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REVIEW ARTICLE

A Review of Dysphagia Presentation and Intervention Following Traumatic Spinal Injury: An Understudied Population

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Abstract Dysphagia is reported to be a common secondary complication for individuals with traumatic spinal injuries. Different etiologies of traumatic spinal injuries may lead to different profiles of swallowing impairment. We conducted a systematic review to determine the characteristics of dysphagia after traumatic spinal injury and to describe interventions currently used to improve swallowing function in this population. A comprehensive multi-engine literature search identified 137 articles of which five were judged to be relevant. These underwent review for study quality, rating for level of evidence, and data extraction. The literature describing dysphagia after traumatic spinal injury was comprised predominantly of low-level evidence and single case reports. Aspiration, pharyngeal residue, and decreased/absent hyolaryngeal elevation were found to be common characteristics of dysphagia in this population. The most commonly used swallowing interventions included tube feeding, compensatory swallowing strategies, and steroids/antibiotics. Improvement in swallowing function following swallowing intervention was reported in all studies; however, there was no control for spontaneous recovery. The results demonstrate a need for high-quality research to profile the pathophysiology of dysphagia after traumatic spinal injury and controlled studies to demonstrate the efficacy of swallowing interventions in this population.

Keywords Deglutition · Deglutition disorders · Swallowing · Traumatic spinal injury · Dysphagia · Systematic review

Introduction

Dysphagia (swallowing impairment) has been identified as a common secondary complication for individuals with traumatic spine injuries and can have life-threatening consequences including aspiration pneumonia [1]. However, there is currently a lack of evidence describing the nature of swallowing impairment in the traumatic spine injury population or describing interventions that have been shown to improve swallowing function. Previous studies have reported an incidence of dysphagia following spinal cord injury ranging from 16.6 to 60 %, with a greater probability of dysphagia following cervical spinal cord injuries [1–3].

Swallowing impairment may occur as a primary or secondary result of a traumatic spinal injury due to a variety of factors including intubation, soft tissue swelling, peripheral nerve damage, and surgery [3]. Speech-language pathologists have reported using a variety of compensatory strategies and exercises to improve swallowing function in individuals with swallowing impairment related to traumatic spinal injury, including the Mendelsohn Maneuver, the supraglottic swallow, and exercises practiced under biofeedback guidance from surface electromyography [4]. Anecdotal evidence and case reports currently inform our understanding of the efficacy of swallowing interventions

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to improve swallowing safety and efficiency in this population.

We conducted a systematic review to improve our understanding regarding the nature of dysphagia in the traumatic spinal injury population and regarding effective swallowing interventions for this population by reviewing the evidence for the following questions:

(1) What is the pathophysiology of swallowing in the traumatic spinal injury population?
(2) What swallowing interventions are currently being used to treat swallowing disorders in the traumatic spinal injury population?

The purpose of this systematic review is to synthesize and evaluate the current evidence regarding swallowing pathophysiology and the efficacy of behavioral interventions to improve swallowing function in the traumatic spinal injury population.

Methods

Search Strategy

A comprehensive literature search was conducted in July 2015. This search was completed following the standards outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement [5]. Seven electronic databases were searched including Ovid MEDLINE, MEDLINE In-Process, EMBASE, AMED, CINAHL, CENTRAL, and PubMed Supplementary Search. The search strategy, which is illustrated in Fig. 1, looked for the keywords: deglutition, deglutition disorders, dysphagi*, swallow*, 'paraplegia* or quadriplegia* or tetraplegia*,' 'surg*,' and 'spine or spinal fracture* or wound* or injur* or damage*.' Asterisks were used with certain search terms to allow for the retrieval of words sharing a common stem or root but different endings, such as "swallow," "swallows," or "swallowing." The full list of search terms used for citation retrieval from the Ovid Medline database is depicted in Fig. 2. It was decided, based on discussion with two speech-language pathologists and an experienced librarian, not to limit the search to search terms focusing on intervention or therapy, given the possibility that intervention may not have been listed as a keyword or subject heading. There were no date or language limitations specified in this search. Using these parameters, the search yielded 2512 citations for review.

