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ORIGINAL RESEARCH

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Esophageal stenosis in head and neck cancer patients: Imaging's accuracy to predict dilation response

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Abstract

Objectives: The primary goal of this study was to examine how well findings of cervical esophageal stenosis on modified barium swallow (MBS) and esophagram correlate with clinical improvement following dilation in patients with a history of head and neck (H&N) cancer.

Methods: A retrospective review was performed at an academic hospital. The study population included H&N cancer patients with a history of neck dissection surgery who underwent esophageal dilation from 2010 to2018. Pre and postdilation swallowing function was assessed. The Functional Outcomes Swallowing Scale (FOSS) and Functional Oral Intake Scale (FOIS) were used as outcome measures.

Results: The 95 patients were included. All patients had imaging prior to dilation. Post-dilation FOSS and FOIS scores were significantly improved ($P < .001$). In identifying the patients that would have improvement from dilation, esophagram and MBS had average sensitivities of 81% and 82%, respectively. The negative predictive value (ie, the ability of a normal esophagram or normal MBS to exclude patients that would not improve with dilation) was only 46% and 38%, respectively. When the specific finding of aspiration on MBS was considered, the positive predictive value (PPV) (ie, the ability of an MBS positive for aspiration to predict that a patient would benefit from dilation) was 87% ($P = .03$). When only the specific finding of stenosis on esophagram was considered, the PPV of improvement post-dilation was 58% ($P = .97$). The delay in time from imaging to dilation was significantly longer in those who had an unidentified stenosis (false negative) on imaging when compared to those who did not (46.8 ± 35.2 days vs 312.6 ± 244.1 days, $P < .001$).

Conclusion: In high risk patients for cervical esophageal stenosis, such as those with a history of H&N cancer and open neck surgery with or without radiation, MBS and esophagram appear to have mixed reliability as predictors of response to esophageal dilation. In these patients, a "negative" result on MBS and esophagram may not be diagnostically accurate enough to exclude patients from consideration of dilation.

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Level of Evidence: IIb

KEYWORDS

cervical esophageal stenosis, dysphagia, esophagram, head and neck surgery, modified barium swallow

1 | INTRODUCTION

In recent years, there has been an overall trend towards organ preservation in the treatment of advanced head and neck (H&N) cancer. A potential consequence of these treatment protocols is clinically significant esophageal stenosis, which can lead to persistent dysphagia, gastrostomy tube dependence, and decreased quality of life.[1] The care of H&N cancer patients is complex, and they are already predisposed to malnutrition and its poor outcomes. Therefore, accurate and timely diagnosis of cervical esophageal stenosis is vital to appropriate management.

The modified barium swallow (MBS) and esophagram are the two primary imaging studies utilized in the evaluation of dysphagia. These imaging studies are often considered valuable tools in establishing the diagnosis as they can demonstrate both structural and functional swallowing irregularities. In general, the decision to perform esophageal dilation is based on the presence of stenosis identified on imaging. However, the sensitivity of MBS or esophagram for detecting cervical esophageal stenosis has been poorly studied and the rate of diagnostic accuracy is undefined.

At our institution, we have observed that some patients with a history of prior neck surgery and/or radiation have had improvement in dysphagia symptoms after esophageal dilation despite negative preoperative imaging studies. We consider patients with a history of open neck surgery, with or without radiation, high risk for cervical esophageal stenosis. The primary goal of this study was to examine how well findings of cervical esophageal stenosis on MBS or esophagram correlate with clinical improvement following dilation in this population. The secondary aim of the study was to identify potential factors that may correlate with successful dilation. In high risk patients, we hypothesized that both MBS and esophagram are unreliable predictors of who will have improvement in dysphagia symptoms after dilation. Thus, these imaging studies may be poor indicators of the presence of clinically relevant esophageal stenosis.

