The Laryngoscope

The Effect of Pneumonia on Short-Term Outcomes and Cost of Care After Head and Neck Cancer Surgery

Yevgeniy R. Semenov, MA; Heather M. Starmer, MA, CCC-SLP; Christine G. Gourin, MD, MPH

Background: The Centers for Medicare and Medicaid Services has threatened to discontinue reimbursements for ventilator-associated pneumonia (VAP) as a preventable "never event." We sought to determine the relationship between pneumonia and in-hospital mortality, complications, length of hospitalization and costs in head and neck cancer (HNCA) surgery.

Study Design: Retrospective cross-sectional study.

Methods: Discharge data from the Nationwide Inpatient Sample for 93,663 patients who underwent an ablative procedure for a malignant oral cavity, laryngeal, hypopharyngeal, or oropharyngeal neoplasm from 2003 to 2008 were analyzed using cross-tabulations and multivariate regression modeling.

Results: VAP was rarely coded. Infectious pneumonia was significantly associated with chronic pulmonary disease (odds ratio [OR], 1.5; $P < .001$), while aspiration pneumonia was associated with dysphagia (OR, 2.0; $P < .001$). Pneumonia from any cause was associated with weight loss (OR, 3.3; $P < .001$), age >80 years (OR, 2.0; $P = .007$), comorbidity (OR, 2.3; $P < .001$), and major procedures (OR, 1.6; $P < .001$), with increased in-hospital mortality for infectious (OR, 2.9; $P < .001$) and aspiration pneumonia (OR, 5.3; $P < .001$). Both infectious and aspiration pneumonia were associated with postoperative medical and surgical complications, increased length of hospitalization, and hospital-related costs.

Conclusions: Postoperative pneumonia is associated with increased mortality, complications, length of hospitalization, and hospital-related costs in HNCA surgical patients. Variables associated with an increased risk of pneumonia are inherent comorbidities in HNCA and known risk factors for VAP, making this a high-risk group for this never event. Caution must be used in the institution of reforms that threaten to inadequately reimburse the provision of care to this vulnerable population. Aggressive preoperative identification and treatment of underlying pulmonary disease, weight loss, and dysphagia may reduce morbidity and mortality.

Key Words: Pneumonia, ventilator-associated pneumonia, pulmonary disease, dysphagia, head and neck neoplasms, complications, surgery, Nationwide Inpatient Sample.

Level of Evidence: 2c

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INTRODUCTION

Ventilator-associated pneumonia (VAP) is a common complication in intensive care unit (ICU) patients, occurring in 8% to 28% of all patients who receive mechanical ventilation.[1,2] Prolonged mechanical ventilation beyond 48 hours is the most important factor associated with nosocomial pneumonia; however, VAP may occur within the first 48 hours after intubation, and duration of mechanical ventilation, although an incremental risk factor for VAP, is not part of the Centers for Disease Control (CDC) definition of VAP.[2–4] VAP is the most common hospital-acquired infection in the ICU, with mortality rates of 24% to 75% and mean treatment costs in excess of $40,000 per patient, and imposes a significant burden on the US health care system.[2,5–7] The Centers for Medicare and Medicaid Services (CMS) has proposed including VAP as a "never event" exempt from reimbursement, considering this a preventable complication.[8–12]

VAP has been shown to be associated with both modifiable and nonmodifable risk factors.[6] Modifiable risk factors are related to management of hygiene, oral secretions, and the ventilator circuit, and the institution of prevention guidelines aimed at preventing infection, aspiration, and prolonged ventilation have been shown to reduce the incidence of VAP in the ICU setting.[2,5,6,13] Despite these measures, VAP remains a common complication of critical illness as a result of nonmodifiable underlying medical conditions, which have a major influence on the epidemiologic characteristics of VAP. Aspiration, malnutrition, underlying chronic obstructive pulmonary disease, advanced age, male gender, reintubation, tracheostomy status, surgery, and a high American Association of Anesthesiologists score have all been shown to be associated with an increased risk of VAP.[2,5,6,13] Head and neck cancer (HNCA) surgical patients may be at particularly high risk for VAP, as many of the variables associated with an increased risk of VAP are inherent comorbidities in HNCA patients,

From the Department of Otolaryngology–Head and Neck Surgery, Johns Hopkins University, Baltimore, Maryland, U.S.A.

