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Internal Lymphedema Correlates with Subjective and Objective Measures of Dysphagia in Head and Neck Cancer Patients

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Abstract

Background: Tumor/treatment-related internal lymphedema (IL) and/or external lymphedema (EL) are associated with functional deficits and increased symptom burden in head and neck cancer patients (HNCP). Previously, we noted association between EL/IL and patient-reported dysphagia using the Vanderbilt Head and Neck Symptom Survey (VHNSS) version 1.0.

Objective: To determine the relationship between IL/EL and subjective and objective measures of swallowing function.

Methods: Eighty-one HNCP completed: (1) VHNSS version 2.0, including 13 swallowing/nutrition-related questions grouped into three clusters: swallow solids (ss), swallow liquids (sl), and nutrition(nt); (2) physical assessment of EL using Foldi scale; (3) endoscopic assessment of IL using Patterson scale ($n = 56$); and (4) modified barium swallow study rated by dysphagia outcome and severity scale (DOSS) and in conjunction with a swallow evaluation by National Outcomes Measurement System (NOMS). Examinations were performed at varied time points to assess lymphedema spectrum, from baseline ($n = 15$, 18.1%) to 18 months post-therapy ($n = 20$, 24.1%).

Results: VHNSS swallow/nutrition items scores correlated with NOMS/DOSS ratings ($p < 0.001$). Highest correlation was with NOMS: ss (–0.73); sl (–0.61); nt (–0.56). VHNSS swallow/nutrition scores correlated with maximum grade of swelling for any single structure on Patterson scale: ss (0.43; $p = 0.001$); sl (0.38; $p = 0.004$); nt (0.41; $p = 0.002$). IL of aryepiglottic/pharyngoepiglottic folds, epiglottis, and pyriform sinus were most strongly correlated with VHNSS and NOMS ratings. NOMS/DOSS ratings correlated with EL (>=–0.34; $p < 0.01$). No meaningful correlations exist between VHNSS swallow/nutrition items and EL (< ± 0.15, $p > 0.20$).

Conclusions: IL correlated with subjective and objective measures of swallow dysfunction. Longitudinal analysis of trajectory and impact of IL/EL on dysphagia is ongoing.

Introduction

Aggressive multimodality treatment for locally advance care directive head and neck cancer (HNC) has resulted in improved overall survival rates, as well as an increase in secondary complications from cancer treatment.[1] Chemotherapy, radiotherapy and/or surgery, and tumor infiltration can disrupt lymphatic structures and cause inflammation, fibrosis, or scar tissue, which places the patient at high risk to develop secondary lymphedema.[2,3] Secondary lymphedema is a common and underreported late effect of HNC.[1,4] External lymphedema (EL) involves soft tissues of the head and neck. Internal lymphedema (IL) involves the upper aerodigestive tract (e.g., pharynx and larynx).[5] A comprehensive literature review from 1989 to 2009 noted 12–54% incidence of lymphedema in HNC patients.[4] Studies differed in treatment modalities, follow-up duration, grading criteria, and structures evaluated.[4] More exacting and comprehensive assessment tools noted a prevalence of 75.3% (61/81 patients) with some form of late-effect lymphedema three or more months post-treatment. Of those with

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lymphedema, 9.8% had EL as measured by the Foldi's lymphedema scale, 39.4% had IL as measured by the Patterson scale, and 50.8% had both EL and IL.[2] Lymphedema correlated with decreased quality of life, impaired functional status, and increased symptom burden.[6]

Dysphagia is a common and often debilitating complication of HNC and its treatment. Potential underlying mechanisms of dysphagia include surgical removal of tissue critical to deglutition, radiation-associated complications (including edema, fibrosis, xerostomia, thickened secretions), muscular atrophy, and neurosensory alterations.[7] Although some degree of acute dysphagia is ubiquitous during and immediately after radiotherapy to the larynx, pharynx, and oral cavity, up to 50% of patients have late-effect dysphagia (>3 months) after combined chemoradiotherapy (CCR).[8] Understanding the underlying causes of late-effect dysphagia is critical to improve long-term outcomes.[7] Our earlier work demonstrated an association between lymphedema and dysphagia supporting the hypothesis that this may be an important cause of late-effect dysphagia. Herein, we report results of a study exploring the relationship between EL and IL with both subjective and objective measures of swallowing function.

