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Review Article

Presentation of oropharyngeal dysphagia and rehabilitative intervention following esophagectomy: a systematic review

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SUMMARY. **No study has systematically reviewed the evidence on presentation of oropharyngeal dysphagia and swallowing rehabilitation following esophagectomy. The purposes of this systematic review are to 1) qualitatively synthesize the current findings on oropharyngeal swallowing abnormalities identified by instrumental swallowing evaluations, 2) describe the reported health-related outcomes in relation to swallowing abnormality following esophagectomy, and 3) examine the efficacy of reported rehabilitative interventions for oropharyngeal dysphagia in patients who underwent esophagectomy. Publications were searched using five electronic databases. No language or publication date restrictions were imposed. Two authors performed a blind review for published or unpublished studies that reported swallowing biomechanics and dysphagic symptoms using instrumental evaluation of swallowing, specifically the videofluoroscopic swallowing study and fiberoptic endoscopic evaluation of swallowing, and/or health-related outcomes in relation to swallowing abnormalities, and/or therapeutic interventions for oropharyngeal dysphagia following esophagectomy. Twelve studies out of 2,193 studies including 458 patients met the inclusion criteria. Reported abnormal swallowing biomechanics included vocal fold immobility, delayed onset of swallowing, reduced hyolaryngeal elevation, and reduced opening of the upper esophageal sphincter. Aspiration (0–81%) and pharyngeal residue (22–100%) were prevalent. Those abnormal swallowing biomechanics and swallowing symptoms were commonly reported following both transhiatal and transthoracic esophagectomy. Pneumonia presented in 5–25% of the study patients. One quasi-experimental study examined the effectiveness of swallowing exercises for postoperative oropharyngeal dysphagia; three case series reported a benefit of the chin-tuck maneuver in reducing aspiration and residue. This review revealed distinct swallowing impairments and increased pneumonia risks following esophagectomy. This review also found that evidence on the efficacy of therapeutic interventions was limited. Future studies are warranted to develop effective rehabilitative interventions for postesophagectomy patients with oropharyngeal dysphagia.**

KEY WORDS: **deglutition disorders, esophagectomy, rehabilitation.**

INTRODUCTION

Esophageal cancer is ranked as the eighth most common cancer worldwide and is the sixth most common cause of cancer-related death.[1] Although the effectiveness of definitive chemotherapy,[2] perioperative chemotherapy,[3,4] and chemoradiotherapy[5] has been reported, radical resection of the esophageal cancer has been the mainstay of treatment for this fatal malignancy.[6] Meanwhile, complication rates for this highly invasive surgery have been reported to be as high as 22–29%.[7-11] Unfavorable outcomes of the surgery can significantly impair patients' long-term survival[7] and quality of life.[12-14]

Major complications include anastomotic leakage, pulmonary complications, damage to the recurrent laryngeal nerve, dysphagia, strictures, reflux, and other gastrointestinal symptoms.[10,11] Above all, the presence of dysphagia has been reported to increase the risk of pneumonia and mortality following

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esophagectomy.[10] In addition, recent literature has found that patients who underwent surgical treatment for esophageal cancer had lower quality of life scores across many domains including swallowing impairments.[15] Thus, it is crucial to provide patients with an adequate dysphagia assessment and therapeutic interventions in order to achieve better health outcomes and quality of life.

When presence of dysphagia is suspected, two instrumental procedures are often used to assess the swallow function: the videofluoroscopic swallowing study (VFSS)[16] and the fiberoptic endoscopic evaluation of swallowing (FEES).[17] This study focused on impairments of the oropharyngeal stage of swallowing to investigate, given is prevalence in the postesophagectomy patient population. Understanding the oropharyngeal swallowing impairments as well as efficacy of behavior or postural modifications and exercises will improve our therapeutic intervention. To our knowledge, no research study has systematically examined the current findings about biomechanics of oropharyngeal swallowing and dysphagic symptoms following esophagectomy identified by instrumental evaluations. In order to better understand the underlying mechanism of postoperative oropharyngeal dysphagia, it will be valuable to synthesize the knowledge of pathophysiology and dysphagic symptoms associated with esophagectomy. It will also be important to understand the reported health-related outcomes in patients with oropharyngeal dysphagia following esophagectomy. Further, a summary of the reported rehabilitative interventions for oropharyngeal swallowing impairment will help develop a core set of swallowing exercises that may be most effective in treating this patient population.

