Dysphagia (2019) 34:548–555
https://doi.org/10.1007/s00455-019-10001-4

ORIGINAL ARTICLE

Association Between Laryngeal Sensation, Pre-swallow Secretions and Pharyngeal Residue on Fiberoptic Endoscopic Examination of Swallowing

Yael Shapira-Galitz[1] · Hagit Shoffel-Havakuk[1,2] · Doron Halperin[1] · Yonatan Lahav[1]

Received: 10 May 2018 / Accepted: 14 March 2019 / Published online: 25 March 2019

Abstract

Reduced laryngeal sensation and accumulated pharyngeal secretions are known predictors of aspiration. Yet, their association with residue has not been fully explored. One Hundred and ten fiberoptic endoscopic examination of swallowing (FEES) examinations were retrospectively analyzed. Murray's secretion scale (MSS) for secretion stasis and laryngeal sensation were tested for association with residue severity (Yale pharyngeal residue severity rating scale, YPR-SRS) and the number of swallows required to clear the bolus. The bolus challenges of each consistency (liquid, purée and solid) with the highest PAS and YPR-SRS scores were analyzed. Impaired laryngeal sensation (ILS) and MSS were both independently significantly associated with higher YPR-SRS for all consistencies examined. Mean YPR-SRS for patients with both ILS and secretion stasis was respectively 2.4 ± 1.1, 2.5 ± 1.2, 2.4 ± 1.2 for liquid, purée and solids in the vallecula, and 2.9 ± 1.3, 2.3 ± 1.1, 2 ± 1 for pyriform sinuses residue compared to 1.8 ± 0.7, 1.6 ± 1, 1.6 ± 1 for vallecular residue and 1.8 ± 0.8, 1.4 ± 0.8, 1.3 ± 0.7 for pyriform sinus residue of patients with normal laryngeal sensation and no stasis ($p < 0.05$ for all except liquids in vallecula). The combined findings of both ILS and MSS ≥ 1 had a sensitivity of 25.9%, specificity of 94.2%, positive predictive value (PPV) of 83.3% and negative predictive value (NPV) of 53.3% for prediction of pharyngeal residue and a sensitivity of 58.3%, specificity of 88.8%, PPV of 39.9% and a NPV of 94.6% for prediction of aspiration. Both ILS and MSS were significantly associated with increased number of swallows required to clear a bolus. Abnormal laryngeal sensation and secretion stasis are associated with pharyngeal residue severity and reduced residue clearing on FEES.

Keywords Pharyngeal residue · Laryngeal sensation · Murray secretion scale · Aspiration · Fiberoptic endoscopic examination of swallowing · Dysphagia

Introduction

Oropharyngeal dysphagia (OD) is a prevalent disorder affecting up to a sixth of the general population [1, 2], and in designated populations, such as patients after stroke or the elderly, its prevalence is much higher [3–5]. OD has many possible etiologies including neurogenic causes, age-related changes and head and neck surgery or radiation [6–9]. Individuals with OD can be physically affected with malnutrition, dehydration, aspiration pneumonia and asphyxia [10, 11] and on functional and emotional levels, OD can lead to anxiety, depression and social isolation [10–12]. From a public health standpoint, OD leads to extended hospital admission lengths and prolonged rehabilitation [5].

Fiber-optic flexible laryngoscopy is performed by clinicians as part of the physical head and neck examination. It facilitates the visualization of the pharynx and larynx and the evaluation of laryngeal functions such as phonation and breathing. Fiber-optic endoscopic evaluation of swallowing (FEES) starts by performing a laryngoscopy, noting any anatomical or functional abnormalities on a "clean" throat. The examiner then appreciates the physiology of the swallowing

Presented as an oral presentation annual meeting of the Dysphagia Research Society, March 2018.

✉ Yael Shapira-Galitz
yael@galitz.co.il

[1] The Department of Otolaryngology Head and Neck Surgery, Kaplan Medical Center, Hebrew University of Jerusalem, POB 1, 76100 Rehovot, Israel

[2] Department of Otolaryngology Head and Neck Surgery, Rabin Medical Center, Tel-Aviv University, Petah-Tikva, Israel

process, to apply appropriate therapeutic interventions if the swallowing process is impaired and to test the efficiency of these interventions. Many anatomical and functional parameters are assessed during FEES. Two such parameters are penetration-aspiration of a bolus into the airway and pharyngeal residue, defined as part of the bolus retained in the pharynx post-swallow. These two parameters are interconnected [13, 14] and have a significant impact on patient wellbeing [13, 15]. However, aspiration usually takes center-stage in OD evaluation, due to its more intuitive relationship with the sometimes devastating pulmonary consequences of OD [16] and also because residue is harder to accurately scale [17].

While FEES is excellent at outlining the patient's swallowing pathologies and assisting in tailoring clinical and rehabilitative recommendations for OD treatment, it requires special expertise, can be time intensive, and is not always available. For this reason, several studies have examined the ability of laryngoscopy findings, mainly the severity of pooled secretions and impaired laryngopharyngeal sensation (ILS) to predict dysphagia and to identify patients at risk who require more extensive dysphagia evaluation [18–24]. However, the aforementioned studies focused only on the correlation of these laryngoscopy findings with aspirations as the hallmark sign of OD, and not pharyngeal residue.

