Dysphagia Rehabilitation Interventions in Moderate-Severe Acquired Brain Injury: A Scoping Review

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Abstract

Objectives: To conduct a scoping review of the available literature and identify existing interventions for dysphagia rehabilitation among individuals with moderate to severe ABI during the acute and chronic phases of recovery. Design: Scoping review involving a literature search of multiple databases for studies published in English up to July 2018. Inclusion criteria: (1) moderate-severe ABI, (2) participants aged 18+ years, and (3) a dysphagia rehabilitation intervention was provided. The Physiotherapy Evidence Database (PEDro) tool was used to determine methodological quality. Results: 17 studies met inclusion criteria; nine of which had <50% ABI participants, four had >50% ABI, and four did not specify ABI percentage. Twelve studies were published between 2012-2018, and five were published between 1990-2007. Fifteen journal articles and two conference abstracts met inclusion. Five randomized controlled trials (RCTs) were included, two level 1b evidence, two level 2 evidence, and one was of unknown quality. Four prospective controlled trials (PCTs) provided level 2 evidence. Three post-test and three pre-post studies provided level 4 evidence, and two case reports provided level 5 evidence. Nine different interventions were investigated, with electrical stimulation, individualized management programs, and diet manipulation being the most common. Eleven unique outcome measures were used overall, which crossed several domains. Conclusions: The literature investigating dysphagia rehabilitation interventions for ABI, the vast majority of which are traumatic brain injury is limited, with wide variability in intervention type, study design, injury etiology, and outcome assessment across studies. There remains an important evidence gap for ABI dysphagia rehabilitation.

Introduction

Acquired brain injury (ABI) can occur from a traumatic (i.e., falls, assaults, injuries, motor vehicle accidents) or non-traumatic (tumors, congenital defects, aneurysm, etc.) etiology (1, 2). Traditionally, ischemic or hemorrhagic strokes have not been included in the definition of ABI given their unique pathophysiology and outcomes. Following an ABI, patients may present with a number of impairments including dysphagia, a common and challenging problem affecting the rehabilitation process. Dysphagia or oropharyngeal dysphagia is characterized by abnormal function or structural deficit of the oral cavity, pharynx, larynx, or esophagus as a result of damage to motor and sensory coordinating pathways (3). Delayed pharyngeal movement and failure to coordinate the passage of food into the esophagus, while also protecting the airway or trachea, can result in aspiration of food and liquids. While many patients with dysphagia do not aspirate, the risk of aspiration rises with the severity of the dysphagia.

Severity of dysphagia is typically related to the severity of the underlying brain lesion. Moderate and severe ABIs result in high rates of dysphagia (4, 5); dysphagia is rare in those with mild ABI (6). Overall, prevalence rates of dysphagia range 27-30% in patients with traumatic brain injury (TBI) (7). Dysphagia can cause severe and sometimes life-threatening problems largely due to airway obstruction, aspiration, and the risk of pneumonia and sepsis (8). Additionally, poor nutritional intake with resultant malnutrition and dehydration can present later (3). Nutritional status is important after ABI as it impacts both short and long-term recovery. Malnutrition and dehydration have been shown to significantly extend a patient's acute care hospital stay, 1.6 times longer compared to non-malnourished, and impact functional independence during rehabilitation (9-11). The consequences of dysphagia can be mitigated if this condition is diagnosed and managed promptly (12). Generally, Speech Language Pathologists assess and apply interventions to reduce the risk of aspiration and improve swallowing function (6). While the most common interventions are dietary-related (food texture modification), compensatory and rehabilitative strategies are also used.

Controversy remains regarding the effectiveness of dysphagia interventions in neurological populations. Research often focuses on either a single intervention type or on a specific research question, not reflecting the significant heterogeneity of data (13). The majority of dysphagia studies examine the stroke population, or a mixed populations with little attention to the underlying etiology (14, 15). Since deficits are similar between ABI and stroke (16), often ABI rehabilitation therapists "borrow" strategies from the stroke rehabilitation literature. Unfortunately, differences in underlying pathophysiology of ABI may warrant the use of distinct approaches (17). While stroke leads to focal brain damage, TBI lesions may be a complex mixture of focal injury and diffuse axonal injury (18). In fact, there is a paucity of ABI-specific literature for dysphagia interventions. Reviewing ABI-specific studies are necessary to better address the rehabilitation needs of these patients. To investigate the available literature and identify existing interventions for dysphagia rehabilitation, we sought to conduct scoping review of individuals with moderate to severe ABI during the acute and chronic phases of recovery.