This review aims to qualitatively synthesize the current evidence on oropharyngeal swallowing abnormalities captured by instrumental evaluations of swallowing, specifically VFSS or FEES, in patients who underwent esophagectomy. Specific research questions of this systematic review are:

1. What are the abnormalities in oropharyngeal swallowing biomechanics identified during VFSS or FEES following esophagectomy?
2. What are the symptoms of oropharyngeal dysphagia identified during VFSS or FEES following esophagectomy?
3. What are the reported health-related outcomes in relation to swallowing abnormality following esophagectomy?
4. Is there any evidence to support that rehabilitative interventions are effective in improving swallowing function or health-related outcomes in patients with oropharyngeal dysphagia following esophagectomy?

MATERIALS AND METHODS

The review reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[18] The predefined review protocol was registered at Center for Review and Dissemination (CRD42017056330).

Search strategy

Publications were searched from the August 30th, 2017 through the August 31st, 2017 using the MEDLINE [PubMed], Web of Science, CINAHL, Cochrane Database of Systematic Reviews, and Cochrane Central Register of Controlled Trials. To reduce investigator selection bias, all relevant search terms were defined a priori. The following is the search algorithm for searching MEDLINE: (esophageal cancer OR esophagus cancer) AND (esophagectomy OR esophageal surgery OR esophageal resection OR esophagus/surgery [MeSH Terms]) AND (dysphagia OR swallow OR deglutition OR deglutition disorders OR swallowing disorders OR oropharyngeal dysphagia) AND (modified barium swallow OR videofluoroscopy OR instrumental swallow OR VFSS OR FEES OR videofluoroscopic swallow study OR endoscopy OR videoendoscopy OR fiberoptic endoscopic evaluation of swallowing OR endoscopic evaluation of swallowing). Search was restricted to human studies. No language or publication date restriction was imposed. To ensure a comprehensive search, the first author scanned reference lists of included studies and previously published review articles.

Study eligibility

This review included studies that met the following criteria: 1) were published or unpublished original research articles; 2) retrospective and prospective studies; 3) studied adult (18 years or older) patients; 4) with a diagnosis of esophageal cancer; 5) treated with first-time esophagectomy (including both open esophagectomy and minimally invasive esophagectomy) with or without perioperative chemotherapy/chemoradiotherapy; 6) examined swallowing function of the patients using instrumental evaluations; and 7) reported swallowing biomechanical measurements and/or any symptoms of oropharyngeal dysphagia, rehabilitative interventions, and/or health-related outcomes in relation to oropharyngeal dysphagia using clearly described method(s). Studies that did not utilize VFSS or FEES to assess swallowing function were excluded because clinical swallowing evaluations do not allow researchers to objectively measure swallowing biomechanics or to accurately identify presence of swallowing symptoms.[19] Further, case reports and case series that profiled fewer than five patients were excluded

given the limited information provided by those studies.

In this review, *swallowing biomechanical measurements* referred to any displacement measures of relevant structures for swallowing and time variables of swallowing motion identified by using VFSS or FEES.[20,21] *Symptoms and signs of oropharyngeal dysphagia* included penetration, aspiration, pharyngeal residue, and other abnormalities due to their frequent reporting in the literature.[22,23] *Health-related outcomes in relation to swallowing abnormality* included pneumonia, nutrition status, diet levels, and the use of alternative nutrition.[24] *Rehabilitative interventions* included exercise therapies that can be executed with or without accompanying food[25,26] and compensatory swallowing strategies.

Literature review

Two review authors independently screened the abstracts of the identified studies for eligibility. The two authors then read full articles of potentially eligible studies for determining the eligibility. When publications were written in languages other than English, speech language pathologists, or medical doctors native to those languages reviewed the articles. Discrepancies in the inclusion between the two authors were resolved by discussion.

Data extraction

One review author extracted the following data from the included studies and the second reviewer checked the extracted data: 1) study characteristics, 2) the features of esophageal cancer treatment provided, 3) the key findings on biomechanical measurements and swallowing symptoms identified in the swallowing assessment performed, 4) health-related outcomes of esophagectomy in relation to swallowing abnormality; and 5) types of rehabilitative intervention and the effect of those interventions reported. Meta-analysis of the data was not possible due to high level of heterogeneity in subjects, research design, cancer treatment protocols, or swallowing assessment protocols across the included studies. Therefore, the extracted data were presented descriptively.

