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Prevalence and Resource Utilization for Vocal Fold Paralysis/Paresis After Esophagectomy

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Objectives/Hypothesis: Vocal fold paralysis/paresis (VFP) is an uncommon but serious complication following esophagectomy. The objectives of this study were to: 1) identify the prevalence of VFP and associated complications after esophagectomy in the United States, and 2) determine the utilization and otolaryngology-head and neck surgery/speech-language pathology (OHNS/SLP) and predictors of such utilization in the management of these patients.

Study Design: Retrospective database analysis.

Methods: The National Inpatient Sample (NIS) represents a 20% stratified sample of discharges from US hospitals. Using *International Classification of Diseases, Ninth Revision, Clinical Modification* codes, patients undergoing esophagectomy between 2008 and 2013 were identified in the NIS. Subcohorts of patients with VFP and OHNS/SLP utilization were also identified. Weighted logistic regression models were used to compare binary outcomes such as complications; generalized linear models were used to compare total hospital charges and length of stay (LOS).

Results: We studied 10,896 discharges, representing a weighted estimate of 52,610 patients undergoing esophagectomy. The incidence of VFP after esophagectomy was 1.96%. Compared to those without VFP, patients with VFP had a higher incidence of postoperative pneumonia, more medical complications, and were more likely to undergo tracheostomy; hospital charges and LOS were also higher. Of the patients with VFP, 35.0% received OHNS/SLP intervention.

Conclusions: VFP after esophagectomy is associated with postoperative complications, prolonged LOS, and higher hospital costs. OHNS/SLP intervention occurred in roughly one-third of postesophagectomy VFP patients, suggesting there may be opportunities for enhanced evaluation and management of these patients.

Key Words: Vocal fold paralysis, esophagectomy, database analysis, speech-language pathology.

Level of Evidence: 4

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INTRODUCTION

The intrinsic muscles of the true vocal folds are innervated by the recurrent laryngeal nerve (RLN). Given the course of the right and left RLNs and their proximity to the esophagus, they are at considerable risk of injury during thoracic procedures such as esophagectomy. Vocal fold paralysis/paresis (VFP) is a serious complication following esophagectomy, with reported incidence rates ranging from 9.8% to 59.5%,[1–8] and is associated with other complications such as dysphagia, aspiration pneumonia, prolonged mechanical ventilation, and need for tracheostomy.[1–3,7,8] VFP after esophagectomy has also been shown to increase intensive care unit utilization and hospital length of stay (LOS).[1–3]

Several studies have suggested that early diagnosis and treatment of VFP and related complications, such as aspiration, may provide benefit to patients.[9,10] However, prior work has shown that speech-language pathology (SLP) services may be underutilized in patients with VFP after anterior cervical spine surgery.[11] However, treatment of VFP may improve swallowing function and reduce both postoperative pneumonia and overall LOS.[10,12,13]

Considering the available treatment options and potential impact on patients, there is a need to better understand VFP prevalence rates, adverse outcomes associated with VFP, and practice patterns of otolaryngology–head and neck surgery (OHNS)/SLP intervention in an esophagectomy cohort on a national scale. Such data may provide insights about current treatment patterns and serve as a foundation for future studies exploring evaluation and management strategies for VFP in esophagectomy patients. The objectives of this study were to 1) identify the prevalence of VFP and associated complications after esophagectomy in the United States using a national administrative database, and 2) understand the practice patterns involving OHNS/SLP care in the management of these patients.

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MATERIALS AND METHODS

This study was reviewed by the Duke University Medical Center Institutional Review Board and deemed exempt from formal review (protocol #Pro00074265).

Study Population

A retrospective analysis of patients who underwent esophagectomy between 2008 and 2013 was performed using discharge data from the National Impatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ). The NIS database is a national claims database that represents a 20% stratified sample of discharges from hospitals in the United States. The *International Classification of Disease, Ninth Revision, Clinical Modification* (ICD-9-CM) procedure codes were used to identify relevant hospitalizations for esophagectomy procedures (42.4, 42.40, 42.41, 42.42, 43.99). Patient demographics, hospital characteristics, geographic region, comorbidities, insurance, and medical/surgical complications were collected. We further identified subcohorts of esophagectomy patients with VFP (ICD-9-CM diagnosis codes 478.3, 478.30, 478.31, 478.32, 478.33, 478.34) and those who received OHNS/SLP services (ICD-9-CM procedure codes 31.0, 31.98, 93.72, 93.74, 93.75).

