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Is a Colectomy Always Just a Colectomy? Additional Procedures as a Proxy for Operative Complexity

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Abstract

Background—Studies of surgical outcomes can be confounded by operative complexity. Complexity is difficult to assess from claims data due to the absence of established measures, but information on additional procedures is typically available. We hypothesized that analyzing same-day procedures (SDPs) would provide a useful step toward including operative complexity in risk adjustment.

Study Design—Colon resections were identified in California, Florida, and New York (2008 to 2011). Same-day procedures were categorized using 6 definitions. In-hospital mortality and postoperative complications were examined. For all outcomes, we developed multivariable logistic regression models to measure the association between the SDP category and outcomes.

Results—Rates of SDP were 74.9% total, 69.5% surgical, 31.6% nonsurgical, 36.6% colon, 51.4% abdomen, and 34.3% other for the 215,041 colon resections examined. Mortality was associated with the inclusion of any SDP category in univariate (6.2% vs 1.7%; $p < 0.001$) and multivariable (odds ratio [OR] = 2.14; 95% CI, 1.99–2.30; $p < 0.001$) analysis. The association with mortality was high for nonsurgical (OR = 2.36; 95% CI, 2.26–2.46) and other (OR = 2.33; 95% CI, 2.23–2.43) procedures and moderate for surgical (OR = 1.45; 95% CI, 1.37–1.54) and colon (OR = 1.51; 95% CI, 1.44–1.57) procedures, but abdominal procedures were not independently associated with mortality (OR = 1.01; 95% CI, 0.97–1.06). The total number of SDPs was also associated with higher complication rates.

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Conclusions—The risk of complications and mortality associated with colectomy was increased among patients with SDPs and the magnitude of the association was dependent on the type and quantity of additional procedures. Information on SDPs might reflect a component of operative risk not typically captured and should be considered as a candidate variable for risk adjustment when using claims to compare outcomes across large cohorts.

The number of health services research studies using administrative claims data has increased exponentially during the past decade. Risk adjustment is a key analytic method in many of these studies. Patient demographic information drawn from administrative claims data are well documented, and the importance of using patient diagnoses in the risk-adjustment process has also been widely reported.[1-3]

On the other hand, intraoperative complexity is seldom addressed in studies that rely on claims because of the absence of physiologic data and knowledge about operative details. Typically, procedure codes for the single procedure of interest and exclusion criteria are used to select the cases and the rest of the data on procedures remain unused. However, one of the strengths of claims data is the presence of multiple procedure codes used for billing. For example, although the difference between a straightforward colectomy in a healthy person and a more difficult resection in a septic patient is not obvious from a review of claims records, a colon resection without a lysis of adhesions is technically easier than one with adhesiolysis, and this can be examined in claims data. Similarly, a colon resection that requires more nonoperative procedures, such as the insertion of an arterial line for monitoring, can be distinguished from one that requires mechanical ventilation alone.

The number and type of additional procedures performed on a given day (same-day procedures [SDPs]) can therefore provide important information about intraoperative complexity from both a medical and surgical perspective. In this study, we considered the possibility of using the full list of procedures in claims data as a proxy for surgical complexity. Specifically, we focused on colectomy as an example procedure due to its relative frequency of performance and high rate of adverse events. We asked whether risk adjustment based on claims data could be improved by considering additional procedure codes.

Methods

Data

We analyzed inpatient claims from California, Florida, and New York for procedures performed between 2008 and 2011. The individual state databases were obtained from the following sources: California data from the State Inpatient Databases, Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality[4]; Florida data from the Florida Center for Health Information and Policy Analysis, Agency for Health Care Administration[5]; and New York data from the Statewide Planning and Research Cooperative System, Bureau of Health Informatics, New York State Department of Health.[6] Each dataset includes records for all inpatient admissions within the state. A record is made up of an individual discharge claim. Each record includes up to 31 procedure codes, with corresponding entries for the days between admission and each procedure, as well as information on patient demographics, diagnoses, and hospital characteristics.

Records for adult patients who underwent a colon resection in 1 of the 3 states during the specified time period were identified for inclusion using the ICD-9[7] procedure codes shown in Table 1. Records were excluded if any of the demographic variables shown in Table 2 were missing (n = 18,286). The ICD-9 procedure codes were used because CPT[8] codes were not available in the inpatient claims. The ICD-9 codes often provide less detail about the procedures performed than CPT codes.