2 | MATERIALS AND METHODS

2.1 | Data source

The study was approved by the Institutional Review Board of Loma Linda University. A retrospective review was performed of all patients with history of dysphagia and open neck surgery (with or without radiation) who presented to the Loma Linda Voice and Swallowing Center from 2010 to 2018 after trial of swallow therapy following H&N cancer treatment. Criteria for inclusion were age > 18, history of prior open neck surgery, presenting complaint of dysphagia, underwent therapeutic rigid esophagoscopy and dilation, and imaging study (MBS/ esophagram) completed prior to dilation. The Functional Outcomes Swallowing Scale (FOSS) and Functional Oral Intake Scale (FOIS) were used as outcome measures.[2,3]

Data regarding demographics, MBS and esophagram findings, pre-dilation FOSS and FOIS, and post-dilation FOSS and FOIS were collected. Patients were excluded if they had a history of prior dilations or surgical therapeutic interventions for dysphagia, no imaging available prior to dilation, or a prior history of free flap reconstruction. The primary outcomes were improvement in FOSS and FOIS scores. Improvement in FOSS and FOIS were considered to be markers of positive clinical improvement following dilation. With respect to imaging findings (both MBS and esophagram), rigid esophagoscopy showing cervical narrowing and post-dilation improvement in FOSS and FOIS were considered to be indicators of the true presence of pre-operative stenosis.

MBS and esophagram studies were not completed at a single location. Some were performed at Loma Linda Medical Center while others were performed at community radiology centers. The imaging reports and radiologist interpretations were reviewed. The presence of stenosis and/or other findings was recorded. Esophageal dilation was performed in the operating room under general anesthesia using Maloney dilators. The extent of dilation was specific to each patient.

FOSS is a clinical measure of oropharyngeal dysphagia severity which categorizes patients into six performance stages: 0) normal function without symptoms, 1) normal but with episodic or daily dysphagia symptoms, 2) abnormal function with significant dietary modification or prolonged mealtime without weight loss or aspiration, 3) abnormal function with weight loss of 10% or less over 6 months or aspiration, 4) abnormal function with weight loss >10% over 6 months or severe aspiration with bronchopulmonary complications, 5) complete non-oral feeding.[3] Lower FOSS score indicates better swallowing function. FOIS is a clinical measure of functional oral intake which categorizes patients into 7 levels: 1) no oral intake, 2) tube-dependent with minimal oral intake, 3) oral intake with tube supplementation, 4) total oral intake with only 1 consistency of food, 5) total oral intake with multiple consistencies but with special preparation, 6) total oral intake with avoidance of specific foods or drinks, 7) total oral intake with no restrictions.[2] Higher FOIS score indicates better swallowing function. These two swallowing scales were selected based on their prevalence in the literature, inter-observer reliability, and ease of scoring. Importantly, they do not rely on radiographic findings and thus avoid confounding the data analysis.[2,3]

2.2 | Statistics

The two-tailed, Student *t*-test or Fisher exact test were used when appropriate. FOSS and FOIS data were treated as ordinal variables. Binary logistic regression was performed using independent variables with the potential to correlate with outcomes. Odds ratios (OR) and confidence intervals (CI) were reported as OR [lower 95% CI, upper 95% CI], along with Cox-Snell correlation coefficients (R^2). Means were reported as mean ± SD (SD). Significance was established at the $P < .05$ level. Receiver operating characteristic (ROC) curve was calculated with a binary predictor using MedCalc Statistical Software version 19.1.5 (MedCalc Software bv, Ostend, Belgium; https://www.medcalc.org; 2020).

3 | RESULTS

3.1 | Descriptive data

The 95 patients were identified and included in the study. All had open neck surgery, of which 83% had a neck dissection. The mean age was 67.4 ± 11.8 years (range 43-94). Seventy-nine percent of patients had a history of radiation therapy (RT) and 55% of patients had a history of gastrostomy tube (GT). Patients who received radiation were more likely to have GTs in place, 73% vs 27% ($P = .018$). On average, patients initially presented with 24 ± 27.6 months of dysphagia symptoms. Esophagoscopy with dilation was performed an average of 6.8 ± 9.1 months after either a MBS or esophagram. In patients with a history of RT, the average time from completion of RT to dilation was 50.8 ± 58.1 months.

3.2 | Imaging results

Completed esophagram and MBS radiology report findings were reviewed for stenosis, penetration, and aspiration. Imaging results are as listed in Figure 1.