Outcomes

In patients who underwent esophagectomy, the primary outcome was the diagnosis of VFP. Secondary outcomes included LOS from esophagectomy procedure to discharge, total hospital encounter costs, diagnosis of aspiration pneumonia, diagnosis of dysphagia, tracheostomy placement, and the need for gastrostomy (ICD-9-CM codes in Table I). Hospital-related charges for each hospital discharge were converted to cost estimates by multiplying total charges with the appropriate cost-to-charge ratio from the HCUP cost-to-charge ratio files. All costs were then adjusted for inflation based on US Bureau of Labor Statistics indices to 2013 US dollars. Due to the redesign of the NIS database in 2012, national cost estimates were obtained using revised NIS Trend Weights Files to reweight all discharges. Discharges with extreme LOS or cost (less than 1% or greater than 99%) were excluded from LOS or cost analyses. Within the subcohort of esophagectomy patients with VFP, the outcome of interest was the utilization of OHNS/SLP services.

Key Predictor

For the analyses of LOS and total hospital encounter costs, the key predictor was the diagnosis of VFP. We were interested in determining the relationship between diagnosis of VFP and LOS or costs while adjusting for other confounders in the model. For all other analyses, we aimed to identify risk factors associated with the outcomes, and there was no specific key predictor tested.

Covariates

Variables considered to be confounders included urgent or emergent admission, age (<65, 65–79, ≥ 80 years), gender, race, primary insurance coverage, hospital bed size, teaching status of hospital, region of hospital, Elixhauser-based comorbidity score, revision esophagectomy (more than one esophagectomy procedure in the discharge record), lung cancer, aspiration pneumonia, number of types of acute medical complications, and number of types of acute surgical complications (ICD-9-CM codes in Table I). Dysphagia and dysphonia (i.e., voice disturbance) were considered as candidate confounders in the analyses of LOS, total cost, and in-hospital death. Race was missing more than 10% of the population and were coded with a dummy variable to represent the missing data in regression analyses. Race was classified into four categories: white, black, other, and unknown. Primary insurance payer was grouped as Medicare, Medicaid, private insurance, and other. The 29 AHRQ comorbidities of the NIS identified coexisting medical conditions that were not directly related to the principal diagnosis, and they were used to derive the Elixhauser-based comorbidity index.[14]

Statistical Analyses

We used SURVEY procedures in SAS (version 9.4; SAS Institute Inc., Cary, NC) to account for stratification, clustering, and unequal weighting of the NIS survey design; discharge trend weights, NIS hospital number, and stratum used to sample hospital were utilized to generate nationally representative estimates. As we analyzed multiple years of NIS data, year was added as a stratification variable. The Taylor series linearization method was applied to estimate standard errors. We adopted the analytic procedures suggested by AHRQ for analyzing subpopulations.

Univariate associations between variables were analyzed using cross-tabulations, second order Rao-Scott χ^2 test for categorical variables, and Wald F test for continuous variables. For all multivariable models, backward variable selection with Bayesian information criterion was adopted on all candidate confounders, except that the key predictor was not a candidate for removal. The primary outcome, diagnosis of VFP, and other binary outcomes were modeled with weighted logistic regression models, and adjusted odds ratios with 95% confidence intervals (CIs) were reported. To account for clustering of the data, a generalized estimating equation approach using generalized linear models with gamma-distributed responses and a log-link function was employed to examine the association of diagnosis of VFP with LOS and total costs. Regression diagnostic was performed, and the area under the receiver operating characteristics curve was used to assess model discrimination. The level of significance was set to .05 for all analyses.

RESULTS

Predictors of VFP in Esophagectomy Cohort

There were 10,896 discharges in the NIS esophagectomy cohort, which represented a weighted estimate of 52,610 patients. The weighted frequency of VFP was 1,016 (1.93%), and no VFP was present in 51,594 (98.07%) patients. In the univariate analyses, the distribution of all covariates in the esophagectomy VFP cohort was assessed (Table II). In the backward selection multivariate weighted logistic regression model, age 65 to 79 years, large hospital based on hospital bed size, lung cancer diagnosis, and increased number of postoperative medical complications were associated with VFP. In contrast, patients treated at hospitals located in the south compared to the northeast were associated with less VFP (Table III).

Impact of VFP in Esophagectomy Cohort

The median LOS for the overall cohort was 10.24 days (interquartile range [IQR]: 7.64–15.95). Patients with VFP had a median length of stay of

TABLE I.
ICD-9-CM Diagnosis or Procedure Codes for Complications and Procedures.

