Original Contribution

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Relationship Between Occurrence of Surgical Complications and Hospital Finances

Sunil Eappen, MD; Bennett H. Lane, MS; Barry Rosenberg, MD, MBA ;et al

Author Affiliations |Article Information

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Abstract

Importance The effect of surgical complications on hospital finances is unclear.

Objective To determine the relationship between major surgical complications and per-encounter hospital costs and revenues by payer type.

Design, Setting, and Participants Retrospective analysis of administrative data for all inpatient surgical discharges during 2010 from a nonprofit 12-hospital system in the southern United States. Discharges were categorized by principal procedure and occurrence of 1 or more postsurgical complications, using *International Classification of Diseases, Ninth Revision*, diagnosis and procedure codes. Nine common surgical procedures and 10 major complications across 4 payer types were analyzed. Hospital costs and revenue at discharge were obtained from hospital accounting systems and classified by payer type.

Main Outcomes and Measures Hospital costs, revenues, and contribution margin (defined as revenue minus variable expenses) were compared for patients with and without surgical complications according to payer type.

Results Of 34 256 surgical discharges, 1820 patients (5.3%; 95% CI, 4.4%-6.4%) experienced 1 or more postsurgical complications. Compared with absence of complications, complications were associated with a \$39 017 (95% CI, \$20 069-\$50 394; *P* < .001) higher contribution margin per patient with private insurance (\$55 953 vs \$16 936) and a \$1749 (95% CI, \$976-\$3287; *P* < .001) higher contribution margin per patient with Medicare (\$3629 vs \$1880). For this hospital system in which private insurers covered 40% of patients (13 544), Medicare covered 45% (15 406), Medicaid covered 4% (1336), and self-payment covered 6% (2202), occurrence

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Conclusions and Relevance In this hospital system, the occurrence of postsurgical complications was associated with a higher per-encounter hospital contribution margin for patients covered by Medicare and private insurance but a lower one for patients covered by Medicaid and who self-paid. Depending on payer mix, many hospitals have the potential for adverse near-term financial consequences for decreasing postsurgical complications.

National health expenditures for surgical procedures are estimated to cost $400 billion annually and are expected to outpace economic growth during the next 10 years.[1,2] The rate of inpatient surgical complications is significant, with estimates ranging from 3% to 17.4%, depending on type of procedure, type of complications, length of follow-up, and data analyzed.[3-8] In addition to patient harm, major complications add substantial costs, previously estimated at $11 500 per patient.[9]

Effective methods for reducing surgical complications have been identified.[8-10] However, hospitals have been slow to implement them.[11] Resource constraints may be a factor. Quality improvement efforts often require expenditures for staff time and technologies, and financial benefits are uncertain.[12,13] Improvements can reduce revenues under per diem reimbursement schemes and even diagnosis related group-based reimbursement because complications can result in severity adjustments or diagnosis related group changes that increase revenues. For example, a colectomy patient's diagnosis could change from code 148 (major bowel procedure with complications) to 483 (tracheostomy with mechanical ventilation >96 hours), triggering a 5-fold increase in Medicare reimbursement.[14] On the other hand, some complications—such as certain “never event” complications—are no longer reimbursed by many payers.[15,16] Previous estimates suggest that reducing surgical complications could harm hospital financial results but have been limited by use of small data sets or simplified surrogates such as patient length of stay.[17-20]

We therefore conducted a study to measure the financial implications associated with postsurgical complications, using internal claims-administration and cost-accounting data of a nonprofit southern US hospital system with both higher- and lower-volume facilities located in urban and suburban/rural areas that included academic and nonacademic surgical departments. The goal was to evaluate the fixed and variable hospital costs and revenues associated with the occurrence of 1 or more major postsurgical complications for 4 primary payer types—private insurance, Medicare, Medicaid, and self-payment.

Methods

Study Population and Procedures

Harvard School of Public Health and the nonprofit hospital system provided institutional research approval. The study population was generated from the administrative data of 12 hospitals in 1 southern hospital system for inpatient surgical patients who were discharged during the 2010 calendar year. Both elective and emergency procedures were included. Certified professional coders coded all data, following the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*).[21]

For each patient encounter, age, sex, admission status (emergency or elective/scheduled), length of stay, discharge status, insurance payer, and all *ICD-9* procedure, diagnosis, and present-on-admission codes were collected. The first listed diagnosis and procedure code were identified as the principal diagnosis and principal procedure, respectively.

Patients were entered into the study if they had inpatient status, a charge for the minimum unit of 60 minutes of operating room time, validated charges of more than $0.10, at least 1 coded diagnosis and 1 coded procedure, a date of discharge in calendar year 2010, and no principal procedure code for cesarean delivery (*ICD-9-CM* procedure codes 74.00, 74.10, 74.40, and 74.99).