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Send correspondence to Christine G. Gourin, MD, MPH, Johns Hopkins Outpatient Center, Department of Otolaryngology–Head and Neck Surgery, 601 N. Caroline Street, Suite 6260, Baltimore, MD 21287. E-mail: cgourin1@jhmi.edu

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TABLE I.
ICD-9 Diagnosis and Procedure Codes for Included Cases.

Variable	ICD-9 Code
Diagnosis codes	
Neoplasms	
Laryngeal neoplasm (malignant)	161.0, 161.1, 161.2, 161.3, 161.8, 161.9, 146.4, 146.5
Hypopharyngeal neoplasm (malignant)	148.0, 148.1, 148.2, 148.3, 148.8, 148.9
Oral cavity neoplasm (malignant)	140.0, 140.1, 140.3, 140.4, 140.6, 140.8, 140.9, 141.1, 141.2, 141.3, 141.4, 141.9, 143.0, 143.1, 143.8, 143.9, 144.0, 144.4, 144.8, 144.9, 145.0, 145.1, 145.2, 145.6, 145.8, 145.9, 170.1
Oropharyngeal neoplasm (malignant)	141.0, 141.5, 141.6, 141.8, 145.3, 145.4, 146.0, 146.1, 146.2, 146.3, 146.6, 146.7, 146.8, 146.9, 149.0, 149.1
Procedure codes	
Laryngeal cancer procedures	
Excision/destruction of lesion	30.09
Partial laryngectomy	30.1, 30.21, 30.29
Total laryngectomy/laryngopharyngectomy	30.3, 30.4
Esophagectomy	42.40, 42.41, 42.42
Hypopharyngeal cancer procedures	
Excision/destruction of lesion	29.39, 30.09
Partial laryngectomy	30.1, 30.29
Total laryngectomy/laryngopharyngectomy	30.3, 30.4
Pharyngectomy	29.33
Esophagectomy	42.40, 42.41, 42.42
Oral cavity cancer procedures	
Excision/destruction of lesion	25.1, 27.3, 27.31, 27.4, 27.42, 27.43, 27.49
Partial glossectomy	25.2
Total glossectomy	25.3, 25.4
Maxillectomy	27.32
Mandibulectomy	76.31, 76.41, 76.42
Oropharyngeal cancer procedures	
Excision/destruction of lesion	25.1, 27.72, 27.79, 28.5, 28.91, 29.39
Tonsillectomy	28.2
Partial glossectomy	25.2
Total glossectomy	25.3, 25.4
Pharyngectomy	29.33
Mandibulectomy	76.31, 76.41, 76.42
Non–site-specific procedures	
Neck dissection	40.40, 40.41, 40.42, 40.3
Pedicled or free flap reconstruction	86.7, 86.70, 86.71, 86.72, 86.73, 86.74, 86.75, 86.8, 86.89
Tracheostomy tube placement	31.1, 31.2, 31.29, V44.0, V55.0

ICD-9 = International Classification of Disease, 9th Revision.

but a paucity of data exists regarding VAP in HNCA patients. We sought to determine the effect of VAP on in-hospital mortality, postoperative complications, length of stay, and costs in patients undergoing HNCA surgery using a national hospital discharge database.

MATERIALS AND METHODS

A cross-sectional analysis of patients with a diagnosis of oral cavity, laryngeal, hypopharyngeal, or oropharyngeal cancer was performed using discharge data from the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project, 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.[14] 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 ($\geq$18 years of age) who underwent an ablative procedure for a malignant oral cavity, laryngeal, hypopharyngeal, or oropharyngeal neoplasm for the years 2003 through 2008 (Table I). Oropharyngeal cancer patients undergoing biopsy were included if neck dissection was the index admission procedure and no other ablative procedure was recorded. Reconstructive procedures were obtained from codes for pedicled or free flap reconstruction.

TABLE II.
ICD-9 Diagnosis Codes for Comorbid Conditions.

Variable	ICD-9 Code
Chronic comorbid conditions	
Dysphagia	787.2, 787.20, 787.21, 787.22, 787.23, 787.24, 787.29, 438.82
Pulmonary disease (chronic pulmonary disease, pulmonary circulation disorders)	415.11–415.19, 416.0–416.9, 417.9, 490–492.8, 493.00–493.92, 494–494.1, 495.0–505, 506.4
Weight loss	260, 261, 262, 263.0, 263.1, 263.2, 263.8, 263.9, 783.0, 783.2, 783.21, 783.22, 783.7, V85.0
Prior radiation	V15.3
Acute complications	
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	
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
Ventilator-associated pneumonia	997.31
Ventilator status	
Continuous invasive mechanical ventilation of unspecified duration	96.70
Continuous invasive mechanical ventilation for less than 96 hours	96.71
Continuous invasive mechanical ventilation for more than 96 hours	96.72

ICD-9 = International Classification of Disease, 9th Revision.