Duplicate records were removed from the initial search yield of 2512 citations, resulting in 1984 citations. At this point in the process, titles were screened for relevance to the study questions. Records that focused on a patient population with nontraumatic spinal injuries, congenital/developmental disorders, or comorbid neurological disorders were excluded. Traumatic spinal injury was defined as an injury caused by an external force, such as in a fall. Therefore, participants with traumatic spinal injuries caused by internal forces, such as infarcts, were excluded from this review. As well, patients with preexisting nontraumatic injuries, such as cervical spondylosis, were not included in this review. Records were excluded from the study if the nature of the spinal injury was not specified, or if it included a heterogeneous group of spinal injury patients and data for those with a traumatic spinal injury could not be separated from the data for participants with other types of spinal injuries. Further, records were excluded if they concentrated on esophageal rather than oropharyngeal dysphagia. After reviewing the titles of all 1984 citations, 1069 records were excluded, and 915 records were retained for further review. Abstract review was completed for all 915 records by the first rater, yielding a set of 137 articles considered relevant and suitable for inclusion. Inter-rater agreement for ratings of relevance was calculated based on blinded review of 25 % (i.e., 228) of the abstracts by a second rater. The two raters achieved 91 % agreement regarding relevance and eligibility for inclusion ($\kappa = 0.74$, $p < 0.01$).

The 137 articles that were included based on abstract review underwent full-text review to confirm relevance to the study using the questions found in Table 1. Studies retained in the final set were required to be published in a peer-reviewed journal. Additionally, studies were excluded if they did not involve the assessment of swallowing function using instrumental evaluation, such as a videofluoroscopic swallow study (VFSS) or a fiberoptic endoscopic evaluation of swallowing (FEES). All included studies had to provide a description of dysphagia within the studied sample and/or the type of intervention(s) used. Articles that discussed only the incidence of dysphagia in the population without describing the pathophysiology of dysphagia or resultant intervention were excluded. Consideration of the questions in Table 1 led to the exclusion of 132/137 articles during the full-text review. Data extraction from the articles was performed independently by the first author.

Risk of Bias

Evaluation of the risk of bias was performed by the first author for each of the five articles retained for full review, based on the study design. The CARE checklist [6] was used to evaluate the risk of bias for the four case studies, and the STROBE checklist [7] was used to evaluate the risk of bias for the single retrospective case series study [8]. A summary of the risk of bias in each study is summarized in Table 2 (case studies) and Table 3 (retrospective case series).