Variable	ICD-9-CM Codes
Aspiration pneumonia	507, 507.0
Dysphagia	787.2, 787.20, 787.21, 787.22, 787.23, 787.24, 787.29
Tracheostomy (procedure)	31.1, 31.2, 31.29, V440, V550
Gastrostomy (procedure)	V551, V441, 93.36, 43.1, 43.11, 43.19, 97.02
Lung cancer	197.0, 197.1, 197.2, 197.3, 196.1, V10.11, 162, 162.0, 162.2, 162.3, 162.4, 162.4, 162.5, 162.8, 162.9, 163, 163.0, 163.1, 163.8, 163.9
Dysphonia or voice disturbance	784.4, 784.40, 784.41, 784.42, 784.49
Medical complications	
Acute cardiac event	410, 4100, 41000, 41001, 41002, 4101, 41010, 41011, 41012, 4102, 41020, 41021, 41022, 4103, 41030, 41031, 41032, 4104, 41040, 41041, 41042, 4105, 41050, 41051, 41052, 4106, 41060, 41061, 4107, 41070, 41071, 41072, 4108, 41080, 41081, 41082, 4109, 41090, 41091, 41092, 4111, 4118, 4150, 4200, 4209, 4209, 4210, 4211, 4219, 4220, 4229, 4270, 4271, 4272, 4273, 42731, 42732, 4274, 42741, 42742, 4275, 428, 4280, 4281, 4282, 42820, 42821, 42822, 42823, 4283, 42830, 42831, 42832, 42833, 4284, 42840, 42841, 42842, 42843, 4289
Acute pulmonary edema/failure	518.4, 518.81, 518.82, 518.84
Acute cerebrovascular event	997.00, 997.01, 997.02, 997.09
Acute renal failure	584.5, 584.6, 584.7, 584.8, 584.9
Acute hepatic failure	570
Sepsis	995.9, 038.0, 038.1, 038.10, 038.11, 038.12, 038.19, 038.2, 038.4, 038.40, 038.41, 038.42, 038.43, 038.44, 038.49, 999.3
Urinary tract infection	599.0, 996.64, 996.31, V13.02
Pneumonia/infectious pneumonia	480, 480.0, 480.1, 480.2, 480.3, 480.8, 480.9, 481, 482, 482.0, 482.1, 482.3, 482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.42, 482.49, 482.8, 482.81, 482,82, 482.83, 482.84, 482.89, 482.9, 483, 483.1, 483.8, 484, 484.1, 484.3, 484.5, 484.6, 484.7, 484.8, 485, 487.0, 997.31, V12.61
Surgical complications	
Shock	998
Hemorrhage, hematoma, or seroma	998.1, 998.11, 998.12, 998.13
Accidental perforation or laceration of blood vessel, nerve, or organ	998.2
Wound dehiscence	998.3, 998.30, 998.31, 998.32, 998.33
Foreign body	998.4
Postoperative infection	998.5, 998.51, 998.59
Postoperative fistula	998.6
Nonhealing surgical wound	998.83
Other unspecified procedural complications	998.8, 998.81, 998.89, 998.9

ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification.*

13.76 days (IQR: 9.76–21.86), which is longer than patients without VFP (median: 10.18, IQR: 7.61–15.85, $P < .001$). Total hospital costs were higher in those with VFP than those without VFP (median cost: $53,843 vs. $38,529, $P < .001$). After adjustment of potential confounders, VFP was associated with longer LOS, 22% higher costs, and increased odds of aspiration pneumonia, tracheotomy, gastrostomy tubes, and dysphagia (Table IV).

OHNS/SLP Utilization in Esophagectomy Patients With VFP

There were 211 discharges with VFP in the esophagectomy cohort, representing a weighted estimate of 1,016 patients (Table V). The weighted frequency of OHNS/SLP service was 359 (35.3%), and no OHNS/SLP services were provided in 657 (64.7%). In the univariate analysis, more medical complications and hospital teaching status data were associated with an increased rate of OHNS/SLP service utilization (Table V). Patients with OHNS/SLP intervention had similar costs and LOS, respectively (median: $58,183, IQR: $36,936–$96,381; median: 14.3 days, IQR: 10.8–23.1 days) to patients without OHNS/SLP intervention (median: $52,953, IQR: $36,372–$82,136, $P = .4063$; median: 13.4 days, IQR: 9.4–21.8 days, $P = .2947$).