Comorbidity was graded using the Romano adaptation of the Charlson comorbidity index,[15–17] excluding ICD-9 codes for the index cancer diagnosis from the solid tumor category. Cancer staging information is not available in the NIS, and as a result ICD-9 codes for metastases were excluded as these have not been shown to be a reliable surrogate for disease stage.[18] Codes for specific comorbid illnesses were obtained from codes used in AHRQ definitions of comorbidities,[19] with additional categories created for chronic pulmonary disease using codes for chronic pulmonary disease and pulmonary circulation disorders, weight loss including codes for adult failure to thrive and body mass index (BMI) <19, and dysphagia (Table II) Prior irradiation was obtained from codes for previous exposure to therapeutic or other ionizing radiation. 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, and urinary tract infection 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. Codes for pneumonia were obtained from ICD-9 codes for infectious pneumonia, aspiration pneumonia, and VAP.

In-hospital death, complications, length of hospitalizations, and costs were examined as dependent variables. Independent variables included were age, sex, race, payer source (commercial or health maintenance organization, Medicare, Medicaid, self-pay, or other), procedure, comorbidity, nature of admission (emergent/urgent or other), discharge disposition, dysphagia, chronic pulmonary disease, weight loss, infectious pneumonia, aspiration pneumonia, and VAP. Procedures were categorized by severity as minor (excision/destruction of lesion, tonsillectomy,

and partial glossectomy, with or without neck dissection, and neck dissection alone when performed as the index admission procedure) and major (partial or total laryngectomy, esophagectomy, total glossectomy, pharyngectomy, mandibulectomy, and maxillectomy, with or without neck dissection). The American Joint Commission on Cancer tumor stage, tumor grade, histological subtype, and outcome after discharge were not available from the NIS database.

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.[20] This ratio was multiplied by each patient's charge to obtain the cost per admission.[21] All costs were adjusted for inflation based on US Bureau of Labor Statistics indices, with results converted to 2011 US dollars.[22] To obtain national cost estimates, all discharges were reweighted to account for cases where cost estimates were missing.[20]

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. Data were weighted, and modified hospital and discharge weights to correct for changes in sampling over time were applied.[14] 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 93,663 cases between 2003 and 2008 (Table III). The majority of patients did not have a history of postoperative pneumonia; 4,364 cases (5%) were diagnosed with infectious pneumonia, 2,026 cases (2%) were diagnosed with aspiration pneumonia, and only 45 cases (<1%) were diagnosed with VAP. Overall, there were 6,035 cases (6%) with a diagnosis of pneumonia. The majority of patients were male, white, and under 65 years of age. The mean age was 62 years (range, 18–104 years) and differed significantly between age groups based on pneumonia status, with patients >80 years of age more likely to have aspiration pneumonia. Prior radiation was documented in only 5% of cases and did not significantly differ by pneumonia status. Patients who developed pneumonia were more likely to have advanced comorbidity, dysphagia, chronic obstructive pulmonary disease, weight loss, Medicaid or Medicare, more likely to undergo major surgical procedures, more likely to require postoperative mechanical ventilation, and more likely to require medical care at another facility or at home after discharge.

Acute medical comorbidity developed in 15% of patients and developed in 49% of patients with pneumonia compared to 13% of patients without pneumonia ($P < .001$). Compared to patients without pneumonia, the incidence of acute medical comorbidity was higher in patients with infectious pneumonia (49%), aspiration pneumonia (51%), and VAP (88%). Acute cardiac events and acute pulmonary edema or failure were the most common causes of acute medical comorbidity in patients with pneumonia from any cause. Postoperative surgical complications were significantly more common in patients with pneumonia from any cause (24%) compared to patients without pneumonia (10%; $P < .0001$). Wound healing complications (fistula, dehiscence, and nonhealing wound) comprised 44% of all postoperative surgical complications and were significantly more common in patients with infectious pneumonia (14%), aspiration pneumonia (10%), and VAP (13%) compared to patients without pneumonia (4%; $P < .0001$). Postoperative wound infection comprised 22% of all postoperative surgical complications and was significantly more common in patients with infectious pneumonia (7%), aspiration pneumonia (5%), and VAP (12%) compared to patients without pneumonia (2%; $P < .0001$).