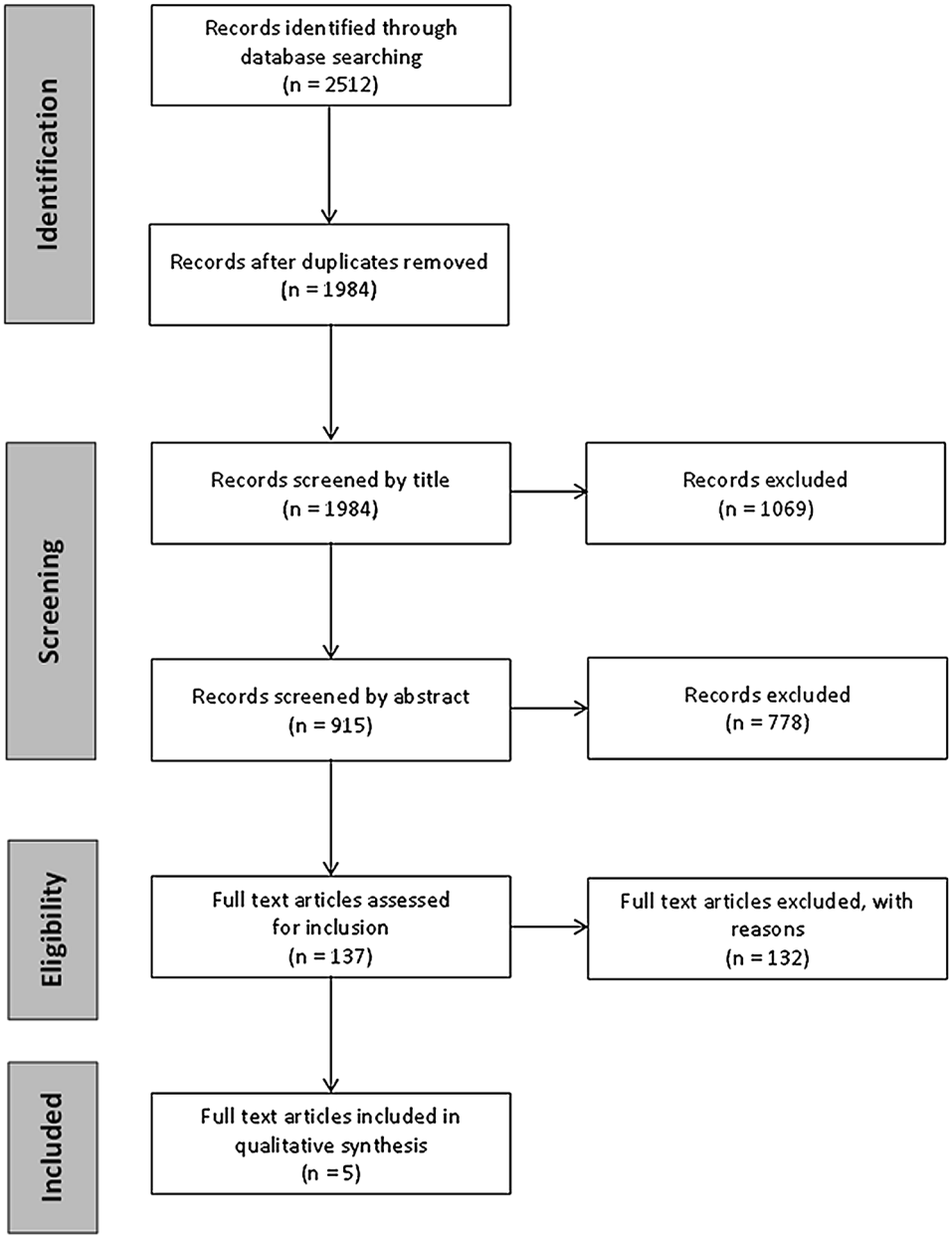

Fig. 1 PRISMA diagram used for article selection inclusion

The most common risks of bias found in the case studies were a lack of information regarding intervention administration, such as dosage, frequency, and duration, as well as absent assessment of intervention adherence and tolerability in the long term. In most studies, duration of tube feedings and diet texture modification were reported in relation to weeks post surgery or post injury; however, the administration of antibiotics or steroids was not routinely described other than noting that these interventions were used to treat symptoms of pneumonia or reduce swelling. In addition, none of the studies discussed the patient's perspective regarding their swallowing issue, other than the initial complaint. This may present a bias in reporting as other studies have shown that patient experience of dysphagia severity and impact may not agree with clinician opinion [9] and patient perception of improvement in their swallowing disorder and quality of life may not always correlate with the objective improvement observed through instrumental assessment [10]. Using the STROBE checklist, the retrospective study conducted by Martin et al. [8] was found to have a low risk of bias, with clear study objectives and methodology described.

Results

The articles accepted for qualitative review and synthesis consisted primarily of case reports (4 of 5 articles). All five of the included studies described the characteristics of

Fig. 2 Search strategy used for Ovid Medline database for citation retrieval

Database: Ovid MEDLINE(R) <1946 to July Week 3 2015>

Search Strategy:

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1 exp Spinal Cord Injuries/ (39477)

2 exp Spinal Cord Ischemia/ (1114)

3 exp Central Cord Syndrome/ (68)

4 (myelopathy adj3 (traumatic or post-traumatic)).tw,kw. (84)

5 ((spine or spinal) adj3 (fracture* or wound* or trauma* or injur* or damag* or surg* or fusion*)).tw,kw. (51861)

6 (spinal cord adj3 (contusion* or laceration* or transaction* or trauma* or ischemi*)).tw,kw. (5548)

7 SCI.tw,kw. (21640)

8 exp Paraplegia/ (11828)

9 exp Quadriplegia/ (7252)

10 (paraplegia* or quadriplegia* or tetraplegia*).tw,kw. (13922)

11 Spinal Cord Compression/ (9943)

12 exp Spine/in (12682)

13 exp Spine/su (28489)

14 central spinal cord syndrome.tw,kw. (9)

15 central cord injury syndrome.tw,kw. (1)

16 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 (121874)

17 exp deglutition disorders/ (43082)

18 Deglutition/ (7594)

19 dysphagi*.tw,kw. (17686)

20 swallow*.tw,kw. (19718)

21 deglutition*.tw,kw. (2727)

22 17 or 18 or 19 or 20 or 21 (66622)

23 16 and 22 (700)

Table 1 Questions used in the relevance review

Relevance review questions	
1	Is the article in a peer-reviewed journal?
2	Does the study involve individuals with a spinal injury due to trauma?
3	Does the study report dysphagia postinjury, with no preinjury history?
4	Does the study use instrumental assessment (VFSS or FEES) to confirm the diagnosis of dysphagia?
5a	Were the characteristics of dysphagia reported?
5b	Was swallowing therapy provided?
	If YES to question 5a or 5b, continue on to question 6.
	If NO, exclude article.
6	Does the study use instrumental assessment (VFSS or FEES) to evaluate swallowing function posttherapy?

dysphagia in the studied sample, and four studies provided information about various interventions used to improve swallowing function. The level or severity of traumatic spinal injury was not restricted in this review; however, all five studies reported a traumatic cervical spine injury at level C4 or higher.

