Estimating the Annual Incremental Cost of Several Complications Following Pulmonary Lobectomy

Oliver K. Jawitz, MD,[*] Daniel J. Boffa, MD,[,†] Frank C. Detterbeck, MD,[*,†] Zuoheng Wang, PhD,[†,‡] and Anthony W. Kim, MD[*,†]*

Determine the incremental increase in cost as well as length of hospital stay associated with several major complications following pulmonary lobectomy using a large national dataset. A retrospective cohort analysis of the 2012 National Inpatient Sample, Healthcare Cost and Utilization Project database was performed. Demographic and clinical data on patients ≥18 years having undergone an open or VATS lobectomy were included in the analysis. The median increase in cost and length of stay associated with relevant major complications were determined using a multivariable quantile regression model. Nearly one-quarter (24.9%) of hospitalizations for pulmonary lobectomy resulted in at least one complication such as air leak and acute respiratory failure, among others. The most costly complication was empyema with fistula, which was associated with a median net increase in hospital cost of $21,427 and an increased length of hospital stay of 11.6 days. Overall, however, acute respiratory failure accounted for the largest increase in aggregate national costs—$13.4 million. The most common complication was postoperative air leak, which was associated with a median net increase in cost and length of hospitalization of $3219 and 1.9 days, respectively. In aggregate, these complications accounted for nearly $40 million of annual health care expenditures. Complications following pulmonary lobectomy significantly increase in the cost and length of hospitalization. This data has the potential to help identify future areas of improvement, especially in today's era of shifting reimbursement policies aimed at cutting costs and improving health care quality.

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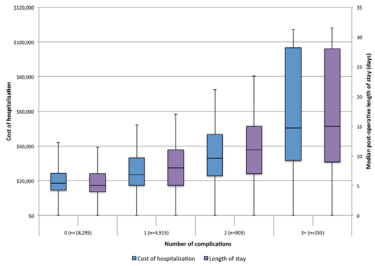

Affect of postlobectomy complications on cost of hospitalization and length of stay.

Central Message

Complications following pulmonary lobectomy result in a significant increase in the cost and length of hospitalization.

Perspective

With increasing national attention focused on health care cost containment, there is a lack of published data documenting the cost of postlobectomy complications. In this analysis, these costs were evaluated and found to amount to nearly $40 million annually. These findings would help clinicians and policymakers determine future areas of improvement and provide benchmarks for cost-saving initiatives.

INTRODUCTION

Prompted by the rapidly increasing health care costs seen in recent years, several national policy initiatives including changes to Medicare reimbursement patterns have been enacted to help decrease costs and promote the long-term economic viability of the health care system. In 2005, these ballooning health care expenditures accounted for close to $2 trillion, and have been increasing at over double the rate of the United States Gross Domestic Product. Almost one-third of this amount has been attributed to surgical costs.[1] For the purposes of cutting costs and improving quality, there has been a widespread effort to investigate the effect of complications on postoperative outcomes. It has already been well established that, as expected, complications and health care costs are directly related.[2,3] There is a lack of published data, however, evaluating the effect of specific individual perioperative events and complications on total hospital costs.

The purpose of this study was to determine the incidence of various relevant postlobectomy complications and subsequently ascertain the incremental increase in hospital costs that can be attributed to each. This otherwise unavailable data has the potential to be very useful for physicians, administrators, and policymakers who wish to more fully understand the economic effect of perioperative complications. Specifically, this analysis may help identify future areas of improvement and

[*]Department of Surgery, Duke University School of Medicine, Durham, North Carolina
[†]Section of Thoracic Surgery, Yale School of Medicine, New Haven, Connecticut
[‡]Department of Biostatistics, Yale School of Public Health, New Haven, Connecticut

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Address reprint requests to Anthony W. Kim, MD, Section of Thoracic Surgery, Yale School of Medicine, 330 Cedar St, BB 205, New Haven, CT 06520. E-mail: anthony.kim@yale.edu

highlight the need for investments in complication-averting strategies.