Nine common procedure groups were identified with Clinical Classifications Software–defined grouping of procedure codes[22-24]: craniotomy, colorectal resection, total or partial hip replacement, knee arthroplasty, coronary artery bypass graft, spinal surgery (laminectomy, excision of intervertebral disk, or spinal fusion), hysterectomy (abdominal or vaginal), appendectomy, and cholecystectomy and common bile duct exploration. The specific clinical classification software–defined groups are listed in **eTable 1**. Patient encounters were included in a procedure group according to their principal procedure code.

Complications and Comorbidities

A subset of 10 potentially preventable, severe surgical complications was identified in our data set. This subset is referred to as "complications" in this article, does not capture all possible complications, and includes surgical site infection, wound disruption, sepsis/severe inflammatory response syndrome/septic shock, pulmonary embolism or deep vein thrombosis, stroke, myocardial infarction, cardiac arrest, pneumonia, ventilator use of 96 hours or longer, and infections (other than surgical site).[8,18,25-27] Each complication was identified by a predefined set of *ICD-9-CM* codes (**eTable 2**) and confirmed to be absent on admission according to *ICD-9* codes for present on admission. In addition, for the postsurgical complication of mechanical ventilation for 96 hours or longer, additional exclusion *ICD-9* diagnosis codes (listed in **eTable 2**) were also applied. In-hospital mortality for patients who had inpatient surgery was captured separately from postsurgical complications, using discharge status.

Patient comorbidities were assessed with modified Charlson comorbidity scores,[28-30] which were incorporated into propensity score models.

Financial Information

For each inpatient surgical discharge, financial information (net revenue, total cost, fixed cost, and variable cost) was extracted from the hospital system's EPSI cost accounting system (Allscripts Inc). EPSI uses actual payroll and general ledger expenses and categorizes them as either fixed or variable costs. Fixed costs are defined as those that do not vary with patient volume, whereas variable costs are those that do. Examples of fixed costs include the cost of constructing parking or purchasing a computed tomography scanner. In this hospital system's implementation of EPSI, fixed costs are allocated to each revenue department that treats patients. A patient discharge is allocated a portion of the fixed costs from revenue departments whose services were accessed by that patient, according to the specific charges incurred. Variable costs are those incurred during treatment of patients; examples include knee implant hardware and nursing labor. For each discharge, total hospital costs were calculated according to expenses accrued from both fixed and variable costs. Net revenue was based on actual reimbursement from the payer. (Gross revenue is sometimes defined as hospital charges; we do not use this terminology and revenue is always used to correspond to net revenue.) Physician professional fee or salary data were not collected.

We calculated and report both contribution margin and total margin but focus on the former (Box). Hospital managers seeking to improve financial performance work to maximize contribution margin. As long as it is positive

Box. Definitions of Costs and Margins

Variable costs: Costs that vary with patient volume (ie, supplies and nurse staffing).

Fixed costs: Costs that do not vary with patient volume (ie, costs for the hospital building, utilities, and maintenance).

Total margin: Revenue minus variable costs and fixed costs.

Contribution margin: Revenue minus variable costs. These are revenues available to offset fixed costs.

However, hospitals with negative total margins will ultimately go bankrupt. To calculate total margin, hospital managers must allocate a portion of fixed costs to each patient. As activities in a hospital increase, the total fixed costs remain the same but the proportion of fixed costs attributed to each activity decreases. We report total margin because eventually it reflects the comprehensive financial outlook of a hospital. We focus on contribution margin analysis because it drives hospital decision making in the near term.

Statistical Analysis

We calculated results with means, totals, medians, and proportions, with 95% CIs for each. Because the continuous outcome variables (eg, revenue, costs, margin) were right skewed, 95% CIs for unadjusted and adjusted totals, means, medians, and differences were calculated with a nonparametric bootstrap percentile method, which does not assume normality,[32] with resampling to account for clustering at the facility level. For testing whether a continuous outcome variable had the same underlying probability distribution for patients with and without complications, the nonparametric Wilcoxon rank sum test adjusting for clustering at the facility level[33] was used. For dichotomous outcomes (eg, mortality, complications), 95% CIs were calculated with a modified Wilson CI for clustered binary data.[34]

Our main analysis concerns differences in costs by complication occurrence and payer. Propensity-score weighting was used to adjust for case-mix differences between patients with and without complications within payer group. By estimating the propensity for being in the groups of interest, propensity score methods provide better control for observed confounding factors than regression models alone. Propensity methods improve the ability to compare groups in observational studies. The propensity for being in the 2 complication groups was calculated with logistic regression models, with all demographic covariates available as predictors: patient age (age and age squared), sex, Charlson score (0, 1-2, ≥3), and risk of death according to clinical classification software–defined procedure group (scored as low, medium, or high).[35] We ran logistic regression models for each of the 4 payers, with noncomplications as the reference group and main effects for the covariates. The clinical classification software–defined covariate was obtained with group-level mortality rate data from the Nationwide Inpatient Sample and divided into tertiles. In the propensity-weighted approach, each patient's information was weighted by the inverse propensity of being in the given payer/complication group, with the goal of balancing characteristics across the complication groups. The Hosmer-Lemeshow goodness-of-fit statistic was used to assess the fit of the logistic regression propensity score models.[36,37]

To determine the sensitivity of the results, we performed sensitivity analyses, including linear mixed-model regression adjustment, as well as other propensity-score model adjustments (eTable 3).