Summary of Articles Included in Qualitative Review

Boczko and Mckeon [11] described the case of a 90-year-old male who was admitted to a subacute rehabilitation facility after a motor vehicle accident that resulted in a C1

Table 2 Risk of bias summary for case studies using the CARE checklist

Topic	CARE checklist item description	Bozcko et al.	Cumpston et al.	Dettling et al.	Shin et al.
Title	The words "case report" should be in the title along with the area of focus	–	–	+	+
Keywords	Four to seven key words—include "case report" as one of the key words	–	–	–	–
Abstract	Background: what does this case report add to the medical literature?	–	–	+	–
	Case summary: chief complaint, diagnoses, interventions, and outcomes	–	+	+	+
	Conclusion: what is the main "take-away" lesson from this case?	–	+	+	+
Introduction	The current standard of care and contributions of this case—with references (1–2 paragraphs)	–	+	–	+
Timeline	Information from this case report organized into a timeline (table or figure)	–	–	–	–
Patient information	Deidentified demographic and other patient or client specific information	+	+	+	+
	Chief complaint—what prompted this visit?	+	+	+	+
	Relevant history including past interventions and outcomes	*	+	+	+
Physical exam	Relevant physical examination findings	+	+	+	+
Diagnostic assessment	Evaluations such as surveys, laboratory testing, and imaging	+	+	+	+
	Diagnostic reasoning including other diagnoses considered and challenges	–	+	–	+
	Consider tables or figures linking assessment, diagnoses, and interventions	–	+	+	+
	Prognostic characteristics where applicable	–	–	–	–
Interventions	Types such as life-style recommendations, treatments, medications, and surgery	+	+	+	+
	Intervention administration such as dosage, frequency, and duration	*	*	*	*
	Note changes in intervention with explanation	*	*	*	+
	Other concurrent interventions	N/A	N/A	N/A	N/A
Follow-up and outcomes	Clinician assessment (and patient or client assessed outcomes when appropriate)	+	+	+	+
	Important follow-up diagnostic evaluations	+	+	+	+
	Assessment of intervention adherence and tolerability, including adverse events	–	–	–	–
Discussion	Strengths and limitations in your approach to this case	–	–	–	–
	Specify how this case report informs practice or clinical practice guidelines (CPG)	–	+	+	+
	How does this case report suggest a testable hypothesis?	–	–	+	–
	Conclusions and rationale	–	+	+	+
Patient perspective	When appropriate include the assessment of the patient or client on this episode of care	–	–	–	–
Informed consent	Informed consent from the person who is the subject of this case report is required by most journals	–	–	+	–
Additional information	Acknowledgement section; competing interests; IRB approval when required	–	+	+	–

+ sufficient information was provided in the article

– information was not provided in the article

* insufficient information was provided for this criterion

fracture, C2 dislocation, T1–2 fracture, and left eye trauma. He underwent surgery via an anterior approach to place surgical pins, and then proceeded to have a surgical fusion of C1–C2 via a posterior approach. Postoperatively, the patient was unable to swallow safely and a percutaneous endoscopic gastrostomy tube was placed. FEES examination indicated that the patient was not appropriate for oral intake and a subsequent treatment plan to improve swallowing function was developed. The patient was seen twice a day for treatment including thermal-tactile stimulation and swallowing strategies such as the Mendelsohn Maneuver and effortful swallow practiced with electromyography biofeedback. After an unspecified number of weeks of intervention, a VFSS was performed, during

Table 3 Risk of bias summary for retrospective studies using the STROBE checklist