In the backward selection multivariate logistic regression model, hospital teaching status, dysphonia, and medical complications were associated with an increased rate of OHNS/SLP service utilization (Table VI).

DISCUSSION

VFP is an uncommon but potentially serious complication following esophagectomy. The objectives of this

TABLE II.
Summary Statistics of Demographic Characteristics and Outcomes With Univariate Analysis Stratified by Vocal Fold Paralysis/Paresis in a National Inpatient Sample Adult Esophagectomy Patient Cohort.

	No Vocal Fold Paralysis/ Paresis Weighted, N = 51,594	Vocal Fold Paralysis/Paresis Weighted, N = 1,016	Total Weighted, N = 52,610	*P* Value
Urgent admission				.0459
No	47,894 (92.83%)	973 (95.74%)	48,866 (92.88%)	
Yes	3,700 (7.17%)	43 (4.26%)	3,743 (7.12%)	
Age, yr				.0236[1]
<65	27,788 (53.87%)	446 (43.88%)	28,234 (53.68%)	
65–79	20,762 (40.25%)	503 (49.51%)	21,265 (40.43%)	
≥80	3,035 (5.88%)	67 (6.61%)	3,102 (5.9%)	
Race				.2560
White	36,303 (70.36%)	754 (74.22%)	37,057 (70.44%)	
Black	3,117 (6.04%)	34 (3.37%)	3,151 (5.99%)	
Other	6,499 (12.60%)	137 (13.45%)	6,636 (12.61%)	
Unknown	5,674 (11.00%)	91 (8.97%)	5,765 (10.96%)	
Sex				.0100[1]
Male	37,658 (73.04%)	818 (80.47%)	38,476 (73.18%)	
Female	13,900 (26.96%)	198 (19.53%)	14,099 (26.82%)	
Primary expected payer				.1227
Medicare	23,006 (44.65%)	522 (51.37%)	23,528 (44.78%)	
Medicaid	4,375 (8.49%)	73 (7.15%)	4,448 (8.47%)	
Private insurance	21,748 (42.21%)	387 (38.10%)	22,135 (42.13%)	
Other	2,396 (4.65%)	34 (3.38%)	2,431 (4.63%)	
Hospital bed size				<.0001[1]
Small	4,008 (7.87%)	27 (2.67%)	4,035 (7.77%)	
Medium	7,833 (15.38%)	86 (8.51%)	7,920 (15.25%)	
Large	39,078 (76.74%)	903 (88.82%)	39,980 (76.98%)	
Teaching status of hospital				.1036
Nonteaching	10,103 (19.84%)	156 (15.36%)	10,259 (19.76%)	
Teaching	40,816 (80.16)	860 (84.63%)	41,676 (80.25%)	
Region of hospital				.0674
Northeast	11,963 (23.19%)	300 (29.56%)	12,263 (23.31%)	
Midwest	12,682 (24.60%)	245 (24.12%)	12,937 (24.59%)	
South	16,685 (32.34%)	225 (22.09%)	16,909 (32.14%)	
West	10,255 (19.88%)	246 (24.22%)	10,501 (19.96%)	
Elixhauser comorbidity index, 29 comorbidities, mean (SE)	9.07 (0.16)	10.13 (0.72)	9.1 (0.16)	.1377
No. medical complications, mean (SE)	0.64 (0.01)	0.82 (0.06)	0.65 (0.01)	.0051[1]
No. surgical complications, mean (SE)	0.19 (0.01)	0.25 (0.04)	0.19 (0.01)	.1066*
Dysphagia				.0002[1]
No	47,254 (91.59%)	827 (81.35%)	48,080 (91.39%)	
Yes	4,340 (8.41%)	189 (18.65%)	4,530 (8.61%)	
Aspiration pneumonia				.0003[1]
No	48,641 (94.28%)	858 (84.47%)	49,499 (94.09%)	
Yes	2,953 (5.72%)	158 (15.53%)	3,110 (5.91%)	
Dysphonia/voice disturbance				<.0001[1]
No	51,441 (99.70%)	915 (90.07%)	52,356 (99.52%)	
Yes	152 (0.30%)	101 (9.93%)	253 (0.48%)	
Lung cancer				.0193[1]
No	48,046 (93.12%)	883 (86.93%)	48,930 (93.00%)	
Yes	3,547 (6.88%)	133 (13.07%)	3,680 (7.00%)	
Procedures performed				

(Continues)

