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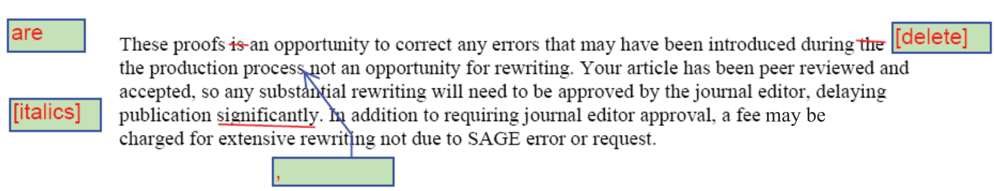


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Original Research

# Laryngeal Preservation in Glottic Cancer: A Comparison of Hospital Charges and Morbidity among Treatment Options

Otolaryngology–Head and Neck Surgery
1–9

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*Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.*

## Abstract

*Objective*. When total laryngectomy is not required, organ preservation surgery or radiotherapy is considered the standard of care for primary glottic cancer. These accepted treatment options are available for early and advanced glottic cancers due to equivalent locoregional control and survival rates. However, in today's climate of accountable care, the financial burden of treatment choices continues to increase in significance. We therefore compared hospital charges and treatment-related morbidity between organ-preserving surgery and radiation with or without chemotherapy—herein, *(chemo)radiation*—[AQ: 2] in the primary treatment of glottic cancer.

*Study Design*. Nationwide Inpatient Sample Database was analyzed to assess clinical and financial information.

*Setting*. Population-based analysis.

*Subjects*. Patients (N = 5499) with primary glottic cancer undergoing treatment with laryngeal preservation strategies.

*Methods*. Patients were subdivided by *ICD-9* codes into 3 treatment groups: endoscopic resection, open partial laryngectomy, and (chemo)radiation. Treatment-related outcomes, charges, and length of hospitalization were analyzed among treatment groups.

*Results*. When adjusting for sex, age, race, comorbidity, and primary payer, (chemo)radiotherapy was associated with increased direct charges ($P < .001$; coefficient, $23,658.99; 95% confidence interval [95% CI]: $10,227.15-$37,090.84) and length of hospitalization ($P < .001$; hazard ratio, 0.593; 95% CI: 0.502-0.702) when compared with endoscopic surgery. As compared with open surgery, endoscopic surgery was associated with reduced hospital charges ($P = .012$; coefficient, $11,967.01; 95% CI: $2,784.17-$21,249.85) and duration of hospitalization ($P < .001$; hazard ratio, 0.749; 95% CI: 0.641-0.876).

*Conclusions*. This analysis suggests that increased utilization of endoscopic surgery in patients with primary glottic cancer not requiring total laryngectomy may lead to reduced financial burden and duration of hospitalization when compared with open surgery or (chemo)radiation therapy.

**Keywords**

larynx, cancer, endoscopic, radiation, cost, hospital charges, cost-effectiveness, morbidity

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Laryngeal cancer presents unique treatment considerations due to the vital role of the larynx in human communication, deglutition, and quality of life.[1] Approximately one half of laryngeal cancers arise from the glottis subsite, with the majority of patients with glottic cancer presenting at early stages (T1 and T2) without vocal cord fixation, nodal involvement, or distant metastases.[2,3] High locoregional control and excellent survival rates for laryngeal cancer have made organ-preserving treatment standard of care, supplanting total laryngectomy in the treatment of all but the most advanced laryngeal tumors or as salvage after failure of other modalities.[2-4] The use of open laryngeal conservation surgery in the treatment of primary glottic cancer is also declining due to advances in endoscopic tumor resection—namely, transoral laser microsurgery and transoral robotic surgery, which have demonstrated improved functional outcomes.[2,5-8]

For early-stage (T1 and T2) glottic tumors, single-modality treatment with either endoscopic resection or radiotherapy can be appropriately recommended with comparable oncologic outcomes.[5-11] Among patients with advanced-stage disease for which surgical intervention does not necessitate total laryngectomy (select T3 tumors), concurrent chemoradiotherapy has