Multiple logistic regression analysis of variables known at the time of admission that were significantly associated with the risk of developing pneumonia from any cause, including VAP, are shown in Table IV. A diagnosis of pneumonia from any cause was significantly associated with dysphagia, chronic pulmonary disease and weight loss, after controlling for all other variables (Table IV). The small number of patients with VAP precluded separate analysis. Both infectious and aspiration pneumonia were associated with advanced comorbidity, Medicare and Medicaid payor status, and weight loss. Infectious pneumonia was significantly associated with underlying chronic pulmonary disease, an increased likelihood of major surgical procedures, and pedicled or free flap reconstruction, whereas aspiration pneumonia was not significantly associated with extent of surgery but was significantly associated with dysphagia and laryngeal primary site disease.

Multiple logistic regression analysis of independent variables predictive of in-hospital death and complications are shown in Table V. After controlling for the effects of all variables, statistically and independently significant factors associated with the risk of in-hospital death were urgent or emergent admission, age ≥80 years, Medicare or Medicaid payor status, advanced comorbidity, pedicled or free flap reconstruction, major surgical procedures, infectious pneumonia, and aspiration pneumonia. Postoperative surgical complications and acute medical complications were both significantly associated with pedicled or free flap reconstruction and major surgical procedures, weight loss, Medicaid payor status, infectious pneumonia, and aspiration pneumonia. Acute medical complications were in addition significantly associated with elderly patients, Medicare payor status, urgent or emergent admission, and comorbidity. Postoperative surgical complications were not associated with advanced comorbidity score.

Multivariate generalized linear regression analyses of independent variables predictive of length of hospital

TABLE III.
Demographic Characteristics.

	All Patients (93,663), %	Infectious Pneumonia (4,364), %	Aspiration Pneumonia (2,026), %	Ventilator-Associated Pneumonia (45), %	*P* Value
Primary Site					<.001
Oral cavity	39.0	39.0	32.7	76.8	
Larynx	26.5	32.9	38.7	11.5	
Hypopharynx	3.5	4.9	5.7	0	
Oropharynx	31.0	23.2	23.0	11.8	
Age group					<.001
≤40 years	4.0	2.3	1.1	0	
40–64 years	53.9	42.6	35.0	51.5	
65–80 years	34.0	45.0	44.5	23.6	
>80 years	8.2	10.1	19.5	25.0	
Race					.695
White	61.3	60.9	63.4	51.7	
Black	6.4	8.2	5.9	11.8	
Hispanic	4.4	5.3	2.2	13.2	
Asian or Pacific Islander	1.6	1.5	1.3	0	
Native American	0.3	0.2	0.8	0	
Other	1.9	2.1	2.7	0	
Unknown	24.1	21.9	23.7	23.3	
Sex					.003
Male	69.6	75.5	69.1	64.9	
Female	30.4	24.5	30.9	35.1	
Payor					<.001
Private	40.2	24.6	19.5	35.5	
Medicare	42.4	55.7	65.3	35.4	
Medicaid	10.3	13.6	10.9	13.2	
Self-pay	3.7	2.9	3.0	0	
No charge	0.5	0.6	0.3	0	
Other	2.8	2.6	1.1	15.9	
Nature of admission					<.001
Elective	84.3	75.5	71.9	88.2	
Emergency/urgent	15.7	24.5	28.1	11.8	
Comorbidity					<.001
0	61.7	40.7	40.3	51.0	
1	26.2	35.4	33.1	0	
2	8.5	16.8	16.5	49.0	
≥3	3.7	7.1	10.2	0	
Surgical Procedures					
Excision/destruction	34.5	34.8	38.9	64.9	.129
Cordectomy	1.2	0.4	0.6	0	.500
Partial laryngectomy	4.9	6.2	10.6	0	<.001
Laryngectomy	22.1	28.9	25.7	23.3	.001
Partial glossectomy	24.6	21.8	19.7	24.0	.032
Tonsillectomy	5.8	3.2	3.6	0	.003
Total glossectomy	3.0	4.8	0.5	0	<.001
Pharyngectomy	4.2	4.8	3.6	0	.469
Maxillectomy	2.2	1.3	1.1	0	.222
Mandibulectomy	14.8	25.0	20.2	52.7	<.001
Esophagectomy	0.4	0.7	0.5	0	.424
Neck dissection	50.7	52.1	39.5	76.8	.001
Flap	9.8	19.1	11.3	25.0	<.001

(*Continued*)

TABLE III.
(*Continued*).