ILS is usually deduced during routine laryngoscopy by eliciting the laryngeal adductor reflex (LAR). The LAR can be elicited in response to contact with the supraglottic mucosa, either by employing physical contact (the touch method) or using an air-pulse. The latter method is also termed FEES with sensory testing (FEESST) [25]. Of the two methods, the touch method is commonly practiced, as FEESST's measuring equipment is no longer marketed. Regardless of the elicitation method, using LAR to evaluate laryngeal sensation has limitations. The examiner noticing an absent LAR must always entertain the possibility of pathologies affecting different sites of the reflex arc, such as the efferent motoric arm or the brainstem, while the afferent arm, i.e., laryngeal sensation, is in fact intact. Nonetheless, LAR testing is considered an acceptable method for evaluating laryngeal sensation [26]. While ILS has been shown to correlate with aspirations and pneumonia [22–24], the relationship between pharyngeal residue and ILS has not been firmly established.

The severity of pooled secretions has also been shown to predict aspirations and pneumonia [18–21, 27]. However, despite the intuitive link between pooled saliva secretions and post-swallow bolus residue, these parameters are considered different manifestations of impaired pharyngeal clearing, and their association with each other has not been well established in the literature.

The purpose of this current study was to examine whether ILS and secretion stasis are associated with the severity of pharyngeal residue and its clearing efficiency on FEES. We hypothesized that pharyngeal residue is associated with both pooled secretions and ILS, similar to aspiration.

Methods

This is a retrospective cohort of patients examined at our institution's Dysphagia Clinic between July 2014 and November 2016. Video-recorded FEES were performed, reviewed and scored by the same otolaryngologist, who specializes in swallowing disorders and is also experienced in performing FEES. The study was approved by our institutional ethics committee.

The study included consecutive examinations of patients over 18 years of age with fully recorded examinations, in which the patient was offered and was able to handle at least one bolus challenge of one food consistency. Exclusion criteria were age under 18 years. Data collection included: patient's age, gender and etiology of dysphagia which was categorized into: neurogenic (cerebrovascular accidents and neurodegenerative diseases), previous head and neck operation for both malignant and benign causes, with/without radiation to the neck, unknown, and other, including esophageal abnormality, presbyphagia and prolonged intubation.

The standard FEES protocol [28] was followed with slight modifications described hereafter. A flexible digital video rhinolaryngoscope (ENF-V2, Olympus Medical System Corporation, Tokyo, Japan) was passed through the most patent naris with the administration of trace amounts of topical anesthetic (2% Lidocaine hydrochloride gel) to coat the laryngoscope, which has been shown to insignificantly alter the FEES results [29, 30]. Laryngeal sensation was evaluated by gently touching the both arytenoids and noting laryngeal adductor reflex (LAR) or cough response. Absence of LAR or cough after contact with at least one arytenoid was categorized as ILS. If after retracting the laryngoscope from the arytenoids the larynx was not properly visualized, subsequent attempts were made until adequate visualization of the larynx immediately after touching the arytenoid was achieved. Secretion stasis was scored using the Murray secretion scale (MSS) [20]. The MSS is a 4-point scale scoring pharyngeal secretions according to severity and mainly according to location; 0—no secretions, 1—minimal secretions in the pharynx not entering the laryngeal vestibule (illustrated by Murray and defined as the laryngeal lumen above the level of the vocal folds, bounded by the epiglottis anteriorly, the aryepiglottic folds laterally, and the arytenoid cartilages posteriorly), 2—secretions that accumulate in the vestibule during the examination, and 3—secretions in the laryngeal vestibule.

Swallowing was evaluated with nine bolus challenges, three of each consistency (liquid, purée and solid) of approximately 5 cc volume each, presented in

the following order: purée consistency (green dyed apple purée) followed by a solid consistency challenge of whole wheat bread (two pieces without crust and one with the crust) and concluded with thin liquid boluses (green dyed 3% fat milk). Patients were encouraged to feed themselves, with assistance as needed. All patients were allowed to swallow spontaneously without a verbal command to swallow.

Residue was scored using the Yale pharyngeal residue severity rating scale (YPR-SRS) [31] and visualized using freeze-frame imaging immediately after the first swallow following the bolus challenge. The YPR-SRS scores residue in the vallecula and pyriform sinuses. Each site receives a score of 1 to 5 according to a descriptive and an image-based scale; (1) no visible residue; (2) trace (1–5%) residue, depicted as mild coating of the mucosa; (3) mild (< 25%) residue, with the epiglottic ligament still visible; (4) moderate (25–50%) residue, with the epiglottic ligament covered; (5) severe (> 50%) residue, with residue reaching the epiglottic rim (vallecula) or aryepiglottic fold (pyriform sinuses). For each FEES examination, the bolus challenge with the most severe rating out of every consistency tested (defined as the bolus challenge with the highest YPR-SRS score out of all bolus challenges) was chosen for analysis, with a maximum of three bolus challenges per FEES. Each analyzed bolus challenge was scored using the YPR-SRS for the vallecula and pyriform sinus. For bolus challenges other than the first, if residue of another consistency was present in the pharynx from previous bolus challenges it was not scored. Only residue of the offered consistency was scored. Differentiating between residue types was possible because their color-green dyed apple sauce was dark green, the bread was yellow-white and the dyed milk was light green. Patients who did not spontaneously attempt to clear their residue were cued to swallow as needed. Presence of severe residue despite clearing attempts usually leads to modifying the FEES protocol to maintain patient safety, such as limiting the consistencies tested during the FEES or offering water to clear the throat.