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emerged as an acceptable alternative to laryngeal conservation surgery after the landmark Veterans Affairs study, which demonstrated the efficacy of nonsurgical management of select advanced-stage tumors with induction chemotherapy and radiotherapy.[5,12,13] Oncologic and survival outcomes among various treatment modalities are described elsewhere in the literature;[AQ: 3] however, the success of laryngeal conservation overall, when applied appropriately, has expanded treatment goals beyond survival and tumor control rates to prioritize optimization of posttreatment function, reduced treatment-related morbidity, and overall cost-effectiveness.[9,14-16] To further assess the issue of cost efficacy, we utilized a population-based database and the largest reported cohort of glottic cancer patients to examine hospital charges and indicators of treatment-related morbidity among single-modality organ-preserving strategies for the treatment of primary glottic cancer: endoscopic resection, open partial laryngectomy, and radiation with or without chemotherapy—henceforth, *(chemo)radiation*.

## Methods

A cross-sectional analysis of patients with a diagnosis of primary glottic cancer between the years of 2001 and 2011 was performed with hospital discharge data from the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality. The NIS estimates discharge data for >36 million hospitalizations per year when weighted and provides demographic, clinical, and resource use information regarding the index hospital admission.[17] The application and utility of the NIS, particularly in evaluating laryngeal cancer outcomes, has been previously documented.[18,19]

*International Classification of Disease Ninth Revision* (*ICD-9*) codes were used to ascertain treatment information from discharge records of patients with a primary diagnosis of glottic cancer. **Table 1** details *ICD-9* codes utilized in this study. Patients were subdivided into 3 treatment groups: endoscopic or closed tumor resection, open partial laryngectomy, and (chemo)radiation. There is currently no standardized *ICD-9* coding method for endoscopic laryngeal tumor resection. Research into the coding procedures used by various institutions, as well as review of previous studies,[2,20,21] suggested that surgeons used endoscopic or laryngoscopic procedural codes in addition to partial laryngectomy codes to document endoscopic resection with or without the use of a laser. We therefore utilized endoscopic biopsy and laryngoscopy codes, in addition to codes for unspecified removal of tissue from the larynx and partial laryngectomy codes, to define this group and exclude patients who underwent only biopsy without tumor excision. We excluded patients with these codes from the open partial laryngectomy group to ensure that endoscopic techniques were not utilized in this group.

Inclusionary *ICD-9* treatment codes for 1 treatment group were used as exclusionary criteria for the other treatment groups to ensure that only patients undergoing single-modality treatment were included. Patients with a documented history of glottic cancer prior to the presenting diagnosis, those who received prior irradiation, and those who underwent total laryngectomy were excluded from analysis. Data cells with <11 observations were excluded in statistical analysis and not reported, in compliance with the Healthcare Cost and Utilization Project data use agreement.

Outcomes from the index hospital admission—primarily hospital charges and length of hospitalization—were extracted from the discharge data in the NIS. Measures of posttreatment morbidity and complications were also ascertained from *ICD-9* diagnosis and procedure codes, as depicted in **Table 1**. Socioeconomic status was inferred from the reported average income percentile by zip code, as validated by other population-based studies of this kind.[4] The Charlson comorbidity index and SAS code by Quan et al were utilized to identify, grade, and weight patient comorbidity, excluding *ICD-9* codes for the index cancer diagnosis from the solid tumor category.[22,23] Since the American Joint Committee on Cancer (AJCC) staging is not included in the NIS, disease stage was approximated with the Medstat classification system, where disease severity is defined as risk of organ failure or death. Medstat staging was not included in composite analyses of patient data, since it cannot be used as a reliable substitute for AJCC staging; however, it was applied post hoc to ensure that differences observed among treatment groups were not confounded by disease severity. This study was determined to be exempt from Institutional Review Board approval by the Office of the Human Research Protection Program at the University of California, Los Angeles.

### *Statistical Analyses*

Data were weighted with database hospital and discharge weights, and survey data were analyzed with SAS 9.4 software (SAS Institute, Cary, North Carolina). Survey data characteristics, including clustering, stratification, and weighting, were accounted for in all procedures. Wald $F$ tests were used to evaluate the overall significance of variables in logistic regression models. Demographic characteristics, excluding age and comorbidity indices for which linear regression was used, were analyzed across treatment groups with binary and multinomial logistic regression. Treatment-related morbidity outcomes were assessed with binary logistic regression to account for data skewness toward zero. Hospital charges were analyzed with linear regression in a composite model to adjust for potential confounders, and Cox hazard modeling was used to analyze length of stay among the treatment groups, where the event in the Cox model was defined as discharge from the hospital. A 2-sided $P$ value $<.05$ was considered statistically significant.