Same-day procedures

To capture the complexity of the operative encounter, we used the procedure codes recorded for each colectomy patient. We defined 6 binary variables to categorize the types of procedures performed on the same day as the colectomy (ie, same-day procedures [SDPs]). The first variable, "ANY," captured all of the procedures performed on the same day as the colon resection. Procedures that reflected care provided beyond the operative encounter, such as continuous invasive mechanical ventilation, were not included as SDPs. The ANY procedures were divided along the following dimensions: surgical or nonsurgical and relationship to colectomy. Along the first dimension, we categorized surgical and nonsurgical procedures as "SURG" and "NONSURG," respectively. Surgical procedures required an incision and nonsurgical procedures did not. For example, creation of an ostomy was classified as surgical and ureteral catheterization was classified as nonsurgical.

The SDPs were also classified based on the relationship to the colon resection. The first category, "COLON," consisted of ostomy, anastomosis, and proctectomy. These procedures are often performed as part of a routine colectomy and were chosen to approximate the detailed procedure information included in CPT codes. Next, we created a separate category, "ABDOMEN," for other intra-abdominal procedures that are not captured by the CPT codes used for a routine colon resection. Many of these procedures were likely performed for reasons related to the indication for colectomy, but were coded as separate procedures. Our final category, "OTHER," consisted of all procedures not counted as COLON or ABDOMEN. The most common procedures in each category are shown in Supplementary Table 1 (available at: http://www.journalacs.org). Note that the procedure counts might add up to more than the total number of cases because many patients had more than one additional procedure done. Four clinicians (RLH, LEK, DNH, RRK) independently classified the procedure codes and resolved discrepancies through discussion.

To test the use of a simple measure for SDPs, we also constructed a variable indicating the number of SDPs performed. In computing this variable, we included all procedure codes on the same day as colectomy, even those procedures generally done outside the operating room. In all analyses, the number of SDPs was defined as a categorical variable with categories 0, 1, 2, or 3 or more procedures. Coding differences across the states and hospitals were explored. To minimize bias associated with any such differences, the states and significant hospital characteristics were included in the multivariable models.

Outcomes

Our primary end point of interest was in-hospital mortality. Secondary outcomes of interest were wound disruption, wound infection, and respiratory complications. These complications were defined using the ICD-9-CM codes shown in Table 1 and were restricted to diagnoses that occurred during the same hospital visit and were not designated present on admission.

Statistical analysis

We estimated the independent association between outcomes and SDPs using logistic regression. Each of the patient and hospital characteristics shown in Table 2 was tested for inclusion in the multivariable regression using a chi-square test with a threshold of $p < 0.10$. To control for differences due to the site or extent of colon resection, we also included the colectomy ICD-9 procedure code as a covariate in all models. Eight separate logistic regression models were constructed for outcomes. The null model included patient and hospital characteristics but no information on SDPs. Additional models included these factors, as well as ANY, SURG, NONSURG, COLON, ABDOMEN, OTHER, or the number of additional procedures as the covariate of interest. Model performance was assessed using C-statistics with internal validation via bootstrapping.[9] The null model was compared with every other model using likelihood ratio tests with the Bonferroni correction for multiple comparisons.

All analyses were performed using Stata/MP 13.0 statistical software (Stata Corp) and SAS software, version 9.4 (SAS Institute). This study was deemed exempt from review by the University of Pennsylvania IRB.

Results

Use of same-day procedures

The study cohort included 215,041 adult admissions with a colon resection. Patient and hospital characteristics are shown in Table 2. During the admissions of interest, 160,990 (74.9%) had at least one additional procedure coded on the day when the colectomy was performed. In 149,437 cases (69.5%), at least 1 additional surgical procedure was performed, and 67,975 cases (31.6%) included at least 1 nonsurgical procedure. There were 78,664 (36.6%) patients with COLON procedures, 110,570 (51.4%) with ABDOMEN procedures, and 73,802 (34.3%) with OTHER procedures (Table 3). The most common procedures in each category are listed in Supplementary Table 1 (available at: http://www.journalacs.org). Note that each procedure was categorized both as SURG or NONSURG and as COLON, ABDOMEN, or OTHER, as illustrated by the overlap in procedures for the NONSURG and OTHER categories. Patients with more comorbid diagnoses were more likely to have SDPs and tended to have a higher number of procedures performed (Table 3).