Methods

One-hundred HNC patients with stage II or greater disease planned for either definitive or postoperative chemoradiation were recruited from the Henry Joyce Outpatient Cancer Clinic of the Vanderbilt-Ingram Cancer Center. Study visits were completed between August 2010 and April 2014. Enrollment criteria included the following: ≥21 years of age, English speakers, and able to provide written informed consent. Patients had to be willing and able to undergo baseline and follow-up assessments for 18 months post-HNC treatment. Recurrent disease was excluded. The study was approved by the Scientific Review Committee and Institutional Review Board at Vanderbilt University. All patients signed informed consent before study enrollment. Of the 100 patients enrolled on the R0-1, 81 patients completed at least one modified barium swallow study. We report results on this cohort of patients.

Each patient completed (1) the Vanderbilt head and neck symptom survey (VHNSS) version 2.0, including 13 questions related to swallowing and nutrition (questions are grouped into three clusters: swallow solids [ss], swallow liquids [sl], and nutrition [nt]); (2) physical assessment of EL using the Foldi scale; (3) endoscopic assessment of IL using the Patterson scale ($n = 56$); (4) modified barium swallow study (MBSS) (MBSS was rated by the dysphagia outcome and severity scale [DOSS]; in addition, information from MBSS in conjunction with a swallow evaluation by the speech and language pathologist [SLP] was graded by the National outcomes measurement system [NOMS]). Examinations were performed at varied time points to assess a spectrum of lymphedema, from baseline ($n = 15$, 18.1%) to 18 months post-therapy ($n = 20$, 24.1%; Table 1).

Measures

Demographic questionnaire. Recorded general epidemiologic data, including gender, age, race, ethnicity, marital status, highest grade of education, work status, annual household income, insurance status, transportation access, alcohol, and tobacco use.

VHNSS. VHNSS version 2.0 is a 50-item survey that assesses HNC-related symptom burden. See Table 2 for wording of selected swallowing/nutrition-related items. Response time frame ''within the past week'' was scored using a scale between 0 (none at all) and 10 (severe symptoms). The three clusters listed in Table 2 are included in this analysis. Cronbach's alpha for the swallow solids cluster scores in validation studies was 0.92, Cronbach's for the swallow liquids was 0.74, and Cronbach's for nutrition was 0.83.

Patterson scale. Flexible fiber optic endoscopic evaluation was used in assessment and grading of IL scored through the Patterson scale. Eleven structures and two spaces are considered with this scale; structures are rated as normal, mild, moderate, or severe edema; spaces are rated as normal, mildy, moderately, or severely reduced. The scale has been tested for inter-rater reliability (weighted kappa, 0.54) and intrarater reliability (weighted kappa, 0.84). Lower levels of agreement were noted for base of tongue, valleculae, anterior commissure, and pharyngeal walls.[9]

Foldi scale. EL was graded using the four Foldi ''Stages of Lymphedema'' from 0 (latency) to III (elephantitis). The score was developed using data from over 100,000 patients. Lymphedema is considered present if a patient scores I (reversible) edema or higher.[10,11]

MBSS. MBSS was conducted at Vanderbilt Hospital in accordance with routine radiographic protocols approved by the institution. Subjects swallowed liquid barium, barium paste, and a barium-coated cookie while seated in the upright position and imaged from the lateral plane. Oral preparatory, oral, pharyngeal, and cervical esophageal phases were assessed by the SLP. All patients were given diet recommendations to optimize safe swallowing. Those who required further swallow therapy were appropriately referred.

Dysphagia outcome and severity scale. DOSS is a seven-point functional outcome scale designed to assess dysphagia severity on a MBSS.[12] Swallowing is rated based on objective assessment to make recommendations for diet status and independence level of swallowing. Level 7 is normal, and level 1 severe dysphagia results in inability to tolerate any oral intake safely. Cues for swallowing are considered. Outside of a clinical trial setting, this protocol does not have a procedure for order and consistency of intake.