	All Patients (93,663), %	Infectious Pneumonia (4,364), %	Aspiration Pneumonia (2,026), %	Ventilator-Associated Pneumonia (45), %	*P* Value
Procedure severity					<.001
Minor	48.7	29.4	38.4	12.2	
Major	51.3	70.6	61.6	87.8	
Dysphagia	5.6	7.8	14.3	0	<.001
Chronic pulmonary disease	22.1	39.7	37.3	35.8	<.001
Weight loss	6.1	19.2	23.3	52.4	<.001
Acute comorbidity					
Acute cardiac event	9.8	26.1	26.3	48.7	<.001
Acute pulmonary edema/failure	3.8	22.4	21.5	63.3	<.001
Acute cerebrovascular event	0.4	1.0	1.2	0	.007
Acute renal failure	1.2	7.4	7.1	23.6	<.001
Acute hepatic failure	0	0.1	0	0	.522
Sepsis	0.9	8.3	7.8	23.6	<.001
Urinary tract infection	1.9	7.0	7.9	11.5	<.001
Postoperative surgical complications	10.8	26.0	21.9	25.4	<.001
Mechanical ventilation					
Unspecified duration	0	0.1	0.2	0	.014
<96 hours	4.2	9.8	14.6	0	<.001
>96 hours	2.8	18.9	15.5	59.0	<.001
Any mechanical ventilation	7.0	28.7	29.7	59.0	<.001
Disposition					<.001
Routine	58.3	26.9	20.5	15.9	
Short-term hospital stay	0.8	1.9	3.6	0	
Other facility	10.4	31.9	38.9	24.9	
Home health care	29.5	34.8	30.0	47.3	
Against medical advice	0.1	0.1	0	0	
Died in hospital	0.9	4.4	7.0	11.8	

stay and hospital-related costs are shown in Table VI, with mean values representing the change in the value of the intercept mean. After controlling for all other variables, comorbidity, urgent or emergent admission, hypopharyngeal primary site disease, major surgical procedures, pedicled or free flap reconstruction, Medicare, Medicaid, and self-pay payor status, dysphagia, and weight loss were significantly associated with greater length of hospitalization, whereas comorbidity, urgent or emergent admission, major surgical procedures, pedicled or free flap reconstruction, Medicaid or self-pay payor status, dysphagia, and weight loss were significantly associated with increased hospital costs. Pneumonia from any cause was associated with significantly increased length of hospitalization and hospital-related costs, with infectious pneumonia having the single largest impact on both length of hospitalization and costs of care.

DISCUSSION

These data show that pneumonia is a common problem in HNCA surgical patients and is an independent predictor of mortality, acute medical and surgical complications, length of hospitalization, and costs in patients undergoing surgery for HNCA. Advanced comorbidity, weight loss, and major surgical procedures are associated with an increased risk of developing pneumonia, with chronic pulmonary disease associated with an increased risk of infectious pneumonia, and dysphagia associated with an increased risk of aspiration pneumonia. Because these variables are particularly prevalent in the HNCA population, HNCA patients represent a unique group at increased risk of pneumonia in whom prevention may not always be possible.

In response to the Deficit Reduction Act of 2005, CMS was required to select and adjust hospital payments for high-cost or high-volume hospital-acquired conditions that could reasonably be prevented through the application of evidence-based guidelines.[8] CMS identified 10 hospital-acquired medical conditions termed never events, that are considered within the control of the hospital and preventable, which Medicare will not reimburse for treatment. Recently, CMS proposed including VAP for payment exclusion, considering this a preventable complication.[9–12] One of the difficulties in defining VAP as a never event lies in reliably distinguishing its diagnosis from other forms of nosocomial pneumonia. The CDC defines VAP as pneumonia that

TABLE IV.
Multivariate Logistic Regression Analysis of Variables Associated With Pneumonia.

