Dysphagia in individuals with tetraplegia: incidence and risk factors

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Background/objective: Dysphagia following cervical spinal cord injury (SCI) can increase risk for pulmonary complications that may delay the rehabilitative process. The objective of this study was to identify risk factors for dysphagia after cervical SCI.
Design: Prospective cohort study.
Methods: Individuals with cervical SCI within 31 days of injury underwent a bedside swallow evaluation (BSE) followed by a videofluoroscopy swallow study (VFSS) within 72 hours of the BSE. Subjects were diagnosed as having dysphagia if they had positive findings in either BSE or VFSS.
Results: Twenty-nine patients (7 female and 22 male) were enrolled. Of these, 21 (72%) had high cervical tetraplegia (C4 or higher) and 8 (38%) had lower cervical tetraplegia. A tracheostomy was present in 18 (62%) patients; 15 (52%) subjects were on ventilators. Dysphagia was diagnosed in 12 (41%) subjects. Dysphagia was noted in 62% of the subjects with tracheostomy and 53% of the subjects on the ventilator, but only tracheostomy resulted in a statistically significant association with dysphagia ($P = 0.047$). All three subjects who had nasogastric tubes were diagnosed with dysphagia ($P = 0.029$). The relationships between dysphagia and gender, high versus low tetraplegia, presence of halo or collar, head injury, and ventilator use were not statistically significant, but age was a significant risk factor ($P = 0.028$).
Conclusions: Dysphagia is present in about 41% of individuals with acute tetraplegia. Only age, tracheostomy, and nasogastric tubes were identified as significant risk factors for dysphagia for individuals with tetraplegia. No relationship between dysphagia and level of SCI, spine surgery, collar, and ventilator use was found to exist.

Keywords: Spinal cord injuries, Tetraplegia, Rehabilitation, Physical, Dysphagia, Bedside swallow evaluation, Videofluoroscopy swallow study, Tracheostomy

Introduction

Dysphagia is known to be present in a significant number of individuals with cervical spinal cord injury (SCI) presenting to acute care and rehabilitation.[1–3] However, the exact incidence of dysphagia in this population has not been studied prospectively. The current estimate of incidence from a retrospective study is that 17% of individuals with tetraplegia have dysphagia at admission to inpatient rehabilitation.[1] It has been assumed that the rate of dysphagia in 'acute' SCI prior to admission to inpatient rehabilitation is higher.[2] We are aware of only one cross-sectional study from Germany that estimated the incidence of 'mild' to 'moderate' swallowing dysfunction in 'acute' SCI to be at 80%.[3] However, in that study, the definition of 'acute' SCI included individuals with SCI who have been injured up to 3 months. Also, fiberoptic endoscopic examination was used to assess for dysphagia, which is not as readily available in standard clinical practice to assess for dysphagia in the United States.

The term dysphagia is used to describe swallowing disorders affecting the regular transport of food from mouth to stomach. There are three phases in the swallowing process: oral, pharyngeal, and esophageal. The larynx is positioned at the crossing paths of respiration and deglutition and serves to prevent respiration during swallowing to prevent aspiration. If aspiration occurs, coughing will clear the respiratory tract in physiologically normal individuals. This protective cough reflex is often disrupted by medical conditions and interventions common to individuals with SCI, thus putting this patient population at a higher risk for silent aspiration.[1] Individuals who have swallowing

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difficulties will often have the following symptoms: wet, hoarse or breathy voice, watery eyes, runny nose, and coughing or choking. Speech pathologists (SPs) evaluating for dysphagia may identify decreased excursion of the larynx with either palpitation and/or observation, uncoordinated laryngeal movement and/or audible swallow.