Methods

Identifying the Research Question

A scoping review of the literature was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR) (19) and informed by the methodological framework described by Arksey and O'Malley (20). Scoping reviews address a research question aimed at mapping key concepts, types of evidence and gaps in research related to a defined field. They are useful to identify literature regardless of study design or data heterogeneity (20). Therefore, a scoping review was deemed appropriate given the scarce literature in ABI and dysphagia. The research question identified was: *What literature is available investigating dysphagia-specific interventions for moderate-severe ABI in the acute and chronic phase of recovery?*

Study Search

A literature search was conducted for studies published from 1970 to July 2018 using the following databases: PubMed/MEDLINE, EMBASE, Web of Science, Scopus, and CINAHL. The search strategy contained three constructs: brain injury, dysphagia, and rehabilitative interventions used for patients with dysphagia; the final search strategy is shown in Appendix A. Only studies published in the English language and in peer-reviewed journals were included.

Study Selection

Search results were managed using EndNote (v7.0). After removing duplicates, two reviewers (BB, AMc) assessed study relevance by title, then abstract, and finally full text. A third reviewer (MM) resolved discrepancies. Articles must have met the inclusion criteria: (1) participants had moderate-severe ABI defined as post-traumatic amnesia >1 hour, or Glasgow Coma Scale score <13, or loss of consciousness >15 minutes; (2) participants were 18+ years old; and (3) a dysphagia rehabilitation intervention was provided to participants. Studies were excluded if they were a general review article, systematic review, or scoping review (e.g., Cochrane, ASHA evidence maps). Further, study protocols, feasibility studies, and studies using only qualitative methodology were excluded. Participants with mild ABIs were excluded and based on the following criteria: (1) post-traumatic amnesia <1 hour; or (2) Glasgow Coma Scale score of 13-15; or (3) loss of consciousness <15 minutes. Unavailable full-text articles or conference abstracts with previously included full-text articles were removed. Reference lists of included studies were scanned to identify any publications missed studies.

Methodological Quality Assessment

The methodological quality of randomized controlled trials (RCTs) was assessed using the Physiotherapy Evidence Database (PEDro) tool (21). The PEDro is an 11-item scale; a point is awarded for each satisfied criterion that yields a score out of ten with the first item excluded. Scores were determined by two independent reviewers (BB, AMc). PEDro scores were used to categorize RCTs as poor (<4), fair (4-5), good (6-8), or excellent (9-10) quality (22). Additionally, studies were assigned a level of evidence based on a their research design according to a modified Sacket scale (23).

Data Extraction

A single reviewer (BB) extracted key information including: author(s), year and country of publication, study design, sample size, demographic information (e.g., age, gender, injury etiology), intervention type, comparators, and outcome measures.

Data Synthesis

Studies were organized into tables and categorized based on the proportion of the sample with ABI. The following three categories were used: <50% ABI, >50% ABI, or unknown. These three groupings were used to separate studies to clarify the number and type of interventions studied with a uniquely homogenous ABI population, mixed heterogenous stroke and ABI population, or proportion unknown population, respectively. This is to aide in transparency of the research literature with respect to dysphagia interventions in ABI.

Results

Study Selection

The PRISMA flow chart outlining the study selection process is presented in Figure 1. The literature search was conducted on March 2, 2019 which resulted in a total of 1,291 publications. After removal of duplicates, the remaining 885 titles and abstracts were reviewed for inclusion which resulted in 270 references for full text review. In total, 17 studies met inclusion criteria and were included for this scoping review.

Insert Figure 1 about here.

Study and Participant Characteristics

Among the 17 studies included for review, nine studies (24-32) had a population of <50% ABI, four had >50% ABI (33-36), and four had included an ABI population but did not specify what percentage or proportion was included for study (37-40). Table 1 presents the study and participant characteristics. Specific information regarding patient feeding patterns (i.e., whether individuals were exclusively fed orally pre and post neurological event) were not provided in the articles selected.

Insert Table 1 about here.