TABLE II.
Continued

	No Vocal Fold Paralysis/Paresis Weighted, N = 51,594	Vocal Fold Paralysis/Paresis Weighted, N = 1,016	Total Weighted, N = 52,610	*P* Value
Revision esophagectomy				.7845
No	50,719 (98.31%)	1,001 (98.56%)	51,721 (98.31%)	
Yes	874 (1.69%)	15 (1.44%)	889 (1.69%)	
Gastrostomy				.1275
No	49,091 (95.15%)	938 (92.33%)	50,029 (95.09%)	
Yes	2,503 (4.85%)	78 (7.67%)	2,581 (4.91%)	
Tracheotomy				.0011[†]
No	48,269 (93.56%)	868 (85.44%)	49,138 (93.40%)	
Yes	3,324 (6.44%)	148 (14.56%)	3,472 (6.60%)	
ENT/SLP				<.0001[†]
No	50,874 (98.61%)	657 (64.67%)	51,531 (97.95%)	
Yes	720 (1.39%)	359 (35.33%)	1,079 (2.05%)	
Adjusted total costs (to 2013 USD), median (Q1, Q3)	38,529 (27,361, 61,317)	53,843 (36,599, 90,233)	38,781 (27491, 61756)	<.0001[†]
Length of stay from esophagectomy to discharge, median (Q1, Q3)	10.18(7.61, 15.85)	13.76 (9.76, 21.86)	10.24 (7.64, 15.95)	<.0001[†]

All values were estimated to yield nationally representative estimates for the US population. Outliers of total costs and length of stay were removed before summary. *P* values were calculated using SAS PROC SURVEYFREQ (second order Rao-Scott χ^2 test) for categorical variables, and PROC SURVEYREG (Wald *F* test) for continuous variables, which took the complex survey design into consideration.

[†] Significant associations.

ENT = ear, nose, and throat; SE = standard error; SLP = speech-language pathology; USD = United States dollars.

TABLE III.
Backward Selection Weighted Logistic Regression Parameter Estimates of Vocal Fold Paralysis/Paresis in Esophagectomy Cohort.

Parameter	Level	Adjusted OR (95% CI)	*P* Value
Age, yr	≥80	1.31 (0.72-2.40)	.3771
	65–79	1.43 (1.08-1.91)[†]	.0142[†]
Hospital bed size	Large	2.35 (1.48-3.75)[†]	.0003[†]
Hospital type	Teaching	1.45 (0.97-2.19)	.0733
Hospital region	West	1.13 (0.70-1.83)	.6128
	South	0.61 (0.39-0.95)[†]	.0278[†]
	Midwest	0.86 (0.53-1.40)	.5551
Lung cancer diagnosis	Yes	1.94 (1.24-3.02)[†]	.0037[†]
No. medical complications		1.17 (1.04-1.32)[†]	.0086[†]

[†] Significant associations.

CI = confidence interval; OR = odds ratio.

study were to identify the prevalence of VFP and associated complications after esophagectomy in the United States, and to characterize the involvement of OHNS/SLP colleagues in managing these patients. We found that the frequency of VFP was 1.93%. This is lower than VFP rates in contemporary literature, which ranges from 9.8% to 59.5%.[1–8] Methodological differences across studies may explain the difference in VFP prevalence rates. In our study, we were dependent on ICD-9-CM codes to determine VFP. Many of the prior studies with much higher VFP rates used laryngoscopy.[1–5] Potentially, undercoding and underdiagnosis (in patients without OHNS/SLP care) may affect our VFP rates. Additionally, the NIS does not include outpatient follow-up, during which time additional diagnoses of VFP not identified during inpatient stay could be made.

VFP after esophagectomy is associated with significant morbidity. Several studies have demonstrated that postoperative aspiration and pneumonia is significantly higher in esophagectomy patients with VFP.[1,7,8,10,12,13] Similarly, our study found increased odds of dysphagia, aspiration pneumonia, tracheotomy, and gastrostomy tubes in esophagectomy patients with VFP after adjusting for several factors (Table IV). Patients with VFP are also more likely to require reintubation, prolonged mechanical ventilation, and subsequent tracheotomy placement.[2,3] Considering these resultant morbidities, it is not surprising that VFP is associated with prolonged intensive care units and total hospital stays.[1–3] In particular, the LOS and costs in esophagectomy patients with VFP were 1.22 times greater than esophagectomy patients without VFP (Table IV). Although we attempted to control for multiple factors, such as comorbidity and medical and surgical complications, other unmeasured factors, such as preoperative VFP or preoperative dysphagia or the extent of the esophageal cancer, could also be associated with our adverse outcomes. However, our data suggest that postoperatively identified VFP is an indicator or poor outcomes in esophagectomy patients. In addition, although the NIS data cannot differentiate between temporary or permanent VFP, and the rate of permanent VFP after esophagectomy ranges widely from 4% to 63.6%, VFP can result in significant deterioration of quality of life well after discharge.[15] How to prevent, if possible, VFP after esophagectomy and evaluating how different management strategies affect patient outcomes