National outcomes measurement system. NOMS was designed as a data collection system to measure the benefit of SLP services to patients with communication and swallowing disorders.[13] Eight functional communication measures (FCMs) are components of NOMS. The swallowing FCM is scored on a seven-point scale with level 1 reflecting inability to swallow anything safely and level 7 fully independent eating, not limited by swallow function. NOMS incorporates findings from the MBSS as well as functional information garnered on patient interview by the SLP. Cues for swallowing are considered.

Table 1. Demographics, Patient Characteristics, and Visit Timing ($N=81$)

	Mean (SD)
Age (years)	58.5 (11.0)
Education (years)	13.7 (2.3)
	N (%)
Male	62 (76.5)
Female	19 (23.5)
Race	
Caucasian/White	77 (95.1)
Black or African American	4 (4.9)
Marital Status	
Married	59 (72.8)
Single	11 (13.6)
Single, living with partner	4 (4.9)
Widowed	4 (4.9)
Other	3 (3.7)
History of smoking[a]	57 (70.4)
History of alcohol use[b]	49 (60.5)
Clinical characteristics of sample, $N=81$, n (%)	
HN cancer location	
Oropharynx	38 (46.9)
Oral cavity	19 (23.5)
Larynx	12 (14.8)
Salivary gland	4 (4.9)
Nasopharynx	3 (3.7)
Hypopharynx	2 (2.5)
Paranasal sinuses	2 (2.5)
Other	1 (1.2)
Squamous cell carcinoma	71 (87.7)
HPV+	26 (32.1)
Stage	
I	1 (1.2)
II	3 (3.7)
III	18 (22.2)
Iva	54 (66.7)
Ivb	5 (6.2)
Surgery	36 (44.4)
Tracheotomy (at any time)	18 (22.2)
PEG tube (at any time)	44 (54.3)
Total treatment received $N=79$, n (%)	
ChemoXRT	12 (15.2)
Induction and chemoXRT	36 (45.6)
Surgery and chemoXRT	22 (27.8)
Surgery and radiotherapy	2 (2.5)
Induction, surgery, and chemoXRT	7 (8.9)
	Median [IQR]
Months since HNC diagnosis	1.0 [0–2]
Months since surgery ($n=36$)	1.1 [−1 to 2]
Total radiation dose (cGy)	6930 [6255–11370]
Cycles of induction chemotherapy ($n=45$)	7.0 [3–8]
No. of concurrent chemoradiation treatments ($N=77$)	6.0 [5–7]
Closest study visit to swallow study date	N (%)
Baseline	13 (16.0)
End of treatment	13 (16.0)
6 Weeks	16 (19.8)
12 Weeks	5 (6.2)
18 Weeks	5 (6.2)
24 Weeks	1 (1.2)
30 Weeks	1 (1.2)
36 Weeks	1 (1.2)
42 Weeks	3 (3.7)
15 Months	3 (3.7)
18 Months	20 (24.7)

[a]$N=55$.
[b]$N=44$.
HNC, head and neck cancer; IQR, interquartile range; SD, standard deviation.

Statistical analyses

Statistical analyses were conducted using SPSS version 22. Nominal and ordinal (e.g., grading scales) were summarized using frequency distributions (counts,%s); normally distributed continuous data were summarized using mean and standard deviation (SD), otherwise median and 25th–75th interquartile range were used. Correlations among patient reported, clinician/staff reported, and objective measure scores were generated using Spearman Rho coefficients. An alpha of 0.05 was used for determining statistical significance.

Results

Patient characteristics

Demographic, tumor and treatment characteristics, and examination time points of the study sample are summarized in Table 1. Patients were predominantly white ($n=77$, 95.1%) males ($n=62$, 76.5%) with a history of smoking ($n=57$, 70.4%). Mean age was 58.5 years (SD 11.0). Most common cancer locations were oropharynx ($n=38$, 46.9%), oral cavity ($n=19$, 23.5%), and larynx ($n=12$, 14.8%).