## Results

### *Description of Study Population*

We identified 5499 patient records with a diagnosis of a primary glottic cancer and documented treatment with either surgical resection or nonsurgical therapy between 2001 and 2011. Demographic and hospital stay variables are analyzed in **Tables 2** and **3**. The study population was predominantly

**Table 1.** *ICD-9* Diagnosis and Procedure Codes.

| Diagnosis | Code |
|---|---|
| Glottic cancer | 161.0 |
| History of laryngeal cancer | V10.21 |
| Tobacco use | 305.1, 989.84, V15.82 |
| Prior radiation | V15.3 |
| Dysphagia | 787.20, 787.21, 787.22, 787.23, 787.24, 787.29 |
| Posttreatment complications | |
| Surgical complications | 998.2, 998.4, 998.81 |
| Wound complications | 998.3, 998.31, 998.32, 998.33, 998.83 |
| Infection | 998.51, 998.59, 995.91, 995.92 |
| Shock | 998.0, 998.01, 998.02, 998.09 |
| Hemorrhage, seroma, or bleeding | 998.11, 998.12, 998.13 |
| Fistula | 998.6 |
| Other | 998.89, 998.9 |
| **Procedure** | **Code** |
| Total laryngectomy | 30.3, 30.4 |
| Partial laryngectomy: endoscopic resection | 30.1, 30.21, 30.22, 30.29, 31.42, 31.43, 30.09, 31.98 |
| Nonsurgical therapy: external beam radiation | 92.21, 92.22, 92.23, 92.24, 92.25, 92.26, 92.27, 92.28, 92.29, 92.30, 92.31, 92.32, 92.33, 92.39, 92.41 |
| 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 |
| Gastrostomy | 97.51, 42.52, 42.62, 43.11, 43.19, 44.62, 96.36, 9.702 |
| Tracheostomy | 31.1, 31.21, 31.29, 31.74 |

male (83.72%) and white (55.81%), with a mean age of 64.8 years and mean comorbidity index of 1.7. Medicare was most commonly listed as primary payer on hospital discharge records (52.15%), followed by private insurance (27.97%). Treatment of all types was most often classified as elective (47.86%).

### *Factors Associated with Treatment Type*

Endoscopic resection was performed in 2428 cases (44.15%), open partial laryngectomy in 1496 cases (27.20%), and (chemo)radiation in 1575 cases (28.64%). Multinomial logistic regression analysis of variables across treatment groups is shown in **Table 4**. Sex did not statistically differ among treatment groups. Younger patients were more likely to receive nonsurgical therapy ($P$ = .040; coefficient, –2.53; 95% confidence interval [95% CI]: –4.935 to 0.1216). White patients received surgical therapy significantly more often than (chemo)radiotherapy ($P < .001$; odds ratio [OR], 0.601; 95% CI: 0.489-0.738), a trend not observed for black or Hispanic patients; 42.3% of black and 44.69% of Hispanic patients received (chemo)radiotherapy, as opposed to only 26.3% of white patients. Similarly, 49.3% of Medicaid patients received (chemo)radiotherapy, in contrast to only 27.9% of Medicare patients, 21.3% of patients with private insurance, and 20.9% of self-paying patients. Decreased rates of (chemo)radiotherapy were observed among patients with Medicare ($P < .001$; OR, 0.607; 95% CI: 0.488-0.755), patients with private insurance ($P$ = .003; OR, 0.558; 95% CI: 0.378-0.824), and self-paying patients ($P$ = .002; OR, 0.331; 95% CI: 0.166-0.660), whereas Medicaid patients had higher odds of receiving (chemo)radiotherapy as compared with patients with other types of insurance ($P$ = .003; OR, 1.986; 95% CI: 1.269-3.108). Medstat disease severity did not differ between (chemo)radiotherapy and surgical treatment of glottic cancer ($P$ = .6987; OR, 0.030; 95% CI: –0.122 to 0.182).