The detrimental consequences of swallowing dysfunction in SCI include transient hypoxemia, chemical pneumonitis, mechanical obstruction, atelectasis, bronchospasm, and pneumonia.[1] Thus, early and accurate diagnosis of swallowing dysfunction is thought to be imperative to reduce the risk of a patient with SCI developing life-threatening complications.[2,4] Ventilator and tracheostomy dependence, surgical interventions, and certain neurological factors are thought to be risk factors for swallowing dysfunction in individuals with cervical SCI.[1,5–9] For example, anterior spine fusion is considered generally safe, but postoperative dysphagia has been reported to occur.[1,5–8] The cause of dysphagia after anterior cervical spine surgery is poorly understood, but complications from cervical graft and implanted hardware complications such as loosening of screws are a few of the hypothesized causes.[4]

Studies reporting an association between swallowing difficulty and tracheostomy date back to the 1960s. Feldman described three patients with disordered swallowing reflexes after tracheostomy.[10] This impaired reflex caused food and fluid to enter the larynx and cause aspiration. It was speculated that swallowing dysfunction resulted from desensitization of the larynx or a fixation of the larynx by the tracheostomy. Another research work suggests that the tracheostomy tube applies pressure to the esophagus, thus altering the swallowing function.[11] Another consequence of tracheostomy is a reduction in elevation and anterior displacement of the larynx, which interferes with relaxation of the hypopharyngeal sphincter.[11] In summary, the causes of aspiration due to the 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.[12]

Pre-injury medical history may also be an important predictor of dysphagia after SCI. Patients with premorbid diagnoses such as osteophytes and gastroesophageal reflux disease (GERD) may be at higher risk for swallowing complications. Osteophytes can cause compression of the esophagus.[13] Patients with GERD often experience difficulty swallowing. The advanced stage of this disease can result in esophageal stricture, Barrett's esophagus, and esophageal ulcers; these complications are likely to complicate the management of dysphagia in individuals with SCI.[14]

Bedside swallow evaluation (BSE) and videofluoroscopic swallow study (VFSS) are two primary diagnostic procedures that are used to diagnose dysphagia in any patient population.[15] However, BSE has not been validated as an effective screening tool for individuals with SCI. The Consortium Clinical Practice Guidelines also do not have any recommendations on which diagnostic procedures should be used to diagnose dysphagia in individuals with SCI.[4] The primary objective of this research project was to prospectively determine the incidence of dysphagia and its risk factors in individuals with SCI using both BSE and VFSS.

Methodology

Subjects

Individuals with acute SCI who were admitted to the SCI Unit were recruited consecutively. This project was reviewed and approved by the Research and Human Subjects Review. Every subject signed the consent form prior to starting the project. The inclusion criteria included subjects at least 18 years with tetraplegia due to cervical SCI who are admitted to our facility within 31 days of injury, medically stable to be able to participate in BSE initially and expected to be able to participate in VFSS subsequently. The exclusion criteria were: individuals who were orally or nasally intubated, individuals with known pre-injury swallowing dysfunction, individuals with severe brain injury or any other significant cognitive deficits who could not follow instructions during BSE or VFSS, and individuals with acute SCI requiring the use of a Rotorest bed since VFSS cannot be conducted in a Rotorest bed. Individuals with concomitant head injury were recruited as long as their cognitive deficit did not interfere with their ability to participate in the BSE and VFSS. All subjects received standardized respiratory treatment based on the patients' clinical situation and vital capacity as per our respiratory therapy protocol. If potential subjects had tracheostomy or were intubated, then they were placed on aspiration precautions.

Data collection

Demographic and injury characteristic data including the level of injury, American Spinal Injury Association (ASIA) Impairment Scale, age, and premorbid diagnosis of osteophytes, GERD, 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 were collected.

Every subject with acute tetraplegia who was admitted to our SCI Unit was asked to undergo BSE and VFSS as soon as the individual was capable of participating in BSE and VFSS. VFSS was conducted within 72 hours of BSE.

Chi-square analyses were used to determine associations between a diagnosis of dysphagia and potential risk factors such as the presence/absence of premorbid diagnoses, spine fusion surgery, halo vest, cervical collars, tracheostomy tubes, and pulmonary infections.

Evaluation procedures

Bedside swallow evaluation

At our facility, the BSE has been the preferred screening method for dysphagia in individuals with tetraplegia. The BSE is less costly and invasive than a VFSS. One SP who is experienced with performing a BSE in individuals with tetraplegia assessed all of the subjects for dysphagia and determined whether it was safe for the individuals to be fed by mouth. During the BSE, individuals could be tested on regular beds or in wheelchairs. Positioning depended on spine precautions such as 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. The RCP 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 the food and deciding when the patients should be suctioned and when the cuff should be deflated. Also, placement of a one-way speaking valve (Passy-Muir valve) was utilized in some cases to determine whether the added backpressure that the valve provides would help in preventing aspiration. The one-way speaking valve, however, was not used in all cases because the patient must have a stable respiratory status and a proper ventilator. The evaluation continued unless and until the individual aspirated or showed covert signs of aspiration.