Patient-reported outcome measures

Completion rate for swallow and nutrition-related VHNSS questions was high (98–100%). Frequency and severity of response to specific VHNSS swallow/nutrition questions are shown in Table 2. Cronbach's alpha for swallow solids' cluster of symptoms was 0.93, swallow liquids' cluster score was 0.89, and nutrition was 0.83.

Clinician reported patient EL and IL

The Foldi Scale was used to evaluate EL. Of 80 patients assessed, 23 (28.7%) had no EL, 43 (53.8%) had grade I, and 14 (17.5%) had grade II EL. No patients had grade III (elephantitis) EL.

Patterson scores for IL are summarized in Table 3. Sites with highest rates of moderate–severe IL included interarytenoid space (13 of 54, 24.1%), aryepiglottic folds ($n=12$ of 53, 22.6%), epiglottis ($n=12$ of 54, 22.2%), arytenoids ($n=10$ of 55, 18.2%), and base of tongue ($n=10$ of 56, 17.9%). Sites with the highest percentage of normal findings were the anterior commissure ($n=47$ of 54, 87.0%) and true vocal folds ($n=42$ of 54, 77.8%)

Table 2. Selected Questions and Responses from Vanderbilt Head and Neck Symptom Survey Version 2.0

Question No.	*VHNSS version 2.0 question*	N	*None 0* N *(%)*	*Mild 1–4* N *(%)*	*Moderate 5–6* N *(%)*	*Severe 7–10* N *(%)*
Cluster	Nutrition					
1	I have been losing weight	81	45 (55.6)	22 (27.2)	7 (8.6)	7 (8.6)
2	I have lost my appetite	81	37 (45.7)	20 (24.7)	6 (7.4)	18 (22.2)
3	I have to use liquid supplements (like Ensure® or Boost®) to maintain my weight	81	32 (39.5)	14 (17.3)	9 (11.1)	26 (32.1)
4	I have trouble maintaining my weight because of swallowing problems	80	41 (51.2)	15 (18.8)	7 (8.8)	17 (21.3)
Cluster	Swallow liquids					
6	I have trouble drinking thin liquids (like water, tea, and Ensure)	80	41 (51.2)	23 (28.7)	7 (8.8)	9 (11.3)
9	I choke or strangle on liquids	80	39 (48.8)	28 (35.0)	8 (10.0)	5 (6.3)
Cluster	Swallow solids					
5	I have trouble eating certain solid foods (like hard to chew, crumbly, or sticky foods)	80	13 (16.3)	20 (25.0)	7 (8.8)	40 (50.0)
7	Food gets stuck in my mouth	80	23 (28.7)	29 (36.3)	12 (15.0)	16 (20.0)
8	Food gets stuck in my throat	80	28 (35.0)	32 (40.0)	6 (7.5)	14 (17.5)
10	I choke or strangle on solid foods	80	31 (38.8)	28 (35.0)	8 (10.0)	13 (16.3)
11	I cough after I swallow	80	31 (38.8)	34 (42.5)	6 (7.5)	9 (11.3)
12	Swallowing takes great effort	80	22 (27.5)	35 (43.8)	7 (8.8)	16 (20.0)
13	It takes me longer to eat because of my swallowing problem	80	18 (22.5)	27 (33.8)	8 (10.0)	27 (33.8)
45	The lining of my mouth and throat is sensitive to spicy, hot, or acidic foods	79	20 (25.3)	25 (31.6)	4 (5.1)	30 (38.0)

VHNSS, Vanderbilt head and neck symptom survey.

Finally, of the patients who had both EL and IL assessments ($N=57$), 6 (10.5%) patients had no indication of either EL or IL, 8 (14.0%) only had EL, while 8 (14.0%) only had some indication of IL. The remaining 35 (61.5%) patients had some indication of both EL and IL.

Objective swallow dysfunction measures

Summaries of NOMS-FCM and DOSS scores are summarized in Table 4. Scores on NOMS in this sample ($n=60$) ranged from three to seven of the possible range of one to seven. The full range of DOSS scores, from normal to severe, was observed in this sample ($n=81$).