Patients receiving (chemo)radiotherapy were more likely to necessitate home health care after hospital discharge ($P$ = .011; OR, 2.20; 95% CI: 1.202-4.029) and were less commonly classified as routine category of discharge ($P$ = .002; OR, 0.498; 95% CI: 0.322-0.772). These patients also had higher rates of dysphagia ($P$ = .024; OR, 1.885; 95% CI: 2.965-26.285) and gastrostomy tube placement ($P < .001$; OR, 4.446; 95% CI: 2.891-6.836) compared with patients who underwent surgery.

Of the patients who underwent surgical resection of glottic tumors, 61.88% of cases were endoscopic. The odds of receiving endoscopic resection were greater for white patients than for patients who were black ($P$ = .001; OR, 0.516; 95% CI: 0.347-0.767) and Hispanic ($P$ = .010; OR, .435; 95% CI: 0.231-0.819). Endoscopic surgery was more frequently categorized as routine compared with open surgery ($P$ = .010; OR, 0.623; 95% CI: 0.435-0.892) and

**Table 2.** Demographic Characteristics.[a]

| | Endoscopic Resection | Open Partial Laryngectomy | (Chemo)radiation | All Treatment Groups | *P* Value |
|---|---|---|---|---|---|
| Patients | 2428 (44.15) | 1496 (27.20) | 1575 (28.64) | 5499 (100) | |
| Male | 2046 (84.27) | 1282 (85.70) | 1277 (81.08) | 4604 (83.72) | .2106 |
| Mean age, y | 65.97 | 64.35 | 63.44 | 64.80 | **.0492** |
| Race | | | | | <**.0001** |
| White | 1345 (55.40) | 917 (61.30) | 808 (51.30) | 3069 (55.81) | |
| Black | 272 (11.20) | 95 (6.35) | 269 (17.08) | 636 (11.57) | |
| Hispanic | 189 (7.78) | 66 (4.41) | 206 (13.08) | 461 (8.38) | |
| Asian | 25 (1.03) | 20 (1.33) | 11 (0.70) | 56 (1.02) | |
| Native American | — | 16 (1.07) | — | 26 (0.47) | |
| Other | 73 (3.01) | 31 (2.07) | 45 (2.86) | 149 (2.71) | |
| Mean comorbidity | 1.82 | 1.03 | 2.15 | 1.70 | <**.0001** |
| Primary payer | | | | | <**.0001** |
| Medicare | 1324 (54.53) | 741 (49.53) | 803 (50.98) | 2868 (52.15) | |
| Medicaid | 276 (11.37) | 66 (4.41) | 333 (21.14) | 676 (12.29) | |
| Private insurance | 587 (24.18) | 624 (41.71) | 328 (20.83) | 1538 (27.97) | |
| Self-pay | 149 (6.14) | 36 (2.41) | 49 (3.11) | 235 (4.27) | |
| Income percentile | | | | | <**.0001** |
| 0-25th | 299 (12.31) | 165 (11.03) | 220 (13.97) | 684 (12.44) | |
| 26th-50th | 312 (12.85) | 151 (10.09) | 193 (12.25) | 656 (11.93) | |
| 51st-75th | 264 (10.87) | 170 (11.36) | 239 (15.17) | 673 (12.24) | |
| 76th-100th | 347 (14.29) | 313 (20.92) | 201 (12.76) | 860 (15.64) | |
| Admission type | | | | | <**.0001** |
| Emergency | 770 (31.71) | 38 (2.54) | 711 (45.14) | 1520 (27.64) | |
| Urgent | 406 (16.72) | 143 (9.56) | 264 (16.76) | 812 (14.77) | |
| Elective | 1002 (41.26) | 1147 (76.67) | 482 (30.60) | 2632 (47.86) | |

[a]*(Chemo)radiation* indicates radiation with/without chemotherapy. Values presented in n (%) unless indicated otherwise. Bold *P* value indicates significance ($P <$ .05).[AQ: 4]

**Table 3.** Treatment-Related Hospital Outcomes.[a]

| | Endoscopic Resection | Open Partial Laryngectomy | (Chemo)radiation | All Treatment Groups | *P* Value |
|---|---|---|---|---|---|
| Patients, n (%) | 2428 (44.15) | 1496 (27.20) | 1575 (28.64) | 5499 (100) | |
| Length of stay, d | | | | | <**.0001** |
| Mean | 5.54 | 6.63 | 10.82 | 8.44 | |
| SE | 0.33 | 0.38 | 0.95 | 0.16 | |
| Total charges, $ | | | | | <**.0001** |
| Mean | 34,962 | 46,124 | 59,158 | 47,481 | |
| SE | 2191 | 4430 | 5776 | 4362 | |
| Disposition, n (%) | | | | | <**.0001** |
| Routine | 555 (22.86) | 346 (23.13) | 277 (17.59) | 1178 (21.42) | |
| Home health care | 124 (5.11) | 122 (8.16) | 273 (17.33) | 519 (9.44) | |
| Other transfer | 68 (2.80) | 29 (1.94) | 93 (5.90) | 190 (3.46) | |

