Dysphagia (2014) 29:68–77
DOI 10.1007/s00455-013-9482-9

ORIGINAL ARTICLE

Dysphagia, Short-Term Outcomes, and Cost of Care After Anterior Cervical Disc Surgery

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Received: 20 March 2013 / Accepted: 1 July 2013 / Published online: 14 August 2013

Abstract Dysphonia and dysphagia are common complications of anterior cervical discectomy (ACD). We sought to determine the relationship between dysphagia and in-hospital mortality, complications, speech therapy/dysphagia training, length of hospitalization, and costs associated with ACD. Discharge data from the Nationwide Inpatient Sample for 1,649,871 patients who underwent ACD of fewer than four vertebrae for benign acquired disease between 2001 and 2010 were analyzed using cross-tabulations and multivariate regression modeling. Dysphagia was reported in 32,922 cases (2.0 %). Speech therapy/dysphagia training was reported in less than 0.1 % of all cases and in only 0.2 % of patients with dysphagia. Dysphagia was significantly associated with age ≥65 years (OR = 1.5 [95 % CI 1.4–1.7], $P < 0.001$), advanced comorbidity (OR = 2.3 [2.0–2.6], $P < 0.001$), revision surgery (OR = 2.7 [2.3–3.1], $P < 0.001$), disc prosthesis placement (OR = 1.5 [1.0–2.0], $P = 0.029$), and vocal cord paralysis (OR = 11.6 [8.3–16.1], $P < 0.001$). Dysphagia was a significant predictor of aspiration pneumonia (OR = 8.6 [6.7–10.9], $P < 0.001$), tracheostomy (OR = 2.3 [1.6–3.3], $P < 0.001$), gastrostomy (OR = 30.9 [25.3–37.8], $P < 0.001$), and speech therapy/dysphagia training (OR = 32.0 [15.4–66.4], $P < 0.001$). Aspiration pneumonia was significantly associated with in-hospital mortality (OR = 15.9 [11.0–23.1], $P < 0.001$). Dysphagia, vocal cord paralysis, and aspiration pneumonia were significant predictors of increased length of hospitalization and hospital-related costs, with aspiration pneumonia having the single largest impact on length of hospitalization and costs. Dysphagia is significantly associated with increased morbidity, length of hospitalization, and hospital-related costs in ACD patients. Despite the known risk of dysphagia in ACD patients and an established role for the speech-language pathologist in dysphagia management, speech-language pathology intervention appears underutilized in this population.

Keywords Anterior cervical discectomy · Complications · Dysphagia · Vocal cord paralysis · Dysphonia · Nationwide Inpatient Sample · Deglutition · Deglutition disorders · Swallowing

Introduction

Cervical disc surgery is one of the most common procedures performed in the United States and is typically employed to manage nerve root or spinal cord compression. The anterior approach to the cervical spine is preferred over posterior approaches as it provides optimal surgical access and avoidance of the spinal cord. Despite these benefits, the anterior approach carries a unique set of potential complications, with dysphonia and dysphagia being among the most common [1]. Postoperative dysphagia has been reported as the most common complication following anterior cervical discectomy (ACD) [2].

Reports of prevalence of dysphagia after ACD vary widely, largely due to different operational definitions of dysphagia. A systematic review performed by Riley et al. [3] examined dysphagia prevalence after ACD in 17 articles.

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Each report used a different method to capture postoperative dysphagia, yielding high variability at each time point. Across reports, very few used validated measures to assess swallowing dysfunction, and only two papers used physiologic data obtained through instrumental swallowing evaluations. The prevalence of dysphagia immediately following surgery ranged from 0.8 to 78 %, with a mean of 33 %. Less variability was noted in studies measuring dysphagia 1 month following surgery, with a mean prevalence of 53.2 % (range = 50.3–55.7 %). Gradual decline in dysphagia was noted across studies over the first year following surgery, with a 12-month mean prevalence of 16.8 % (range = 12.5–21.3 %). Factors associated with postoperative dysphagia have included extent of surgery, level of surgery and female sex [3–5].

The costs of dysphagia are multidimensional and may include personal, institutional, and societal costs. At a personal level, individuals with dysphagia may experience health complications related to inadequate nutrition or pulmonary complications [6–8]. Further, dysphagia has been shown to have a detrimental impact on patient-perceived quality of life [9–11]. Prolonged length of stay and increased healthcare costs have been associated with dysphagia during hospitalization [12–14]. Early identification and treatment of dysphagia may help to mitigate these negative events.