Differential coding

The highest rate of SDPs was seen in New York (78.7%), followed by Florida (74.8%) and then California (72.3%; $p < 0.001$). Overall, additional procedures were more commonly reported by rural not-for-profit hospitals (78.2% of colon resections in these hospitals) than by investor-owned or urban not-for-profit hospitals (73.7% and 74.9%, respectively; $p < 0.001$) and were more common for large hospitals (76.2%) than for small or medium hospitals (73.1% and 73.4%; $p < 0.001$). The 5 categories of procedures showed similar but not identical patterns. In particular, the rates of COLON procedures, which are standard colectomy components, differed by state and by hospital ownership ($p < 0.001$ in both cases), but not by hospital size ($p = 0.08$). See Table 3.

The number of SDPs also differed between hospitals. The fraction of patients that had 3 or more additional procedures was higher in New York (33.4%) compared with California (25.3%) and Florida (26.5%), and higher in large hospitals (30.4%) compared with small (25.0%) or medium (25.1%) hospitals. Conversely, the rate of exactly one noncolectomy procedure was higher in California (28.7%) and Florida (29.2%) than in New York (26.1%) and higher in small (28.4%) and medium (29.4%) hospitals than in large hospitals (27.1%; $p < 0.001$ in all cases). To minimize confounding due to such differential coding, hospital factors were included in multivariable analyses. Results were similar for subset analyses based on each state individually.

Mortality

The overall rate of in-hospital mortality was 5.0%. Higher mortality was associated with the presence of SDPs using each of the procedure categories, as shown in Table 4. Mortality was 1.7% among patients with no additional procedures and 6.2% when ANY procedure was performed on the same day. The highest mortality rates were seen in cases with NONSURG (9.3%) or OTHER (9.0%) procedures. Mortality was moderately increased in COLON cases (8.2%) and to a lesser extent in SURG (6.1%) and ABDOMEN (5.4%) cases.

To adjust for differences in patient and hospital factors, we performed logistic regression. The first model of mortality, without controlling for SDPs, showed high discrimination ($C = 0.840$; Table 4) and explained 11.3% of variance. The addition of any of the SDP categories except for ABDOMEN as a covariate improved model fit, as measured by likelihood ratio tests ($p < 0.001$ in all cases, corrected for multiple comparisons). Addition of a covariate for ANY additional procedure was associated with an odds ratio (OR) of 2.14 (95% CI, 1.99–2.30). The magnitude of ORs associated with the more focused measures of additional procedures reflected the differences seen in univariate tests: NONSURG and OTHER had particularly strong associations with mortality (OR = 2.36; 95% CI, 2.26–2.46 and OR = 2.33; 95% CI, 2.23–2.43, respectively). SURG and COLON showed more modest associations (OR = 1.45; 95% CI, 1.37–1.54 and OR = 1.51; 95% CI, 1.44–1.57), and ABDOMEN was not associated with an increase in mortality (OR = 1.01; 95% CI, 0.97–1.06).

Complications

The complications that we examined were all associated with presence of SDPs in both univariate and multivariable analyses (Table 4). Respiratory complications, like mortality, were most strongly associated with NONSURG (OR = 2.32; 95% CI, 2.26–2.39) and OTHER (OR = 2.30; 95% CI, 2.24–2.37) procedures. Wound disruption and infection both showed this same pattern in univariate analyses. After risk adjustment, the relative effects of NONSURG and SURG procedures were reversed (disruption OR = 1.37; 95% CI, 1.28–1.47 and OR = 1.40; 95% CI, 1.27–1.53; infection OR = 1.27; 95% CI, 1.22–1.32 and OR = 1.40; 95% CI, 1.33–1.47), and differences between ABDOMEN, COLON, and OTHER were reduced or reversed (disruption OR = 1.12; 95% CI, 1.05–1.20; OR = 1.37; 95% CI, 1.27–1.47; and OR = 1.44; 95% CI, 1.34–1.54; infection OR = 1.32; 95% CI, 1.27–1.37; OR = 1.22; 95% CI, 1.17–1.27; and OR = 1.30; 95% CI, 1.25–1.35).