Quality assessment

Two review authors independently appraised the methodological quality of identified studies using the JBI Critical Appraisal Checklists for case series, diagnostic test accuracy studies, and quasi-experimental studies.[27] Disagreements in the judgment between the two authors were resolved by discussion.

RESULTS

A total of 2193 records were identified from all sources (Fig. 1). After excluding duplicates, 2117 titles and abstracts were screened for eligibility. Of those, 34 studies (31 studies written in English, two in French, and one in German) were read in full for eligibility. Twelve studies consisting of 458 patients met all inclusion criteria and were included in the final systematic review.

Characteristics of included studies

Table 1 displays the characteristics of the 12 studies included in this review. One quasi-experimental study,[28] one test accuracy study,[29] and ten case series were included.[30-39] Table 2 shows the features of cancer treatment provided in the included studies by surgical approach. Four studies from North America reported oropharyngeal dysphagia following transhiatal esophagectomy;[32,33,37,38] seven studies from East Asia reported oropharyngeal dysphagia following transthoracic esophagectomy with lymph node dissection.[28-31,34,35,39] One study involved patients who received either transhiatal or transthoracic esophagectomy.[36] Table 3 summarizes the swallowing assessment performed in the included studies. Two of 12 studies performed VFSS both before and after esophagectomy.[28,30,33] However, two of the three studies performed VFSS only on a part of their study participants,[28,33] resulting in an unclear comparison between pre- and postoperative swallowing functions. No study performed longitudinal follow-up evaluations for swallowing.

Abnormalities in swallowing biomechanics and swallowing symptoms after esophagectomy

Table 3 also displays the reported key findings on swallowing biomechanics and swallowing symptoms following esophagectomy. In patients who received transhiatal esophagectomy, several abnormal swallowing biomechanics were reported: vocal fold immobility (25.0%[32]–33.0%[38]), delayed onset of swallowing,[33] reduced hyolaryngeal elevation during swallowing,[32,33] and reduced maximum anterior–posterior diameter of the UES during swallowing.[33] As for swallowing symptoms, overt aspiration (0%[37]–81.0%[29]) and pharyngeal residue (22.0%[37] in the pyriform sinus and 62.5%[32] in the valleculae) presented.

Reported abnormalities in swallowing biomechanics after transthoracic esophagectomy were similar to those presented after transhiatal esophagectomy: vocal fold immobility (12.7%[29]–76.0%[35]), delayed onset of swallowing,[34] reduced hyolaryngeal elevation during swallowing,[31,35] particularly in