Given the prevalence of dysphagia in previous reports of patients who underwent ACD, we sought to better understand the prevalence of dysphagia at the national level and its impact on factors such as in-hospital mortality, complications, use of speech/swallowing therapy, length of hospitalization, and hospitalization costs.

Methods

A cross-sectional analysis of patients with a diagnosis of anterior cervical disc disease was performed using discharge data from the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ). The NIS is the largest all-payer inpatient care database in the United States, containing data from approximately 8 million hospital stays each year from a stratified sample of 20 % of nonfederal US hospitals from participating states [15]. The NIS database provides information regarding the index hospital admission and includes patient demographic data, primary and secondary diagnoses, primary and secondary procedures, hospital characteristics, and inpatient and discharge mortality rates. The International Classification of Disease, 9th revision (ICD-9) codes were used to identify adult patients (≥18 years of age) with a diagnosis of anterior cervical disc disease (721.0, 721.1, 722.0, 722.4, 722.6, 722.71, 722.81, 722.91, 723.0, 723.1, 723.2, 723.3, 723.4, 723.7, 723.9, 738.4, 738.5, 756.12) who underwent an anterior cervical discectomy or fusion (ICD-9 codes 80.51, 81.02, 81.32, 84.61, 84.62, 84.66) for the years 2001 through 2010. Patients with neoplasms of the spine, congenital spinal deformity, and inflammatory spinal disease and patients who underwent fusion of four or more vertebrae or posterior approaches were excluded.

In-hospital death, complications, length of hospitalization, and cost were examined as dependent variables. Independent variables included were age, sex, race, payer source (commercial or health maintenance organization [HMO], Medicare, Medicaid, self-pay, or other), procedure, nature of admission (emergent/urgent or other), hospital bedsize, hospital location (rural or urban), hospital teaching status, comorbidity, obesity (ICD-9 codes 278.00, 278.01, 278.02, 793.91, V77.8), revision surgery (ICD-9 codes 81.32 and 84.66), disc prosthesis insertion (ICD-9 codes 84.61, 84.62, 84.66), acute medical complications, and acute surgical complications (Table 1). Comorbidity was graded using the Romano adaptation of the Charlson comorbidity index [16–18]. Acute medical complications were derived from codes for acute cardiac events, acute pulmonary edema or failure, acute renal failure, acute hepatic failure, acute cerebrovascular events, sepsis, pneumonia, and UTI assigned at the time of hospital discharge, and surgical complications were derived from codes for complications directly resulting from surgical procedures assigned at the time of hospital discharge. Procedure-specific complications were derived from codes for mechanical, infectious, and other complications (pain, hemorrhage, stenosis) of prosthetic devices, implants, or grafts; dysphonia/voice disturbance; unilateral vocal cord paralysis; dysphagia; and procedures related to dysphagia or dysphonia, including speech or dysphagia training, barium swallow, vocal cord injection, tracheostomy, and gastrostomy (Table 1).

Hospital-related charges for each index admission were converted to the organizational cost of providing care using cost-to-charge ratios for individual hospitals. Cost-to-charge ratios were calculated using information from the detailed reports by hospitals to the Centers for Medicare and Medicaid Services, providing an estimate of the all-payer inpatient cost-to-charge ratio by hospital [19]. This ratio was multiplied by each patient's charge to obtain the cost per admission [20]. All costs were adjusted for inflation based on US Bureau of Labor Statistics indices, with results converted to 2012 USD [21]. To obtain national cost estimates, all discharges were reweighted to account for cases where cost estimates were missing [19].

Data were analyzed using Stata 12 (StataCorp, College Station, TX). Associations between variables were analyzed using cross-tabulations, multivariate logistic regression, and multinomial logistic regression modeling. Nonzero