To represent the efficiency of the residue clearance, we summed the number of swallows the patient required to reach a YPR-SRS ≤ 2 in both sites (vallecula/pyriform sinuses). Swallows were either spontaneous or cued. If the patient reached the goal YPR-SRS ≤ 2 in 1–2 swallows, the bolus challenge received a score of 1, if in 3–5 swallows, a score of 2, and if more than 5 swallows were required to reach YPR-SRS ≤ 2, a score of 3 was given. If the goal of YPR-SRS ≤ 2 was not reached despite multiple swallowing attempts, a score of 4 was given. This classification is similar to Farneti's pooling score [32], with the exception that Farneti scored patients who required more than 5 swallows to clear residue the same as patients who failed to clear residue altogether.

The penetration-aspiration scale (PAS) [33] was scored according to the highest penetration/aspiration observed in either the primary swallow or any of the subsequent swallows for the analyzed bolus challenge. The highest PAS of every consistency was chosen for analysis.

Statistical analysis was performed using SPSS version 21.0 (IBM, Armonk, NY, USA). PAS, YPR-SRS and residue clearing scores are described as mean and standard deviation. Non-normally distributed variables were compared using the nonparametric Mann–Whitney test if two variables were tested, and Kruskal–Wallis test if three or more variables were compared. Categorical variables were compared using the χ^2 test. The level of significance was set at 0.05. Sensitivity, specificity, negative and positive predictive values were calculated for ILS and MSS for prediction of both PAS and YPR-SRS. All tests were two tailed.

Results

Demographic Data and FEES Results

One hundred and ten FEES examinations were included in the study. The patients' median age was 68; IQR 61–77. 54.5% were males ($n = 60$). Dysphagia etiologies were head and neck disorders related (H&N) (42.7%, $n = 45$), neurogenic (30.9%, $n = 33$), unknown (20.9%, $n = 23$) (e.g., globus sensation, chronic cough work-up, affective disorders), and other ($n = 6$, 5.5%) including esophageal dysphagia and presbyphagia. Twelve patients (10.9%) received a PAS ≥ 6, meaning that they aspirated during the FEES. Median and IQR YPR-SRS for the vallecula were 2 (1–2) for liquids, 1 (1–3) for puree and 1 (1–2.25) for solids. YPR-SRS for the pyriform sinuses were 2 (1–3), 1 (1–2) and 1 (1–1.25) for liquids, puree and solids, respectively.

Impaired Laryngeal Sensation

Eighty-four patients (76.3%) were categorized as having normal laryngeal sensation (NLS) and 26 (23.6%) as having ILS. Table 1 presents a comparison between the PAS, YPR-SRS and number of swallows required to clear the pharynx between patients with NLS and ILS. Patients with ILS had significantly higher YPR-SRS for both the vallecula and the pyriform sinuses in all consistencies tested (liquid/purée/solid) as well as higher PAS scores and scores representing the number of swallows required to clear the residue compared to patients with NLS.

Secretion Stasis

Sixty-seven (60.9%) patients had an MSS = 0, 22 patients (20%) had an MSS = 1, 10 patients (9.1%) an MSS = 2,

Table 1 Comparison of residue severity, penetration-aspiration and number of required clearing swallows between patients with normal and impaired laryngeal sensation

	Liquid ($n=101$)		Purée ($n=110$)		Solid ($n=100$)	
	NLS	ILS	NLS	ILS	NLS	ILS
PAS	1.7 ± 1.2	4.2 ± 2.7	1.3 ± 0.8	2.0 ± 1.8	1.3 ± 0.8	1.6 ± 1.0
p value	$U=395.5, Z=-4.42, p=0.0001$		$U=727, Z=-3.1, p=0.002$		$U=603, Z=-2.79, p=0.005$	
YPR-SRS—vallecula	1.9 ± 0.7	2.3 ± 1.0	1.7 ± 1.0	2.5 ± 1.2	1.7 ± 0.9	2.4 ± 1.3
p value	$U=634.5, Z=-2.21, p=0.026$		$U=618, Z=-3.39, p=0.001$		$U=608, Z=-2.19, p=0.028$	
YPR-SRS—Pyriform	3.5 ± 1.5	4.5 ± 2.4	1.5 ± 0.9	2.3 ± 1.2	1.3 ± 0.8	1.9 ± 1.0
p value	$U=441, Z=-3.85, p=0.0001$		$U=631, Z=-3.51, p=0.0001$		$U=562, Z=-3.19, p=0.001$	
Residue clearing	1.3 ± 0.6	1.9 ± 0.9	1.4 ± 0.8	2.1 ± 1.1	1.4 ± 0.6	1.8 ± 0.9
p value	$U=534.5, Z=-3.5, p=0.0001$		$U=631, Z=-3.51, p=0.0001$		$U=645, Z=-3.19, p=0.042$	

The results are presented as mean and standard deviation. Residue clearing: 1 = residue cleared in 1–2 swallows, 2 = residue cleared in 3–5 swallows, 3 = residue cleared in > 5 swallows, 4 = residue not cleared

YPR-SRS yale pharyngeal residue severity rating scale, *PAS* penetration aspiration scale, *ILS* impaired laryngeal sensation, *NLS* normal laryngeal sensation

p values were calculated using the Mann–Whitney test

and 11 (10%) an MSS = 3. Table 2 presents the comparison between the PAS, YPR-SRS and the number of swallows required to clear the pharynx between patients with MSS < 1 and MSS ≥ 1. Patients with secretion stasis (MSS ≥ 1) had significantly higher YPR-SRS for both the vallecula and the pyriform sinuses in all consistencies tested (liquid/purée/solid) as well as significantly higher scores representing the number of swallows required to clear the residue compared to patients without secretion stasis. PAS scores were significantly higher in patients with MSS ≥ 1 compared to MSS < 1 for liquid and puree consistency but not for solids.