Correlations

Correlations of subjective measures of swallow/nutrition with objective measures of swallow. Statistically significant correlations were observed for each VHNSS swallow/nutrition cluster scores with NOMS and DOSS ratings. Highest correlations were with NOMS score (swallow solids: $r_s=-0.73$, swallow liquids: $r_s=-0.61$, nutrition: $r_s=-0.56$, $n=60$, all $p<0.001$). Correlations with DOSS scores were

Table 3. Internal Lymphedema through the Patterson Scale

Patterson scale sites and spaces	N	*None* n *(%)*	*Mild* n *(%)*	*Moderate* n *(%)*	*Severe* n *(%)*	*Combined moderate–severe* n *(%)*
Base of tongue	56	31 (55.4)	15 (26.8)	9 (16.1)	1 (1.8)	10 (17.9)
Posterior pharyngeal wall	57	33 (57.9)	21 (36.8)	3 (5.3)	0 (0.0)	3 (5.3)
Epiglottis	54	29 (53.7)	13 (24.1)	12 (22.2)	0 (0.0)	12 (22.2)
Pharyngoepiglottic folds	53	28 (52.8)	15 (28.3)	10 (18.9)	0 (0.0)	10 (18.9)
Aryepiglottic folds	53	25 (47.2)	16 (30.2)	12 (22.6)	0 (0.0)	12 (22.6)
Interarytenoid space	54	22 (40.7)	19 (35.2)	11 (20.4)	2 (3.7)	13 (24.1)
Cricopharyngeal prominence	44	24 (54.5)	14 (31.8)	5 (11.4)	1 (2.3)	6 (13.7)
Arytenoids	55	26 (47.3)	19 (34.5)	10 (18.2)	0 (0.0)	10 (18.2)
False vocal folds	54	30 (55.6)	20 (37.0)	4 (7.4)	0 (0.0)	4 (7.4)
True vocal folds	54	42 (77.8)	11 (20.4)	0 (0.0)	1 (1.9)	1 (1.9)
Anterior commissure	54	47 (87.0)	5 (9.3)	2 (3.7)	0 (0.0)	2 (3.7)
Valleculae	55	30 (54.5)	19 (34.5)	6 (10.9)	0 (0.0)	6 (10.9)
Pyriform sinus	56	30 (53.6)	19 (33.9)	5 (8.9)	2 (3.6)	7 (12.5)

TABLE 4. NOMS-FCM AND DOSS SCORE SUMMARIES

NOMS-FCM (Swallowing)[a]	
3	4 (6.7)
4	11 (18.3)
5	4 (6.7)
6	13 (21.7)
7	28 (46.7)
DOSS[b]	
Normal (WNL, WFL)	26 (32.1)
Mild	26 (32.1)
Mild–moderate	10 (12.3)
Moderate	14 (17.3)
Moderate–severe	4 (4.9)
Severe	1 (1.2)

[a] $N = 60$.
[b] $N = 81$.
DOSS, dysphagia outcome and severity scale; FCM, functional communication measure; NOMS, National outcomes measurement system; WNL, within normal limits; WFL, within functional limits.

slightly lower (swallow solids: $r_s = -0.54$, swallow liquids $r_s = -0.41$, nutrition: $r_s = -0.47$, $n = 80$ or 81, all $p < 0.001$).

Correlation of subjective measures of swallow/nutrition with clinician-rated EL. No statistically significant correlations of the VHNSS symptom cluster scores with EL as measured by the Foldi Scale ($r_s < \pm 0.15$, $p > 0.20$).

Correlations of subjective measures of swallow/nutrition with clinician/objective measures of IL. Statistically significant correlations of each of the three VHNSS cluster scores with maximum grade of swelling for any single structure on the Patterson scale were observed ($n = 56$ or 57, $r_s >= 0.38$, $p < 0.01$, see Table 5). Given the increased range of possible scores with increasing prevalence, the magnitude of the correlations of the cluster scores with Patterson grades was larger for sites with a higher prevalence of moderate-to-severe IL (Table 3). With the exception of severity of lymphedema of the base of tongue, all correlations of the swallow solids' symptom cluster score with severity of swelling at the sites were statistically significant ($r_s >= 0.27$, $p < 0.05$). Strongest correlations for that symptom cluster were with swelling of the aryepiglottic folds ($r_s = 0.53$, $p < 0.001$). Correlations of nutrition cluster scores were strongest for severity of swelling in the pyriform sinus ($r_s = 0.49$, $p < 0.001$) and base of tongue ($r_s = 0.42$, $p = 0.001$). Finally, correlations of the swallow liquids cluster score tended to be lower than other associations with the strongest being with swelling of the aryepiglottic folds ($r_s = 0.44$, $p = 0.001$; Table 5).