3.3 | Outcomes

Overall, 55 (57.9%) patients had an improvement in FOSS score after dilation and 56 (58.9%) patients had improvement in FOIS score. An improvement in FOSS or FOIS score of ≥1 was considered a marker of response to treatment. The distribution of pre- and post-dilation FOSS scores are shown in Figure 2. The distribution of pre- and post-dilation FOIS scores are shown in Figure 3. Post-dilation FOSS scores were overall significantly better than pre-dilation scores (mean 2.1 ± 1.5 vs 3.2 ± 1.2, $P < .001$). Similarly, FOIS scores were significantly better post-dilation compared to pre-dilation (mean 4.9 ± 1.7 vs 3.8 ± 1.7, $P < .001$). The distribution of improvement in FOSS and FOIS scores is shown in Figure 4. For FOSS, 1 patient (1.1%) was noted to have a worsening of the score by one point. For FOIS, two patients (2.1%) were noted to have a worsening of the score by one point and one patient (1.1%) was noted to have a worsening of the score by two points.

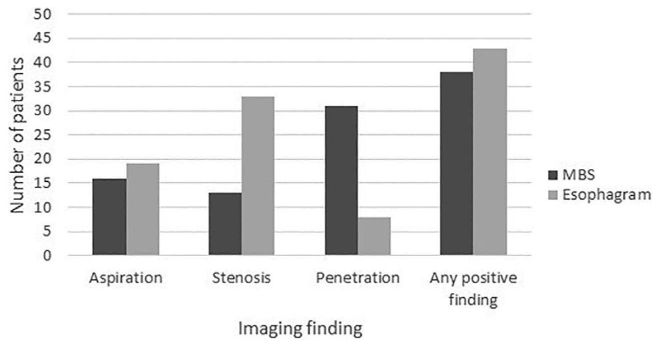

FIGURE 1 Histogram of patient findings on esophagram and MBS. MBS, modified barium swallow

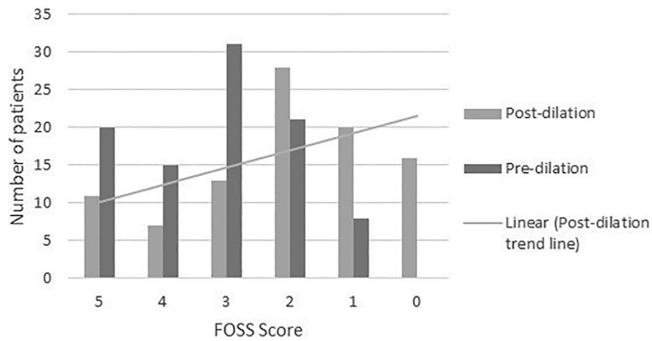

FIGURE 2 Histogram of pre-dilation and post-dilation FOSS scores. Lower FOSS score is indicative of lower dysphagia severity. FOSS, functional outcome swallowing scale

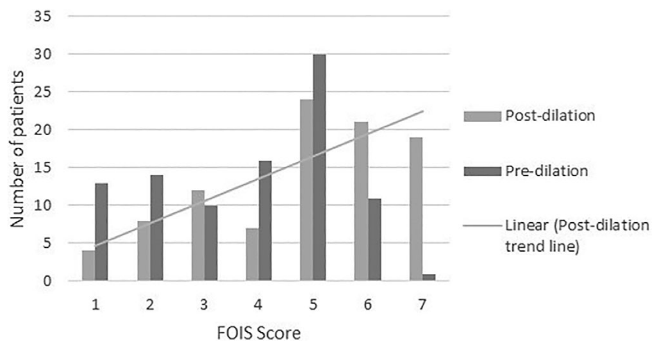

FIGURE 3 Histogram of pre-dilation and post-dilation FOIS scores. Higher FOIS score is indicative of better functional oral intake. FOIS, functional oral intake scale

3.4 | Imaging ability to predict dilation success

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of MBSs and esophagrams to predict improvement in FOSS stage and FOIS level after esophageal dilation are presented in Table 1. Based on ROC analysis, only MBS in the context of isolated finding of aspiration was noted to be statistically significant (area under curve = 0.64, 95% confidence interval [CI] 0.49-0.77, *P* = .031).