Impaired Laryngeal Sensation and Secretion Stasis Combined

Of our cohort, 59 patients (53.6%) had both MSS < 1 with NLS, 8 patients (7.2%) had MSS < 1 with ILS, 25 patients (22.7%) had MSS ≥ 1 and NLS, and 18 patients (16.3%) had MSS ≥ 1 and ILS. Table 3 presents a comparison of the YPR-SRS and PAS scores between four categories of patients: Patients with NLS and no secretion stasis (MSS < 1), patients with NLS and with secretion stasis (MSS ≥ 1), patients with ILS and no secretion stasis, and patients with ILS and secretion stasis. The four groups showed significant differences in PAS and YPR-SRS. Patients with ILS and MSS ≥ 1 showed the highest PAS and YPR-SRS, while

Table 2 Comparison of residue severity, penetration-aspiration and number of required clearing swallows between patients with and without secretion stasis

	Liquid ($n=101$)		Purée ($n=110$)		Solid ($n=100$)	
	MSS ≥ 1	MSS < 1	MSS ≥ 1	MSS < 1	MSS ≥ 1	MSS < 1
PAS	3.3 ± 2.4	1.8 ± 1.6	2.0 ± 1.8	1.2 ± 0.5	1.5 ± 0.8	1.3 ± 0.9
p value	$U=724.5, Z=-3.62, p=0.0001$		$U=981.5, Z=-3.5, p=0.0001$		$U=939.5, Z=-1.48, p=0.137$	
YPR-SRS vallecula	2.2 ± 0.9	1.9 ± 0.7	2.3 ± 1.3	1.7 ± 1.0	2.2 ± 1.1	1.7 ± 1.1
p value	$U=934, Z=-2.0, p=0.044$		$U=955.5, Z=-3.12, p=0.002$		$U=790, Z=-2.41, p=0.016$	
YPR-SRS Pyriform	2.4 ± 1.2	1.8 ± 0.8	2.0 ± 1.2	1.5 ± 0.9	1.7 ± 1.1	1.3 ± 0.7
p value	$U=908, Z=-3.35, p=0.03$		$U=1147, Z=-1.94, p=0.052$		$U=854, Z=-2.29, p=0.022$	
Residue clearing	1.8 ± 0.9	1.3 ± 0.5	2.0 ± 1.1	1.3 ± 0.7	1.7 ± 0.9	1.4 ± 0.6
p value	$U=798.5, Z=-3.35, p=0.001$		$U=946, Z=-3.51, p=0.0001$		$U=866.5, Z=1.96, p=0.049$	

The results are presented by mean and standard deviation. Secretion stasis was scored with the Murray secretion scale. Residue clearing: 1 = residue cleared in 1–2 swallows, 2 = residue cleared in 3–5 swallows, 3 = residue cleared in > 5 swallows, 4 = residue not cleared

PAS penetration aspiration scale, *MSS* murray secretion scale, *YPR-SRS* yale pharyngeal residue severity rating scale

p values were calculated using the Mann–Whitney test

Table 3 Comparison of residue severity and penetration-aspiration for patients with and without secretion stasis and with and without impaired laryngeal sensation

		MSS ≤ 1, NLS	MSS ≥ 1, NLS	MSS ≤ 1, ILS	MSS ≥ 1, ILS	*p* value
YPR-SRS vallecula-	Fluid ($n=101$)	1.8 ± 0.7	2.1 ± 0.7	2.2 ± 0.6	2.4 ± 1.1	0.105
	Puree ($n=110$)	1.6 ± 1	2.2 ± 1.3	2.4 ± 1.2	2.5 ± 1.2	0.001
	Solid ($n=100$)	1.6 ± 1	2 ± 1	2.3 ± 1.5	2.4 ± 1.2	0.035
YPR-SRS pyriform sinuses	Fluid ($n=101$)	1.8 ± 0.8	2.0 ± 0.9	2.5 ± 0.5	2.9 ± 1.3	0.001
	Puree ($n=110$)	1.4 ± 0.8	1.7 ± 1.2	2.1 ± 1.2	2.3 ± 1.1	0.005
	Solid ($n=100$)	1.3 ± 0.7	1.5 ± 1.1	1.6 ± 0.9	2 ± 1	0.007
PAS	Maximal	1.6 ± 1.1	2.7 ± 1.9	3.8 ± 2.7	4.8 ± 2.3	<0.0001

The results are presented as mean and standard deviation. Secretion Stasis was scored using the Murray secretion scale