Correlations of objective measures of swallow with clinician-reported measures of IL. As summarized in Table 6, correlations of severity of swelling at specific sites on the Patterson scale tended to be stronger with NOMS score than with DOSS. Strongest correlations with NOMS were seen for pharyngoepiglottic folds ($r_s = -0.50$, $p = 0.001$), aryepiglottic folds ($r_s = -0.47$, $p = 0.001$), as well as epiglottis, arytenoids, and pyriform sinus ($r_s = -0.44$, $p = 0.002$; Table 6).

Correlations objective measures of swallow with clinician-reported measures of EL. Correlations of both NOMS and DOSS ratings with EL as measured by the Foldi were statistically significant. Once again NOMS demonstrated a stronger association ($r_s = -0.42$; $p = 0.001$) than DOSS did ($r_s = -0.34$; $p = 0.002$).

Discussion

Our study found both subjective (VHNSS) and objective (NOMS, DOSS) measures of swallowing dysfunction correlated with IL as measured by the Patterson Scale. Strongest

TABLE 5. CORRELATIONS BETWEEN VHNSS QUESTIONS AND PRESENCE OF INTERNAL LYMPHEDEMA AS MEASURED BY THE PATTERSON SCALE

	VHNSS swallow solids	*VHNSS swallow liquids*	*VHNSS nutrition*
Presence of swelling for any structure on Patterson scale	0.29[a] (56, 0.030)	0.25 (56, 0.064)	0.26[a] (57, 0.048)
Maximum grade of swelling for any single structure on Patterson scale	0.43[b] (56, 0.001)	0.38[b] (56, 0.004)	0.41[b] (57, 0.002)
Selected sites			
Base of tongue	0.22 (55, 0.107)	0.34[a] (55, 0.010)	0.42[b] (56, 0.001)
Posterior pharyngeal wall	0.35[b] (56, 0.009)	0.28[a] (56, 0.036)	0.35[b] (57, 0.008)
Epiglottis	0.39[b] (53, 0.004)	0.36[b] (53, 0.009)	0.36[b] (54, 0.007)
Pharyngoepiglottic folds	0.41[b] (52, 0.003)	0.35[a] (52, 0.012)	0.41[b] (53, 0.002)
Aryepiglottic folds	0.53[a] (52, <0.001)	0.44[b] (52, 0.001)	0.41[b] (53, 0.003)
Interarytenoid space	0.30[a] (53, 0.029)	0.15 (53, 0.287)	0.27 (54, 0.053)
Cricopharyngeal prominence	0.32[a] (44, 0.034)	0.23 (44, 0.137)	0.23 (44, 0.126)
Arytenoids	0.39[b] (54, 0.004)	0.31[a] (54, 0.023)	0.35[b] (55, 0.009)
False vocal folds	0.41[b] (53, 0.003)	0.24 (53, 0.081)	0.24 (54, 0.084)
True vocal folds	0.27[a] (53, 0.047)	0.20 (53, 0.153)	0.25 (54, 0.075)
Anterior commissure	0.29[a] (53, 0.037)	0.20 (53, 0.153)	0.29[a] (54, 0.036)
Valleculae	0.33[a] (54, 0.016)	0.35[a] (54, 0.011)	0.35[b] (55, 0.009)
Pyriform sinus	0.46[a] (55, <0.001)	0.37[b] (55, 0.005)	0.49[b] (56, <0.001)

Values in the cells r_s (n, p-value).
[a]Correlation is significant at the 0.05 level (two-tailed).
[b]Correlation is significant at the 0.01 level (two-tailed).