Univariate binary logistic regression was performed to determine the correlation of independent variables to FOSS stage improvement and FOIS level improvement followed by multivariate regression. The independent variables tested included age, presence of GT, imaging results (stenosis, penetration, aspiration), time from imaging to dilation, duration of dysphagia symptoms prior to presentation, history of RT, time from RT completion to dilation, and pre-FOSS and pre-FOIS scores. The finding of aspiration on MBS was statistically significant with regard to both FOSS improvement (OR 5.67, 95% CI 1.33-24.12, *P* = .019) and FOIS improvement (OR 15, 95% CI 1.75-128.39, *P* = .013). History of radiation itself was not significant (FOSS *P* = .932, FOIS *P* = 0.991). However, with respect to FOIS improvement, time from RT to dilation was significant (OR 1.0, CI 0.99-1.0, *P* = .007). The remainder of the variables were not significantly correlated with improvement after dilation.

Improvement in FOSS and FOIS was compared among three imaging-specific groups: stenosis on MBS, stenosis on esophagram, and no stenosis on imaging. There were not significant differences in improvement whether stenosis was found on imaging or not (*P* = .173 and *P* = .768 for FOSS and FOIS, respectively).

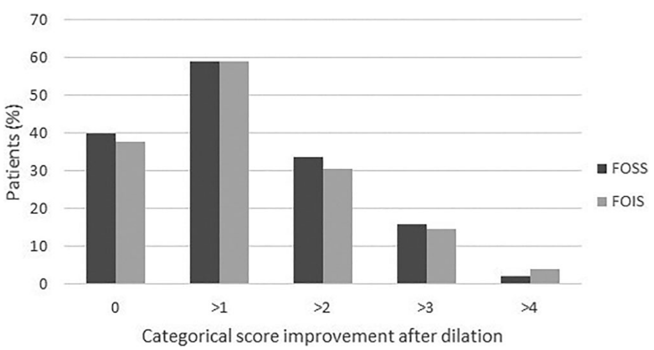

FIGURE 4 Histogram of FOSS and FOIS categorical score improvement after dilation. FOSS, functional outcome swallowing scale; FOIS, functional oral intake scale

3.5 | Treatment delay

The delay in time from imaging to dilation was significantly lower in those who had stenosis seen on imaging (130.22 ± 278.39 days) compared to those who had no stenosis (267.24 ± 253.51 days) (95% CI 28.7-245.4, *P* = .0138). The delay in time from imaging to dilation was significantly more in those who had an unidentified stenosis (false negative) on imaging when compared to those who did not (46.8 ± 35.2 days vs 312.6 ± 244.1 days, *P* < .001).

4 | DISCUSSION

Among H&N cancer patients with dysphagia, those with cervical esophageal stenosis make up a small but clinically relevant population. Factors that have been shown to be associated with the development of esophageal stenosis include high radiation dose, pretreatment presence of gastrostomy tubes, combined radiation and chemotherapy, female gender, primary cancers of the larynx and hypopharynx, high-grade mucositis, and taxane-based chemotherapy.[4] The prevalence of esophageal stenosis in patients who are treated with organ preservation protocols that include radiation therapy ranges from 17.2 to 33% in small studies.[5-8] Dysphagia due to esophageal stenosis may be underdiagnosed due to difficulties in locating the pathologic region. Patient identified location of symptoms has been shown to correlate poorly with actual anatomic location of pathology.[9-11] Therefore, clinicians often turn to imaging studies such as the MBS and esophagram for guidance.