Table 1 ICD-9 diagnosis codes for medical and surgical complications

Variable	ICD-9 code
Surgical complications	
Shock	998.0
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
Medical complications	
Acute cardiac event	410.0–410.9, 411.1, 411.8, 415.0, 420.0, 420.9, 421.0, 421.1, 421.9, 422.0, 422.9, 427.0–427.5, 428.0–428.9
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	584.5–584.9
Acute hepatic failure	570
Sepsis	995.9, 038.0–038.4, 999.3
Urinary tract infection	599.0, 996.64, 996.31, V13.02
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, 507, 507.0, 997.31, V12.61
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, V12.61
Aspiration pneumonia	507, 507.0
Procedure-specific airway complications	
Prosthetic complications of device, implant, or graft	996.4, 996.5, 996.6, 996.7
Dysphonia/voice disturbance	784.4, 784.40, 784.41, 784.49
Unilateral vocal cord paralysis	478.3, 478.30, 478.31, 478.32
Injection of vocal cords	31.0, 31.98
Barium swallow	87.61
Tracheostomy	31.1, 31.2, 31.29, V440, V550
Gastrostomy	V551, V441, 93.36, 43.1, 43.11, 43.19, 97.02
Speech therapy/dysphagia training	93.72, 93.74, 93.75

discharge counts with fewer than 11 observations were masked in accordance with the HCUP data-use agreement. Data were weighted, and modified hospital and discharge weights to correct for changes in sampling over time were applied. Variance estimation was performed using procedures for survey data analysis with replacement. Strata with one sampling unit were centered at the population mean. Variables with missing data for more than 10 % of the population were coded with a dummy variable to represent the missing data in regression analysis. The primary clinical end points were evaluated using multiple logistic regression analysis. Generalized linear regression modeling with a log link was used to analyze costs and length of stay because these variables were not normally distributed. This protocol was reviewed and approved by the Johns Hopkins Medical Institutions Institutional Review Board.

Results

There were 1,659,871 cases of ACD between 2001 and 2010 (Table 2), with dysphagia reported in 32,922 cases (2 %). The majority of ACD patients were female, white, and under 65 years of age. The mean age was 53 years (range = 18–110). Dysphagia was more common in patients 65 years of age and older. Patients who developed dysphagia were more likely to be male, have advanced comorbidity, use Medicaid or Medicare, be admitted urgently or emergently, have undergone a revision procedure, experience complications related to insertion of a disc prosthesis, have sustained surgical or acute medical complications, and require medical care at another facility or at home after discharge. Compared to patients without dysphagia, patients with dysphagia were significantly more likely to have dysphonia and unilateral vocal cord paralysis and develop aspiration pneumonia, and were more likely to undergo speech therapy and/or dysphagia training, vocal cord injection, gastrostomy tube placement, or tracheostomy placement during admission (Table 2). Speech therapy and/or dysphagia training was coded in only 157 cases (<0.1 %) and in only 0.2 % of patients with dysphagia, 0.2 % of patients with dysphonia, 0.4 % of patients with vocal cord paralysis, and 0.1 % of patients who required gastrostomy placement. No cases with complications related to insertion of a disc prosthesis, revision surgery, tracheostomy placement, or aspiration pneumonia had speech therapy and/or dysphagia training reported.

Multiple logistic regression analysis of independent variables predictive of in-hospital death and complications is given in Table 3. After controlling for the effects of all variables, statistically significant factors associated with the risk of in-hospital death were urgent or emergent admission, age ≥65 years, Medicaid payer status, comorbidity, and aspiration pneumonia. Dysphagia was significantly associated with urgent or emergent admission, age ≥65 years, Medicare or Medicaid payer status, comorbidity, disc prosthesis placement, revision procedures, and vocal cord paralysis, while vocal cord paralysis was significantly associated with age >80 years, advanced comorbidity, revision procedures, and complications related to insertion of a disc prosthesis. Aspiration pneumonia was significantly associated with urgent or emergent admission, age ≥65 years, Medicare or Medicaid payer status, comorbidity, revision surgery, vocal cord paralysis, and dysphagia.

Multiple logistic regression analysis of independent variables predicted to be associated with dysphagia is shown in Table 4. After controlling for the effects of all variables, including medical complications, tracheostomy or gastrostomy placement was significantly associated with urgent or emergent admission, Medicaid payer status, comorbidity, vocal cord paralysis, dysphagia, and aspiration pneumonia, while gastrostomy placement was additionally associated with age ≥65 years and Medicare payer status. Speech therapy and/or dysphagia training was significantly associated with age ≥65 years, advanced comorbidity, and dysphagia, but was not associated with vocal cord paralysis, aspiration pneumonia, tracheostomy, or gastrostomy placement.