PAS penetration aspiration scale, *MSS* murray secretion scale, *YPR-SRS* yale pharyngeal residue severity rating scale, *ILS* impaired laryngeal sensitivity, *NLS* normal laryngeal sensitivity

p values were calculated with Kruskal–Wallis test

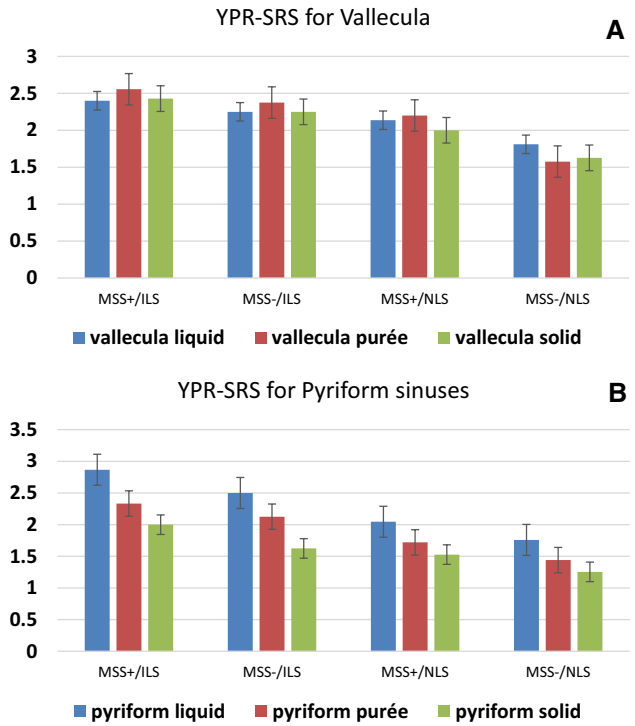

Fig. 1 YPR-SRS for patients with and without secretion stasis and with and without impaired laryngeal sensation. Mean and standard error of residue severity scores for vallecula (**a**) and pyriform sinuses (**b**) residue for patients with and without laryngeal hypoesthesia and with and without secretion stasis. *MSS* murray secretion scale, *YPR-SRS* yale pharyngeal residue severity rating scale, *ILS* impaired laryngeal sensation, *NLS* normal laryngeal sensation

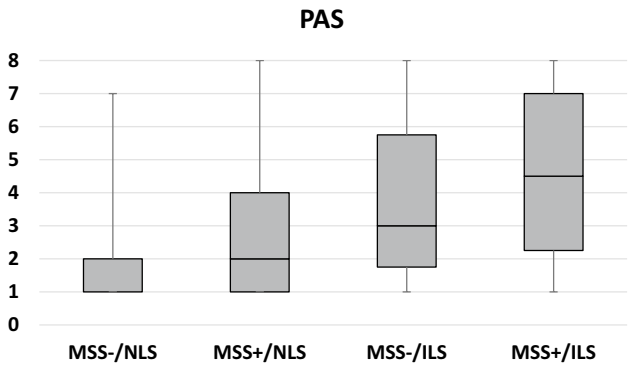

Fig. 2 PAS for patients with and without secretion stasis and with and without impaired laryngeal sensation. Mean PAS scores for patients with and without laryngeal hypoesthesia and with and without secretion stasis. MSS + represents MSS ≥ 1, MSS- represents MSS < 1. The PAS score presented is the highest out of all consistencies and bolus challenges. *MSS* murray secretion scale, *PAS* penetration-aspiration scale, *ILS* impaired laryngeal sensitivity, *NLS* normal laryngeal sensitivity

patients with MSS < 1 and NLS showed the lowest scores. Figures 1 and 2 show the YPR-SRS and PAS scores for the four categories, respectively. Table 4 presents the sensitivity, specificity and predictive values of ILS and of MSS ≥ 1 for predicting aspiration and residue on FEES. The sensitivity of ILS and MSS ≥ 1 for aspiration was 75% for both, with a specificity of 82.6% and 65.3%, respectively. The negative predictive value for aspiration was 96.4% for ILS and 95.5% for MSS ≥ 1. The sensitivity of ILS combined with MSS ≥ 1 for pharyngeal residue was 25.9%, with a specificity of 94.2%, PPV of 83.3% and NPV of 53.3%. The relative risk (RR) of patients with ILS and MSS ≥ 1 for pharyngeal residue was 1.8 and 7.2 for aspiration during FEES compared to the group with NLS and MSS < 1.

Discussion

Several previous studies have addressed the ability to predict penetration and aspiration by relying on routine laryngoscopy findings [20, 21, 23, 24, 26]. To the best of our knowledge, this study is the first to examine the

Table 4 Sensitivity, specificity, predictive values and relative risk of impaired laryngeal sensation, secretion stasis and the combination of both for aspiration and pharyngeal residue

			Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	RR
	Aspiration (*n*)	No aspiration (*n*)					
ILS	9	17	75	82.6	34.6	96.4	9.7
NLS	3	81					
MSS ≥ 1	9	34	75	65.3	20.9	95.5	4.7
MSS < 1	3	64					
ILS + MSS ≥ 1	7	11	58.3	88.8	39.9	94.6	7.2
NLS + MSS < 1	5	87					
	Residue (*n*)	No residue (*n*)					
ILS	20	6	34.5	88.5	76.9	54.8	1.7
NLS	38	46					
MSS ≥ 1	31	12	53.4	76.9	72.1	59.7	1.8
MSS < 1	27	40					
ILS + MSS ≥ 1	15	3	25.9	94.2	83.3	53.3	1.8
NLS + MSS < 1	43	49					