[a]*(Chemo)radiation* indicates radiation with/without chemotherapy. Bold *P* value indicates significance ($P <$ .05).

nonsurgical therapy (*P* = .002; OR, 0.498; 95% CI: 0.322-0.772). Ancillary procedures, including neck dissection and free flap or pedicled reconstruction of the surgical site, were performed most commonly in open surgery, with rates of 15.98% and 1.94%, respectively. No significant differences in rates of dysphagia (*P* = .238; OR, 0.665; 95% CI: 0.338-1.309) or gastrostomy tube placement (*P* = .247; OR, 1.314; 95% CI: –0.189 to 0.735) were detected between endoscopic and open surgery. Rates of postoperative complications—including but not limited to wound complications, hemorrhage, shock, and infection—were also not statistically different between modes

**Table 4.** Logistic Regression of Demographic Variables Across Treatment Groups.[a]

| | Open Partial Laryngectomy | | | (Chemo)radiation | | |
|---|---|---|---|---|---|---|
| | *P* Value | Relative Risk Ratio | 95% CI | *P* Value | Relative Risk Ratio | 95% CI |
| Sex | .408 | 0.841 | 0.558 to 1.268 | .226 | 1.265 | 0.865 to 1.851 |
| Age | .080 | –1.63[b] | –3.450 to 0.193 | **.040** | –2.53[b] | −4.935 to −0.122 |
| Comorbidity | <**.001** | –0.789[b] | –1.063 to –0.515 | .076 | 0.328[b] | –0.034 to 0.690 |
| Race | | | | | | |
| White | **.002** | 0.682 | 0.538 to 0.864 | < **.001** | 0.601 | 0.489 to 0.738 |
| Black | < **.001** | 0.348 | 0.195 to 0.623 | .959 | 0.988 | 0.615 to 1.587 |
| Hispanic | < **.001** | 0.348 | 0.189 to 0.641 | .769 | 1.093 | 0.604 to 1.976 |
| Asian | .699 | 0.781 | 0.223 to 2.735 | .333 | 0.422 | 0.073 to 2.421 |
| Primary payer | | | | | | |
| Medicare | < **.001** | 0.560 | 0.442 to 0.710 | < **.001** | 0.607 | 0.488 to 0.755 |
| Medicaid | < **.001** | 0.238 | 0.138 to 0.412 | .364 | 1.205 | 0.805 to 1.804 |
| Private insurance | .665 | 1.063 | 0.806 to 1.403 | **.003** | 0.558 | 0.378 to 0.824 |
| Self-pay | < **.001** | 0.241 | 0.111 to 0.523 | **.002** | 0.331 | 0.166 to 0.660 |
| Income percentile | | | | | | |
| 0-25th | **.012** | 0.552 | 0.347 to 0.877 | .236 | 0.735 | 0.442 to 1.222 |
| 26th-50th | **.001** | 0.482 | 0.331 to 0.702 | .072 | 0.616 | 0.365 to 1.045 |
| 51st-75th | .063 | 0.646 | 0.408 to 1.024 | .623 | 0.906 | 0.610 to 1.344 |
| 76th-100th | .595 | 0.904 | 0.622 to 1.313 | **.017** | 0.579 | 0.370 to 0.907 |
| Admission type | | | | | | |
| Emergency | < **.001** | 0.050 | 0.020 to 0.122 | .515 | 0.923 | 0.727 to 1.174 |
| Urgent | < **.001** | 0.352 | 0.216 to 0.573 | **.020** | 0.652 | 0.455 to 0.934 |
| Elective | .253 | 1.144 | 0.908 to 1.442 | **.001** | 0.481 | 0.310 to 0.746 |

[a]Endoscopic resection: referent treatment group. *(Chemo)radiation* indicates radiation with/without chemotherapy. Bold *P* value indicates significance ($P < .05$).
[b]Coefficient in linear regression model.

of surgical resection ($P$ = .685; OR, 1.152; 95% CI: 0.581-2.282).

