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Cost-Identification Analysis of Total Laryngectomy: An Itemized Approach to Hospital Costs

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Abstract

Objectives—To understand the contribution of intraoperative and postoperative hospital costs to total hospital costs, examine the costs associated with specific hospital services in the postoperative period, and recognize the impact of patient factors on hospital costs.

Study Design—Case series with chart review.

Setting—Large tertiary care teaching hospital system.

Subjects and Methods—Using the Pittsburgh Head and Neck Organ-Specific Database, 119 patients were identified as having total laryngectomy with bilateral selective neck dissection and primary closure from 1999 to 2009. Cost data were obtained for 112 patients. Costs include fixed and variable costs, adjusted to 2010 US dollars using the Consumer Price Index.

Results—Mean total hospital costs were \$29 563 (range, \$10 915 to \$120 345). Operating room costs averaged 24% of total hospital costs, whereas room charges, respiratory therapy, laboratory, pharmacy, and radiology accounted for 38%, 14%, 8%, 7%, and 3%, respectively. Median length of stay was 9 days (range, 6–43), and median Charlson comorbidity index score was 8 (2–16).

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Author Contributions

Raj C. Dedhia, substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; **Kenneth J. Smith**, substantial contribution to conception and design; **Joel L. Weissfeld**, substantial contribution to conception and design; **Melissa I. Saul**, substantial contribution to conception and design; **Steve C. Lee**, substantial contribution to analysis and interpretation of data; **Eugene N. Myers**, substantial contribution to analysis and interpretation of data; **Jonas T. Johnson**, substantial contribution to conception and design.

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Patients with 1 day in the intensive care unit had significantly higher hospital costs (\$46 831 vs \$24 601, $P < .01$). The authors found no significant cost differences with stratification based on previous radiation therapy (\$27 598 vs \$29 915 with no prior radiation, $P = .62$) or hospital readmission within 30 days (\$29 483 vs \$29 609 without readmission, $P = .97$).

Conclusion—This is one of few studies in surgery and the first in otolaryngology to analyze hospital costs for a relatively standardized procedure. Further work will include cost analysis from multiple centers with investigation of global cost drivers.

Keywords

cost-effectiveness analysis; laryngeal cancer; health economics; hospital finance

The focus on global cost containment in the United States health system has received heightened attention both politically and academically in the recent past.^{1,2} In 2006, the United States spent \$649 billion in national health expenditures related to hospital care.³ In this same year, 62% of all hospital admissions (ie, 24 million admissions) involved at least 1 procedure. With the growth of biomedical technology and prevalence of age-related illness, the cost and quantity of hospital-based procedures have risen. Between 1997 and 2006, both average costs per stay (after inflation adjustment) and number of discharges with at least 1 procedure rose by 35% and 14%, respectively.⁴ Given the steadily increasing costs and volume of procedure-related health care, identifying cost drivers in procedure-based care serves as a basic step in practicing cost-effective medicine. Although the term *procedures* encompasses both surgical and nonsurgical interventions, our group's interests lie in the field of surgery, on which the remainder of this article will focus.

Cost-analysis in medicine can be performed from 1 of 4 perspectives: cost-identification, cost-benefit, cost-effectiveness, and cost-utility.⁵ We have chosen to study the perspective of cost-identification, a simple accounting of the costs incurred as the result of an intervention. Unlike the other types of cost-analysis, this type of analysis does not include the benefit of each treatment modality. Given the exclusive focus on costs, this method best serves the objective of studying drivers for cost variation.

To isolate sources of variation in intraoperative and postoperative hospital costs, it is ideal to examine a single procedure that is both relatively common and standardized with respect to surgical technique and postoperative care. As a result, we have selected total laryngectomy with bilateral neck dissection (levels II–IV) and primary closure as the study surgery.

Methods

The study protocol was approved by the University of Pittsburgh's Institutional Review Board in December 2009. The initial search was conducted via the clinical database of the National Cancer Institute–funded University of Pittsburgh Cancer Institute's Head and Neck Organ-Specific Database (HNOSD). In an effort to minimize case variation, surgeries requiring total pharyngectomy and local and/or distal flap reconstruction were excluded. Surgeries involving partial/ total thyroidectomy and partial pharyngectomy were not excluded as this was unlikely to add significant operative time or significantly change postoperative care.

As procedure type is a free text field in this database, we were not able to search by specific procedure. Instead, the patient records were initially filtered by selecting for (a) attending physician in the head and neck division, (b) site of primary cancer potentially resulting in total laryngectomy, and (c) surgical procedure between January 1, 1999, and January 1, 2010. In total, 681 procedures resulted from this search. Of 681 procedures fulfilling these

criteria, 174 included total laryngectomy with bilateral neck dissection with primary closure. Of the 174 cases, 55 cases included total pharyngectomy or neck dissection other than bilateral lateral (levels II–IV) neck dissection. As a result, 119 cases satisfied the study criteria. Four of these records were incomplete, yielding 115 cases from the HNOSD (Figure 1). Patient characteristics, including patient age at time of surgery, gender, attending surgeon, and previous radiation therapy, were recorded.

