessitates the use of bronchodilators. Although McMichan recommends early fiberoptic bronchoscopy and bronchial lavage for secretion clearance,[18] appropriate and aggressive pulmonary toileting by experienced respiratory therapists can avoid the need for bronchoscopy.[17]

Intrapulmonary percussive ventilation (IPV), Cough Assist Mechanical Insufflation-Exsufflation device, suctioning, warm moist air, bronchodilators, and mucolytics are helpful in secretion management.[5] IPV is a therapeutic modality used to mobilize and clear retained secretions by delivering high frequency pulsations up to 300 breaths per minute of low pressurized air. These vibrations loosen retained secretions and deliver a high volume of aerosol to hydrate viscous mucus plugs. IPV can be used in combination with mechanical ventilation. There are several techniques of assisted coughing used to duplicate a normal cough. A "quad cough" is a maneuver in which a care provider performs an abdominal thrust and/or squeeze over the chest wall that is coordinated with either the patient's spontaneous cough or with an assisted breath. The Cough Assist Mechanical Insufflation-Exsufflation device

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(cough assist machine) effectively clears retained broncho-pulmonary secretions by gradually applying a positive pressure to the airway and then rapidly shifting to negative pressure. The rapid shift in pressure produces a high expiratory flow from the lungs, simulating a cough. The use of a Rotorest (kinetic therapy) bed and postural drainage have been recognized to increase respiratory secretion drainage and decrease the incidence of pneumonia.[9,13]

Suctioning is essential for secretion management, but it is not without complications. Possible complications seen with suctioning in SCI include hypoxia, hypotension, infection, tracheal mucosa damage, vagal nerve stimulation, patient anxiety and fear, and increased bronchial mucus production.[19] Isotonic sterile saline may be used in conjunction to mobilize secretions that are thickened due to dehydration.[5]

Ventilation management

Assisted ventilation is often required in acute tetraplegia. Some unique considerations for ventilation management of individuals with tetraplegia are excessive secretions that may be caused by an artificial airway and hypoventilation due to weak respiratory muscles.[20] The decision to perform a tracheostomy should not be delayed beyond 1 to 2 weeks, because prolonged nasotracheal or endotracheal intubation has been associated with complications such as subglottic stenosis and sinusitis.[10] Tracheostomy is more comfortable for the patient and facilitates the patient getting out of bed and starting to eat orally sooner. Pulmonary hygiene can be done more effectively when compared with nasotracheal and endotracheal intubation. Trachostomy is easier for the patient when attempting to wean as there is less dead space and reduced airway resistance.[21]

There is considerable controversy over the use of low volume versus high volume ventilation in patients with SCI because of a concern for barotrauma resulting from high volume ventilation.[22] However, prior studies were on patients without SCI. In individuals with SCI, low tidal volume may lead to atelectasis, mucus plugging, and decreased production of surfactant, thus increasing the work of breathing. Patients ventilated with tidal volumes greater than 20 cc per kilogram of ideal body weight showed decreases in atelectasis and pneumonia, and weaning time decreased significantly.[23]

Respiratory intervention that may affect swallowing in SCI is the use of a Passy-Muir speaking valve (PMV). The PMV is a one-way silicone diaphragm check valve that fits over the end of the tracheostomy tube. The valve opens during inspiration and closes during expiration, allowing the exhaled air to pass through the upper airway and through the vocal cords.[24] There are at least 2 reports of lower incidence of aspiration and improved swallowing with the use of PMV.[24,25] PMV is frequently used in individuals with SCI with tracheostomy to allow them to vocalize. Anecdotally, we did not see any significant effect of PMV on dysphagia, but the subjects were more appreciative of being able to vocalize during the bedside evaluation (BSE) and videofluoroscopic swallow study (VFSS).

Assessment of Dysphagia in Spinal Cord Injury

The Consortium of Spinal Cord Medicine Clinical Practice Guidelines on Respiratory Management Following Spinal Cord Injury recommends evaluation for dysphagia of individuals with the following risk factors[5]:

- Supine position
- Spinal shock
- Slowing of gastrointestinal tract
- Gastric reflux
- Inability to turn the head to spit out regurgitated material
- Medications that slow gastrointestinal activity or cause nausea and vomiting
- Recent anterior cervical spine surgery
- Presence of a tracheostomy
- Advanced age

Ventilator and tracheostomy dependence, surgical interventions, collar, and certain neurological factors such as complete SCI have been previously identified as risk factors for dysphagia in individuals with cervical SCI.[1,26-31] The pathophysiology of dysphagia after anterior cervical spine surgery is poorly understood,