Topic	STROBE item description	Martin et al.
Title and abstract	Indicate the study's design with a commonly used term in the title or the abstract	+
	Provide in the abstract an informative and balanced summary of what was done and what was found	+
Introduction	Background/rationale: explain the scientific background and rationale for the investigation being reported	+
	Objectives: state specific objectives, including any prespecified hypotheses	+
Methods	Study design: present key elements of study design early in the paper	+
	Setting: describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	+
	Participants: cohort study—give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	+
	Variables: clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	+
	Data sources/management: or each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	+
	Bias: describe any efforts to address potential sources of bias	–
	Study size: explain how the study size was arrived at	+
	Quantitative variables: explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
	Statistical methods:	N/A
	(a) Describe all statistical methods, including those used to control for confounding	
	(b) Describe any methods used to examine subgroups and interactions	
	(c) Explain how missing data were addressed	
Results	Participants:	+
	(a) Report numbers of individuals at each stage of study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	
	(b) Give reasons for nonparticipation at each stage	
	(c) Consider the use of a flow diagram	
	Descriptive Data:	+
	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	
	(b) Indicate number of participants with missing data for each variable of interest	
	Main results:	N/A
	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95 % confidence interval). Make clear which confounders were adjusted for and why they were included	
	(b) Report category boundaries when continuous variables were categorized	
	(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
	Other analyses: report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion	Key results: summarize key results with reference to study objectives	+
	Limitations: discuss limitations of the study, taking into account sources of potential bias or imprecision.	+
	Discuss both direction and magnitude of any potential bias	
	Interpretation: give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	+
	Generalizability: discuss the generalizability (external validity) of the study results	+
Other information	Funding: give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	+

+ sufficient information was provided in the article

– information was not provided in the article

* insufficient information was provided for this criterion

which decreased hyolaryngeal elevation and incomplete airway closure were noted. The strategies that had been used in therapy were interpreted to have been effective for increasing laryngeal elevation and pressure generation during swallowing. It was recommended that trials of puree solids and nectar-thick liquids be incorporated into the therapy sessions using these strategies. A second VFSS was subsequently conducted to confirm the patient's tolerance for a diet upgrade following observed improvements in the patient's ability to properly use the recommended compensatory swallowing strategies and a reported increase in oral intake. The results showed that he was able to tolerate mechanical soft consistencies while using his compensatory strategies. The authors report that the patient was able to progress to eating three meals daily of regular consistency foods and thin liquids each day after <3 months of therapeutic intervention and was able to return home without a feeding tube.

Cumpston and Bock [12] described the case of an 84-year-old male who presented with a displaced and unstable C2 odontoid fracture following a fall at home. After surgery, which included a C1–C2 fusion via a posterior approach, the patient experienced swallowing difficulties and showed signs of aspiration pneumonia 5 days post surgery. A swallowing study revealed frank aspiration, absent elevation of the larynx, and pooling of secretions and barium in the hypopharynx. A percutaneous endoscopic gastrostomy tube was placed on day 12 for nutrition. A second modified barium swallowing study, 3 weeks post surgery demonstrated absent pharyngeal contraction and laryngeal elevation, minimal tongue base movement, and aspiration. The patient was reported to have a strong cough. Three weeks later, a third swallowing study showed continuing concerns of diffuse pharyngeal paralysis and aspiration. A computed tomography scan of the neck was ordered because right sided vocal fold paresis was noted. The CT scan showed the projection of a screw through the C1 body into the right side of the retropharynx. Continued tube feeding was recommended. Two months later, the patient presented with improvement in his voice and swallowing function. Videostroboscopy showed improvements with respect to the pooling of secretions and the vocal fold paresis. A further modified barium swallowing study showed resolution of aspiration. Considering these results, oral feeding was reintroduced and the patient's diet was advanced over a 4-week timeframe to a normal diet.

Dettling et al. [13] reported the case of a 16-year-old male who sustained a C1 burst facture with bilateral anterior ring fractures and a posterior fracture on the right side of the C1 ring during a tackle while playing football. Following surgery for halo fixation, the patient complained of dysphagia. Clinical assessment using nasopharyngoscopy (henceforth referred to as fiberoptic endoscopic evaluation of swallowing) revealed decreased soft palate movement, decreased gag reflex, pooling of secretions in the pyriform sinuses, poor laryngeal elevation, decreased true vocal cord movement, and a wet voice quality. These findings indicated that the patient was at risk for aspiration; therefore, a nasogastric tube was placed and tube feedings commenced. A videofluoroscopy swallow study was conducted two and a half weeks post injury and showed that the patient was aspirating liquids and continued to have pooling in the pyriform sinuses. A second videofluoroscopic evaluation was conducted 4 weeks following the injury and showed resolution of aspiration. At this time, the patient's feeding tube was removed and he resumed oral feeding of all liquids and solids.