TABLE V.
Summary Statistics of Demographic Characteristics and Outcomes With Univariate Analysis Stratified by Utilization of OHN/SLP Services in the National Inpatient Sample Adult Esophagectomy Patient Cohort.

Parameter	Level	No OHN/SLP Weighted, N = 657	OHN/SLP Weighted, N = 359	Total Weighted, N = 1,016	*P* Value
Age, yr	<65	286 (43.45%)	160 (44.67%)	446 (43.88%)	.8654
	≥65	371 (56.55%)	199 (55.33%)	570 (56.12%)	
Race	White	473 (72.05%)	281 (78.19%)	754 (74.22%)	.3938
	Other or unknown	184 (27.95%)	78 (21.81%)	262 (25.78%)	
Sex	Male	507 (77.10%)	311 (86.65%)	818 (8.47%)	.0771
	Female	150 (22.90%)	48 (13.35%)	198 (19.53%)	
Primary expected payer	Medicare	336 (51.18%)	186 (51.73%)	522 (51.37%)	.1727
	Medicaid or other	87 (13.23%)	20 (5.56%)	107 (1.52%)	
	Private insurance	234 (35.59%)	153 (42.71%)	387 (38.10%)	
Bed size of hospital	Small/medium	58 (8.82%)	56 (15.50%)	114 (11.18%)	.2675
	Large	599 (91.18%)	303 (84.50%)	903 (88.82%)	
Hospital teaching status	Nonteaching	141 (21.42%)	15 (4.29%)	156 (15.37%)	.0002
	Teaching	516 (78.58%)	344 (95.71%)	860 (84.63%)	
Hospital region	Northeast	165 (25.15%)	135 (37.65%)	300 (29.56%)	.3791
	Midwest	166 (25.31%)	79 (21.94%)	245 (24.12%)	
	South	164 (25.02%)	60 (16.75%)	224 (22.09%)	
	West	161 (24.52%)	85 (23.66%)	246 (24.22%)	
Elixhauser comorbidity index, 29 comorbidities, mean (SE)		10.59 (0.89)	9.29 (1.01)	10.13 (0.72)	.3019
No. of medical complications, mean (SE)		0.7 (0.07)	1.02 (0.11)	0.82 (0.06)	.0153
No. of surgical complications, mean (SE)		0.28 (0.05)	0.20 (0.07)	0.25 (0.04)	.3448
Dysphagia	No	531 (80.82%)	296 (82.32%)	827 (81.35%)	.8016
	Yes	126 (19.18%)	63 (17.68%)	189 (18.65%)	
Aspiration pneumonia	No	568 (86.40%)	291 (80.94%)	858 (84.47%)	.3154
	Yes	89 (13.60%)	68 (19.06%)	158 (15.53%)	
Dysphonia/voice disturbance	No	610 (92.86%)	305 (84.96%)	915 (9.07%)	.1239
	Yes	47 (7.14%)	54 (15.04%)	101 (9.93%)	
Lung cancer	No	553 (84.16%)	330 (92.02%)	883 (86.93%)	.1092
	Yes	104 (15.84%)	29 (7.98%)	133 (13.07%)	
Procedures performed					
Gastrostomy	No	594 (90.38%)	344 (95.90%)	938 (92.33%)	.0910
	Yes	63 (9.62%)	15 (4.10%)	78 (7.67%)	
Tracheotomy	No	549 (83.62%)	319 (88.77%)	868 (85.44%)	.2708
	Yes	108 (16.38%)	40 (11.23%)	148 (14.56%)	
Adjusted total costs, to 2013 USD, median (Q1, Q3)		52,953 (36,372, 82,136)	58,183 (36,936, 96,381)	54,582 (36,658, 91,843)	.4063
Length of stay from esophagectomy to discharge, median (Q1, Q3)		13.38 (9.43, 21.77)	14.33 (10.81, 23.09)	13.85 (9.83, 22.11)	.2947

All values were estimated to yield nationally representative estimates for the US population. Outliers of total costs and length of stay were removed before summary. *P* values were calculated using SAS PROC SURVEYFREQ (second order Rao-Scott χ^2 test) for categorical variables, and PROC SURVEYREG (Wald *F* test) for continuous variables, which took the complex survey design into consideration.