Using identifying information, including patient medical record number and date of operation, the 115 cases from the HNOSD were cross-matched with the study administrative database, the University of Pittsburgh Medical Center Medical Archival System (MARS), using an honest broker. A total of 112 matching records were retrieved. Patient data containing the following variables were obtained: Charlson comorbidity index, hospital readmission within 30 days of discharge, length of stay, and time in intensive care unit (ICU).

Patient hospital charges were itemized by date of service, description of service, and revenue department. Hospital costs were calculated from hospital charges using known departmental cost/charge ratios. Costs in this analysis were in the form of fully loaded cost (FLC), the sum of fixed and variable costs. All costs from 1999 to 2009 were adjusted to January 2010 US dollars using the US Consumer Price Index.

Two-tailed Student *t* tests assuming equal variances, one-way analysis of variance (ANOVA), and linear regression were performed to evaluate differences among subgroups with respect to costs.

Results

Table 1 demonstrates the baseline patient characteristics of the study population.

Total hospital costs followed a skew normal distribution with a positive skew. The mean value was \$29 563 with a standard deviation of \$17 451. Six values fell beyond 2 standard deviations above the mean, with maximum value at \$120 345.

Length of stay also followed a skew normal distribution with a positive skew (Figure 2). Mean length of stay was 11.0 days with standard deviation of 6.3 days.

Operating room costs averaged 24% of total hospital costs, whereas room charges, laboratory, pharmacy, and radiology accounted for 38%, 8%, 7%, and 3% respectively. Respiratory therapy unexpectedly accounted for 14% of all costs (or \$4223). Costs apportioned to respiratory therapy remained consistent over the hospital stay.

Figure 3 illustrates the fraction of hospital costs applied on postoperative days 1 to 10. Error bars represent 1 standard deviation from the mean value. Postoperative day 0 accrued 38% of total hospital costs followed by postoperative day 1 consuming 9% of total costs. The remainder of the postoperative period consumed less than 8% of total costs and trended steadily downward.

Table 2 demonstrates the patient characteristic variables and their effect on total costs. Linear regression revealed no correlation between hospital costs and age, a slight correlation between hospital costs and Charlson comorbidity index, and a strong, positive correlation between length of stay and hospital costs. Gender, previous radiation therapy, and hospital readmission within 30 days of discharge did not bear significance with respect to total hospital costs. One-way ANOVA was used to examine the relationship between attending

surgeon and hospital costs. There was no difference in mean costs among 8 attending surgeons.

Patients who spent at least 1 day in the ICU had nearly twice the hospital costs compared to non-ICU users (\$46 831 vs \$24 601, $P < .01$). Patients requiring intensive care were found to be older (69.4 vs 63.9 years, $P = .03$) and of poorer health status by Charlson comorbidity index (9.7 vs 7.1, $P < .01$) than non-ICU patients.

Discussion

To our knowledge, this is the first study to perform a cost-identification analysis in the field of head and neck surgery. The above findings demonstrate a 10-fold range of hospital costs (roughly \$10 000 to \$100 000) for total laryngectomy with bilateral neck dissection and primary closure bearing a high correlation with a wide range of lengths of stay (6–43 days). Most hospital costs (38%) were borne on the first hospital day (postoperative day 0), commensurate with the high costs of operating room time and materials. The costs associated with patient rooms, operating room, and respiratory therapy represented 38%, 24%, and 14%, respectively of the total hospital costs. The value added from respiratory therapy is unclear; this topic will be addressed later in this section.

Comorbid factors, including patient age and the Charlson comorbidity index, had little/no impact on hospital costs as well as previous radiation therapy and return to hospital within 30 days of discharge. In addition, the 8 attending surgeons did not have a statistically significant difference in hospital costs related to the surgery. Apart from length of stay, only the presence of an ICU stay yielded statistically significant subgroup differences.

There is a dearth of literature analyzing sources for cost variation in general surgery and surgical subspecialties. Two larger studies warrant discussion. In 2006, Hall et al⁶ studied the effect of 29 general surgeons on variation in hospital costs. The authors examined various surgeries while using procedural complexity based on work relative value units and patient case mix to standardize surgeries. The study concluded that “individual surgeons appear to have statistically and clinically significant differences in their costs and volatility of costs when holding patient factors and procedural complexity constant.” In the field of orthopedic surgery, Green et al⁷ examined factors related to a single procedure, rotator cuff surgery, in 1077 rotator cuff repairs performed by 32 surgeons. In lieu of targeting costs as the primary outcome, the study focused on readmission rates, length of stay, and operative time as outcome measures. The authors concluded that “variation in length of stay and operative time [not readmission rates] associated with rotator cuff surgery is largely explained by surgeon practice patterns.” The above 2 studies indicate that surgeon variation plays a significant role in hospital costs and related variables.