Martin et al. [8] conducted a retrospective study to describe the patterns of dysphagia that occur following anterior cervical spine surgery. A heterogeneous sample of individuals with spinal cord injury was included. For the purpose of this review, results for the single patient who had sustained a traumatic spine injury (traumatic dislocation of C2 on C3 related to a motor vehicle accident) were discussed. The following findings were noted during a VFSS examination of this patient's swallowing: reduced pharyngeal wall movement, impaired UES opening, incomplete epiglottic deflection, absent pharyngeal swallow, laryngeal penetration, aspiration, reduced tongue propulsive action, vallecular pooling, pyriform sinus pooling, and impaired reflexive cough. The authors attributed some of these difficulties to the anterior surgical approach used and to postoperative complications such as prevertebral soft tissue swelling or nerve damage.

Shin et al. [14] presented the case of a 75-year-old man who reported mild dysphagia following anterior cervical discectomy with fusion, performed after he had fallen while hiking. Videofluoroscopic examination showed silent aspiration on 3 cc boluses of thin and thick liquids. Based on the results of a variety of assessments, including laryngoscopy and laryngeal EMG, the patient was also diagnosed with right superior laryngeal nerve (SLN) and left internal branch of the SLN palsy. It should be noted that the internal branch of the SLN is considered a critical nerve for the initiation of swallowing [15]. A small-bore "L-tube" feeding tube was inserted at that time to reduce the risk of aspiration. Following 2 weeks of tube feeding, a second videofluoroscopic swallow study was conducted, showing some improvement with reduced aspiration. The L-tube was removed and the patient resumed oral feeding on a soft consistency. A third videofluoroscopic examination was conducted 2 weeks following removal of the L-tube and showed complete resolution of aspiration.

Discussion

Characteristics of Dysphagia

All of the articles accepted for qualitative synthesis described dysphagia based on results of instrumental assessment. Videofluoroscopic swallowing studies were the most commonly used instrumental assessment; however, FEES was used in conjunction with VFSS in two studies [11, 13]. Synthesis of the results from the five studies revealed a common pattern of swallowing difficulties for individuals with spinal cord injury; these results are summarized in Table 4. Each study utilized different parameters to determine if swallowing was pathological, yielding a variety of different terms used to describe the characteristics of the impaired swallow. For example, the terms residue and pooling were often used interchangeably to refer to bolus material remaining in the pharyngeal space following the swallow. Aspiration, pharyngeal residue, reduced/absent pharyngeal movement, and decreased/absent hyolaryngeal elevation were found to be common characteristics of dysphagia in this population.

The characteristics of dysphagia identified in the traumatic spinal injury population suggest an underlying mechanism of neurologic injury to structures and nerves necessary for safe and efficient swallowing, as well as short-term postsurgical complications that impair movement and coordination of the swallowing musculature. The exact cause of dysphagia in the traumatic spinal injury is still unknown and is likely to be multifactorial. Relevant factors include, but may not be limited to, soft tissue swelling, displacement of the esophagus and/or pharynx, damage to critical nerves from retraction and dissection, and hematoma [16, 17]. Sensory deficits as a result of damage to the pharyngeal and laryngeal branches of the vagus nerve or the glossopharyngeal nerve may also be implicated due to reported observations of silent aspiration and impaired cough reflex in this population [18]. Further investigation into a patient's history, injury, and/or course of surgery can provide information regarding potential causes of and contributing factors to dysphagia.

Swallowing Interventions

The most commonly used swallowing interventions in the studies reviewed included tube feeding, diet texture modification, compensatory swallowing strategies, and steroids/antibiotics. These interventions are summarized in Table 5.

Tube Feeding

Tube feeding provides an alternative means of maintaining adequate nutritional status for individuals who are at risk for aspiration, malnutrition, or dehydration related to their dysphagia. This form of nutritional support may provide a safe alternative for feeding for those who are unable to tolerate an oral diet due to swallowing safety impairments [19]. The placement of feeding tubes, whether nasogastric or percutaneous endoscopic gastrostomy, is a common trend evident in current literature describing the management of swallowing impairment for individuals with a spinal injury. All of the studies that reported and described swallowing intervention, summarized above, used feeding tube placement as part of the short- or long-term management plan.