The SP identified a subject as having 'dysphagia' if she observed any dysfunction of oral, pharyngeal, and/or esophageal phases of swallowing during BSE. If these individuals have positive finding with the BSE, depending on the SP's assessment of dysphagia, they may be placed on one of the following modified diets: dysphagia pureed (applesauce consistency), dysphagia ground (ground beef consistency), mechanical soft (regular diet with the exception of canned fruits and vegetables only/no fresh fruit or vegetables), no liquids (dry tray), thin liquids, thick liquids, carbonated liquid, or all liquids.

Videofluoroscopy swallow study

VFSS provides direct visualization of the anatomy and physiology of swallowing under fluoroscopy. Foods and liquids of different consistency were made radiopaque by adding barium. For those with a stable respiratory status and a proper ventilator, a one-way speaking valve (Passy-Muir speaking valve (PMV)) was utilized to determine whether the added backpressure of the valve helped in preventing aspiration. Dysphagia with VFSS was identified if a subject had the following findings: pooling of the test material in valleculae and/or piriformis sinus, decreased laryngeal elevation, lack of epiglottic inversion, and penetration of test material into the larynx. In addition, aspiration was identified if test material entered into the larynx below the level of the vocal cords.

Results

Twenty-nine individuals with tetraplegia (22 men and 7 women) were enrolled in the study (Table 1). The average age of the subjects was 41 (SD = 17.6). Their ethnicities were: Caucasian ($n = 19$, 66.5%), Hispanic ($n = 3$, 10.3%), African American ($n = 3$, 10.3%), Asian ($n = 3$, 10.3%), and other ($n = 1$, 3.5%). Twenty-one subjects (72%) had high cervical tetraplegia (C4 or higher) and eight (38%) had lower cervical tetraplegia. Etiologies of SCI were: motor vehicle accident ($n = 5$, 17.2%), fall ($n = 7$, 24.1%), gunshot wound ($n = 3$, 10.3%), diving ($n = 3$, 10.3%), bicycle accident ($n = 3$, 10.3%), motorcycle accident ($n = 3$, 10.3%), and other ($n = 5$, 17.2%). In terms of cervical spine surgery, 13 subjects (44.8%) had anterior surgery only, 3 (10.3%) had only posterior spine surgery, 7 (24.1%) had both anterior and posterior spine surgeries, and 6 subjects (20.7%) had no spine surgery. Two subjects had a halo vest immobilization. The average number of days to admission to our system was 12.9 days (SD = 8.9). A tracheostomy tube was present in 18 (62.1%) patients, and 14 (52%) subjects were on mechanical ventilation with one additional subject being on non-invasive positive pressure ventilation (Bi-PAP). Among the individuals who had a tracheostomy tube, 11 subjects (61.1%) were using Shiley tubes, 6 subjects (33.3%) were using Bivona tubes, and 1 (5.6%) was using a Portex tube. Three subjects had nasogastric tubes because of dysphagia and to provide adequate nutrition. The subjects were at our facility on average 44.0 days (range 12–98 days, SD = 20.13), prior to being discharged to home ($n = 23$), a subacute facility ($n = 2$), a Veterans Administration SCI unit ($n = 2$), or to another acute hospital ($n = 2$). Co-morbid conditions noted at the time of SCI were: brain injury ($n = 11$, 37.9%), diabetes mellitus ($n = 3$, 10.3%), and osteoarthritis ($n = 3$, 10.3%). None