The majority (n=12, 70.6%) of studies were published in the last seven years (2012-2018) (25, 26, 28, 30-32, 34-38, 40) and the remaining studies (n=5, 29.4%) were published more than ten years ago (1990-2007) (24, 27, 29, 33, 39). Fifteen studies were published as journal articles, and two were conference abstracts. Four studies originated in the United States, three each from Spain and South Korea, two from each of the following countries, Canada, and Japan, and one each from South Africa, Germany, and Italy. The mean sample size (standard deviation) was 38.1 (34.9) subjects.

Methodological Quality

In total, five RCTs were captured from the included studies, two of which were of good methodological quality (level 1b evidence; PEDro=7 and 8, respectively (31, 37), and two were fair (level 2 evidence; PEDro=5; (30, 40). The RCT conference abstract was of unknown quality, as a PEDro score could not be calculated with the information reported (38). Four prospective controlled trials (PCTs) provided level 2 evidence (25, 27, 28, 32). Three pre-post studies (26, 29, 36), and three post-test studies (24, 35, 39) provided level 4 evidence; finally, two case reports (33, 34) provided level 5 evidence.

Dysphagia Interventions

Study interventions and outcome measures are presented in Table 2. Of the 17 studies included, there were nine different interventions used for dysphagia rehabilitation.

Three RCTs and one PCT examined the use of neuromuscular electrical stimulation (NMES) versus sham stimulation in their study populations, which had either <50% ABI (31, 32), or the study authors did not specify the proportion (37, 40). A PCT with <50% ABI population examining the use of laryngopharyngeal NMES coupled with conventional swallowing therapy (CST) was compared to CST alone (25). An additional case report examined the use of a specific type of neuromuscular stimulation, VitaStim (VsT), versus CST (including swallowing exercises, shaker exercise, hyoid lift, compensation postures, and dietary changes) alone to manage dysphagia symptoms (34). A unique bilateral muscle stimulation intervention that targeted the "k-point" intraorally was examined by Kojima et al. (39), with an unknown proportion of participants having an ABI.

Three studies examined dysphagia-specific rehabilitation programs including combined muscle exercises and a prescribed swallowing routine, two of which had <50% ABI populations (24, 26); the remaining post-test conference abstract had >50% ABI population (35).

Swallowing therapies that involved manipulating participants' diet and adjusting bolus viscosity and velocity were studied in two articles, including a TBI-specific case report (33) and a post-test study with 22% ABI population (24).

Single studies made up the remaining intervention types. Terre and Mearin (30) conducted a RCT with 37% ABI population, where patients either performed a chin-down maneuver compared to anatomical positioning while eating and drinking to investigate if there was improvement in swallowing ability or presence of aspiration. A PCT by Seedat and Penn (28) investigated the effect of scheduled oral care versus inconsistent oral care in relation to dysphagic symptoms in a 70% stroke and 30% TBI population. Facio-oral tract therapy, which used a combination of interventions targeting nutrition, oral hygiene, non-verbal communication, stimulation of the oral cavity, and speech therapy, was performed by Seidl et al. (29) on a study population of <50% TBI. A training program focused on improving tongue-pressure strength and accuracy (TPSAT) for improving dysphagia and aspiration outcomes was studied among six individuals who had a TBI (36). Finally, a unique program that offered a remote, online tele-dysphagia swallowing intervention compared to a traditional, in-person dysphagia management program was presented as a conference abstract (ABI % unknown) (38).

Insert Table 2 about here.

Outcome Measures and Evaluation

A total of 11 unique outcome measures were used, with the most commonly used measures being the penetration aspiration scale (PAS, n=3), functional dysphagia scale (FDS, n=2), level of oral intake (ASHA National Outcome Measurement System (NOMS), n=2), and functional oral intake scale (FOIS, n=2). Outcome measures in the included studies crossed several domains and evaluated various outcomes including swallowing function, nutritional status, and aspiration.

Discussion

This scoping review sought to gain an understanding of the available literature on interventions for dysphagia rehabilitation among individuals with moderate to severe ABI. There has been a growth in the number of relevant studies within recent years, suggesting an increased focus on evidence-based dysphagia rehabilitation for this clinical population. However, among the included studies, there was significant variability with respect to study design, intervention type, and outcome measures. Furthermore, most of the studies reviewed included mixed etiological populations, wherein stroke subjects were included alongside, and frequently outnumbered, ABI subjects. Furthermore, apart from the two case reports identified, there were only two other studies which recruited an entirely ABI population (>1 participant). Taken together, the evidence base for dysphagia among those with ABI is weak.