### *Treatment-Related Outcomes*

Total hospital charges and length of stay were greatest for patients who received (chemo)radiotherapy (mean $59,158 and 10.8 days) and lowest for those who received endoscopic resection (mean $34,962 and 5.5 days). Multivariate generalized linear regression of total charges and Cox hazard ratio analysis of length of stay are shown in **Table 5**. When adjusting for sex, age, race, and primary payer, only 2 factors significantly affected hospital charges and length of hospitalization: comorbidity and treatment group. Patients who received open surgery ($P$ = .012; coefficient, $11,967.01; 95% CI: 2784.17-21,149.85) and nonsurgical therapy ($P$ = .001; coefficient, $23,658.99; 95% CI: 10,227.15-37,090.84) incurred increased hospital-related charges compared with those who received endoscopic surgery. Hazard ratios <1.0, demonstrating a reduced chance of hospital discharge, were observed for patients who received open surgery ($P < .001$; hazard ratio, 0.749; 95% CI: 0.641-0.876) and nonsurgical therapy ($P < .001$; hazard ratio, 0.593; 95% CI: 0.502-0.702), as opposed to patients who received endoscopic surgery. Patients with high comorbidity indices incurred greater hospital-related charges and had longer lengths of hospitalization.

## Discussion

While survival rates for primary cancer of the glottis are excellent, current recommendations for the treatment of glottic cancer when total laryngectomy is not necessitated are without clear consensus.[5,8,14] Surgical and nonsurgical treatment modalities both have associated advantages and disadvantages. Surgery offers the benefits of immediate treatment, the ability to analyze tumor histopathology (including locoregional spread and perineural invasion), as well as increased salvage options in the case of recurrence. Tumor resection, however, disrupts the complex anatomy of the head and neck and confers risks of general anesthesia and postoperative complications. Minimally invasive transoral techniques—including transoral microsurgery with laser or cold knife and, more recently, transoral robotic surgery—have been shown to ameliorate some of these disadvantages by optimizing postsurgical function and decreasing complications.[2,5-8,24] However, these advanced endoscopic techniques require access to high-volume and experienced surgeons as well as to institutions equipped to perform these complex procedures.[8,14,18,24,25] Notwithstanding, the use of endoscopic surgery is increasing, coupled with a decrease in utilization of open surgery,[2,8,20] and in this nationwide study population, indeed more patients underwent endoscopic surgery than open surgery to resect glottic tumors.

**Table 5.** Total Treatment Charges and Length of Stay.[a]

| | Linear Regression Analysis of Total Treatment Charges | | | Cox Hazard Analysis of Hospital Discharge | | |
|---|---|---|---|---|---|---|
| | Estimate | 95% CI | *P* Value | Hazard Ratio | 95% CI | *P* Value |
| Intercept | $29,745.91 | –21,915.05 to 81,406.87 | .258 | — | — | — |
| Treatment group | | | | | | |
| Endoscopic resection | Referent | Referent | Referent | Referent | Referent | Referent |
| Open partial laryngectomy | $11,967.01 | 2784.17 to 21,249.85 | **.012** | 0.749 | 0.641 to 0.876 | < **.001** |
| (Chemo)radiation | $23,658.99 | 10,227.15 to 37,090.84 | **.001** | 0.593 | 0.502 to 0.702 | < **.001** |
| Age | $109.80 | –507.17 to 726.78 | .727 | 0.993 | 0.986 to 1.000 | .066 |
| Male | –$4459.93 | –19,578.07 to 10,660.21 | .562 | 1.140 | 0.962 to 1.351 | .130 |
| Race | | | | | | |
| White | Referent | Referent | Referent | Referent | Referent | Referent |
| Black | –$4,933.04 | –21,633 to 11,767 | .562 | 0.898 | 0.709 to 1.138 | .374 |
| Hispanic | –$7,529.61 | –21,757 to 6697.46 | .299 | 0.991 | 0.828 to 1.187 | .925 |
| Asian | $20,152 | –10,814 to 51,118 | .202 | 0.870 | 0.484 to 1.565 | .641 |
| Native American | $62,110 | –37,263 to 161,484 | .220 | 0.393 | 0.147 to 1.048 | .062 |
| Comorbidity | $3,813.68 | 1967.33 to 5660.03 | < **.001** | 0.917 | 0.893 to 0.942 | < **.001** |
| Primary payer | | | | | | |
| Medicare | Referent | Referent | Referent | Referent | Referent | Referent |
| Medicaid | $6,013.16 | –17,837 to 29,864 | .620 | 0.891 | 0.677 to 1.172 | .407 |
| Private insurance | –$7,327.62 | –19,552 to 6896.56 | .239 | 1.176 | 0.993 to 1.393 | .061 |
| Self-pay | $5,206.51 | –25,247 to 35,660 | .737 | 0.802 | 0.549 to 1.172 | .254 |