Multivariate generalized linear regression analyses of independent variables predictive of length of hospital stay and hospital-related costs are shown in Table 5, with mean values representing the change in the value of the intercept mean. After controlling for all other variables, urgent or emergent admission, comorbidity, age ≥65 years, Medicare or Medicaid payer status, revision procedures, complications related to insertion of a disc prosthesis, vocal cord paralysis, dysphagia, and aspiration pneumonia were significantly associated with greater length of hospitalization and increased hospital costs, with aspiration pneumonia having the single largest impact on both length of hospitalization and costs of care.

Discussion

These data discussed here demonstrate several important considerations for patients undergoing ACD. Although dysphagia is coded infrequently in this sample, the consequences of dysphagia are significant, with an increased risk of aspiration pneumonia, feeding tube dependence, and tracheostomy noted in those individuals with dysphagia. Approximately 1 in 15 patients with dysphagia following ACD required use of a feeding tube. Furthermore, dysphagia was associated with prolonged hospital stay and cost of hospitalization with more than one additional day of hospitalization and an additional >$4,500 in contrast to those without dysphagia.

Among ACD patients with dysphagia, 4 % developed aspiration pneumonia during their hospital stay, and dysphagia was a significant predictor of the development of aspiration pneumonia, which was associated with increased mortality. Aspiration pneumonia was found to have the greatest impact on hospital stay and cost compared to all other variables. Aspiration pneumonia resulted in significant prolongation of length of hospitalization and increased hospital-related costs and was the variable with the single greatest impact on length of stay and costs. Patients with aspiration pneumonia were 16 times more likely to die during hospitalization. Of those ACD patients diagnosed with aspiration pneumonia, none were referred for speech and swallowing evaluation/intervention; perhaps some of this aspiration might have occurred intraoperatively and it was thought that further investigation was not necessary.

Table 2 Demographic characteristics (all values are %)

	All (*N*=1,659,871)	No dysphagia (*N*=1,626,949)	Dysphagia (*N*=32,922)	*P* value
Age (years)				<0.0001
18–39	15.8	15.9	9.1	
40–64	65.7	65.9	59.5	
65–80	17.0	16.8	26.5	
>80	1.5	1.4	4.9	
Race				<0.0001
White	60.2	60.2	60.0	
Black	6.0	5.9	9.7	
Hispanic	3.2	3.2	4.0	
Asian or Pacific Islander	0.8	0.8	1.3	
Native American	0.3	0.3	0.2	
Other	1.6	1.6	1.6	
Unknown	27.9	28.0	24.2	
Sex				<0.0001
Male	46.5	46.4	49.8	
Female	53.5	53.6	50.2	
Payer status				<0.0001
Private/HMO	58.2	58.4	47.8	
Medicare	23.4	23.1	35.9	
Medicaid	5.0	5.0	5.5	
Self-pay	1.4	1.5	1.1	
No charge	0.2	0.2	0.1	
Other	11.8	11.8	9.6	
Comorbidity score				<0.0001
0	76.0	76.3	62.7	
1	17.0	16.9	23.0	
2	4.9	4.8	8.5	
≥3	2.1	2.0	5.8	
Obesity				0.6784
No	92.8	92.8	92.6	
Yes	7.2	7.2	7.4	
Hospital bedsize				0.0050
Small	11.4	11.5	9.3	
Medium	22.8	22.8	20.1	
Large	65.8	65.7	70.6	
Hospital teaching status				0.3040
Nonteaching hospital	48.7	48.7	47.0	
Teaching hospital	51.3	51.3	53.0	
Hospital location				0.2512
Rural	5.1	5.2	4.4	
Urban	94.9	94.8	95.6	
Hospital admission type				<0.0001
Elective	89.5	89.6	84.8	
Emergency/urgent	10.5	10.4	15.2	
Procedures				
Revision surgery	1.7	1.6	4.1	<0.0001
Insertion of disc prosthesis	0.8	0.8	0.9	0.3661

Table 2 continued

	All (*N*=1,659,871)	No dysphagia (*N*=1,626,949)	Dysphagia (*N*=32,922)	*P* value
Postoperative complications				
Surgical complications	1.9	1.9	6.5	<0.0001
Medical complications	5.0	4.9	13.6	<0.0001
Prosthetic complications	0.6	0.6	1.0	<0.0001
Dysphonia/voice disturbance	1.1	0.1	51.9	<0.0001
Unilateral vocal cord paralysis	0.1	0.1	1.0	<0.0001
Injection of vocal cords	<0.1	0	0.1	<0.0001
Barium swallow	<0.1	0	0.2	<0.0001
Speech therapy/dysphagia training	<0.1	<0.1	0.2	<0.0001
Aspiration pneumonia	0.3	0.2	3.7	<0.0001
Gastrostomy tube	0.3	0.1	6.8	<0.0001
Tracheostomy	0.2	0.1	1.2	<0.0001
Disposition				<0.0001
Routine	87.5	87.9	70.0	
Short-term hospital care	0.3	0.2	0.8	
Other facility	6.2	6.0	18.0	
Home health care	5.8	5.7	10.6	
AMA	0.1	0.1	0.2	
Died in hospital	0.1	0.1	0.4	