OHN/SLP = otolaryngology-head and neck/speech-language pathology; SE = standard error; USD = United States dollars.

in postoperatively identified VFP esophagectomy patients warrants further investigation.[8,16–18]

Given the adverse outcomes associated with VFP in esophagectomy patients, we evaluated the utilization of OHNS/SLP intervention in the postoperative care of esophagectomy patients with VFP. OHNS/SLP providers are instrumental in the diagnosis and management of VFP and related complications. SLP providers not only assist in the diagnosis of VFP and aspiration, but can also provide strategies to mitigate negative outcomes of dysphagia, such as dietary modification and teaching of compensatory techniques.[11]

When VFP is identified, treatment can be performed. While the timing of VFP treatment after thoracic

TABLE VI.
Backward Selection Weighted Logistic Regression Parameter Estimates of OHN/SLP Service Utilization in Esophagectomy Patients With Vocal Fold Paralysis/Paresis.

Parameter	Level	Adjusted OR (95% CI)	*P* Value
Hospital type	Teaching	6.83 (1.71-27.31)	.006
Dysphonia	Yes	2.79 (1.05-7.41)	.0395
No. medical complications		1.44 (1.09-1.91)[1]	.0098[1]

[1] Significant associations.
CI = confidence interval; OHN/SLP = otolaryngology-head and neck/speech-language pathology; OR = odds ratio.

procedures such as esophagectomy can be difficult to standardize given the acuity of the patients' illnesses and occurrence of postoperative complications, vocal fold medialization procedures to treat impaired vocal fold closure have been associated with less mechanical ventilation, fewer tracheotomies, decreased aspiration and pneumonia, decreased LOS, improved vocal quality, and improved dysphagia resulting in an oral diet.[3,10,12,13] Although VFP after esophagectomy may be a factor contributing to postoperative dysphagia in this patient population, medialization procedures may not entirely fix the functional deficits. Bhattacharyya et al. found that one-third of patients had persistent radiographically significant penetration or aspiration after medialization for VFP for mixed indications.[19] Another study reported persistent penetration and aspiration in as high as 43% and 24% of patients, respectively.[20] Moreover, one limited report noted spontaneous improvement in VFP after cardiovascular surgery in over 25% of the patients observed.[21] Whereas we found that OHNS/SLP teams were involved in 35.3% of postesophagectomy patients with VFP, we cannot determine the appropriateness of OHNS/SLP involvement. However, as previously stated, postoperatively identified VFP in esophagectomy patients appears to be a marker for poor outcomes, and thus, shared decision-making strategies can ensue with this patient group to determine best treatment options. Potential medialization procedures could be performed at the bedside in hospitalized patients.[22] Additionally, it seems reasonable for thoracic surgery care teams to be vigilant in evaluating patients for possible VFP after esophagectomy given associated poor outcomes and possibly to adopt and evaluate a systematic approach for all esophagectomy patients.[9]

Although we cannot determine the exact reasons for OHNS/SLP evaluation and treatment, variation in practice patterns was identified. Our multivariate logistic regression model determined that hospital teaching status, with higher rates in urban teaching hospitals, dysphonia, and medical complication were associated with OHNS/SLP service utilization. Potentially, treating providers or nursing staff in teaching hospitals had heightened awareness in patients with audible voice changes, prompting OHNS/SLP care. Although the reasons for hospital teaching status variation in OHNS/SLP utilization may reflect training, physician experience and preference, availability of OHNS/SLP specialists, and demographics of the regional population, the variability warrants further investigation into the causes of the variability and the potential impact on patient outcomes. Training nursing staff in routine screening for swallowing and voice problems postesophagectomy may help with early

TABLE IV.
Parameter Estimates of GEE Gamma and Weighted Logistic Regressions of Length of Stay From Esophagectomy to Discharge, Total Hospital Cost, Dysphagia, Aspiration Pneumonia, Tracheotomy, and Gastrostomy Tube Placement.