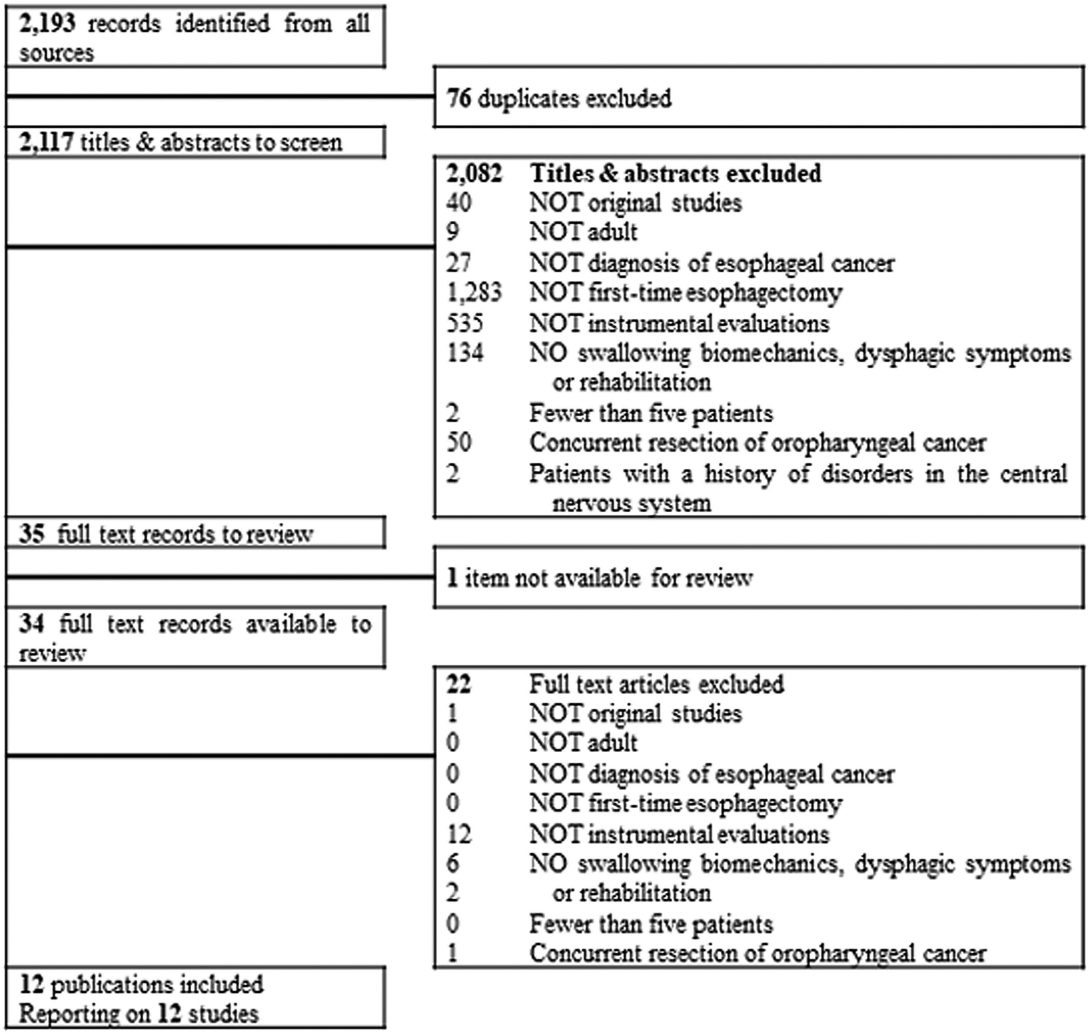

Fig. 1 PRISMA flowchart.

patients who underwent three-field lymphadenectomy,[31] and reduced maximum anterior–posterior diameter of the UES during swallowing particularly with reconstruction via the retrosternal route.[30] Overt aspiration (12.7%[29]–76.0%[35]), silent aspiration (14.4%[29]), and pharyngeal residue (100%) were also reported.[39]

Aspiration was found to be significantly associated with vocal fold immobility,[29,38] decreased excursion of the hyoid,[32,35] reduced UES anterior–posterior opening,[32] the three-field lymphadenectomy,[31] and operation time greater than or equal to six hours in postesophagectomy patients.[29] Thickening liquids decreased the occurrence of aspiration during the swallowing evaluation.[36] Additive complete division of the bilateral infrahyoid muscles attached to the sternum was found to be a significant suppressor of penetration and aspiration after esophagectomy with three-field lymphadenectomy.[31]

Health-related outcomes after esophagectomy

Three studies reported the occurrence of pneumonia,[28,29,31] which ranged between 5%[31] and 25%[28] of the patients who underwent transthoracic esophagectomy. Occurrence of pneumonia was higher in patients who aspirated during VFSS trials (13.2%) than in patients who did not aspirate (0%);[29] in patients who underwent the three-field lymphadenectomy (20%) than in patients who underwent the two-field lymphadenectomy (10%) or the three-field lymphadenectomy with complete division of the bilateral infrahyoid muscles attached to the sternum (5%).[31]

One study reported patients' diet levels following transthoracic esophagectomy.[35] Majority of patients were temporarily dependent on tube-feeding or total parenteral nutrition at the time of postoperative VFSS, and had learned the chin tuck as a compensatory swallowing maneuver. Nearly 100% of the

Table 1 Characteristics of the included studies ($n = 12$).