Table 1 Demographics

Level of Injury	*N*	Average age (years)	Mechanical ventilation (%)	Tracheostomy (%)	Nasogastric tube (%)	Collar (%)	Dysphagia (%)
C1	1	45 ± 0	1 (100.0%)	1 (100.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)
C2	3	64.7 ± 21.0	2 (66.7%)	2 (66.7%)	0 (0.0%)	2 (66.7%)	2 (66.7%)
C3	7	33.7 ± 17.2	4 (57.1%)	5 (71.4%)	1 (14.3%)	5 (71.4%)	3 (42.9%)
C4	10	40.7 ± 15.9	6 (60.0%)	7 (70.0%)	2 (20.0%)	6 (60.0%)	4 (40.0%)
C5	4	32.3 ± 6.2	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (75.0%)	0 (0.0%)
C6	2	39.0 ± 26.9	1 (50.0%)	2 (100.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)
C7	2	50.0 ± 19.8	1 (50.0%)	1 (50.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)

Note: One C2 patient and one C7 patient had a halo.

of the subjects had other co-morbid conditions that may be potential risk factors for dysphagia such as: prior history of esophageal dilation, GERD, and prior radiation treatment to the neck area. Approximately 20 potential subjects were excluded from the study based on age younger than 18 years, time since injury longer than 31 days, severe head injury that precluded informed consent, or pressure sores.

All 29 subjects underwent BSE, but 8 (27.6%) subjects did not complete the VFSS due to refusal ($n = 7$, 24.1%) and intolerance ($n = 1$, 3.4%). The average number of days from the date of injury to BSE was 19.7 days (range 3–32 days, SD = 8.1). VFSS was conducted on average 1.76 days (SD = 1.30) after the initial BSE. Twelve subjects (41%) were diagnosed as having dysphagia based on the BSE results. Among the subjects who completed the VFSS, nine (42.9%) were diagnosed with dysphagia, and four subjects (19.1%) were diagnosed with aspiration. Of the 21 subjects who completed the VFSS, all 9 subjects diagnosed as having dysphagia by VFSS also had dysphagia by BSE; one of 12 subjects diagnosed as not having dysphagia by VFSS was diagnosed with dysphagia by BSE. Diet and liquid recommendations are listed in Tables 2 and 3. None of the subjects who were diagnosed as not having dysphagia by the BSE were diagnosed as having dysphagia by the VFSS. Different diet consistency in three cases and liquids in five cases were recommended based on BSE and VFSS (Tables 4 and 5).

Possible risk factors for dysphagia such as surgery, collar, mechanical ventilation, and tracheostomy were evaluated (Table 6). Age was a significant risk factor for dysphagia ($P = 0.028$). There was a trend for a statistically significant association between dysphagia and presence of halo ($P = 0.081$) and dysphagia and posterior spine surgery ($P = 0.090$). There was no statistical significance with regard to gender ($P = 0.43$), presence of head injury ($P = 0.26$), high versus low tetraplegia ($P = 0.79$), complete injury or not ($P = 0.30$), anterior spine surgery ($P = 0.82$), or presence of collar ($P = 0.97$)

Table 2 Diet recommendations after BSE and VFSS

Diet Recommendations	BSE ($n = 29$)	VFSS ($n = 21$)
Regular	17 (58.6%)	12 (57.1%)
Dysphagia ground	2 (6.9%)	1 (4.8%)
Dysphagia pureed	0 (0%)	1 (4.8%)
Mechanical soft	4 (13.8%)	4 (19.0%)
NPO	6 (20.7%)	3 (14.3%)

Table 3 Liquid recommendations after BSE and VFSS

Liquid recommendations	BSE ($n = 29$)	VFSS ($n = 21$)
No liquid restriction	16 (55.2%)	11 (52.4%)
Ice chips	1 (3.4%)	0 (0%)
Carbonated liquids	2 (6.9%)	0 (0%)
Thin liquids	6 (20.7%)	7 (33.3%)
No liquids	4 (13.8%)	3 (14.3%)

Table 4 Summary of different diet recommendations based on BSE followed by VFSS

Number of subjects	Recommendation based on BSE	Recommendation based on VFSS
1	NPO	Dysphagia ground
1	Regular	Mechanical soft
1	Dyshagia ground	Regular

Table 5 Summary of different liquid recommendations based on BSE followed by VFSS

Number of subjects	Recommendation based on BSE	Recommendation based on VFSS
2	All liquids	Thin
2	Thin	All liquids
1	No liquids	Think