To whatever degree this aspiration occurs in awake and alert patients, it would seem that opportunities to intervene and perhaps positively influence patient outcomes are being missed.

Treatment applied by speech-language pathologists to address dysphagia has been associated with a reduced risk of medical and pulmonary complications as well as in-hospital mortality [22]. Early identification of dysphagia and implementation of appropriate dysphagia care may mitigate some of these negative outcomes. Interventions may include muscular strength training, dietary modifications, and implementation of compensatory techniques to improve swallowing efficiency and safety. That speech pathology services were not employed for any patients with aspiration pneumonia and only 0.2 % of patients with dysphagia suggests that speech pathology services were significantly underutilized in this at-risk population.

Previous data suggest that dysphagia is a common outcome following ACD regardless of how dysphagia is operationally defined [3]. Dysphagia is reported in more than one third of ACD patients in the immediate perioperative period, about half of the ACD patients experience dysphagia at 1 month postoperatively, and about one third report dysphagia at 2–4 months postoperatively [3]. Our current data from hospital discharge records demonstrate a much lower frequency of reported dysphagia. In this sample, dysphagia was coded in only 2 % of those who underwent ACD, suggesting probable undercoding of this postoperative complication. This may reflect a lack of routine surveillance for potential swallowing dysfunction in the perioperative period or a tendency to code only clinically significant dysphagia that has a marked impact on patient recovery and discharge. Given that the preponderance of the evidence using tools to measure swallow function and quality of life suggests a higher rate of difficulty even several months postoperatively, greater attention to dysphagia in the perioperative period appears warranted.

Postoperative vocal fold paralysis, like dysphagia, had significant consequences when it was noted. Vocal fold paralysis was documented in only 0.1 % of our sample; this significantly differs from prior reports where paralysis was noted in 2–5 % of patients [23, 24]. Patients with identified postoperative vocal fold paralysis had a 12-fold increased risk of dysphagia and a sevenfold increased risk of aspiration pneumonia. Despite the repercussions to voice and swallowing of vocal fold paralysis, those with identified vocal fold paralysis were unlikely to receive speech-language pathology care. Again, the underutilization of speech and swallowing assessment and intervention is concerning.

These data serve as a call to arms for those providing postoperative care following ACD. Postoperative complications such as dysphagia and vocal fold paralysis appear to be underrecognized, which may lead to negative repercussions for the patient's health, quality of life, and the healthcare system at large. Speech-language pathologists (SLP) are uniquely positioned to provide assessment and

Table 3 Multivariate logistic regression analysis of variables predictive of risk of in-hospital death and postoperative complications