[a]*(Chemo)radiation* indicates radiation with/without chemotherapy. Bold *P* value indicates significance ($P < .05$).

Conversely, (chemo)radiotherapy does not require administration of general anesthesia and is not dependent on accessible tumor location and adequate surgical exposure to the glottis. Nonsurgical therapy has been suggested to lead to superior functional outcomes, particularly with respect to voice quality[8,26-28]; however, several other reports demonstrate that endoscopic resection can lead to equivalent or even superior levels of voice and swallowing function when compared with radiotherapy.[6,9,14,29-33] Disadvantages of nonsurgical therapy include the requirement for patient compliance in a 6-week treatment regimen, radiation- and chemotherapy-specific adverse effects, and necessitation of surgical salvage in the case of recurrence.[10] Salvage after radiotherapy requires total laryngectomy in more than half of cases and predisposes patients to higher rates of wound complications postoperatively.[34-36]

While more prospective data trials comparing treatment modalities for primary glottic cancer are needed to better guide treatment recommendations, our nationwide analysis helps to elucidate the single-modality treatment decisions that are currently employed for patients with primary glottic cancer and the associated direct financial costs and morbidity. Particularly, the use of the NIS offered the largest glottic cancer cohort analysis within the English-language literature. In this study, treatment type was influenced by comorbidity, race, and insurance type. Patients with greater comorbidity received nonsurgical treatments more commonly and rarely underwent open surgery, possibly due to the higher risks of surgery in these patients. Nearly 75% of white patients received surgery to resect glottic tumors, most frequently endoscopic, while patients of racial-ethnic minorities were roughly twice as likely to be treated with nonsurgical modalities. Shin et al examined existing racial disparities in laryngeal cancer treatment and outcomes in a similar patient population and found that black patients were more likely to present with advanced-staged cancer than white patients and had poorer survival statistics.[12,37-39] Black patients have also been shown to be less likely than white patients to receive larynx-conserving surgery for similarly staged tumors.[40] Racial inequalities in cancer treatment are not unique to laryngeal cancer and have been thought to be in part due to differences in socioeconomic status, barriers in access to health care resources, advanced staging at presentation, and preexisting comorbidities.[38] In support of socioeconomic status as a driver of these disparities, we observed that Medicaid patients also had much higher rates of nonsurgical treatment for glottic cancer than did patients with other insurance types. Chen and Halpern previously demonstrated increased risk of mortality from laryngeal cancer among black patients and patients with Medicaid as compared with whites and patients with private insurance.[12]

Cost-effective strategies are paramount in today's climate of increased scrutiny regarding increasing health care costs and attempts to make treatment resources widely accessible and affordable. Financial variables can play an even more substantial role in treatment recommendations when modalities have equivalent oncologic efficacy. In a recent meta-analysis, Higgins demonstrated the cost utility of endoscopic tumor resection via transoral laser excision versus external beam radiation for early-stage glottic cancer.[14] Our results similarly demonstrate the cost utility of endoscopic resection compared with (chemo)radiotherapy as well as open surgery. While financial figures reported in this study solely reflect direct charges associated with hospital stay, consideration of indirect costs is also required to fully elucidate the financial burden of therapy. In discharge disposition data, (chemo)radiotherapy was less likely to be classified as routine, and more patients necessitated home health care than did patients who underwent surgery. Several prior studies also commented on the increased indirect costs associated with (chemo)radiotherapy, including transportation and days missed from work,[16] which may ultimately intensify the findings of the present analysis.