Table 6 Summary of individuals with and without dysphagia

	With dysphagia	Without dysphagia	*P* value
Total number of subjects	12	17	
Age	49.4 ± 20.9	35.1 ± 12.4	0.028
Male	10	12	
Female	2	5	
Length of stay (days)	52.1 ± 21.0	37.9 + 17.8	0.064
Days to wean	35.1 ± 15.2	38.8 ± 14.5	0.60
Days to decannulate	47.3 ± 12.6	47.7 ± 14.5	0.99
Subjects with pneumonia	9	5	0.016
Subjects with bronchosocopy	4	1	0.054
Subjects with reintubation	3	1	0.14
Subjects with tracheostomy	10	8	0.047
Subjects with collar	7	12	0.97
Subjects on mechanical ventilation	8	7	0.18
Subjects with a nasogastric tube	3	0	0.029
Subjects with complete injury	4	9	0.30
Subjects with brain injury	6	5	0.26

as risk factors for dysphagia. Dysphagia was diagnosed in 8 out of 15 of subjects (67%) on the ventilator versus 4 out of 14 subjects (29%) not on the ventilator, but this was not statistically significant ($P = 0.18$). However, the presence of tracheostomy was a statistically significant risk factor for dysphagia ($P = 0.047$) with 10 out 18 subjects (55.6%) with tracheostomy tubes having dysphagia versus only 2 out of 9 subjects (22.2%) without tracheostomy tubes having had dysphagia. All three subjects who had nasogastric tubes were diagnosed with dysphagia ($P = 0.029$).

The effect of dysphagia on medical complications was also examined. Individuals with dysphagia had statistically higher occurrences of pneumonia (75%) compared with those without dysphagia (29%) ($P = 0.016$). In addition, there was a trend ($P = 0.054$) for higher incidence for individuals with dysphagia to undergo bronchoscopy (33%) compared with those without dysphagia (5.9%), but there was no significant difference in those with or without dysphagia on the rate of re-intubation ($P = 0.14$). There was a trend for individuals with dysphagia to have a longer length of stay (52.1 ± 37.9 days versus 21.0 ± 17.8 days) ($P = 0.064$). It also took longer for individuals with dysphagia (22.8 ± 6.3 days) compared with those without dysphagia (17.5 ± 8.6 days) ($P = 0.081$) to have the BSE performed, which may indicate that individuals with dysphagia are more medically complicated.

Discussion

Dysphagia is a significant complication of tetraplegia that is still not well recognized by the healthcare providers treating individuals with acute cervical SCI. In this study, dysphagia was diagnosed in 41% of the subjects based on BSE and 43% based on VFSS, and aspiration was diagnosed in 19% of the subjects with VFSS. This rate of incidence is significantly higher than the previously reported rate of 17% in a retrospective study by Kirshblum *et al.*[1] However, while the prior study examined patients who were admitted to an inpatient rehabilitation setting, this study included and focused more on acutely injured patients most of whom were not yet in the inpatient rehabilitation program.

Prior research has identified tracheostomy tubes, cervical spine fusion surgeries, and ventilator dependence as probable risk factors for dysphagia in individuals with and without SCI.[16] To our knowledge, this study was the first study that examined risk factors for dysphagia in individuals with tetraplegia prospectively. In this study, age, tracheostomy tubes, and nasogastric tubes were identified as statistically significant risk factors for dysphagia in individuals with tetraplegia. The relationship between dysphagia and level of SCI, gender, presence of collar, and mild head injury was not statistically significant. Contrary to previous studies, ventilator use and cervical fusions were also not statistically significant risk factors.

Tracheostomy tubes are commonly used in individuals with cervical SCI to facilitate ventilation. These individuals typically do not satisfy the recommended criteria for decannulation within a short period of time; thus they remain with the tracheostomy tube for a prolonged period of weeks to months. Long-term tracheostomy has been thought to place these individuals at high risk for complications such as dysphagia and pneumonia. Aspiration is another complication resulting from a tracheostomy tube. Elpern *et al.*[17] reported an aspiration incidence of 77% in patients with an artificial airway, which includes nasotracheal, orotracheal, and tracheostomy tubes. The frequency of aspiration was greatest for patients with tracheostomies. Our study confirmed that the tracheostomy tube is a risk factor for dysphagia in individuals with SCI. Individuals who are on prolonged ventilation via tracheostomy are at high risk for dysphagia regardless of whether they have SCI or not. Many individuals with tetraplegia are ventilator dependent, have impaired

cough, and require tracheostomies for secretion management. Poor secretion management and pulmonary congestion are risk factors for pneumonia and possibly dysphagia. Copious secretions are contraindication for swallow evaluation and/or advancing diet. Thus, it is most important that swallowing dysfunction be identified and interventions are initiated early in these individuals to prevent silent aspirations and other complications.