The need for tube feeding may be determined based on the cause and nature of dysphagia following spinal cord injury as well as its duration (whether transient or chronic). For example, postoperative swelling of prevertebral soft tissue can impact an individual's ability to swallow safely. Further, the swelling of soft tissue may impact sensation during swallowing, lead to impaired pharyngeal constriction, and result in swallowing pain or discomfort (odynophagia). Khaki et al. [20] found that soft tissue swelling was at its greatest in the immediate postoperative phase with a rapid decrease in swelling by 6 weeks after surgery. As swelling reduces, the presence and/or severity of dysphagia may subside, allowing a patient to resume oral intake. Therefore, tube feedings may be indicated for a short period of time in a patient with soft tissue swelling to provide nutritional support while they experience symptoms of dysphagia, as well as to avoid aggravation of the tissue while healing. Similarly, retropharyngeal hematomas may develop as a result of trauma and may also cause an individual to experience transient dysphagia. Spontaneous improvement in transient dysphagia was noted over time in all studies following placement of a feeding tube [11–14].

Diet Texture Modification

Diet texture modifications have become a common intervention for individuals with swallowing impairment. Modified diet textures are thought to promote safe swallowing by slowing flow rate, and/or reducing the strength or effort required for effective swallowing [21]. Three of the four studies that discussed swallowing intervention reported the use of modified diets for individuals with traumatic spinal cord injury [11, 12, 14]. Diet textures were individualized as per each patient's needs, and varied both for solids (soft or regular) and liquids (thin or thickened). Diet texture modifications were typically used in addition to other dysphagia management strategies, primarily tube feedings.

Behavioral Compensatory Swallowing Strategies

Compensatory swallowing strategies include maneuvers, postures, and stimulation techniques used to improve swallowing efficiency and safety for a particular diet

Table 4 Summary of data extracted from the selected articles for qualitative synthesis for characteristics of dysphagia

Authors	Year	Sample size	Age (years)	Cause of injury	Type of SCI	Instrumental assessment used for confirmation of dysphagia	Characteristics of dysphagia at initial evaluation
Bozcko and McKeon	2008	1	90	Motor vehicle accident	C1 fracture, C2 dislocation, T1–2 fracture and left eye trauma	Fiberoptic endoscopic evaluation of swallowing and videofluoroscopic swallowing study	FEES: Delayed, weak, and incomplete swallow aspiration VFSS: Decreased hyolaryngeal movement Incomplete airway closure
Cumpston and Bock	2015	1	84	Fall	Displaced and unstable C2 odontoid fracture	Videofluoroscopic swallow study	Aspiration Absent hyolaryngeal elevation Pharyngeal residue
Dettling, Morscher, Masin, and Adamczyk	2013	1	16	Sports injury (tackle collision)	C1 burst fracture with bilateral anterior ring fractures and 1 posterior fracture on the right side of the C1 ring	Fiberoptic endoscopic evaluation of swallowing	Decreased soft palate movement Decreased gag reflex Poor laryngeal elevation Pharyngeal residue Decrease true vocal fold movement
Martin, Neary, and Diamant	1997	13	59 (25–81)	Motor vehicle accident	Traumatic dislocation of C2 on C3 due to MVA	Videofluoroscopic swallowing study	Reduced pharyngeal wall movement Impaired UES opening Incomplete epiglottic deflection Absent pharyngeal swallow Penetration Aspiration Reduced tongue propulsive action Pharyngeal residue Impaired reflexive cough
Shin, Sung, Nam, and Cho	2012	1	75	Fall	Fracture and subluxation at the C3–C4 level with a left vertebral artery injury	Videofluoroscopic swallowing study	Silent aspiration

Table 5 Summary of data extracted from the selected articles for qualitative synthesis for swallowing interventions

Authors	Year	Sample size	Age (years)	Cause of injury	Type of SCI	Instrumental assessment used for confirmation of dysphagia	Dysphagia intervention	Swallowing outcome
Bozcko and McKeon	2008	1	90	Motor vehicle accident	C1 fracture, C2 dislocation, T1–2 fracture and left eye trauma	Fiberoptic endoscopic evaluation of swallowing and videofluoroscopic swallowing study	PEG tube, thermal-tactile stimulation, electromyography, compensatory strategies (Mendelsohn Maneuver and effortful swallow), bolus trials, diet texture modification	Returned to a regular diet texture and thin liquids in <3 months
Cumpston and Bock	2015	1	84	Fall	Displaced and unstable C2 odontoid fracture	Videofluoroscopic swallow study	PEG tube and antibiotics, diet texture modification	Improved, PEG tube was eventually removed and patient was able to return home with normal swallowing function
Dettling, Morscher, Masin, and Adamczyk	2013	1	16	Sports injury (tackle collision)	C1 burst fracture with bilateral anterior ring fractures and 1 posterior fracture on the right side of the C1 ring	Fiberoptic endoscopic evaluation of swallowing	Nasogastric tube and steroids	No evidence of aspiration, feeding tube was removed, oral feeding of all solids and liquids resumed
Shin, Sung, Nam, and Cho	2012	1	75	Fall	Fracture and subluxation at the C3–C4 level with a left vertebral artery injury	Videofluoroscopic swallowing study	L-tube, diet texture modification	No evidence of aspiration, removed L-tube