TABLE 6. CORRELATIONS OF IL SEVERITY ON PATTERSON SCALE WITH NOMS/DOSS SCORES

Site	*NOMS-FCM* r_s (n, p)	*DOSS* r_s (n, p)
Base of tongue	–0.28 (46, 0.065)	–0.15 (56, 0.284)
Posterior pharyngeal wall	–0.33[a] (47, 0.026)	–0.16 (57, 0.245)
Epiglottis	–0.44[b] (46, 0.002)	–0.30[a] (54, 0.029)
Pharyngoepiglottic folds	–0.50[b] (45, 0.001)	–0.33[a] (53, 0.015)
Aryepiglottic folds	–0.47[b] (45, 0.001)	–0.32[a] (53, 0.018)
Interarytenoid space	–0.24 (46, 0.108)	–0.17 (54, 0.231)
Cricopharyngeal prominence	–0.37[a] (38, 0.024)	–0.23 (44, 0.138)
Arytenoids	–0.44[b] (47, 0.002)	–0.36[b] (55, 0.006)
False vocal folds	–0.42[b] (46, 0.004)	–0.34[a] (54, 0.011)
True vocal folds	–0.34[a] (46, 0.019)	–0.22 (54, 0.103)
Anterior commissure	–0.25 (46, 0.092)	–0.26 (54, 0.063)
Valleculae	–0.27 (47, 0.071)	–0.14 (55, 0.318)
Pyriform sinus	–0.44[b] (47, 0.002)	–0.35[b] (56, 0.009)

[a]Correlation is significant at the 0.05 level (two-tailed).
[b]Correlation is significant at the 0.01 level (two-tailed).
IL, internal lymphedema.

correlation overall was to VHNSS question cluster regarding swallowing solids. IL of the aryepiglottic folds was reflected strongly for all VHNSS swallow/nutrition questions. There was a strong correlation with maximum grade of swelling for any single structure on Patterson scale and the VHNSS. A very weak correlation exists between presence of swelling for any structure on the Patterson scale and VHNSS questions, which likely reflect that this question is too global to correlate with function.

In order for patients to experience swallowing dysfunction, one would expect to observe either severe or extensive swelling of critical structures for deglutition. Our results indicate that presence of severe lymphedema on any single item of the Patterson Scale correlated with swallowing dysfunction. However, having a single structure involved by IL did not correlate with swallow function. Swallowing is a complex process; it can by hypothesized that swallowing compensation might be possible depending on which and how many sites are compromised by IL. Further utility of the Patterson Scale might involve developing a model assessing combination of sites/spaces involved by IL in an attempt to garner a more accurate model to predict swallowing dysfunction. In addition, there might be sites/spaces essential to normal swallowing function for which IL is not well captured by the Patterson scale. For example, while critically important to normal swallowing function, pharyngeal wall swelling is difficult to assess through the Patterson scale and might be better evaluated by other imaging techniques, such as CT scan.

Nevertheless, of the sites with IL on the Patterson scale that did correlate with dysphagia, our results were consistent with those shown to be of clinical importance by other investigators. Goguen performed MBSS on 23 HNC patients after CCR and found majority of problems during the pharyngeal phase.[14] The most frequent deficiency was decreased epiglottic movement, followed by decreased base of tongue contracture, decreased laryngeal elevation, and decreased bolus propulsion.[14] Different anatomic sites might play a more prominent role in perception of swallowing dysfunction. In our study, these areas exhibited greatest correlation with patients' perception of dysphagia on VHNSS, with IL of aryepiglottic/pharyngoepiglottic folds, false vocal folds, arytenoids, base of tongue, epiglottis, and pyriform sinus most strongly correlated with VHNSS ratings. To prevent aspiration during swallowing, the true vocal folds close leading to adduction of the false vocal folds and aryepiglottic folds, and subsequently retroversion of the epiglottis.[15] All of these areas, baring the true vocal folds, which were only severely edematous in only 1.9% of patients, showed a correlation to VHNSS questions.