References	Country	Study design	Subject	Mean or median age (range in years)	% male	Main purpose(s) of the study
Easterling *et al.*[32]	USA	Case series	Patient 8 Healthy adult 8	NR (51–78) Age-matched	NR	to correlate the swallowing biomechanics with aspiration in patients with dysphagia after transhiatal esophagectomy
Martin *et al.*[33]	Canada	Case series	10	66.7 (49–76)	90.0	to compare pre- and postoperative swallowing patterns in patients who underwent transhiatal esophagectomy
Lewin *et al.*[36]	USA	Case series	26	66.0 (52–82)	88.5	to evaluate the use of chin tuck maneuver to alleviate aspiration during videofluoroscopy in patients who underwent esophagectomy
Koh *et al.*[37]	Canada	Case series	9	63.0 (52–76)	88.9	to investigate the function of the oral and pharyngeal phases of deglutition, and of the cervical esophagus, in patients who underwent transhiatal esophagectomy
Leder *et al.*[38]	USA	Case series	73	60.0 (39–74)	83.6	to characterize laryngeal physiology in patients who underwent transhiatal esophagectomy and to identify patients who are at high aspiration risk
Kato *et al.*[30]	Japan	Case series	27	64.3 (53–78)	100.0	to analyze the relationship between oropharyngeal swallowing and the alimentary reconstruction route after transthoracic esophagectomy
Yasuda *et al.*[31]	Japan	Case series	2FL 10 3FL 10 3FL + CDBIMS 20	61.4 (51–76) 61.3 (54–68) 61.5 (54–71)	80. 0100. 0 90.0	to compare swallowing function in patients who underwent esophagectomy with 2FL and 3FL, and to evaluate the preventative effect of the addition of CDBIMS for post-operative dysphagia
Okumura *et al.*[28]	Japan	Quasi-experimental	Experiment 14 Control 12	65.9 ± 9.7 68.0 ± 5.1	92. 9100. 0	to assess the preventative and therapeutic effects of perioperative swallowing rehabilitation in patients undergoing esophagectomy
Kim *et al.*[34]	Korea	Case series	Aspiration 23 No aspiration 24 Control 27	62.7 ± 8.2 63.3 ± 7.1 64.7 ± 10.1	100. 0100. 0100.0	to analyze the swallowing biomechanics in patients with oropharyngeal dysphagia after esophagectomy compared to healthy adults
Lee *et al.*[29]	Korea	Diagnostic test accuracy	118	63.4 ± 8.5	93.2	to assess the usefulness of clinical bedside swallowing tests for detecting aspiration after esophagectomy
Kumai *et al.*[35]	Japan	Case series	25	64.8	NR	to identify the main factors associated with aspiration in patients with pharyngeal dysphagia following esophagectomy with 3FL and to assess the effectiveness of the chin-down maneuver
Kumai *et al.*[39]	Japan	Case series	14	65.9 ± 1.9	100.0	to determine the efficacy of the chin-down maneuver after esophagectomy with 3FL on pharyngeal residue, UES opening, and laryngeal closure

2FL, two-field lymphadenectomy; 3FL, three-field lymphadenectomy; CDBIMS, complete division of the bilateral infrahyoid muscles attached to the sternum; NR, not recorded.

study patients were fed orally at discharge, which was at 29.5 ± 2.5 days after the postoperative VFSS was performed.[35]

Rehabilitative interventions for postesophagectomy oropharyngeal dysphagia

Four studies, one quasi-experimental trial[28] and three case series,[35,36,39] reported rehabilitative interventions provided with this patient population. Okumura and colleagues provided perioperative nonswallowing exercises to patients who were undergoing esophagectomy.[28] The rehabilitative program included pursed lip breathing, a cervical range of motion exercise, shoulder stretches, jaw opening, tongue exercises, and submental muscle training. The authors reported that the exercises did not change swallowing biomechanics of the patients, but the volume of laryngeal and pharyngeal residue after esophagectomy decreased significantly in patients who underwent perioperative swallowing exercises.[28]

Three case series observed immediate positive effect of the chin-tuck maneuver for improving airway protection by effectively eliminating aspiration after surgery.[35,36,39] Pyriform sinus residue was significantly reduced when postesophagectomy patients implemented the chin tuck maneuver compared to the neutral position.[39] The chin-tuck maneuver also increased UES opening diameter and prolonged duration of UES opening and duration of laryngeal vestibule closure compared with those in the neutral position.[39]

Table 2 Treatment features of the included studies by surgical approach ($n = 12$).