Variable	Odds Ratio	95% CI	*P* Value
Infectious pneumonia			
Urgent/emergent admission	1.43	1.15–1.78	.001
Medicare	1.37	1.03–1.83	.031
Medicaid	1.50	1.17–1.95	.002
Chronic pulmonary disease	1.47	1.22–1.77	<.001
Weight loss	2.50	1.95–3.20	<.001
Comorbidity score 1	1.35	1.10–1.64	.003
Comorbidity score 2	1.68	1.30–2.17	<.001
Comorbidity score≥3	1.64	1.13–2.37	.009
Pedicled or free flap reconstruction	1.55	1.25–1.92	<.001
Major procedure	1.70	1.38–2.09	<.001
Mechanical ventilation <96 hours	2.26	1.69–2.93	<.001
Mechanical ventilation >96 hours	7.63	5.87–9.91	<.001
Aspiration pneumonia			
Urgent/emergent admission	1.57	1.23–2.00	<.001
Age >80 years	4.63	1.62–13.21	.004
Medicare	1.65	1.15–2.37	.007
Medicaid	1.67	1.09–2.57	.018
Laryngeal primary site	1.52	1.13–2.02	.004
Comorbidity score 2	1.57	1.09–2.24	.013
Comorbidity score ≥3	2.19	1.43–3.35	<.001
Dysphagia	2.19	1.56–3.09	<.001
Weight loss	3.00	2.20–4.08	<.001
Mechanical ventilation <96 hours	3.56	2.43–5.19	<.001
Mechanical ventilation ≥96 hours	5.18	3.61–7.43	<.001
Pneumonia, any cause			
Urgent/emergent admission	1.50	1.25–1.81	<.001
Age >80 years	1.98	1.18–3.33	.010
Medicare	1.50	1.18–1.90	.001
Medicaid	1.58	1.26–1.97	<.001
Comorbidity score 1	1.33	1.12–1.58	.001
Comorbidity score 2	1.75	1.40–2.17	<.001
Comorbidity score ≥3	1.95	1.46–2.60	<.001
Dysphagia	1.58	1.24–2.02	<.001
Chronic pulmonary disease	1.38	1.17–1.62	<.001
Weight loss	2.85	2.34–3.48	<.001
Pedicled or free flap reconstruction	1.43	1.15–1.78	.001
Major procedure	1.47	1.24–1.76	<.001
Mechanical ventilation <96 hours	2.87	2.21–3.73	<.001
Mechanical ventilation >96 hours	7.91	6.12–10.23	<.001

CI = confidence interval.

develops in a person who is on a ventilator,[3] manifested by radiographic evidence of infection, systemic signs of elevated temperature or white blood cell count, and pulmonary evidence of increased ventilatory requirements or abnormal gram stain of respiratory secretions.[4] The lack of specificity of the CDC criteria has led to numerous definitions of VAP, a lack of consensus regarding the gold standard for diagnosis, misdiagnosis, and underdiagnosis.[2,4,23,24] Although prolonged mechanical ventilation beyond 48 hours is the most important factor associated with nosocomial pneumonia, VAP may occur within the first 48 hours after intubation, with different causative pathogens and an improved prognosis.[2] By proposing to include VAP in its list of never events, CMS contends that the condition is entirely preventable. However, differentiating between infectious pneumonia, aspiration pneumonia, and VAP in the HNCA surgical patient is difficult, and the true incidence is likely underestimated. Our data suggest that VAP may not be entirely preventable in the HNCA surgical population due to an increased prevalence of nonmodifiable risk factors in this group.

TABLE V.
Multivariate Logistic Regression Analysis of Variables Associated With the Risk of In-Hospital Death and Postoperative Complications.

Variable	Odds Ratio	95% CI	*P* Value
In-hospital death			
Age >80 years	1.83	1.10–3.03	.019
Medicare	2.51	1.39–3.43	.001
Medicaid	2.30	1.21–4.37	.011
Comorbidity score 1	1.85	1.13–3.03	.015
Comorbidity score 2	4.56	2.63–7.92	<.001
Comorbidity score ≥3	5.16	2.60–10.24	<.001
Urgent/emergent admission	1.70	1.10–2.62	.016
Pedicled or free flap reconstruction	2.24	1.37–43.64	.001
Major procedure	2.18	1.38–3.43	.001
Infectious pneumonia	2.92	1.76–4.83	<.001
Aspiration pneumonia	5.31	3.31–8.52	<.001
Postoperative surgical complications			
Medicaid	1.20	1.00–1.44	.044
Pedicled or free flap reconstruction	1.81	1.54–2.14	<.001
Major procedure	2.46	2.16–2.79	<.001
Weight loss	1.73	1.42–2.11	<.001
Infectious pneumonia	2.32	1.93–2.78	<.001
Aspiration pneumonia	1.81	1.38–2.38	<.001
Acute medical complications			
Urgent/emergent admission	1.40	1.20–1.63	<.001
Age 65–79 years	2.56	1.71–3.84	<.001
Age >80 years	4.32	2.76–6.75	<.001
Medicare	1.31	1.12–1.53	.001
Medicaid	1.30	1.12–1.53	.013
Comorbidity score 1	2.75	2.42–3.11	<.001
Comorbidity score 2	6.62	5.63–7.79	<.001
Comorbidity score ≥3	10.91	8.66–13.75	<.001
Major procedure	1.47	1.31–1.65	<.001
Pedicled or free flap reconstruction	1.36	1.13–1.64	.001
Weight loss	1.84	1.51–2.23	<.001
Infectious pneumonia	4.32	3.55–5.27	<.001
Aspiration pneumonia	3.59	2.73–4.73	<.001

CI = confidence interval.