Among laryngeal conservation treatment approaches, surgical tumor excision, especially endoscopic resection, afforded substantial improvements in length of hospital stay when compared with (chemo)radiotherapy. On average, patients who received (chemo)radiotherapy remained in the hospital roughly 4 days longer than those who underwent surgery, even after correcting for sex, age, race, comorbidity, and primary payer. Swallowing function is another important marker of morbidity following larynx-preserving treatments, and rates of dysphagia were found to be higher in the nonsurgical treatment group, supported by a rate of gastrostomy tube placement that was more than double that seen in endoscopic or open surgery.

While this study provides valuable information regarding treatment costs and morbidity, a major limitation with the methodology is the lack of TNM staging information contained in the NIS database. Endoscopic surgery is primarily recommended for early-stage (T1 and T2) and select T3 glottic tumors, potentially allowing for bias toward advanced-stage tumors in the nonsurgical treatment group (including advanced T3 or even T4 disease). However, the standard error for total charges upon hospital discharge for patients receiving (chemo)radiotherapy was only $5776, supporting the conclusion that charges for the majority of patients within the treatment group, no matter stage of disease, were within a relatively narrow margin. A second corroborating factor supporting our analysis without TNM staging was that the Medstat disease staging in the NIS database, while not a substitute for AJCC staging, did not significantly differ between patients receiving (chemo)radiotherapy and those receiving surgery. As such, we can conclude that the overall severity of disease states among treatment groups did not significantly differ to a level that substantially affected the analyses.

Another limitation of this study is the lack of an established *ICD-9* code for endoscopic resection of glottic tumors. While we ensured that patients who underwent biopsy alone were not included in the endoscopic resection group—which would negate results by potentially making hospital charges associated with endoscopic resection appear lower—there is the possibility that patients who underwent diagnostic laryngoscopy immediately prior to an open partial laryngectomy would be included in this group. However, since open partial laryngectomy was seen to be associated with increased hospital-related charges, if some of these patients were erroneously included, it would only serve to weaken our findings, with endoscopic resection amounting to higher charges than in actuality. Since endoscopic surgery was still observed to be associated with significantly reduced hospital charges versus open procedures, our conclusions about the cost efficacy of endoscopic tumor resection remain valid.

Other limitations of our study included our ability to assess outcomes only for single-modality treatments for laryngeal cancer performed within an index hospital admission. Due to the organization of the NIS into discrete hospital stays, longitudinal follow-up was not possible to assess the impact of multimodality therapy as well as salvage after treatment failure on hospital charges and morbidity. We also were able to examine only hospitalized patients, potentially excluding patients who underwent outpatient surgical procedures or patients who were receiving (chemo)radiation and not admitted to the hospital. Without follow-up data, we were further unable to assess oncologic outcome and survival differences among larynx-preserving treatments. Finally, limitations associated with the use of administrative data of this kind—including low response rates for variables such as disposition and income percentile, as well as potential misclassification of patient data based on *ICD-9* codes—might have caused errors in results and analysis. *CPT* codes are usually used in clinical practice to document procedures, and they provide increased detail as compared with the *ICD-9* codes available through the NIS, possibly leading to misclassification or oversimplification of diagnoses or procedures performed. Notwithstanding the accepted methodological limitations, the advantage of the NIS to offer the largest cohort of primary glottic cancer studied to date yields the substantial statistical power necessary to evaluate these important treatment considerations.

## Conclusion

In this study, endoscopic resection of primary glottic cancer demonstrated superior fiscal responsibility and was associated with decreased length of hospitalization when compared with open surgery and (chemo)radiation without resulting in increased postoperative morbidity. Further study and resources should be directed toward improving appropriate application of endoscopic surgical techniques in the head and neck cancer population. Additionally, as treatment modalities for glottic cancer continue to advance, special attention should be paid to the racial and socioeconomic disparities that currently exist, to avoid exacerbation of these inequalities.

### Author Contributions

**Rachel S. Mandelbaum**, study design, acquisition of data, data analysis and statistics, data interpretation, drafting of the manuscript, edits to the manuscript, final approval, accountability for all aspects of the work; **Elliot Abemayor**, interpretation of data, drafting and edits of the manuscript, final approval, editing of manuscript, accountability for all aspects of the work; **Abie H. Mendelsohn**, study design, interpretation of the data, drafting of the manuscript, edits to manuscript, final approval, accountability for all aspects of the work.

## Disclosures

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