All tests and 95% CIs were 2-sided. $P < .05$ was considered statistically significant. All analysis was completed with SAS/STAT version 9.2.

There were 35 394 unique surgical inpatients discharged during calendar year 2010. We analyzed the 34 256 surgical inpatients who did not have cesarean delivery (eFigure). A total of 1820 procedures (5.3%; 95% CI, 4.4%-6.4%) were identified as having at least 1 complication (Table 1). We identified 428 postsurgical inpatient deaths, for a 1.25% inpatient mortality rate (95% CI, 0.90%-1.75%). The inpatient mortality rate was 0.6% (95% CI, 0.49%-0.82%) for patients without an identified complication and 12.3% (95% CI, 9.31%-15.96%) for patients with a defined complication. The median length of stay (Table 2) was more than 4 times higher for surgical patients who developed 1 or more complications (3 vs 14 days; 95% CI for the difference, 8.5-12.0; $P < .001$). Table 2 displays the total hospital revenue, variable costs, total costs, and resulting contribution margin and total margin for patients with and without 1 or more complications. The occurrence of 1 or more complications was associated with a \$22 398 higher per-patient variable cost (95% CI for the difference, \$18 097-\$25 682; $P < .001$) and with a \$37 917 higher per-patient total cost (95% CI, \$31 017-\$43 801; $P < .001$). The occurrence of 1 or more surgical complications was associated with an \$8084 higher per-patient contribution margin (95% CI, \$4903-\$9740; $P < .001$) and with a \$7435 lower per-patient total margin (95% CI, \$5103-\$10 507; $P < .001$).

Table 1. Complication Rate by Surgical Procedure and Median Length of Stay by Complication Occurrence and Procedurea

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Table 2. Patient Age, Average Length of Stay, Revenue, and Variable Costs, With and Without Complications

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Table 3 displays the detailed hospital cost and revenue results by procedure. Occurrence of 1 or more complications was associated with higher hospital costs in all payer types (Table 4). The relative difference in hospital revenue varied by payer type. Patients experiencing 1 or more complications were associated with a higher contribution margin of \$39 017 (95% CI, \$20 069-\$50 394; $P < .001$) per patient with private insurance and \$1749 (95% CI, \$976-\$3287; $P < .001$) per Medicare patient compared with that of patients without complications.

private insurance (95% CI, $10 590-$35 057; $P < .001$) but a lower total margin of $9218 per Medicare patient (95% CI, $6882-$10 681; $P < .001$).

Table 3. Revenue, Contribution Margin, and Total Margin, by Procedurea

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Table 4. Propensity-Adjusted Revenue, Contribution Margin, and Total Margin, by Payera

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For this particular hospital system, private insurers covered 40% of patients (13 544); Medicare, 45% (15 406); Medicaid, 4% (1336); and self-payment, 6% (2202). Other types of insurance (eg, worker's compensation) constituted 5% of coverage (1768).

The results in Table 4 are propensity adjusted; the Hosmer-Lemeshow goodness-of-fit statistic indicated that the logistic regression models for the propensity of being in the 2 complication groups were excellent fits to the data ($P > .36$ for observed being different than expected for all of the 4 payers). Thus, the observed confounding factors are important to control for when comparing cost and revenue across patients with and without complications. Finally, the sensitivity analyses for Table 4 (regression adjustments and other propensity-score model adjustments) yielded similar results in terms of estimated revenue to contribution margin and total margin and their 95% CIs (eTable 3) and thus affirm that the results presented in this article are robust and not sensitive to the approach that we used.

Comment

We found that under private insurance and Medicare, which cover the majority of US patients, the occurrence of surgical complications was associated with higher hospital contribution margins. Depending on payer mix, efforts to reduce surgical complications may result in worsened near-term financial performance.

The financial effects of surgical complications varied considerably by payer type. Complications were associated complications. As a result, the payer mix will determine the overall economics of surgical complications for a given hospital. The studied hospital system's inpatient surgical payer mix (Medicare, 45%; private, 40%; Medicaid, 4%; and self-pay, 6%) was comparable to that of an average US hospital in 2010 (Medicare, 40%; private, 41%; Medicaid, 9%; and self-pay, 5%) (Marc Capuano, BS/BA, The Advisory Board Company, Washington, DC, October 2012).[38]

Most US hospitals treat patient populations primarily covered by Medicare or private payers,[39] and programs to reduce complications may worsen their near-term financial performance. Some US hospitals, often referred to as safety net hospitals, treat populations primarily covered by Medicaid or selfpayment, and complication reduction efforts might improve their financial performance.