A characteristic pattern of dysphagia in HNC patients treated with radiotherapy involves decreased laryngeal elevation on swallowing, decreased pharyngeal contraction, and reduced bolus clearance.[16,17] While xerostomia is observed to increase oral and pharyngeal transit times, it is not believed to affect laryngeal elevation or pharyngeal contraction. In addition, there is impaired mobility of muscles of the pharynx that can decrease pharyngeal clearance and impair laryngeal closure, resulting in residue pooling. These affects have been postulated to be the result of neuromuscular incoordination and/or lymphedema/fibrosis.

Our study demonstrated a correlation between subjective and objective measures of swallowing function. Using select items from VHNSS version 2.0 as our patient-reported outcome measure, we demonstrated strong correlations with both NOMS and DOSS ratings. Highest correlations were noted between patient self-report and NOMS scores. While both NOMS and DOSS correlated with the VHNSS, NOMS had stronger correlation for each cluster of questions. A point of differentiation between the swallow outcome measures is that level 5 of the DOSS (mild dysphagia) is defined as the presence of ''aspiration of thin liquids only, but with strong reflexive cough to clear completely.'' If this scenario was to be scored on NOMS, a provider might assign this scenario to a level 6: ''swallowing is safe, and the individual eats and drinks independently and may rarely require minimal cueing. ''VHNSS questions related to nutrition had the lowest correlation, likely due in part to 54.3% of patients having PEG tubes. Thus, the questions related to weight loss, lost appetite, use of liquid supplementation, and trouble maintaining weight due to dysphagia might be ameliorated by the use of PEG for feeding.

Similar results have been published by other investigators. There has been extensive study regarding the relationship between patient perception of swallowing dysfunction and objective swallowing measures, with conflicting results.[18–20] Rogus-Pulia found a significant and strong correlation between the overarching statement ''I have difficulty swallowing'' and swallow efficiency values.[18] The same study noted less awareness of specific symptoms of dysphagia, with 83% of aspirations and all laryngeal penetration being ''silent.''[18]

Correlation between IL scored on the Patterson scale and NOMS ratings was significant for many of the same areas: epiglottis, pharyngoepiglottic and aryepiglottic folds, arytenoids, false vocal folds, and pyriform sinus. Much weaker correlations were found between the Patterson scale and the DOSS, once again highlighting the strength of the NOMS classification with swallowing function.[17]

There was a correlation between objective findings on NOMS and DOSS scales with EL on the Foldi scale. Once again NOMS yielded a stronger correlation in each situation than DOSS. However, our study failed to demonstrate a correlation between subjective measures of swallow function with measures of EL as assessed by the Foldi Scale. Potential explanations for the latter are that our sample did not contain enough patients with severe EL or that IL has a greater impact on perception of swallowing function than EL alone.

This study was designed to detect correlations between the investigated parameters, including comparison of differences between statistically significant correlation coefficients.

Limitations

This analysis did not differentiate between patients who had completed surgery for their HNC versus those who had completed chemoradiotherapy alone. In addition, due to the limited size of the sample, patients were not subdivided by primary site; it might be hypothesized for example that tonsillar, oropharyngeal, and laryngeal primaries experience more dysphagia than oral cavity, nasopharyngeal, and salivary gland cancers. The Patterson Scale does not evaluate IL of the oral cavity. Outside of a clinical trial setting, SLPs do not have a standardized protocol for the order and consistency of intake during implementation of the DOSS, which might limit the utility of the test. Our study sample was small and only looked at one time point for assessment of each patient's lymphedema. Further studies are ongoing for the while longitudinal data will be available.

Conclusions

Lymphedema has been postulated to be an important cause of late-effect dysphagia. Our study supports this hypothesis finding that IL, measured by maximum grade of swelling for any single structure on the Patterson scale, correlated with VHNSS version 2.0, a subjective measure of swallow dysfunction. In addition, IL correlated with objective measures scored through MBSS and NOMS/DOSS scales. The NOMS scale had stronger correlations with IL than DOSS. Our study found no correlation between either self-reported or objective measures of swallow dysfunction and EL. Longitudinal analysis of trajectory and impact of IL/EL on dysphagia is ongoing.

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Author Disclosure Statement

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