		P Value
GEE Gamma Regression–Length of Stay From Esophagectomy to Discharge[1]		
Parameter	Adjusted Length of Stay Ratio (95% CI)	<.0001
Vocal fold paralysis/ paresis	1.22 (1.12-1.33)	
GEE Gamma Regression–Total Hospital Encounter Cost[2]		
Parameter	Adjusted Cost Ratio (95% CI)	<.0001
Vocal fold paralysis/ paresis	1.22 (1.11-1.35)	
Weighted Logistic Regression–Dysphagia[3]		
Parameter	Adjusted OR (95% CI)	<.0001
Vocal fold paralysis/ paresis	2.17 (1.49-3.17)	
Weighted Logistic Regression–Aspiration Pneumonia[4]		
Parameter	Adjusted OR (95% CI)	<.0001
Vocal fold paralysis/ paresis	2.83 (1.95-4.10)	
Weighted Logistic Regression–Tracheotomy[5]		
Parameter	Adjusted OR (95% CI)	.0012
Vocal fold paralysis/ paresis	2.21 (1.37-3.57)	
Weighted Logistic Regression–Gastrostomy Tube Placement[6]		
Parameter	Adjusted OR (95% CI)	.134
Vocal fold paralysis/ paresis	1.50 (0.88-2.55)	

[1] Controlled for: dysphagia, comorbidity index, lung cancer, medical complication, surgical complication. Adjusted length of stay ratio gives the ratio of expected length of stay of the vocal fold paralysis/paresis group with respect to those without (reference group). An adjusted length of stay ratio of 1.22 means that the expected length of stay from esophagectomy to discharge of vocal fold paralysis group is 122% of the reference group.
[2] Controlled for: age, gender, race, primary expected payer, hospital bed size, hospital type, hospital region, comorbidity index, revision esophagectomy, aspiration pneumonia, medical complication, surgical complication. Adjusted cost ratio gives the ratio of expected total cost of the vocal fold paralysis/paresis group with respect to those without (reference group). An adjusted cost ratio of 1.22 means that the expected cost of vocal fold paralysis group is 122% of the reference group.
[3] Controlled for: race, hospital bed size, hospital type, hospital region, comorbidity index, aspiration pneumonia, dysphonia, medical complication.
[4] Controlled for: age, race, hospital region, co-morbidity index, dysphagia, medical complication, surgical complication.
[5] Controlled for: gender, race, hospital region, hospital type, co-morbidity index, aspiration pneumonia, medical complication, surgical complication.
[6] Controlled for: urgent admission, primary expected payer, dysphagia, co-morbidity index medical complication, surgical complication.
CI = confidence interval; GEE = generalized estimating equation; OR = odds ratio.

identification and treatment, as has been shown to benefit patients after stroke.[23]

Methodologic limitations standard to this type of research must be addressed. One of the assumptions of our analysis is that the coding of each condition and procedure was correct. There is likely a degree of error in the coding accuracy, which may influence associations. Also, the NIS database cannot differentiate new onset postesophagectomy VFP from preexisting VFP. Additionally, only the first 25 diagnoses and procedures of the discharge abstract in each patient are listed. If patients with more complicated postoperative courses harbor more diagnoses and procedures (e.g., take-back procedures, multiple endoscopies), this may lead to a sample bias toward less complicated patients in our analysis. Moreover, the procedure and diagnosis codes of complicated patients may crowd-out the diagnoses (e.g., VFP, dysphagia, aspiration), and procedures (e.g., OHNS/SLP intervention) sought after in our analysis, leading to an underestimate of VFP and OHNS/SLP utilization rates as previously discussed. Potentially, esophagectomy patients with VFP who were evaluated by, but in whom a billable OHNS/SLP intervention did not occur, were not captured. However, as some patients with VFP may have been counted as not having VFP, our associations between VFP and related adverse events may be stronger than reported. Nonetheless, our investigation provides insights regarding VFP and related adverse outcomes in esophagectomy patients and practice patterns regarding OHNS/SLP utilization.

CONCLUSION

VFP identified after esophagectomy is associated with postoperative complications, dysphagia, aspiration pneumonia, tracheotomy, prolonged length of stay, and higher hospital costs. OHNS/SLP evaluation and treatment was variably used in 35.3% of esophagectomy patients with VFP. Further investigation regarding the variability of OHNS/SLP practice patterns in esophagectomy patients and the impact of OHNS/SLP intervention on associated adverse outcomes is needed. The development and effectiveness of education and multidisciplinary care programs involving inpatient nurses and physicians on the outcomes of esophagectomy patients with VFP are important avenues of investigation. Further study exploring the feasibility of intraoperative monitoring of the recurrent laryngeal nerve as a method for primary prevention may also bring patient benefit.

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