Overall, ABI-specific literature related to dysphagia rehabilitation is limited, especially when compared to other neurological populations such as stroke (16). Often, rehabilitation approaches for dysphagia in stroke and ABI populations are similar (41). However, dysphagia interventions may not necessarily be generalizable to both populations due to the differing nature of the conditions themselves; ABI can be much more complex than stroke, particularly more diffuse brain injuries, and have different recovery rates for motor, sensory, and cognitive function long term (4, 16, 41). Continuing to mix these neurological populations in research studies may be inappropriate without first developing further knowledge in ABI alone and comparing it to existing stroke rehabilitation evidence. By doing so, the generalizability of interventions from the stroke literature to individuals with ABI can be determined. Thus, it is paramount that future studies should strive to recruit more homogeneous brain injury populations, or stratify results by etiology, to establish treatment effectiveness for each clinical population separately.

Currently, several interventions have been examined for dysphagia rehabilitation in the ABI population. However, many interventions were evaluated as a single modality, while only one study used an individualized, multimodal, interdisciplinary therapeutic approach (29). Dysphagia is a complex disorder that involves multiple components, including motor, cognitive, sensory, and coordination mechanisms (17, 42). Post ABI, dysphagia may be accompanied by comorbid deficits, which can vary across cognitive, communication, and behavioural domains (17, 42). Taken together, there is a lack of research examining the potential benefits of using multimodal interventions for dysphagia. It would be worthwhile to evaluate whether ABI populations benefit more from combined or multimodal interventions compared to singular treatments, as it has been suggested that the best way to optimize treatment is to use a multidisciplinary approach (2, 17).

The most examined interventions identified in this review (i.e., forms of electrical stimulation, individualized management programs, diet manipulations and oral care) were each supported by varying study designs, while the least common intervention types were each investigated by single studies. Overall, the included studies were evenly distributed in terms of the strength of evidence supporting a dysphagia intervention, with just over half (n=9) of the included studies being either level 1b or level 2 evidence, and the rest level 4 or lower. Although the body of literature for dysphagia rehabilitation in ABI includes five RCTs, the majority of these (31, 37, 40) investigated the same intervention (i.e., NMES). Thus, a large proportion of other interventions were supported by lower quality evidence. While some interventions lend themselves better to certain study designs, these results demonstrate the continued need for high quality studies with appropriate controls.

In addition to the variability in interventions and study designs, it is important to also note the significant heterogeneity of outcome measures used. This is not unusual in ABI research; a systematic review of assessment tools used in ABI research revealed a large degree of heterogeneity in measures used (43). A total of >700 instruments were identified, with the vast majority being used or mentioned in only a single study (43). Typically, outcome measures should reflect the type of intervention being studied. This scoping review found that even across similar interventions, outcome measures were still highly diverse. Future studies should aim for similar outcome assessment protocols, as well as those psychometrically validated for ABI, as this would aid in better comparing findings across studies and more accurately determining treatment effectiveness.

Limitations

The current review is not without its own limitations. As our search criteria were limited to English publications, our understanding of the available dysphagia rehabilitation literature for ABI does not reflect studies published in other languages. We also focused exclusively on adult participants; therefore, the findings cannot be translated to the pediatric population. Finally, due to studies' inconsistencies in defining brain injury (i.e., ABI, TBI, stroke), it is possible that some studies may have been missed in the literature search during the screening process.

Conclusions

Although the clinical presentation of dysphagia may be similar between ABI and stroke, the rehabilitation needs and appropriate treatment approaches for these two groups may be unique due to differing underlying pathophysiology. Therefore, it is important to collate the number and type of interventions specifically treated in individuals with ABI. This information is important for clinicians who are providing therapy for those with ABI. Traditionally, rehabilitative management for dysphagia in ABI have been guided by the stroke literature; however, the generalizability of stroke dysphagia interventions to those with ABI is unknown. To ensure rehabilitation interventions with the strongest research evidence are offered to patients, therapists must be aware of the options available to them. This review has succinctly summarized the available literature, in terms of number, intervention type, population studied, and outcomes assessed.