Variable	Odds ratio	95 % CI	*P* value
In-hospital death			
Urgent/emergent admission	3.48	2.76–4.38	<0.001
Age 65–80 years	1.93	1.43–2.63	<0.001
Age >80 years	6.38	4.38–9.29	<0.001
Medicaid	1.69	1.20–2.38	0.003
Comorbidity score 1	3.35	2.52–4.46	<0.001
Comorbidity score 2	5.39	3.72–7.80	<0.001
Comorbidity score ≥3	11.50	8.13–16.28	<0.001
Aspiration pneumonia	15.94	10.99–23.09	<0.001
Dysphagia			
Urgent/emergent admission	1.29	1.15–1.43	<0.001
Age 65–80 years	1.52	1.37–1.67	<0.001
Age >80 years	3.08	2.64–3.58	<0.001
Medicare	1.14	1.03–1.25	0.008
Medicaid	1.19	1.05–1.34	0.006
Comorbidity score 1	1.43	1.33–1.64	<0.001
Comorbidity score 2	1.67	1.50–1.85	<0.001
Comorbidity score ≥3	2.28	1.99–2.61	<0.001
Revision surgery	2.68	2.33–3.09	<0.001
Prosthesis placement	1.47	1.04–2.04	0.029
Vocal cord paralysis	11.56	8.29–16.11	<0.001
Vocal cord paralysis			
Age >80 years	2.54	1.25–5.16	0.010
Comorbidity score 2	2.32	1.50–2.58	<0.001
Comorbidity score ≥3	3.43	2.12–5.55	<0.001
Revision surgery	4.60	2.69–7.86	<0.001
Prosthetic complication	4.03	1.91–8.47	<0.001
Aspiration pneumonia			
Urgent/emergent admission	2.70	2.29–3.18	<0.001
Age 65–80 years	1.99	1.61–2.46	<0.001
Age >80 years	3.94	2.93–5.31	<0.001
Medicare	1.67	1.35–2.08	<0.001
Medicaid	1.91	1.44–2.55	<0.001
Comorbidity score 1	2.04	1.72–2.43	<0.001
Comorbidity score 2	3.86	3.14–4.74	<0.001
Comorbidity score ≥3	5.19	4.08–6.61	<0.001
Revision surgery	1.89	1.26–2.84	0.002
Dysphagia	8.57	6.74–10.89	<0.001
Vocal cord paralysis	7.14	3.56–14.30	<0.001

intervention for individuals with swallowing dysfunction, and this intervention may impact patient safety and satisfaction. Postoperative edema and expectations that dysphagic symptoms will improve spontaneously over time may have influenced the SLP referral rate in this sample. Surgeons' expectations of improvement may have negated referral to a SLP. However, given the well-understood benefit of compensatory postures and dietary modifications that a SLP can recommend, even patients with postoperative edema may derive some benefit from SLP consultation even without application of active dysphagia exercise intervention. We suggest that practice pattern considerations in the postoperative period include SLP interventions; whether they target rehabilitation of physiologic deficits or compensation for postoperative edema, they may be worthwhile.

There are several limitations to the use of hospital discharge data that may influence our findings. The NIS database provides no follow-up data beyond the index admission and is limited to a 30-day postoperative window; it contains

Table 4 Multivariate logistic regression analysis of variables predictive of risk of in-hospital death and postoperative complications

Variable	Odds ratio	95 % CI	*P* value
Tracheostomy			
Urgent/emergent admission	2.78	2.20–3.51	<0.001
Medicaid	1.86	1.31–2.65	0.001
Comorbidity score 2	1.74	1.29–2.36	<0.001
Dysphagia	2.32	1.64–3.28	<0.001
Vocal cord paralysis	4.30	1.59–11.70	0.004
Aspiration pneumonia	6.84	4.92–9.50	<0.001
Gastrostomy			
Age 65–80 years	1.81	1.39–2.37	<0.001
Age >80 years	3.00	2.04–4.41	<0.001
Medicare	1.76	1.31–2.36	<0.001
Medicaid	2.17	1.50–3.12	<0.001
Comorbidity score 1	1.72	1.35–2.19	<0.001
Comorbidity score 2	2.47	1.87–3.25	<0.001
Comorbidity score ≥3	3.06	2.29–4.10	<0.001
Dysphagia	30.91	25.30–37.76	<0.001
Vocal cord paralysis	7.43	3.30–16.72	<0.001
Aspiration pneumonia	12.47	9.24–16.82	<0.001
Dysphagia/speech training			
Age 65–80 years	4.43	1.81–10.81	0.001
Age >80 years	6.46	2.63–15.85	<0.001
Comorbidity score 2	3.79	1.10–13.05	0.035
Comorbidity score ≥3	2.87	1.42–5.81	0.003
Dysphagia	32.01	15.44–66.37	<0.001

no information on previous surgical procedures, preoperative functional status, or long-term outcomes. It is possible that these patients may have been identified as having dysphagia with or without aspiration pneumonia following discharge from the hospital. It is also possible that in the context of recovering from major surgery, mild impairments were underreported by patients thus negating the justification for referral during the index admission. Individuals with limited swallowing symptoms may find in the long term that those symptoms become increasingly bothersome. Unfortunately, there is no way to determine patient-perceived function or long-term function with this data set. While procedure codes exist for revision cases, there is no information regarding previous surgical procedures, and codes for voice and swallowing disturbances do not discriminate between acute and chronic conditions. The NIS database does not contain information regarding readmission or previous surgical procedures or nonsurgical management, and care provided on an outpatient basis is not captured. Postoperative complications may not be apparent at the time of discharge, particularly as many surgeons do not routinely evaluate vocal cord function with laryngoscopy or evaluate for dysphagia in the absence of overt symptoms [3], and as a result the incidence of procedure-specific complications may be underreported. The prevalence of these practices cannot be determined from the NIS database. While comorbidity scores were used for risk adjustment, the ability to adequately control for case mix is limited when discharge diagnoses from administrative databases are used. Another potential limitation is that the cost analysis was based on hospital-related charges, adjusted for institutional expense-to-revenue ratios, and did not include physician-related costs, as these data are not contained in the NIS database.