Aspiration was defined as PAS > 5. Residue was defined as YPRSRS < 2 for one or more consistencies at any site (vallecula and/or pyriform sinuses)

ILS impaired laryngeal sensitivity, *NLS* normal laryngeal sensitivity, *MSS* murray secretion scale, *YPR-SRS* yale pharyngeal residue severity rating scale, *NPV* negative predictive value, *PPV* positive predictive value, *RR* relative risk

ability of laryngoscopy findings to predict the presence of pharyngeal residue. We demonstrated that a significant association exists between pooled secretion and ILS to the severity of pharyngeal residue and the efficiency of its clearance. We also reaffirmed the correlation between these findings and PAS.

OD is a prevalent and serious disorder, with significant morbidity and mortality concerns [5, 10–12]. However, it is underdiagnosed and often not managed soon enough [12]. The first step in addressing OD is screening high-risk patients to identify those requiring further evaluation [34, 35]. However, there is no consensus in the literature on the ideal screening tool. Multiple screening methods have been proposed [36, 37], from questionnaires to bedside evaluations. However, their sensitivity and specificity, especially of bedside evaluations, is less than ideal [38]. Furthermore, brevity, ease of administration and applicability on non-verbal or cognitively impaired patients are important characteristics to consider in a screening tool. Our study shows that secretion stasis and ILS upon laryngoscopy are associated not only with penetration-aspiration, which has already been described in the literature [20, 21, 23, 24, 26], but also with pharyngeal residue, strengthening it as a screening tool for OD, especially for cognitively impaired patients who cannot cooperate with questionnaires or clinical bedside evaluations. Knowing that ILS and secretion stasis are associated with dysphagia could also help in detecting patients requiring comprehensive dysphagia work-up among those undergoing routine laryngoscopy as part of a head and neck examination performed for other reasons. Its disadvantages as a screening tool are its invasive nature, special equipment and expertise required.

Pharyngeal residue is given less significance as a symptom of OD than penetration-aspiration, despite its impact on the patient's well-being and quality of life [13, 15]. Pharyngeal residue has also been shown to have a greater impact on health-related quality of life than penetration-aspiration [39]. Moreover, retained residue is by itself is a predictor of aspiration [40–42], suggesting that patients who demonstrate residue on instrumental swallowing assessment (ISA) should be considered as higher risk for aspiration, even if no events of aspirations are caught during the ISA. Clinicians who categorize OD patients on the basis of ISA as aspirators/non-aspirators might be oversimplifying the patient's swallowing problem.

Stratifying the risk of a patient with residue to aspirate is difficult, due to the multiple factors that affect the relationship between residue and aspiration. Residue severity, or the amount of residue in the pharynx, is not the only element to be considered. Additionally, we should consider how well the patient handles the residue. Does the patient *sense* it and how effectively does the patient clear it? While the MSS quantifies retained secretions, which might be considered a result of dysphagia, hinting toward abnormal swallowing function, ILS has a direct contribution to the swallowing pathophysiology. Our study shows that patients with ILS not only had higher residue severity (RR = 1.7), but also cleared it less effectively, and aspirated more often (RR = 9.7). One should also consider that besides the observed aspiration during ISA, patients with ILS, who do not sense the

accumulating residue and make less effort to clear it, might suffer from aspiration long after finishing to swallow. Further studies are required to stratify the clinical outcomes of pharyngeal residue.

When examining the effectiveness of ILS and MSS ≥ 1 as predictors for dysphagia, we learned that these laryngoscopy findings offered in our study cohort low-moderate sensitivity for residue and moderate-high (75%) sensitivity for aspiration, 25% lower compared to the perfect 100% sensitivity of MSS ≥ 1 for aspirations by Kuo et al. [21]. While the PPV for aspirations was also only moderate, probably due to the low pre-test probability of aspirations in our cohort, the NPV for ILS and MSS ≥ 1 for aspiration was very high. This means that the absence of these findings on laryngoscopy predicts the absence of aspirations in over 94% of patients. When examining the predictive strength for residue we observed that the specificity of ILS combined with MSS ≥ 1 was high for the presence of residue with a PPV of 83.3%. We conclude that when screening for dysphagia using secretion stasis severity and ILS, these findings have a high NPV for aspirations, and high specificity and PPV for residue detection.

Our study has several limitations. Firstly, since the institution has only one clinician proficient at interpreting FEES, our study design utilized a single rater evaluation. Although this methodology reduces inter-rater variability, it might be a source for bias. However, both the YPR-SRS and the PAS have well established inter and intra-rater reliability in the literature [32, 34]. Additionally, this is a retrospective study and therefore has inherent limitations by design. Furthermore, testing laryngeal sensation was performed by direct contact on supraglottic mucosa (the "touch method") and was not standardized. The touch method has been shown to vary considerably between tests and testers [43]. Even though all FEES were performed by the same physician using the same technique, variability of sensory testing should still be expected and might skew the results. Another limitation stems from patient safety considerations during FEES, e.g., early terminations of FEES examinations, avoiding testing certain consistencies due to severe aspirations, or the introduction of swallowing maneuvers to minimize aspirations during the exam which might skew results.