Difficulties in diagnosing cervical esophageal stenosis may be partly due to falsely reassuring imaging studies. In the gastroenterology literature, empiric esophageal dilation is commonly performed despite negative imaging and endoscopy.[12] However, this has not

TABLE 1 Calculated sensitivity, specificity, PPV, and NPV of esophagram and MBS in relation to the defined outcomes of FOSS and FOIS improvement along with ROC analysis

		Sensitivity	Specificity	PPV	NPV	AUC	*P*-value
MBS: aspiration	FOSS	48.0%	85.0%	80.0%	56.7%	0.64	.03
	FOIS	48.3%	93.8%	93.3%	50.0%		
[a]MBS: any +	FOSS	80.8%	15.0%	55.3%	37.5%	0.52	.71
	FOIS	83.3%	18.9%	65.8%	37.5%		
Esophagram: stenosis	FOSS	62.5%	38.1%	60.6%	40.0%	0.50	.97
	FOIS	62.1%	37.5%	54.5%	45.0%		
[a]Esophagram: any +	FOSS	81.3%	22.8%	60.5%	45.5%	0.52	.73
	FOIS	79.3%	20.0%	53.5%	45.5%		

Abbreviations: AUC, area under curve; FOSS, functional outcome swallowing scale; FOIS, functional oral intake scale; MBS, modified barium swallow; PPV, positive predictive value; NPV, negative predictive value; ROC, receiver operating characteristic.
[a]Any + (positive) finding included penetration, aspiration, stenosis.

been widely considered or performed in the otolaryngology population. More often, when an esophagram is negative for stenosis, it is likely believed that performing a dilation will not be effective since there is no structural obstruction. “False negative” imaging studies could potentiate unnecessary delays and prevent patients from receiving therapeutic esophageal dilation. Instead, these patients must wait a longer period of time to exhaust other means of dysphagia treatment before attempting trial esophageal dilation as compared to patients who had imaging studies that were initially positive for stenosis. This was true in the current study. The time from imaging to dilation was doubled for patient who did not have findings of stenosis on imaging (267.24 days vs 130.22 days, $P = .0138$). Moreover, the delay in time from imaging to dilation was also significantly longer in those who had an unidentified stenosis (false negative) on imaging when compared to those who did not (46.8 days vs 312.6 days, $P < .001$). The additional time spent in swallow rehabilitation while the cervical esophageal stenosis was undiagnosed may have increased the chance of symptomatic improvement after esophageal dilation was finally performed. However, it may be that these patients with negative imaging would have benefitted from dilation just as much as those who had positive imaging. In this study, we wanted to highlight this potential delay in treatment and investigate how well imaging studies could predict clinical improvement to dilation.

The outcome measures of improvement in FOSS and FOIS represented positive clinical improvement after dilation. With respect to imaging findings (both MBS and esophagram), rigid esophagoscopy showing cervical narrowing in addition to post-dilation improvement in FOSS and FOIS were considered to be indicators of the true presence of pre-operative stenosis. We found that there was no significant differences in outcomes of dilation whether stenosis was present on imaging or not (FOSS $P = .173$; FOIS $P = .768$). This suggests that actual identification of stenosis on preoperative imaging may not be as important a predictor for clinical response to dilation in high risk patients as previously believed. With respect to the finding of clinically significant stenosis, the average sensitivity of esophagram was 63%. The negative predictive value (NPV), or the ability of an esophagram that was negative for stenosis to predict that a patient would not improve with dilation, was only 43%. Moreover, when ROC analysis was performed, esophagram was shown to be equivalent to a random classification model (AUC = 0.5, $P = .97$). These findings suggest that esophagram has poor capacity to discriminate between those with stenosis and those without. When any positive finding is considered (ie, penetration, aspiration, stenosis), the average sensitivity of esophagram improves to 80%; however, the NPV remains relatively unchanged at 45%. This suggests that additional findings, apart from stenosis identification alone, may be important in determining response to dilation. However, it does not improve the ability of a negative esophagram to accurately predict lack of benefit from dilation. Essentially, the potential for false negatives is high. A negative esophagram does not provide a reliable foundation for clinical decisions regarding which patients will benefit from dilation and which will not. Allowing a negative esophagram to direct care away from dilation may result in treatment delay, as seen in this study.