In the head and neck oncologic surgery literature, no studies have directly examined the effect of patient and hospital variables on costs. BuSaba and Schaumberg⁸ examined 68 variables affecting length of stay in the preoperative, intraoperative, and postoperative periods of elective major head and neck surgeries in the Veterans Administration system. They discovered that several comorbid conditions, longer operative time, intraoperative transfusion of erythrocytes, return to operating room within 30 days of initial procedure, and postoperative complications were significantly associated with increased length of stay.

In our study, we sought to combine the approaches of Hall et al⁶ and Green et al⁷ by selecting hospital costs as the primary outcome and choosing total laryngectomy with bilateral neck dissection and primary closure for purposes of standardization. The most surprising finding of this cost-identification study appears to be the costs consumed by respiratory therapy. More than 14% of the total hospital costs are designated as respiratory

therapy costs, which remain consistent for the duration of the hospital. For the immediate postoperative care of the laryngeal stoma, wound care and humidified oxygen represent the standard of care at our institution. Every total laryngectomy patient receives a consult from the respiratory therapy department per the computerized physician order entry (CPOE) order set. The primary role of respiratory therapy at our institution is to minimize the mucous plug–related morbidity and mortality via suction, lavage, and positive-pressure bag ventilation.

Unlike the above-mentioned articles, the attending surgeons in our study did not have an impact on hospital costs. We believe that this is likely reflective of the immense variability in experience of surgical teams at teaching hospitals, which are independent of the attending surgeon. As a result, surgeon experience is unlikely to equate to decreased operating time or decreased operating room costs.

This study bears several limitations. As a retrospective chart review, data collection remains less than ideal. Seven of the 119 patient records that met the criteria were discarded because they were either incomplete or not able to be properly located. Detailed clinical information regarding patient health status and hospital complications was not available. Our sample size of 112 significantly underestimates the number of total laryngectomies performed at our institution. The smaller sample size is largely attributed to our stringent criteria (to maintain standardization), including bilateral lateral neck dissection, exclusion of total pharyngectomies, and local or distal reconstruction. We modeled FLC, which emanates from charges using departmental cost-to-charge ratios. Although cost-to-charge ratios technically apply to entire department budgets, not individual services, we have used cost-to-charge ratios on individual services.

We were not able to precisely measure intraoperative costs from a micro-costing perspective. Micro-costing refers to cost accounting on a small scale and is an ideal method to capture resource usage.⁹ Given the availability of retrospective data, it was not feasible to use the micro-costing technique. We also did not include intraoperative time as a variable. This was done purposefully as surgeons often perform direct laryngoscopy with or without biopsy prior to beginning the procedure. This adds significant time to the operating room time and would not allow for an equal comparison across surgeries.

To address the limitations of this study, a prospective evaluation needs to be performed. Prospective evaluation would allow for capturing key pieces of missing data mentioned above, including detailed clinical information and costs of individual items.

In summary, we have begun the formal exploration of intraoperative and postoperative costs for a standardized procedure in head and neck surgical oncology. Future work will include prospective investigation of cost drivers across institutions to gain a deeper understanding of hospital cost structure and identify potential areas of monetary inefficiency.

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Figure 1. Search strategy. HNOSD, University of Pittsburgh Cancer Institute's Head and Neck Organ-Specific Database; MARS, University of Pittsburgh Medical Center Medical Archival System.

Figure 2.
Variability in length of stay.

Percent Total Costs by Hospital Day

Figure 3.

Fractional daily cost in postoperative period. Black data points = mean percentage of total cost for each day; error bars = ± 1 standard deviation.

Table 1**Baseline Patient Characteristics**

Age, y, mean (SD)	65.2 (10.9)
Gender, % male	76.7
Charlson comorbidity index score, mean (SD)	7.7 (3.3)
Previous chemoradiation therapy, %	15.2
Hospital readmission within 30 days, %	35.8
Length of stay, d, mean (SD)	11.0 (6.3)
1 night in intensive care unit, %	24.1

Table 2

Effect of Patient Characteristics on Total Cost

Stratification	Cost Difference	Statistical Test	Test Value
Age	NA	Linear regression	$R^2 = 0.0039$, $P = .52$
Male gender	\$29 550 (vs \$29 605)	Student <i>t</i> test	$P = .99$
Surgeon	NA	One-way ANOVA	$P = .76$
Previous radiation therapy	\$27 598 (vs \$29 915)	Student <i>t</i> test	$P = .62$
Charlson comorbidity index	NA	Linear regression	Adjusted $R^2 = 0.025$, $P = .052$
Hospital readmission within 30 days of discharge	\$29 483 (vs \$29 609)	Student <i>t</i> test	$P = .97$
Length of stay	NA	Linear regression	Adjusted $R^2 = 0.72$, $P < .01$
1 night in ICU	\$46 831 (vs \$24 601)	Student <i>t</i> test	$P < .01$

Abbreviations: ANOVA, analysis of variance; ICU, intensive care unit; NA, not applicable.