Conclusion

Secretion stasis and laryngeal hypoesthesia are associated with severity of pharyngeal residue in the vallecula and pyriform sinuses and to the efficiency of residue clearing. The presence of secretion stasis and ILS during routine laryngoscopy has a high NPV for aspirations, and high specificity and PPV for residue detection. These findings may be used to identify patients at risk of dysphagia during routine laryngoscopy for more extensive dysphagia evaluation.

Funding This study has not received funding.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

References

1. Kertscher B, Speyer R, Fong E, Georgiou AM, Smith M. Prevalence of oropharyngeal dysphagia in the Netherlands: a telephone survey. Dysphagia. 2015;30(2):114–20.
2. Wilkins T, Gillies RA, Thomas AM, Wagner PJ. The prevalence of dysphagia in primary care patients: a HamesNet Research Network study. J Am Board Fam Med. 2007;20:144–50.
3. Martino R, Foley N, Bhogal S, Diamant N, Speechley M, Teasell R. Dysphagia after stroke: incidence, diagnosis, and pulmonary complications. Stroke. 2005;36:2756–63.
4. Serra-Prat M, Hinojosa G, Lopez D, Juan M, Fabre E, Voss DS, Calvo M, Marta V, et al. Prevalence of oropharyngeal dysphagia and impaired safety and efficacy of swallow in independently living older persons. J Am Geriatr Soc. 2011;59:186–7.
5. Cabré M, Serra-Prat M, Force LL, Almirall J, Palomera E, Clave P. Oro- pharyngeal dysphagia is a risk factor for readmission for pneumonia in the very elderly: observational prospective study. J Gerontol A Biol Sci Med Sci. 2013;69(3):330–7.
6. Mann G, Hankey GJ, Cameron D. Swallowing disorders following acute stroke: prevalence and diagnostic accuracy. Cerebrovasc Dis. 2000;10:380–6.
7. Coates C, Bakheit AM. Dysphagia in Parkinson's disease. Eur Neurol. 1997;38:49–52.
8. Bloem BR, Lagaay AM, vanBeek W, Haan J, Roos RAC, Wintzen AR. Prevalence of subjective dysphagia in community residents aged over 87. BMJ. 1990;300:721–2.
9. Garcia-Peris P, Paron L, Velasco C, de la Cuerda C, Camblor M, Breton I, Herencia H, Verdaguer J, Navarro C, Clave P. Long- term prevalence of oropharyngeal dysphagia in head and neck cancer patients: impact on quality of life. Clin Nutr. 2007;26:710–7.
10. Nguyen NP, Frank C, Moltz CC, et al. Impact of dysphagia on quality of life after treatment of head and neck cancer. Int J Radiat Oncol Biol Phys. 2005;61:772–8.
11. Campbell BH, Spinelli K, Marbella AM, et al. Aspiration, weight loss and quality of life in head and neck cancer survivors. Arch Otolaryngol Head Neck Surg. 2004;130:1100–3.
12. Ekberg O, Hamdy S, Woisard V, Wuttge-Hannig A, Ortega P. Social and psychological burden of dysphagia: its impact on diagnosis and treatment. Dysphagia. 2002;17:139–46.
13. Eisenhuber E, Schima W, Schober E, et al. Videofluoroscopic assessment of patients with dysphagia: pharyngeal retention is a predictive factor for aspiration. Am J Roentgenol. 2002;178(2):393–8.
14. Shapira-Galitz Y, Shoffel-Havakuk H, Lahav Y, Halperin D. Correlation between pharyngeal residue severity and aspiration in