Modifiable risk factors associated with VAP include general measures to reduce infection including hand hygiene and the use of universal infection control measures, early extubation, decontamination of the upper aerodigestive tract, and prevention of aspiration. Immediate postoperative extubation in the operating room has been shown to reduce the incidence of pneumonia in HNCA surgical patients.[25] The historic approach to managing complex HNCA surgical cases with prolonged postoperative intubation after surgery, and planned extubation the following morning because of concerns about the effect of emergence from anesthesia on complex reconstruction, has been shown to result in prolonged ventilatory support for a mean of 21 hours after surgery.[25] The majority of cases of VAP result from aspiration of potential pathogens that colonize the oropharynx and subsequently the trachea, and less commonly from microaspiration of gastric material.[2] Intubation compromises the natural barrier of the glottis between the oropharynx and trachea, which may already be compromised in HNCA patients secondary to tumor effects. Oral decontamination with chlorhexadine or povidone iodine and aspiration of secretions accumulating above the endotracheal tube has been recommended to reduce the incidence of pulmonary contamination,[6] but may not be feasible in HNCA surgical patients because of the potential to disrupt a fresh surgical incision.

Nonmodifiable risk factors associated with VAP include male sex, age >60 years, chronic obstructive pulmonary disease, weight loss, advanced comorbidity, reintubation, tracheostomy status, surgery, and aspiration.[2,5,6,13] Aspiration pneumonia is significantly associated with dysphagia, chronic pulmonary disease, weight loss, and advanced age,[26–29] which are prevalent comorbidities in HNCA patients and risk factors for pneumonia in this study. Dysphagia and aspiration

TABLE VI.
Generalized Linear Regression Analysis of Length of Stay and Hospital Costs.

Variable	Estimate	95% CI	*P* Value	Mean
Length of stay (d)				
Intercept	1.3239	1.2490–1.3987	<.001	7.3
Urgent/emergent admission	0.2461	0.1964–0.2958	<.001	1.8
Hypopharynx primary site	0.1323	0.0567–0.2079	.001	1.0
Medicare	0.0928	0.0411–0.1445	<.001	0.7
Medicaid	0.2869	0.2261–0.3478	<.001	2.1
Self-pay	0.1600	0.0764–0.2436	<.001	1.2
Comorbidity score 1	0.1007	0.0645–0.1370	<.001	0.7
Comorbidity score 2	0.2081	0.1536–0.2626	<.001	1.5
Comorbidity score ≥3	0.3208	0.2454–0.3963	<.001	2.3
Pedicled or free flap reconstruction	0.2381	0.1774–0.2989	<.001	1.7
Major procedure	0.6760	0.6401–0.7120	<.001	4.9
Dysphagia	0.1998	0.1364–0.2632	<.001	1.5
Weight loss	0.3826	0.3054–0.4598	<.001	2.8
Infectious pneumonia	0.7808	0.7107–0.8509	<.001	5.7
Aspiration pneumonia	0.6645	0.5867–0.7423	<.001	4.8
Hospital costs (2011 US$)				
Intercept	9.5312	9.4364–9.6261	<.001	$21,694
Urgent/emergent admission	0.0978	0.0187–0.1769	.015	$2,122
Medicaid	0.2076	0.1471–0.2682	<.001	$4,505
Self-pay	0.0972	0.0179–0.1766	.016	$2,110
Comorbidity score 1	0.0720	0.0244–0.1197	.003	$1,563
Comorbidity score 2	0.1967	0.1406–0.2528	<.001	$4,268
Comorbidity score ≥3	0.2185	0.2297–0.4073	<.001	$6,910
Pedicled or free flap reconstruction	0.2829	0.2217–0.3441	<.001	$6,138
Major procedure	0.6676	0.6321–0.7030	<.001	$14,483
Dysphagia	0.1202	0.0531–0.1874	<.001	$2,609
Weight loss	0.3567	0.2726–0.4408	<.001	$7,739
Infectious pneumonia	0.7880	0.7116–0.8643	<.001	$17,095
Aspiration pneumonia	0.5766	0.4959–0.6574	<.001	$12,510