This scoping review has identified a number of gaps for which future studies should investigate dysphagia rehabilitation interventions in ABI that 1) utilize high-quality study design methodology, 2) further investigate the effect of multimodal interventions, and 3) consider using standardized and/or validated outcome measures to allow for more accurate comparisons of findings across studies investigating similar interventions. Furthermore, to establish an evidence base for dysphagia rehabilitation specifically in ABI, and to determine the generalizability of dysphagia interventions from the stroke literature to individuals with ABI, future studies should strive to recruit more homogeneous brain injury populations or stratify results by etiology when assessing treatment effectiveness.

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Table 1. Study and Participant Characteristics

Author, Year PEDro[a] (if applicable) LOE[b]	**Country**	**Study Design**	**Sample Size by Injury Etiology**	**Gender**	**Gender**	**Mean Age (yr)**
				Males (n)	**Females (n)**	
Malandraki et al. 2016 Level 4	USA	Pre-Post	Stroke=6 TBI[d]=2 Other=2	8	2	64.6
Seedat & Penn 2016 Level 2	South Africa	PCT[e]	Stroke=32 TBI[c]=14	23	23	N/S[f]
Terre & Mearin 2015 PEDro[a]=7, Level 1b	Spain	RCT[g]	Stroke=14 TBI[d]=6	12	8	CG[h]: 51 IG[i]: 46
Terre & Mearin 2012 PEDro[a]=5, Level 2	Spain	RCT[g] Crossover	Stroke=45 TBI[d]=27	50	2	CG[h]: 51 IG[i]: 43
Seidl et al. 2007 Level 4	Germany	Pre-Post	Stroke=8 TBI[d]=2	6	4	39.7

Author, Year PEDro[a] (if applicable) LOE[b]	**Country**	**Study Design**	**Sample Size by Injury Etiology**	**Gender**	**Gender**	**Mean Age (yr)**
Clave et al. 2006 Level 4	Spain	Post-Test	Stroke=24 TBI=22 Other=46	62	38	CG[h]: 40.31 IG[i]**:** 41.92
Martens et al. 1990 Level 2	Canada	PCT[e]	Stroke=11 TBI[d] + ABI[c] = 7 Other=13	17	14	CG[h]: 46.1 IG[i]**:** 49.3
Ko et al. 2016 Level 2	South Korea	PCT[e]	Stroke=16 TBI[d]=2	12	6	CG[h]: 60 IG[i]: 72
Toyama et al. 2014 Level 2	Japan	PCT[e]	Stroke=22 ABI[c]=4	22	4	CG[h]: 57.2 IG[i]: 63.6
Calabro et al. 2016 Level 5	Italy	Case Report	TBI[d]=1	1	0	34
Levitan & Henderson 2015 Level 4	USA	Post-Test (Conference Abstract)	Mod-Sev ABI[c]=38	N/S[e]	N/S[e]	N/S[e]
Steele et al. 2013 Level 4	Canada	Pre-Post	TBI[d]=6	n=4	n=2	42.3
Yuen & Hartwick 1992 Level 5	USA	Case Report	TBI[d]=1	n=1	n=0	53
Cassel 2016 Level 2	USA	RCT[g] (Conference Abstract)	Stroke + TBI[d] =30	N/S[f]	N/S[f]	**Range:** 65-90
Beom et al. 2015 PEDro[a]=8, Level 1b	South Korea	RCT[g]	Stroke + TBI[d] + ABI[c] =132	n=77	n=55	CG[h]: 64.4 IG[i]: 59.8
Nam et al. 2013 PEDro[a]=5, Level 2	South Korea	RCT[g]	Stroke, TBI[d] =50	n=26	n=23	CG[h]: 62.3 IG[i]: 60.9
Kojima et al. 2002 Level 4	Japan	Post-Test11	ABI=12 Other=65	n=47	n=17	66.4