Reference	Surgical approach	Cancer type	Pathological stage	Reconstruction route	Lymph node dissection	Anastomosis site	Neoadjuvant therapy	Adjuvant therapy
Easterling *et al.*[32]	TH	AD	NR	Posterior mediastinum	NR	Cervical	NR	NR
Martin *et al.*[33]		SCC 3 AD 7	T1N0M0 1 T2N0M0 4 T3N0M0 1 T3N1M0 4	Posterior mediastinum	One node 3 Two nodes 1	Cervical	None	None
Koh *et al.*[37]		AD	NR	Posterior mediastinum	NR	Cervical	NR	NR
Leder *et al.*[38]		NR	NR	NR	NR	Cervical	Neoadjuvant therapy 57(Detail was not shown)	NR
Kato *et al.*[30]	TT	NR	NR	Posterior mediastinum	3FL 16 2FL 11	Cervical 16 Intrathoracic 11	None	None
Yasuda *et al.*[31]		NR	I 4 IIA 8 IIB 11 III 10 IVA 1 IVB 6	Retrosternal 39 Orthotopic 1	2FL 4–12 3FL 8–21 3FL + CDBIMS 4–37	Cervical	CT 14 CRT 2	NR
Okumura *et al.*[28]		NR	I/II 20 III/IV 6	Retrosternal 20 Subcutaneous 6	Dissected	Cervical	CT 6 CRT 1	NR
Kim *et al.*[34]		SCC	T2–3 N0–1 M0	NR	3FL	Cervical	NR	CRT 10
Lee *et al.*[29]		NR	NR	NR	Cervical lymph node dissection 27	Cervical 33 Noncervical 85	CRT 24	NR
Kumai *et al.*[35]		NR	NR	Retrosternal 25	3FL 25	Cervical 25	NR	NR
Kumai *et al.*[39]		NR	II 3 III 10 IVa 1	Retrosternal 14	3FL 14	Cervical 14	None	NR
Lewin *et al.*[36]	TH 16 TT 10	SCC 5 AD 19 Barrett's esoph-agus + HGD 2	NR	NR	NR	Cervical 21 Thoracic 5	CRT 12 Photodynamic 1	NR

2FL, two-field lymphadenectomy; 3FL, three-field lymphadenectomy; AD, adenocarcinoma; CRT, chemoradiation therapy; CT, chemotherapy; HGD high-grade dysplasia; NR, not recorded; SCC, squamous cell carcinoma; TH, transhiatal; TT, transthoracic.

Quality assessment

The JBI Critical Appraisal Checklists scores were low for quasi-experimental study[28] (4 out of 9 points) and diagnostic accuracy study[29] (4 out of 10 points), and were varied for case series (5[32,33,36,37]–8[35,40] out of 10 points). The methodological quality of the majority of the included studies was not sufficient.

DISCUSSION

This systematic review revealed several pathological patterns in swallowing biomechanics after transhiatal and transthoracic esophagectomy. The abnormalities in swallowing included delayed onset of swallowing, reduced hyoid or hyolaryngeal elevation, and reduced UES opening. Both overt and silent aspiration and pharyngeal residue were commonly reported following esophagectomy.

The abnormal biomechanics found in this review may explain the underlying mechanism of swallowing symptoms in postesophagectomy patients. In this population, initiation of swallowing tends to be delayed.[41] Thus, the bolus can be propelled into the pharynx before the hyoid and larynx are pulled up and the epiglottis is passively retroflexed to its maximally lowered position to cover the laryngeal vestibule. [42] As a result, the bolus can be misdirected into the laryngeal vestibule. Vocal fold immobility due to the injury to the recurrent nerve during esophagectomy allows the penetrated materials to be easily aspirated to the trachea. Further, the damage to the pharyngeal plexus[33,43] or scarring at the anastomotic area[30] may reduce pharyngeal muscle contraction and UES opening. These pharyngeal dysfunctions may lead to pharyngeal residue, which can be aspirated when the patient attempts to clear them with additional clearing swallows.[44]

This review also aimed to examine the reported health-related outcomes in relation to swallowing abnormality following esophagectomy. Increased risk for pneumonia was found in patients who aspirated during VFSS trials.[29] The high incidence of silent aspiration reported in this patient population[29,36] and low sensitivity of the bedside screening test against VFSS[29] emphasize the importance of instrumental

Table 3 Swallowing biomechanics and dysphagic symptoms in the included studies by surgical approach ($n = 12$).