Number of procedures performed

As an alternative to categorizing SDPs, we also performed analyses in which we simply counted the number of SDPs on each record. Higher numbers of procedures were associated with increased rates of adverse events. Logistic regression models including a categorical variable for number of SDPs (0, 1, 2, or 3+) performed better than models without adjustment for additional procedures, and had C-statistics comparable with models using specific procedure categories (Table 4). Although a single SDP was associated with a moderately increased risk of mortality (OR = 1.46; 95% CI, 1.34–1.59), the association was even stronger for 2 additional procedures (OR = 1.97; 95% CI, 1.81–2.15) or, especially, 3 or more procedures (OR = 3.60; 95% CI, 3.32–3.90). Similar results were seen in models of postoperative complications.

Contribution of individual procedures

The unadjusted mortality rates for the most common SDPs are shown in Supplementary Table 1 (available at: http://www.journalacs.org). Although the risk associated with individual procedures varied widely within the SDP category, the example procedures were, on average, representative of their categories. For example, several of the NONSURG procedures listed had mortality rates much higher than the global mean of 5.0%, and most of the ABDOMEN procedures were associated with relatively low mortality rates. Wound disruption, wound infection, and respiratory complications showed similar patterns.

Discussion

We found that the presence of ICD-9 codes indicating any type of additional procedure on the day of the colon resection was associated with surgical outcomes. In addition, model performance was improved by including such procedures as covariates. The magnitude of association between additional procedures and outcomes varied based on the type of procedure performed, but a simple count of the number of coded procedures concurrently did provide important information on the risk of outcomes measured. Including SDP as a factor in risk adjustment provides a straightforward and effective means to incorporate information on the full operative encounter into analysis of administrative claims data.

Previous studies have used CPT codes in risk adjustment as a measure of operative complexity.[10,11] However, the degree of procedural detail in CPT codes is often lost in inpatient claim datasets that include ICD-9 codes only. For example, there is only one ICD-9 code for a laparoscopic total colectomy, and there are 3 CPT codes that specify the choice of anastomosis or ostomy and whether a proctectomy was also performed. Here we attempted to address this challenge by examining the combination of ICD-9 procedure codes listed on the same day. We distinguished between procedures that are often included in CPT codes (eg, anastomosis, ostomy, and proctectomy; COLON in our terminology) and procedures that would generally be assigned a separate code (ABDOMEN and OTHER). This allowed us to analyze true additional procedures separately from components of colon resections. These additional procedures could indicate complexity due to planned concurrent operations or additional procedures needed to treat the primary disease.

We also examined an alternate approach in which, rather than examine the type of additional procedure, we simply used the number of procedures of all types performed on the same day as colectomy. Models including this count information performed similarly to models with adjustment for specific categories of procedures. This approach can provide a more straightforward option to adjust for additional risk associated with multiple procedures being performed. For interpreting such risk, however, it is informative to analyze the contributions of different categories of procedure.

Classification of concurrent procedures

We performed separate analyses for each of 5 categories of SDPs. Nonsurgical procedures were associated with particularly high rates of adverse events and might be a marker of poor health going into surgery. The high rates of mortality and respiratory complications persisted in multivariable analysis, including, among other things, patient comorbidities and emergency status. Additional nonsurgical procedures might represent some measure of patient health that is not generally captured in claims-based analyses. This category includes a wide variety of major and minor procedures that likely range in their degree of association with adverse events. Many denote additional monitoring done either in anticipation of or in response to a difficult case. The majority of monitoring for anesthesia is planned in advance and would reflect the provider's level of concern about the patient's health status and the anticipated complexity of the operation, not a reaction to unanticipated intraoperative complications. This category likely represents a combination of patient health and operative difficulty.

Operative procedures, on the other hand, are more likely to represent complexity within surgical care. Undergoing more than one operation in a day likely presents additional risks to the patient due to increased operative time, need for additional coordination of care between multiple providers, and/or increased difficulty for the operating physician(s). The fact that additional operative procedures were associated with moderately increased adverse event rates is consistent with previous work[12,13] and is not surprising, given these risk factors.