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but cervical graft and implanted hardware complications, such as loosening of screws, are a few of the known causes.[5] After tracheostomy, impaired reflex may cause food and fluid to enter the larynx and cause aspirations.[32] The causes of aspiration due to tracheostomy tube 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.[32-34] Patients with premorbid diagnoses such as osteophytes and gastroesophageal reflux disease (GERD) may be at a higher risk for swallowing complications. Osteophytes can cause compression of the esophagus.[35] Severe cases of GERD can result in esophageal stricture, Barrett's esophagus, and esophageal ulcers, complicating the management of dysphagia in individuals with SCI.[36]

BSE and VFSS are 2 primary procedures used to diagnose dysphagia in any patient population.[37] However, to date, BSE has not been validated as an effective screening tool for individuals with SCI. The Consortium Clinical Practice Guidelines also does not have any recommendations on which diagnostic procedures should be used to diagnose dysphagia in individuals with SCI.[5] A clinical swallowing examination, which is more commonly called "bedside" swallowing evaluation (BSE), is usually the initial assessment of swallowing function. Although the VFSS has been considered the gold standard as an examination procedure to diagnose dysphagia, this traditional understanding is being questioned.

Incidence and Risk Factors of Dysphagia in Tetraplegia

A research project was undertaken to prospectively determine the incidence of dysphagia and its risk factors in individuals with SCI using both BSE and VFSS. In addition, the accuracy of BSE was compared against VFSS. Individuals with acute tetraplegia, who were admitted to the Santa Clara Valley Medical Center (SCVMC) SCI Service, were enrolled in the study. The exclusion criteria were individuals who are orally or nasally intubated, individuals with significant cognitive deficits who cannot follow instructions during BSE or VFSS, and individuals requiring use of a Rotorest bed since VFSS cannot be conducted in a Rotorest bed. Subjects underwent a BSE as soon as they were capable of participating, and VFSS were conducted within 72 hours of BSE. Detailed procedures have been previously described,[4] but will be summarized herein.

Bedside swallow evaluation

The BSE is less costly and less invasive than a VFSS. For our study, one speech pathologist (SP), experienced with performing a BSE in individuals with tetraplegia, assessed all of the subjects. During the BSE, individuals were tested on hospital beds or in wheelchairs. Positioning of the individuals depended on spine precautions including halo vest, soft/hard collars, and head of bed no greater than 30°. A licensed respiratory care practitioner (RCP) accompanied the SP during the BSE as needed and was responsible for monitoring oxygen saturation, cuff deflation, suctioning, and ventilator changes. In addition to interpreting the patients' performance on the BSE, the SP was responsible for administering food and deciding when the patients should be suctioned and when the cuff should be deflated. The evaluation continued unless or until the individual aspirated or showed covert signs of aspiration. The SP identified a subject as having dysphagia if he or she observed covert signs of aspiration, which included wet or hoarse voice, decreased laryngeal elevation/excursion, watery eyes, and runny nose.

Videofluoroscopy swallow study

VFSS allows direct visualization of the anatomy and physiology of swallowing under fluoroscopy. Foods and liquids of different consistency are made radiopaque by adding barium. There is a minimal risk of radiation exposure, which could be a concern if multiple evaluations are needed. Dysphagia with VFSS was identified if a subject had impairment at the oral, pharyngeal, or esophageal phase of swallow.

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Table 1. Demographic description of the subjects

Etiologies	N	%
Motor vehicle accident	9	22.5
Fall	7	17.5
Gunshot wound	3	7.5
Diving	6	15.0
Bicycle accident	4	10.0
Motorcycle accident	2	5.0
Other	9	22.5
Cervical spine injuries		
Types of surgery		
Anterior	18	45.0
Posterior	4	10.0
Anterior and posterior	11	27.5
No surgery	7	17.5
Type of tracheostomy tube		
Shiley	12	52.2
Bivona-TTS	10	43.5
Portex	1	4.3

Results

Forty individuals with tetraplegia were enrolled to assess incidence and risk factors. Average age was 41 years (*SD* 16.5). Twenty-nine subjects (72%) had high cervical tetraplegia (C4 or higher) and 11 (28%) had lower cervical tetraplegia. Further subject descriptions are listed in **Table 1**. The average number of days to admission to our center was 14.3 days (*SD* 10.98) from date of injury. A tracheostomy tube was present in 23 (57.5%) patients, and 24 (60%) subjects were on mechanical ventilation with one subject receiving noninvasive positive pressure ventilation (Bi-PAP). Three subjects had nasogastric tubes.

All 40 subjects underwent BSE, but 13 (32.5%) subjects did not complete the VFSS due to refusal (n = 12; 30%) and intolerance (n = 1; 2.5%). VFSS was conducted on average 1.52 days (*SD* 1.25) after BSE. Sixteen subjects (40%) were diagnosed as having dysphagia based on the BSE results. Among the subjects who completed the VFSS, 12 (44.4%) were diagnosed with dysphagia, and 4 subjects (14.8%) were diagnosed with aspiration. Only one subject was diagnosed as not having dysphagia with VFSS when dysphagia was diagnosed by the BSE. Diet and liquid recommendations are listed in **Tables 2** and **3**. All subjects not diagnosed with dysphagia following BSE were confirmed via VFSS. Different diet consistency in 4 cases and liquids in 8 cases were recommended based on BSE and VFSS (**Table 4**).