Nevertheless, these data do demonstrate that individuals undergoing ACD surgery are at risk for dysphagia, which is associated with an increased risk of aspiration pneumonia, tracheostomy or gastrostomy placement, increased length of hospitalization, and increased hospital-related costs of care. Despite a recognized beneficial role of the SLP in the treatment of dysphagia, SLP evaluation and treatment occurred in only a minority of patients with documented dysphagia. This may be related to practice patterns favoring a watch and wait approach; however, we suggest that consultation with a SLP may provide compensatory support, even when it is premature to apply physiologic swallowing exercise. Providers caring for individuals following ACD need to remain vigilant regarding the potential for dysphagia in the perioperative period and beyond.

Table 5 Generalized linear regression analysis of length of stay and hospital costs

Variable	Estimate	95 % CI	*P* value	Mean
Length of stay (days)				
Intercept	0.4742	0.4523–0.4961	<0.001	2.2
Urgent/emergent admission	0.6693	0.6053–0.7333	<0.001	1.5
Age 65–80 years	0.2774	0.2589–0.2960	<0.001	0.6
Age >80 years	0.5249	0.4910–0.5588	<0.001	1.2
Medicare	0.0968	0.0760–0.1177	<0.001	0.2
Medicaid	0.1809	0.1486–0.2131	<0.001	0.4
Comorbidity score 1	0.1876	0.1756–0.1996	<0.001	0.4
Comorbidity score 2	0.4526	0.4262–0.4790	<0.001	1.0
Comorbidity score ≥3	0.7252	0.6855–0.7649	<0.001	1.6
Revision surgery	0.0827	0.0424–0.1230	<0.001	0.2
Prosthetic complication	0.5565	0.4858–0.6272	<0.001	1.2
Vocal cord paralysis	0.6521	0.5134–0.7908	<0.001	1.5
Dysphagia	0.5580	0.5173–0.7908	<0.001	1.2
Aspiration pneumonia	1.4145	1.3448–1.4843	<0.001	3.1
Hospital costs (2012 USD)				
Intercept	9.5571	9.5317–9.5824	<0.001	$16,418
Urgent/emergent admission	0.1644	0.1288–0.2000	<0.001	$2,699
Age 65–80 years	0.1941	0.1781–0.2101	<0.001	$3,187
Age >80 years	0.2201	0.1911–0.2492	<0.001	$3,614
Medicare	0.0537	0.0355–0.0720	<0.001	$883
Medicaid	0.0603	0.0332–0.0874	<0.001	$990
Comorbidity score 1	0.1146	0.1049–0.1243	<0.001	$1,882
Comorbidity score 2	0.2408	0.2225–0.2591	<0.001	$3,954
Comorbidity score ≥3	0.3856	0.3573–0.4140	<0.001	$6,332
Revision surgery	0.0967	0.0610–0.1324	<0.001	$1,588
Prosthetic complication	0.3376	0.2618–0.4135	<0.001	$5,544
Vocal cord paralysis	0.3869	0.2771–0.4966	<0.001	$6,352
Dysphagia	0.2858	0.2492–0.3224	<0.001	$4,692
Aspiration pneumonia	0.9537	0.9007–1.0067	<0.001	$15,659

Services of the speech-language pathologist should be rendered to ensure optimal swallowing outcomes and to minimize ramifications of dysphagia.

Conclusions

Dysphagia following ACD is associated with significantly increased morbidity, length of hospitalization, and hospital-related costs. Despite the known risk of dysphagia following ACD and an established role for the speech-language pathologist in dysphagia management, speech-language pathology intervention appears underutilized in this population. Consideration of interventions to compensate for postoperative edema as well as to address identified physiologic deficits may be appropriate and beneficial to patient outcomes and quality of life.

Conflict of interest The authors have no conflicts of interest to disclose

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