patients with dysphagia undergoing FEES. Oral presentation at the European Society of Swallowing Disorders 2017 Congress, Barcelona, Spain, September 2017.
15. Van der Berg M, Rutten H, Rasmussen-Conrad E, et al. Nutritional status, food intake, and dysphagia in long-term survivors with head and neck cancer treated with chemoradiotherapy: a cross-sectional study. Head Neck. 2013;36(1):60–5.
16. Cabré M, Serra-Prat M, Palomera E, Almirall J, Pallares R, Clavé P. Prevalence and prognostic implications of dysphagia in elderly patients with pneumonia. Age Ageing. 2010;39:39–45.
17. Pisegna JM. Rethinking residue, an investigation of pharyngeal residue on flexible endoscopic evaluation of swallowing: the past, present, and future directions. Boston University OpenBU Theses and Dissertations; 2017.
18. Link DT, Willging JP, Miller CK, Cotton RT, Rudolph CD. Pediatric laryngopharyngeal sensory testing during flexible endoscopic evaluation of swallowing: feasible and correlative. Ann Otol Rhinol Laryngol. 2000;109:899–905.
19. Donzelli J, Brady S, Wesling M, Craney M. Predictive value of accumulated oropharyngeal secretions for aspiration during video nasal endoscopic evaluation of the swallow. Ann Otol RhinolLaryngol. 2003;112:469–75.
20. Murray J, Langmore SE, Ginsberg S, Dostie A. The significance of oropharyngeal secretions and swallowing frequency in predicting aspiration. Dysphagia. 1996;11:99–103.
21. Kuo CW, Allen CT, Huang CC, Lee CJ. Murray secretion scale and fiberoptic endoscopic evaluation of swallowing in predicting aspiration in dysphagic patients. Eur Arch Otorhinolaryngol. 2017;274(6):2513–9.
22. Aviv JE, Spitzer J, Cohen M, Ma G, Belafsky P, Close LG. Laryngeal adductor reflex and pharyngeal squeeze as predictors of laryngealpenetration and aspiration. Laryngoscope. 2002;112(2):338–41.
23. Onofri SM, Cola PC, Berti LC, da Silva RG, Dantas RO. Correlation between laryngeal sensitivity and penetration/aspiration after stroke. Dysphagia. 2014;29(2):256–61.
24. Sato S, Fujishima I, Setsu K, Katagiri N, Inao R, Mizuma M. Evaluation for dysphagia by testing laryngeal sensation with a flexible laryngoscope. Jpn J Dysphagia Rehabil. 2002;6(4):44–52.
25. Aviv JE, Kim T, Sacco RL, Kaplan S, Goodhart K, Diamond B, Close LG. FEESST: a new bedside endoscopic test of the motor and sensory components of swallowing. Ann Otol Rhinol Laryngol. 1998;107:378–87.
26. Kaneoka A, Pisegna JM, Inokuchi H, Ueha R, Goto T, Nito T, Stepp CE, LaValley MP, Haga N, Langmore SE. Relationship between laryngeal sensory deficits, aspiration, and pneumonia in patients with Dysphagia. Dysphagia. 2017. https://doi.org/10.1007/s00455-017-9845-8. [Epub ahead of print].
27. Miles A, Hunting A, McFarlane M, Caddy D, Scott S. Predictive value of the new zealand secretion scale (NZSS) for Pneumonia. Dysphagia. 2018;33(1):115–22.
28. Langmore SE, Schatz K, Olsen N. Fiberoptic endoscopic examination of swallowing safety: a new procedure. Dysphagia. 1988;2:216–9.
29. Fife TA, Butler SG, Langmore SE, Lester S, Wright SC Jr, Kemp S, Grace-Martin K, Lintzenich CR. Use of topical nasal anesthesia during flexible endoscopic evaluation of swallowing in dysphagic patients. Ann Otol Rhinol Laryngol. 2015;124(3):206–11.
30. O'Dea MB, Langmore SE, Krisciunas GP, Walsh M, Zanchetti LL, Scheel R, McNally E, Kaneoka AS, Guarino AJ, Butler SG. Effect of lidocaine on swallowing during FEES in patients with Dysphagia. Ann Otol Rhinol Laryngol. 2015;124(7):537–44.
31. Neubauer PD, Rademaker AW, Leder SB. The yale pharyngeal residue severity rating scale: an anatomically defined and image-based tool. Dysphagia. 2015;30(5):521–8.
32. Farneti D. Pooling score: an endoscopic model for evaluating severity of dysphagia. Acta Otorhinolaryngol Ital. 2008;28:135–40.
33. Rosenbek JC, Robbins JA, Roecker EB, Coyle JC, Wood JL. A. penetration-aspiration scale. Dysphagia. 1996;11:93–8.
34. Kaspar K, Ekberg O. Identifying vulnerable patients: role of the EAT-10 and the multidisciplinary team for early intervention and comprehensive dysphagia care. In: Cichero J, Clave P, editors. Stepping stones to living well with dysphagia, Nestle nutr inst workshop ser, vol 72: 19–31.
35. Poorjavad M, Jalaie S. Systemic review on highly qualified screening tests for swallowing disorders following stroke: validity and reliability issues. J Res Med Sci. 2014;19(8):776–85.
36. Poorjavad M, Jalaie S. Systemic review on highly qualified screening tests for swallowing disorders following stroke: validity and reliability issues. J Res Med Sci. 2014;19(8):776–85.
37. Kaspar K, Ekberg O. Identifying vulnerable patients: role of the EAT-10 and the multidisciplinary team for early intervention and comprehensive dysphagia care. Nestle Nutr Inst Workshop Ser. 2012;72:19–31.
38. Logemann JA. Evaluation and treatment of swallowing disorders. San Diego: College Hill Press; 1983. p. 6.
39. Meyer TK, Pisegna JM, Krisciunas GP, Pauloski BR, Langmore SE. Residue influences quality of life independently of penetration and aspiration in head and neck cancer survivors. Laryngoscope. 2017;127(7):1615–21.
40. Perlman AL, Booth BM, Grayhack JP. Videofluoroscopic predictors of aspiration in patients with oropharyngeal dysphagia. Dysphagia. 1994;9(2):90–5.
41. Molfenter SM, Steele CM. The relationship between residue and aspiration on the subsequent swallow: an application of the normalized residue ratio scale. Dysphagia. 2013;28(4):494–500.
42. Dodds WJ, Logemann JA, Stewart ET. Radiologic assessment of abnormal oral and pharyngeal phases of swallowing. AJR Am J Roentgenol. 1990;154:965–74.
43. Kaneoka A, Pisegna JM, Krisciunas GP, Nito T, LaValley MP, Stepp CE, Langmore SE. Variability of the pressure measurements exerted by the tip of laryngoscope during laryngeal sensory testing: a clinical demonstration. Am J Speech Lang Pathol. 2017;26(3):729–36.

Yael Shapira-Galitz MD

Hagit Shoffel-Havakuk MD

Doron Halperin MHA, MD

Yonatan Lahav MD