Contribution margin, defined as revenue minus variable costs, describes the financial resources generated by hospital activities that are available to pay for a hospital's fixed costs. Hospital managers seeking to improve financial performance typically prioritize contribution margin when evaluating hospital activities.[31] For hospitals with substantial unused capacity, which comprises the majority of US hospitals,[40-42] any activity with a positive contribution margin is financially beneficial, regardless of total margin.

We also examined the relationship between occurrence of surgical complications and hospital financial performance on a total margin basis, which provides an understanding of the long-term sustainability of hospital operations. For inpatient procedures covered by private payers, the occurrence of complications was associated with a more than $25 000 greater total margin. In contrast, Medicare, Medicaid, or self-pay encounters all had negative total margins whether a complication occurred or not, and the total margin was worse with a complication. As a result, some hospitals could financially benefit in the long run by reducing complications if they could accept substantial near-term losses.

We did not estimate the effect of 3 potential factors that could affect the hospital economics of surgical complications. First, the shorter lengths of stay of procedures without complications could benefit the small percentage of hospitals operating at full capacity because they might be able to admit additional patients with favorable insurance who were "crowded out."

Second, reduced complications could improve hospital reputation, thereby increasing market share. This effect is unclear, given the absence of public reporting of surgical complication rates.[43-45]

Third, reducing surgical complications is likely to reduce readmission rates, which may help hospitals subject to reimbursement penalties, but our current study was not structured to study the consequences of this effect.

In contrast to previous financial studies that focused on smaller surgical patient pools or fewer procedures, the data set used here comprises a large number of surgical inpatient encounters with a typical mix of surgical procedures.[33,46] Our identification of postsurgical complications in administrative data built on previously existing methods, added new codes, and used present-on-admission codes to improve the clinical relevance of the administrative data, as recommended elsewhere.[47] Our study also avoided the use of surrogates for cost data.

Our study has several potential limitations. A number of studies suggest that administrative data may underestimate surgical complication rates.[47,48] Furthermore, we did not seek to capture all complications (and in complications that we included in our overall complication index were also within the range of that of other studies.[49] The consequence of underestimating the number of surgical complications is that we would also have underestimated the financial influence of complications.

Although we report hospital revenues from Medicare, Medicaid, and private payers, we were not able to account for regional or local variation in reimbursement rates. Variations in Medicare rates (eg, because of adjustments for local wage index) would need to be corrected for in applying our results to individual hospitals.[50] Private payer rates and contracting structures vary widely across the country and even in the same region or city.[51] For example, private payer reimbursement rates range from 100% to 250% of Medicare rates, depending on local market factors.[52] Our results thus must be interpreted in light of these factors. It is possible that with certain combinations of insurances and procedures, findings will differ from our conclusions. However, we believe the hospital system studied reflects a fairly typical set of procedures and payer contracting rules.

All payers benefit financially when surgical complications are avoided because they are associated with higher average payments to hospitals.[53]

The present study suggests that strategies such as payers bundling the average costs of complications into the base diagnosis related group payment for a surgical procedure or limiting the hospital's ability to recode retrospectively into a higher-paying diagnosis related group may give hospitals a stronger financial incentive to avoid complications.

Conclusions

In this hospital system, the occurrence of postsurgical complications was associated with higher per-encounter hospital contribution margin for patients covered by Medicare and private insurance but lower contribution margin for patients covered by Medicaid and self-payment. Depending on payer mix, some hospitals have the potential for adverse near-term financial consequences for decreasing postsurgical complications.

Article Information

Corresponding Author: Atul A. Gawande, MD, MPH, Department of Health Policy and Management, 677 Huntington Ave, Kresge Bldg, Room 400, Boston, MA 02115 (agawande@hsph.harvard.edu).

Author Contributions: Drs Gawande and Eappen had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Eappen, Lane, Rosenberg, Sadoff, Matheson, Berry, Lester, Gawande.

Acquisition of data: Lane, Lester.

Analysis and interpretation of data: Eappen, Lane, Rosenberg, Lipsitz, Sadoff, Berry, Lester, Gawande.

Drafting of the manuscript: Eappen, Lane, Rosenberg, Lipsitz, Sadoff, Lester, Gawande.

Critical revision of the manuscript for important intellectual content: All authors.

Administrative, technical, or material support: Eappen, Lester.

Study supervision: Matheson, Berry, Lester, Gawande.

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Online-Only Material: The Author Audio Interview is available here.

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