It has been previously reported that mechanical ventilation is associated with an increased risk of dysphagia.[18] Tolep *et al.*[16] evaluated 35 consecutive ventilator-dependent individuals without SCI. The patients underwent BSE, followed by a VFSS evaluation if their results were abnormal. VFSS was also performed in patients with normal BSE who were suspected of having aspirations. They reported that 83% of the patients on mechanical ventilation had abnormal VFSS, of whom 43% had aspiration. Moreover, of the patients who had normal results with the BSE but went on to have a VFSS due to high risk for aspiration, 63% showed abnormalities in the VFSS. This finding is particularly interesting, because there may be many individuals with dysphagia that may not be detected by BSE alone. However, we did not find a statistically significant association between dysphagia and patients being on ventilation support in our study. Furthermore, there was no subject who was not diagnosed with dysphagia with BSE who was subsequently diagnosed as having dysphagia based on VFSS.

Another possible respiratory intervention that may affect swallowing function in SCI is the use of a 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, and the exhaled air passes through the upper airway including the vocal cords.[19] There are at least two reports that there is lower incidence of aspiration and better swallowing function with the use of PMV in individuals with tracheostomy.[16,19] Although the PMV is frequently used in individuals with SCI with tracheostomy to allow them to vocalize, we are not aware of any studies specifically in individuals with SCI that studied the effect of PMV on swallowing function. Anecdotally, we did not see any significant effect of PMV on dysphagia. However, the subjects were more appreciative of being able to vocalize during the BSE and VFSS.

In the last decade, we are aware of only two studies (one prospective study from Germany and one retrospective study from the United States) that have studied the incidence of dysphagia in SCI specifically.[1,3] The article by Kirshblum *et al.*[1] is the main reference that has been quoted in both the Consortium Clinical Guidelines[4] and in the Self-Directed Physiatric Education Program of American Academy of Physical Medicine and Rehabilitation[2] to advocate evaluation and management of dysphagia in individuals with SCI. However, it is a retrospective study in which VFSS was performed in only 22.5% of the sample population who complained of symptoms suggestive of dysphagia. The remaining 145 patients were not evaluated for dysphagia. Among the individuals with suspected dysphagia and who were examined with VFSS, 74% were confirmed for dysphagia; this represents only 16.6% of the total population that was studied.

It has been reported that aspiration is more common in older individuals with SCI who are on mechanical ventilation.[1] Age was not the sole predictor of dysphagia in that study, but was included with other contributing factors.[1] We also confirmed that older age is a significant risk factor for dysphagia. ASIA impairment scores and level of injury have been previously recognized as possible predictors of dysphagia.[1] Individuals with complete (ASIA A) SCI have been previously thought to be at higher risk for swallowing complications than incomplete (ASIA B, C, D) SCI, because they are more likely to be mechanically ventilated and require tracheostomies.[1,20] Similarly, the higher the spinal cord lesion is, the greater the respiratory impairment will be and thus the more likely it is that these individuals will require a tracheostomy and/or a ventilator.[1,20,21] However, in our study, the level of SCI was not identified as one of the statistically significant risk factors.

Another possible risk factor in SCI that has not been studied in detail is the use of cervical spine orthoses. For example, Kirshblum *et al.*[1] noted that there was a 'moderate' association of dysphagia and sternal-occipital-mandibular-immobilize (SOMI)/two-post braces, and individuals with halo braces had higher rates of dysphagia estimated at 29%.[1] A more recent study using healthy volunteers in halo-vest braces showed that there was abnormal swallowing function in two of the six volunteers when their cervical spine was placed in hyperextension.[22] One volunteer with his cervical spine in a 'neutral' position in the halo vest also had aspiration. However, in another study, no healthy volunteers aspirated with any of the three cervical orthoses that were studied (Philadelphia collar, SOMI, and halo-vest brace).[23] Although the use of a halo vest seems to be declining in recent years, we had two subjects who had a halo vest immobilization. Both of these individuals had dysphagia, and there was a trend ($P = 0.081$) for

the halo vest to be a risk factor for dysphagia. Subjects in our study had standard hard collar ($n = 2$), Miami J ($n = 3$), or Aspen collar ($n = 4$), and eight subjects had no collar, but the presence of collar was not associated with dysphagia.