Author, Year PEDro[a] (if applicable) LOE[b]	**Country**	**Study Design**	**Sample Size by Injury Etiology**	**Gender**	**Gender**	**Mean Age (yr)**
Note: [a]Physiotherapy Evidence Database (PEDro); [b]Level of evidence (LOE); [c]Acquired brain injury (ABI); [d]Traumatic brain injury (TBI); [e]Prospective Controlled Trial (PCT); [f]Not specified (N/S); [g]Randomized controlled trial; [h]Control group (CG); [i]Intervention group (IG); [j]Amyotrophic lateral sclerosis (ALS); [k]Multiple sclerosis (MS).	*Note:* [a]Physiotherapy Evidence Database (PEDro); [b]Level of evidence (LOE); [c]Acquired brain injury (ABI); [d]Traumatic brain injury (TBI); [e]Prospective Controlled Trial (PCT); [f]Not specified (N/S); [g]Randomized controlled trial; [h]Control group (CG); [i]Intervention group (IG); [j]Amyotrophic lateral sclerosis (ALS); [k]Multiple sclerosis (MS).	*Note:* [a]Physiotherapy Evidence Database (PEDro); [b]Level of evidence (LOE); [c]Acquired brain injury (ABI); [d]Traumatic brain injury (TBI); [e]Prospective Controlled Trial (PCT); [f]Not specified (N/S); [g]Randomized controlled trial; [h]Control group (CG); [i]Intervention group (IG); [j]Amyotrophic lateral sclerosis (ALS); [k]Multiple sclerosis (MS).	*Note:* [a]Physiotherapy Evidence Database (PEDro); [b]Level of evidence (LOE); [c]Acquired brain injury (ABI); [d]Traumatic brain injury (TBI); [e]Prospective Controlled Trial (PCT); [f]Not specified (N/S); [g]Randomized controlled trial; [h]Control group (CG); [i]Intervention group (IG); [j]Amyotrophic lateral sclerosis (ALS); [k]Multiple sclerosis (MS).	*Note:* [a]Physiotherapy Evidence Database (PEDro); [b]Level of evidence (LOE); [c]Acquired brain injury (ABI); [d]Traumatic brain injury (TBI); [e]Prospective Controlled Trial (PCT); [f]Not specified (N/S); [g]Randomized controlled trial; [h]Control group (CG); [i]Intervention group (IG); [j]Amyotrophic lateral sclerosis (ALS); [k]Multiple sclerosis (MS).	*Note:* [a]Physiotherapy Evidence Database (PEDro); [b]Level of evidence (LOE); [c]Acquired brain injury (ABI); [d]Traumatic brain injury (TBI); [e]Prospective Controlled Trial (PCT); [f]Not specified (N/S); [g]Randomized controlled trial; [h]Control group (CG); [i]Intervention group (IG); [j]Amyotrophic lateral sclerosis (ALS); [k]Multiple sclerosis (MS).	*Note:* [a]Physiotherapy Evidence Database (PEDro); [b]Level of evidence (LOE); [c]Acquired brain injury (ABI); [d]Traumatic brain injury (TBI); [e]Prospective Controlled Trial (PCT); [f]Not specified (N/S); [g]Randomized controlled trial; [h]Control group (CG); [i]Intervention group (IG); [j]Amyotrophic lateral sclerosis (ALS); [k]Multiple sclerosis (MS).

Table 2. Dysphagia Interventions and Outcome Measures

Study	**Intervention (I) and Comparator (C) Protocol**	**Outcomes**
<50% ABI[a] in study population (9 studies)	**<50% ABI[a] in study population (9 studies)**	**<50% ABI[a] in study population (9 studies)**