CI = confidence interval.

pneumonia are more common in patients who have undergone nonoperative treatment for HNCA,[30–32] and surgery is increasingly performed following nonoperative treatment failure in the HNCA population.[33,34] Tracheostomy does not reduce the incidence of aspiration in HNCA surgical patients,[35] and inflation of the tracheostomy tube cuff is associated with an increase in silent aspiration because of desensitization of the larynx and pharynx through a lack of airflow through these structures.[36] Interventions targeted at improving compliance with preventive measures have been shown to reduce the incidence of VAP; however, VAP rates remain substantial despite high compliance due to the major influence of underlying medical conditions, which suggests that the goal of eliminating VAP is unobtainable.[5,13,23] HNCA surgical patients represent a particularly vulnerable population given the increased prevalence of nonmodifiable risk factors for VAP that are associated with HNCA.

The intent of CMS's proposal to designate VAP as a never event is to tie reimbursement to hospital performance. Like many of the other hospital-acquired conditions designated by CMS for payment exclusion, the incidence of these outcomes are higher for safety net hospitals that treat a significant number of uninsured, Medicaid, and other vulnerable populations, who have an increased incidence of the nonmodifiable conditions that are often associated with hospital-acquired conditions.[37] Such hospitals are already burdened by a poor payor mix and have less opportunity to subsidize the costs of care provided to vulnerable populations, and because the costs of treating hospital-acquired conditions are high, this results in a double penalty that can jeopardize the financial viability of hospitals that are already operating on low financial margins who will be disproportionately affected. It is magical thinking to assume that making hospitals responsible for these conditions through nonpayment of care when they occur will result in elimination of hospital-acquired conditions such as VAP, which can be reduced but not completely eradicated. Nonpayment for conditions that are more common in high-risk patients runs the risk of further

increasing limitations on the ability of vulnerable populations to receive care, which presumably was not the intent of this legislation. Rather than focusing on the clinical outcome, a more equitable solution would be to focus on reimbursement for the use of process measures known to prevent hospital-acquired conditions.

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, is limited to a 30-day postoperative window, and contains no information on stage, grade, or subtype of the disease or survival. Thus, although extent of surgery may be a surrogate for stage of disease, the effect of tumor stage and size on outcomes cannot be accurately determined. The ability to adequately control for case-mix is limited when discharge diagnoses from administrative databases are used. Postoperative complications may not be apparent at the time of discharge, and as a result the incidence of complications may be underreported. Similarly, the true incidence of VAP is likely underestimated because of undercoding of VAP, which is difficult to distinguish from infectious or aspiration pneumonia and may not be recognized and coded by administrative personnel. Although patients with a BMI <19 were included in the definition of weight loss, a low BMI may not always indicate malnutrition, and patients with a normal BMI may be malnourished. The extent of weight loss as a percentage of body weight, which has been used to classify severity of malnutrition, cannot be determined from this database. Patients receiving aggressive nutritional support administered in the perioperative period or the use of VAP prevention measures cannot be identified in hospital discharge data, which are limited to diagnosis and procedural codes. 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 demonstrate a significant association between pneumonia and mortality, postoperative surgical complications, acute medical complications, length of hospitalization, and costs in HNCA surgical patients after controlling for all other patient variables, and demonstrate that inherent comorbid conditions associated with HNCA are associated with an increased risk of developing postoperative pneumonia in this population. Withholding reimbursement for pneumonia risks restricting access to care for this high-risk vulnerable population. Rather, aggressive preoperative identification and treatment of risk factors, such as underlying dysphagia and malnutrition, and tying reimbursement to quality metrics that reflect process measures rather than outcomes are a more appropriate means of reducing costs, morbidity, and mortality.

CONCLUSION

Postoperative pneumonia is associated with increased mortality, postoperative complications, length of hospitalization, and hospital-related costs in HNCA surgical patients. Differentiating between infectious pneumonia, aspiration pneumonia, and VAP in the HNCA surgical patient is difficult, and many of the variables associated with an increased risk of VAP are inherent comorbidities in HNCA patients, making this a high-risk group for this never event. Caution must be used in the institution of reforms that threaten to inadequately reimburse the provision of surgical care to this vulnerable population.

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