A limitation of the esophagram is that its assessment of swallowing dysfunction is qualitative rather than quantitative. West etal investigated measured esophageal diameters on esophagram to establish a quantitative standard for defining cervical esophageal stenosis that requires surgical intervention.[13] In their study, the initial sensitivity of radiologists' qualitative interpretations was 56%; however, the sensitivity increased to 94% when lateral intraesophageal minimum/maximum ratios were applied. It is possible that routinely adding quantitative determinants in esophagram analysis may improve the sensitivity of detecting cervical esophageal stenosis. One such quantitative determinant is a 12 or 13 mm barium tablet, which has been shown to be useful in identifying strictures that are not seen with routine liquid barium distension.[14,15]

Based on the current findings, we also suggest practitioners incorporate findings of aspiration on imaging into the decision process when considering trial dilation. In this study, when any positive finding on MBS was considered, the average sensitivity of MBS was 82%. This is similar to the 80% sensitivity noted for esophagram. The NPV of any positive finding on MBS is also low at 38% (46% for esophagram). This suggests that a negative or “normal” MBS also poorly predicts patients that will not benefit from dilation. However, when isolated aspiration on MBS was considered, it was noted to have a significant association with dilation outcomes. Using both FOSS and FOIS, identification of aspiration on MBS was significant for improvement following dilation ($P = .019$ and $P = .013$). When isolated aspiration was considered, the MBS PPV was 87%. These results suggest that patients with aspiration on MBS may have a high likelihood of benefit from dilation. Moreover, ROC analysis revealed the MBS to be a useful test (AUC 0.637, $P = .031$).

Aspiration on MBS had a better ability to predict a response to dilation than stenosis on esophagram. Isolated aspiration, in the absence of any structural abnormalities, has the potential to direct the clinical focus toward functional etiologies for dysphagia. This may result in a treatment delay for those patients who would have had an improvement with trial dilation. With our results, we suggest that patients with isolated aspiration on MBS should also be considered as early dilation candidates. Although a trial of swallow therapy is still likely warranted, a more prompt reevaluation and quicker advancement to dilation should be considered.

In light of the low NPV of both esophagram and MBS, the suspicion for clinically relevant stenosis should persist despite a negative MBS or esophagram. Dilation should be offered as an option if dysphagia fails to improve with swallow therapy in a timely manner. Our data demonstrated that time from RT completion to dilation was statistically significant in regards to the outcome of response to dilation ($P = .007$). Chapuy et al. report a two-fold increase in the odds of dilation failing to restore oral nutrition and gastrostomy tube removal when dilation occurred greater than 6 months following chemoradiation.[16] This highlights the deleterious effects of treatment delay. Our findings emphasize the poor predictive value of MBS and esophagram. Treatment decisions based solely on imaging results may contribute to troublesome delays. Thus, it is important to keep a high clinical suspicion for esophageal stenosis in high risk patients even with normal imaging.

This study is limited by a small sample size and the biases inherent to a retrospective review. In addition, this is a single-institution experience and may not be generalizable to all post open neck surgery and radiated dysphagia patients. The MBS and esophagram imaging studies were not performed at a single institution and were not read by a single radiologist. Thus, the variability in performance and interpretation of the studies has the potential to impact our results. As the outcomes of FOSS and FOIS are generated based on self-reported answers by patients, there is the potential for response bias. Additionally, the placebo effect may also have a small impact as patients without stenosis may tend to report improvement simply because an intervention was performed.

Nevertheless, we hope the findings of this study will encourage further investigation into more reliable forms of diagnosing esophageal stenosis in at-risk H&N cancer patients—specifically early esophagoscopy and trial dilation. More robust analysis of clinical imaging accuracy and operative dilation results will help identify more patients with dysphagia whose clinical swallowing outcomes can be improved through esophageal dilation. To improve accuracy of cervical esophageal stenosis diagnosis, development of imaging techniques that are correlated with manometry or intraoperative testing of esophageal muscle distensibility with manometry may be helpful in future research.

5 | CONCLUSION

Although MBS and esophagram are often used to assess dysphagia, both studies appear to be unreliable predictors of response to dilation in high risk patients who have a history of H&N cancer with neck dissection surgery with or without radiation. Overemphasis on these exams may cause a delay in treatment for patients who would otherwise benefit from a trial of esophageal dilation.

CONFLICT OF INTERESTS

The author(s) have no Conflict of Interests to declare.

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