METHODS

Data Source

This study is a retrospective cohort analysis of the 2012 National Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), which is maintained by the Agency for Healthcare Research and Quality. The NIS is the largest database of all-payer inpatient hospital stays in the United States and represents a 20% stratified sample of all discharges from nonfederal hospitals. In aggregate, the database contains discharge records including relevant diagnoses, procedures, and charges from over 8 million inpatient hospital stays annually. Statistical weighting permits extrapolation of national estimates representative of all US hospitals. This study was deemed exempt by Yale University's Institutional Review Board.

Inclusion Criteria

All adult patients (age $\geq$ 18 years) who underwent an open or video-assisted thoracoscopic surgery (VATS) lobectomy in year 2012 were included in the analysis. Prior years were excluded because of an alteration in HCUP-NIS sampling strategy beginning in 2012 as well as the lack of several relevant International Classification of Diseases, Ninth Revision (ICD-9) codes in previous years. Procedure type was defined by the ICD-9, Clinical Modification (ICD-9-CM) codes for open (32.49) or VATS (32.41) lobectomy in any procedure position. Patients undergoing a robotic procedure (ICD-9-CM code 17.4x) were excluded from the study because of the inability to account for the amortized cost of the robot. As a result, the increased costs associated with various complications following robotic procedures could not be precisely differentiated from costs associated with use of the robot, itself. Patients with a preoperative diagnosis of metastatic cancer, as defined by the ICD-9 codes 196.x-199.x were also excluded from the study, except for those patients only carrying a diagnosis of secondary malignant neoplasm of intrathoracic lymph nodes (196.1). Patient records with missing cost data were excluded as well ($n = 118$, 2.1%). Lastly, for the purpose of limiting the analysis to a standard well-defined cohort of patients, hospitalizations flagged as a nonelective admission ($n = 2565$, 9.4%) as well as those in which lobectomies were performed later than day 1 of hospitalization ($n = 455$, 1.8%) were excluded.

Demographics

Patient baseline demographic characteristics included age, gender, elective or nonelective admission, hospital location or teaching status (rural or urban, teaching or nonteaching), and expected primary payer (Medicare or Medicaid or private insurance or self-pay or other). Elixhauser comorbidities were generated from ICD-9-CM diagnosis codes using the HCUP Comorbidity Software.[4] All Elixhauser comorbidities were analyzed, except for metastatic cancer, which was eliminated because of the study's exclusion criteria (Appendix).

Outcomes

Outcome variables in this study included postoperative lobectomy length of stay, in-hospital mortality, specific perioperative complications (Table 2), and total cost of inpatient hospitalization. Length of stay postlobectomy was calculated by subtracting the day of hospitalization in which the lobectomy was performed (HCUP-NIS variable "PRDAYn") from the total length of hospital stay. In-hospital mortality was defined as the percentage of postoperative lobectomy patients who died before discharge. Relevant postoperative complications (Appendix) were selected from a previous study by this group and were defined using ICD-9 diagnosis codes.[5] As the HCUP NIS database does not explicitly distinguish between preoperative and postoperative conditions, only ICD-9 diagnosis codes that clearly represented postprocedural complications instead of baseline patient characteristics were used.

In the cost analysis, HCUP cost-to-charge ratios for each hospital were used to adjust the total charges for each patient and estimate costs. This adjustment was necessary because charge information reflects the amount that hospitals bill for specific services, but not the actual cost of these services or the amount that hospitals ultimately receive. These ratios are "constructed using all-payer, inpatient cost and charge information from the detailed reports by hospitals to the Centers for Medicare & Medicaid Services (CMS)."[6]

Statistical Analysis

Continuous variables with a nonnormal distribution, including postoperative length of hospital stay and total inpatient hospital cost, are presented with medians for comparison. Baseline demographic and clinical characteristics between the primary study cohorts were compared using the chi-square test for categorical variables. Estimates and their associated standard errors are generated for each variable using methods appropriate for complex sample surveys, taking into account clustering, case weighting, and stratification strategy.[7] In accordance with HCUP guidelines, we defined the threshold for including