Age, tracheostomy tube, mechanical ventilation, and nasogastric tube were identified as statistically significant risk factors for dysphagia in individuals with tetraplegia in this study (**Table 5**). Relationships between dysphagia and level of SCI, gender, presence of collar, and mild head injury were not statistically significant. While use of a halo vest has declined in recent years, 2 subjects had halo vest immobilization. Both subjects had dysphagia, and a statistical trend ($P = .076$) was noted for the halo vest as a risk factor for dysphagia.

The effect of dysphagia on medical complications is significant. Individuals with dysphagia have statistically higher occurrences of pneumonia (75%) compared with those without dysphagia (29%) ($P < .5$). There was no significant difference in those with or without dyphagia on having to

Table 2. Diet recommendations after bedside swallow evaluation (BSE) and videofluroscopy swallow study (VFSS)

Diet recommendations	BSE (n=40)		VFSS (n=27)	
Regular	24	60.0%	15	55.6%
Dysphagia ground	4	10.0%	2	7.4%
Dysphagia puree	1	2.5%	2	7.4%
Mechanical soft	4	10.0%	5	18.5%
NPO	7	17.5%	3	11.1%

Note: NPO = not by mouth.

Table 3. Liquid recommendations after bedside swallow evaluation (BSE) and videofluroscopy swallow study (VFSS)

Liquid recommendations	BSE (n=40)		VFSS (n=27)	
No liquid restriction	21	52.5%	13	48.1%
Ice chips	1	2.5%	0	0.0%
Carbonated liquids	2	5.0%	0	0.0%
Thin liquids	11	27.5%	11	40.7%
No liquids	5	12.5%	3	11.1%

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Table 4. Summary of different diet and liquid recommendations based on bedside swallow evaluation (BSE) followed by videofluroscopy swallow study (VFSS)

Number of subjects	Diet recommendation based on BSE	Diet recommendation based on VFSS
1	Dysphagia ground	Regular
1	NPO	Dysphagia ground
1	NPO	Dysphagia puree
1	NPO	Mechanical soft
Number of subjects	**Liquid recommendation based on BSE**	**Liquid recommendation based on VFSS**
3	Thin liquids	All liquids
2	No liquids	Thin liquids
2	All liquids	Thin liquids
1	Ice chips	Thin liquids

Note: NPO = not by mouth.

Table 5. Summary of individuals with and without dysphagia

	With dysphagia	Without dysphagia	*P*
Total number of subjects	16	24	
Age	50.5±18.2	36.0±12.5	.016
Male	14	17	
Female	2	7	
Length of stay (days)	51.8±19.9	36.4±16.7	.064
Days to BSE	26.3±16.0	17.2±8.0	.047
Subjects with pneumonia	12	7	.004
Subjects with bronchosocopy	3	2	.329
Subjects with reintubation	3	1	.132
Subjects on mechanical ventilation	14	11	.003
Subjects with tracheostomy	13	10	.013
Subjects with nasogastric tube	3	0	.027
Subjects with halo vest	2	0	.076
Subjects with complete injury	4	13	.068
Subjects with high tetrpalegia	13	16	.31
Subjects with brain injury	6	6	.398
Subjects with collar	10	17	.97

Note: BSE = bedside swallow evaluation.

undergo bronchoscopy (P = .33) or the rate of re-intubation (P = .13). Length of stay (51.8 days ± 19.9 days vs 36.4 days ± 16.7 days; P = .064) and the number of days the BSE was completed from the date of injury (26.3 days ± 16 days vs 17.2 days ± 8 days; P = .047) for individuals with dysphagia were longer, which may indicate that individuals with dysphagia are more medically complicated.

Conclusions

Early screening and evaluation of all individuals with tetraplegia with risk factors for potential dysphagia is beneficial for health-related outcomes and enhancement of rehabilitation goals toward achieving maximal independence after SCI. Incidence of dysphagia was found to be nearly 40% in individuals with tetraplegia. Older age,

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nasogastric tube, mechanical ventilation, and tracheostomy tube were found to be significant risk factors. Individuals with dysphagia are at higher risk for pneumonia and longer lengths of stay in the hospital. By diagnosing dysphagia as soon as possible, complications such as aspiration pneumonia can be prevented. On the other hand, individuals cleared as not having dysphagia can start oral diets promptly and earlier, thereby expanding the options of oral medications, avoiding gastrostomy tube and its associated complications, and improving the patients' nutritional status and mood.

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