Reference	Surgical approach	Methods	Test materials	Timing of swallowing evaluation		Vocal fold immobility	Key findings regarding swallowing biomechanics and dysphagic symptoms
				Before surgery	After surgery		
Easterling *et al.*[32]	TH	VFSS	5 mL thin barium	N/A	1. 7–10 days 2. 17–29 days 3.42–105 days	25.0%	• Aspiration (5 of 8; 62.5%) • Residue in the pyriform sinus (5 of 8; 62.5%) • The maximum UES anterior–posterior diameter and maximum anterior hyoid elevation in patients who aspirated were significantly smaller than those of age-matched normal controls
Martin *et al.*[33]		VFSS	2,5,10mL thin and thick barium, 1 tsp cookie	2–21 days	44–134 days	NR	• Penetration/aspiration (2 of 5; 40%) • Residue in the valleculae, pyriform sinuses, and/or coating the posterior pharyngeal wall (5 of 5; 100%) • Anterior hyoid elevation was significantly decreased postoperatively for one subject and significantly increased for one subject. Superior hyoid elevation did not differ significantly. • Mild oropharyngeal dysphagia was observed before surgery (delayed initiation of swallowing, abnormal bolus formation, postswallow residue).
Koh *et al.*[37]		VFSS	Barium bolus, volume unspecified	N/A	6–40 months (median 18 months)	NR	• Aspiration (0/9; 0%) • Residue in the valleculae (2 of 9; 22%)
Leder *et al.*[38]		FEES	5mL custard, milk, cracker	N/A	5 days	33.0%	• Aspiration (15 of 73; 21%), penetration (24 of 73; 33%) • Pooling (9 of 73; 12%), spillage (4 of 73; 5%), residue (19 of 73; 26%) • Vocal fold immobility was associated with aspiration.
Kato 2007[30]	TT	VFSS	10ml thin barium	days not specified	14–21days	NR	• Superior/anterior hyoid elevation significantly decreased in patients who underwent intrathoracic esophagectomy with retrosternal reconstruction.
Yasuda *et al.*[31]		VFSS	Thin barium, volume unspecified	N/A	7–62 days	20.0%	• Laryngeal elevation was significantly impaired after 3FL as compared to 2FL. • A significant improvement of laryngeal elevation, compared with the 3FL group, was observed in the 3FL + CDBIMS group • Incomplete airway protection was observed in 25% of the 3FL + CDBIMS group, which was significantly lower than the 3FL group (70%), and was not different from the 2FL group (20%).
Okumura *et al.*[28]		VFSS	Thin iopamidol, volume unspecified	N/A	4 time points for the experiment group, days after surgery not specified	28.6%	• The maximum anterior/superior hyoid elevation and the anteroposterior diameters of the UES opening during swallows did not differ significantly among the four time points.

Table 3 *continued*

Reference	Surgical approach	Methods	Test materials	Timing of swallowing evaluation		Vocal fold immobility	Key findings regarding swallowing biomechanics and dysphagic symptoms
				Before surgery	After surgery		
Kim *et al.*[34]		VFSS	3ml thin barium	N/A	Aspiration group 8.2 ± 1.6 days No aspiration group 8.0 ± 1.8 days	14.9%	• The volume of residue in the laryngeal vestibule and the pyriform sinus decreased significantly. • Aspiration (23 of 47; 48.9%)
Lee *et al.*[29]		VFSS	3,6,9 mL thin barium, barium pudding, 1tsp of barium coated cookie	N/A	7–10 days	12.7%	• Maximal anterior displacement of the hyoid, maximal rotation of the epiglottis, and pharyngeal delay time in normal group were significantly different from patients who underwent esophagectomy. • Pharyngeal delay time was significantly correlated with vocal cord palsy and aspiration. • Aspiration (38/118; 32.2%), silent aspiration (17/118; 14.4%)
Kumai *et al.*[35]		VFSS	NR	N/A	2–3 weeks	76.0%	• Vocal cord paralysis were risk factors for subglottic aspiration. • The clinical bedside swallowing test had a sensitivity of 68.4%. • Aspiration (9/25; 36.0%), penetration (2/25; 8.0%). • Laryngeal aspiration was significantly correlated with reduced laryngeal elevation.
Kumai *et al.*[39]		FEES VFSS	3- or 5-mm thin barium or iopamidol	N/A	14.8 ± 0.4 days	42.9%	• The penetration-aspiration scale score was significantly improved after training in chin-down swallowing. • Aspiration (2/14; 14.2%) • The pharyngeal constriction ratio and residue in the pyriform sinus for the chin-down position were significantly smaller than those in the neutral position. • The residue in the valleculae was not significantly different between the neutral and chin-down positions. • The UES opening diameter, duration of UES opening, and duration of laryngeal vestibule closure in the chin-down position were all significantly prolonged compared with those in the neutral position.
Lewin *et al.*[36]	TH/TT	VFSS	5 mL thin, 5mL thick barium, 5 mL applesauce 1/4 cracker	N/A	6–43 days	NR	• Aspiration on thin liquid (21 of 26; 81.0%); both thin and thickened liquids (8 of 26; 30.8%); puree as well as thin and thickened liquids (3 of 26; 11.5%) • Chin-tuck swallow eliminated aspiration in 17/21 patients (80%).