Study	Intervention (I) and Comparator (C) Protocol	Outcomes
Malandraki et al. 2016	**I:** Dysphagia Rehabilitation protocol (2 oropharyngeal exercise regimens, a targeted swallowing routine, and caregiver participation).	PAS11[b] IOPI[c] EAT-10[d] ASHA NOMS[e]
Seedat & Penn 2016	**I:** Scheduled oral care along with free water provisions. **C:** Inconsistent oral care and liquid restrictive diet.	Presence of aspiration pneumonia Water consumption
Terre & Mearin 2015	**I:** NMES[f] over the mylohyoid muscle plus conventional swallowing therapy. **C:** Sham EST[h] and conventional swallowing therapy.	FOIS[g]
Terre & Mearin 2012	**I:** Chin-down posture swallowing boluses of 3,5,10,15mL of pudding, nectar and liquid viscosities. **C:** Anatomical position swallowing boluses of 3,5,10,15mL of pudding, nectar and liquid viscosities were used.	Aspiration
Seidl et al. 2007	**I:** Facio-oral tract therapy.	Swallowing rate Alertness
Clave et al. 2006	**I:** Swallowing different bolus viscosities (liquid, nectar, pudding) at different velocities (3-20mL).	Oropharyngeal Swallow Response Nutritional Status
Martens et al. 1990	**I:** Dysphagia management program aimed at improving caloric intake and body weight. **C:** Routine care.	Caloric intake Body weight
Ko et el. 2016	**I:** Laryngopharyngeal NMES[f] plus CST[i]. **C:** CST[i].	PAS[b] FDS[o] ASHA NOMS[e]
Toyama et al. 2014	**I:** NMES[f] targeting geniohyoid, mylohyoid, thyrohyoid muscles, plus conventional treatment (tongue exercises, thermal-tactile stimulation with intensive repetition of dry-swallow task). **C:** Conventional treatment.	VDS[q] Anterior/superior displacement of hyoid bone and larynx FOIS[g]
>50% ABI[a] in study population (4 studies)	**>50% ABI[a] in study population (4 studies)**	**>50% ABI[a] in study population (4 studies)**
Calabro et al. 2016	**I:** CST[i] alone (swallowing exercises, shaker exercise, hyoid lift and Mendelssohn maneuver, compensation postures, dietary changes), as well as coupled to a neuromuscular VsT[m].	BSA[j] DOSS[k] FFEES[l]

Study	Intervention (I) and Comparator (C) Protocol	Outcomes
Levitan & Henderson 2015	**I:** Comprehensive Dysphagia Protocol (developing a highly individualized plan, implementing plan, modifying plan).	Reports of swallowing incident (choking, aspiration, excessive coughing, swallowing difficulty)
Steele et al. 2013	**I:** TPSAT[n].	PAS[b] Vallecular residue score Pyriform sinus residue score
Yuen & Hartwick 1992	**I:** 6-day diet manipulation consisting of gradual introduction of diets of different textures (pureed and ground foods, soft foods and regular diets).	Success of diet consumption Weight gain
Unknown % ABI[a] in study population (4 studies)	**Unknown % ABI[a] in study population (4 studies)**	**Unknown % ABI[a] in study population (4 studies)**
Cassel 2016	**I:** Remote online tele-dysphagia swallowing intervention. **C:** Traditional face-to-face swallowing intervention.	Correct/Incorrect responses to visual/auditory swallowing safety cues
Beom et al. 2015	**I:** NMES[f] to the suprahyoid muscles and infrahyoid muscles. **C:** EST[h] to the suprahyoid alone.	FDS[o] SFS[p] Supraglottic penetration Subglottic aspiration
Nam et al. 2013	**I:** NMES[f] to the suprahyoid muscles and infrahyoid muscles. **C:** EST[h] to the suprahyoid alone.	Hyoid excursion Laryngeal elevation
Kojima et al. 2002	**I:** Bilateral K-point (mucosa lateral to the palatoglossal arch and medial to pterygomandibular fold at height of postretromolar pad) stimulation.	Swallowing reflex

Note: 11 [a]Acquired Brain Injury (ABI);[b]Penetration aspiration scale (PAS);[c]Lingual isometric pressures (IOPI);[d]Eating assessment tool (EAT-10);[e]Level of oral intake (ASHA National Outcome Measurement System (NOMS)); [f]Neuromuscular electrical stimulation (NMES); [g]Functional oral intake scale (FOIS); [h]Electrical stimulation therapy (EST);[i]Conventional swallowing therapy (CST);[j]Bedside swallowing assessment (BSA);[k]Dysphagia outcome and severity scale (DOSS);[l]Flexible fiberoptic endoscopic examination of swallowing (FFEES); [m]Vitastim training (VsT);[n]Tongue-pressure strength and accuracy training (TPSAT); [o]Functional Dysphagia Scale (FDS);[p]Swallowing function score (SFS);[q]Videofluoroscopic dysphagia scale (VDS).

Figure Captions

Figure 1. PRISMA Flow Diagram

Hosted file

`Figure 1.docx` available at https://authorea.com/users/727899/articles/709397-dysphagia-rehabilitation-interventions-in-moderate-severe-acquired-brain-injury-a-scoping-review