The recently published 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[4]:

- 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.

Given this information, we have been screening for dysphagia in every patient with cervical SCI who is admitted to our rehabilitation service, and every patient who is diagnosed with dysphagia is actively treated by our SP.

We have previously published a retrospective study examining the risk factors associated with dysphagia in 68 individuals with high tetraplegia (C1–C4).[18] Several individuals presented with a premorbid diagnosis of GERD, anterior osteophytes, and pneumothorax. Individuals with one of these premorbid diagnoses took longer to eat a regular diet compared to individuals without these pre-existing. Individuals with dysphagia also took a significantly longer period of time to start eating a regular diet compared with those who did not, and they had a longer length of stay compared to those without dysphagia.[18] In the current study, there was no significant difference in days to wean ($P = 0.60$) or days to decannulate ($P = 0.99$) regardless of whether the individuals had dysphagia or not, but as in the previous study, there was a trend for longer length of stay for individuals with dysphagia ($P = 0.064$).

In the same previous retrospective study, 56 (82%) individuals with high tetraplegia underwent cervical fusion. Only a slightly higher percentage (75%) of those who had surgery were diagnosed with dysphagia compared to 43% of individuals who did not undergo surgery; this difference was not significant ($P = 0.08$). In our study, 34.8% of those who had any cervical spine stabilization surgery were diagnosed with dysphagia, but surprisingly four out of six individuals who did not have cervical spine surgery also had dysphagia. However, our study was limited due to a relatively small sample size of 29 subjects.

The methods for evaluating dysphagia in individuals with SCI have not been validated to date. A clinical swallowing examination that is more commonly called 'bedside' swallowing evaluation (BSE) is usually the initial assessment of swallowing function. An SP or occupational therapists routinely conduct a BSE. Although the VFSS has traditionally been considered the 'gold standard' as an examination procedure to diagnose dysphagia, more recently this traditional understanding is being questioned. Of the 21 subjects who underwent both BSE and VFSS in this study, there was discrepancy in only one subject. We will continue to assess the sensitivity and accuracy of BSE versus VFSS and plan to present our results in a future publication.

The main limitation of this study was a small sample size, which may limit the ability to generalize the findings of this study. Other limitations include the exclusion of individuals with thoracic or lumbar SCI who have chest wall injuries or tracheostomies for various reasons and who may also have dysphagia. However, the clinical significance of dysphagia as a complication after acute cervical SCI should be recognized with this and other previous studies.

In terms of recovery from dysphagia, a recent prospective longitudinal follow-up study by Lee *et al.* found that after anterior cervical spine fusion with a plate design, almost 50% of individuals had dysphagia at 1 month post-surgery, but the incidence decreased to 37% by 2 months and 20% by 6 months.[24] This finding is similar to other studies that show improvement in dysphagia over several months, and in one study, 71% recovered within 2 months.[6,25] However, we are not aware of any study that examined how the recovery from dysphagia occurs in individuals with SCI. We currently do not have enough data to report on the recovery time in individuals with tetraplegia with dysphagia. Our future research should investigate the natural recover of this pathology.

Conclusions

Incidence of dysphagia was found to be approximately 40% in individuals with tetraplegia. Older age, nasogastric tubes, and tracheostomy tubes were found to be significant risk factors. Individuals with dysphagia are at higher risk for pneumonia and longer length of stay in the hospital. By diagnosing dysphagia as soon as possible, potential complications such as aspiration pneumonia can be prevented. On the other hand, if these individuals are identified as not having dysphagia, then

they can start oral diet promptly and earlier, thereby expanding the options of oral medications, avoiding a gastrostomy tube and its associated complications, and improving the patients' nutritional status and mood.

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