evaluations when assessing patients who received esophagectomy. Only one study reported diet outcomes of the study patients.[35] This lack of evidence suggests the need for future studies examining health-related outcomes of postesophagectomy oropharyngeal dysphagia, including length of time for dependence on alternative means of nutrition such as jejunostomy. Alternative means of nutrition along with a systematic and gradual introduction of the least restrictive diet can improve patient's health related outcomes. This can help set expectations for the healing processing, and rehabilitation postesophagectomy.

Finally, this review revealed that evidence was scant regarding rehabilitative interventions for postesophagectomy oropharyngeal dysphagia. One study provided perioperative swallowing rehabilitation to patients who were undergoing esophagectomy.[28] However, the study did not observe any improvement in swallowing biomechanics. This may be because its rehabilitative program did not target the pharyngeal abnormalities, which have now been identified in this review. The pharyngeal muscle training[45,46] as well as the submental muscle training[47] may be more relevant to restore the impaired hyolaryngeal excursion and pharyngeal contraction that could occur following esophagectomy. Three small case series indicated the potential efficacy of chin-tuck maneuver in reducing aspiration[35] and pharyngeal residue[39] (in both pyriform and valleculae structures). The chin-tuck maneuver appears to be a reasonable strategy to trial during postesophagectomy recovery since this swallowing technique has been found to alleviate aspiration[48] and pharyngeal residue[49] by decreasing distance between the hyoid bone and larynx,[50,51] prolonging the duration of laryngeal vestibule closure[52] and UES opening,[53,54] all of which were often limited in this patient population.

Other potential management strategies include thickening liquids, which may also prevent aspiration of this patient population.[36] Since thickened liquids tend to flow more slowly, it can provide patients with delayed initiation of swallowing more control during swallowing.[36] Although not discussed in the reviewed studies, postural modifications such as head turns and head tilts are compensatory strategies, which could be trialed during swallowing evaluations.

The studies reviewed found a wide range of vocal fold immobility rates between 25.0%[32] and 33.0%[38] for patients who underwent transhiatal esophagectomy, and between 12.7%[29] and 76.0%[35] for patients who underwent transthoracic esophagectomy. In these instances, surgical interventions, both injection medialization and thyroplasty may alleviate swallowing symptoms in patients with vocal fold immobility,[55] which was prevalent in this patient population.

Most of the included studies performed instrumental evaluation only after esophagectomy. Thus, it is difficult to determine if the observed swallowing abnormalities and dysphagic symptoms following esophagectomy are resultant of the surgery or are preexisting characteristics of the patients with esophageal cancer. Further, none of the included studies performed follow-up swallowing evaluation to understand the trajectory of swallowing rehabilitation. In order to understand the recovery process of oropharyngeal dysphagia, follow up evaluations may also assist future development of rehabilitative intervention.

Our review has some limitations. The weak study designs with limited methodological quality of the included studies may make the results of our analyses less conclusive. There may be eligible studies archived in databases and search algorithms that we did not use for literature search and thus were not identified.

In conclusion, our systematic review revealed that vocal fold immobility, delayed onset of swallowing, reduced hyolaryngeal elevation, and reduced UES opening during swallowing were frequently reported in the literature in the patients who underwent esophagectomy. These pathological swallowing patterns may contribute to incomplete airway closure and reduced bolus clearance, resulting in aspiration and pharyngeal residue observed in swallows after esophagectomy. Pneumonia and restricted diets were found in patients who received esophagectomy. Evidence was scant regarding the therapeutic interventions for postesophagectomy oropharyngeal dysphagia. These results indicate the urgent need for future studies for developing effective swallowing exercises and management strategies for oropharyngeal dysphagia secondary to esophagectomy. The results, however, should be interpreted with caution, given limited generalizability and potential biases inherent to the include studies.

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