texture that would, without the use of strategies, be considered unsafe [22]. One study reported using multiple compensatory swallowing strategies in addition to tube feeding for swallowing intervention [11]. These strategies included thermal-tactile stimulation, and surface electromyography biofeedback used to guide practice of the Mendelsohn Maneuver and Effortful Swallow. This case study described an individualized therapy plan for the patient and noted improvement of swallowing function following a course of swallowing intervention using these strategies as defined by the patient's ability to return to a regular diet texture and thin liquids. As this study did not utilize a no-treatment control group for comparison, the contribution of spontaneous recovery cannot be determined.

Steroids/Antibiotics

The use of steroids and antibiotics was reported in two of the articles included for qualitative synthesis. Steroids and antibiotics are often used following spinal surgery to manage complications arising from intubation and surgical procedures. For patients who have undergone cervical spine surgery, steroids are often prescribed to reduce pharyngeal edema, pharyngoesophageal wounds, and fistulas. Antibiotics are typically used following spinal surgery to prevent or treat infections at the surgical site. As these complications can impair swallowing function and lead to secondary restrictions of pharyngeal movement or epiglottic deflection, the use of steroid treatment or antibiotics postoperatively has potential to improve swallowing outcomes [23, 24]. In the studies reviewed, steroids and antibiotics appeared to contribute to improved swallowing function when used in addition to other swallowing interventions, primarily tube feedings [12, 13].

Limitations

Recommendations and clinical decisions to use certain therapeutic interventions should be based on strong research evidence. To best inform one's clinical decisions,

one should strive to find articles that provide high levels of evidence, such as systematic reviews, meta-analyses, randomized controlled trials, and cohort studies [25]. Unfortunately, this type of information is not always available in the literature.

Four of the five articles included in the final set for qualitative synthesis were single case reports, indicating Level 4 evidence according to the Oxford Centre for Evidence-Based Medicine [26]. Although case studies allow for an in-depth analysis of a single event/circumstance and can provide ample qualitative information, the data are usually not generalizable to the wider population. Further, greater variability in reported characteristics and interventions used reduces the applicability of this information to the greater spinal injury population. Finally, given the limited number of articles that qualified for inclusion, and the fact that they exclusively were case studies/series, the generalizability of the findings of this review is limited. This review clearly highlights a large gap in knowledge regarding the nature of dysphagia in the traumatic spinal injury population and points to a need for future research. Therefore, this evidence is not considered a strong basis for clinical decision-making but can be used to inform decisions in conjunction with other available evidence and guide future research in this area.

In this review, dysphagia and swallowing impairment were inconsistently defined across the studies included for full-text review and qualitative synthesis. Within this article set, dysphagia was often diagnosed based on the incidence of aspiration before, during, or following the swallow [13, 14]. Although aspiration can occur when an individual has dysphagia, it is not the only characteristic of a swallowing impairment. To gain a clearer understanding of how traumatic spinal cord injuries may affect swallowing function and which interventions may be effective for rehabilitation, dysphagia must be clearly defined, and detailed investigations of the pathophysiological mechanisms contributing to impaired swallowing safety and efficiency will be needed.

Conclusion

Dysphagia has been identified as a serious condition that affects many individuals following traumatic spinal cord injury. The purpose of this review was to characterize swallowing impairments in the traumatic spinal cord injury population and understand the outcomes of various behavioral interventions used to treat dysphagia in this population. Current evidence is of low-level quality, comprising mainly case studies. Based on this small selection of literature, a clear pattern of swallowing impairment due to a traumatic spinal injury is not yet available. In addition, the effectiveness of the various swallowing interventions used in the studies reviewed cannot be determined. Based on the identified literature gaps in critically and comprehensively describing the characteristics of dysphagia and in evaluating outcomes dysphagia interventions in the traumatic spine injury population, it is clear that further research is needed.

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Compliance with Ethical Standards

Conflicts of Interest The authors have no conflicts of interest to disclose.

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