The weakest associations with adverse events were seen for abdominal procedures. Previous studies of simultaneous abdominal resections have shown mixed effects. Reddy and colleagues[14] found higher morbidity in synchronous vs staged operations for major resections, but not for minor resections. Merkow and colleagues[10] found that morbidity after colectomy was associated with synchronous performance of one of several abdominal operations, but that mortality was only associated with synchronous small bowel resection. Our study builds on this and similar works by implementing the same approach in claims data, where we have less detailed procedure information than in American College of

Surgeons NSQIP data or medical records. The lack of an association with mortality that we observed for abdominal procedures, as well as the small increase in wound disruption and respiratory complications, might reflect the fact that this category included a mix of procedures that range from minimal risk (such as laparoscopic adhesiolysis) to high risk (including small bowel resection). Grouping procedures together in this way likely obscures some detailed information, but allows us to produce concise models that are easily applied to a variety of cases. Patient selection can also play a role in the relatively small effect size, if surgeons preferentially undertake involved multipart operations on relatively healthy patients who have a lower baseline risk of adverse events.[14]

Finally, variation in procedures that are standard components of colon resections might reflect differential billing and coding practices as much as variation in the patient experience. The rate at which such procedures were coded differed by state and hospital type, as well as by indication for colectomy: rates were lower in colon cancer patients and higher in patients with rectal cancer or inflammatory bowel disease. These results are consistent with previous studies that found high variability in coding of minor procedures, especially those done as components of more major procedures.[15] On the other hand, the association between these procedures and adverse events suggests that the differences in coding might also reflect differences in surgical practice. Our COLON indicator might have captured some aspect of patient disease or other factors that contribute to surgical decision making, but were not included in our analysis. Differential coding of component procedures warrants additional study.

We included a category for nonabdominal procedures so as not to exclude patients. However, we do not recommend making this category a primary component of risk adjustment because it is poorly defined and largely overlaps the nonsurgical category in procedures included (Supplementary Table 1; available at: http://www.journalacs.org) and association with adverse events (Table 4).

Limitations

There are a number of limitations with this study, most of which are inherent in research based on claims data. First, we do not have information on relative timing of procedures within a day. We cannot distinguish procedures performed during the same operative episode from those performed before or after colectomy. If available, such information would enhance the current study by allowing us to determine which procedures might have been needed to address complications arising during colon resection and which were performed in preparation for, or unrelated to, the colectomy. However, because clinical observation would suggest that rates of reoperation are quite low within the first 24 hours after the index operation, we believe our method of analysis has face validity.

In addition, there might be unmeasured factors that are associated with differences in coding independent of differences in procedures performed. For example, some minor nonsurgical procedures, such as venous catheterization, were likely performed but not recorded. As the determinants of such differential coding are largely unknown, our results might be skewed in this manner.

Finally, we have not shown external validity for SDPs as a proxy for operative complexity. It is reasonable to surmise that there is some correlation, but factors such as physician and patient preferences, billing practices, and patient health might also contribute to differential coding. In this case, however, we would expect our results to be biased toward the null hypothesis. The fact that we found positive results despite potential confounders suggests, at a minimum, that the additional codes indicate a previously unmeasured source of risk.

Conclusions

Based on our findings, we recommend that research into postoperative outcomes take into account any additional procedures beyond the operation of interest. Although a uniform guideline for all surgical research is impractical, given the range of study questions and populations, as a starting point we suggest adjusting for nonsurgical procedures. Nonsurgical procedures showed the strongest association with adverse events and could provide a measure of operative complexity or patient health not captured otherwise. In addition, nonsurgical procedures as a category have a clear definition independent of the type of operation being studied. In some cases, investigators might prefer not to code such a variable due to limitations on time or expertise. In this case, we recommend adjusting for the number of SDPs as a viable alternative. Including the total number of procedures performed on the same day as colectomy improved our models to an extent comparable with the more specific categories. Although simply counting procedures risks the loss of specific procedural information, this approach has the advantage that it is defined in a fully objective and straightforward manner and is simple to implement.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
International Classification of Diseases, 9th Revision Codes Used

	ICD-9 code
Procedure, colectomy	17.31 – 17.39, 45.7–45.83
Diagnosis	
Wound disruption	998.3, 998.32, 998.32
Wound infection	998.5, 998.51, 998.59
Respiratory complications	415.0, 415.11, 415.19, 512.1, 518.5, 518.81, 518.82, 799.1, 997.3

Table 2

Cohort Characteristics

Characteristic	Data
Year	
2008	56,238 (26.2)
2009	55,782 (25.9)
2010	51,886 (24.1)
2011	51,135 (23.8)
State	
California	88,600 (41.2)
Florida	67,041 (31.2)
New York	59,400 (27.6)
Age, y, median (IQR)	66 (53–76)
Sex	
Female	115,163 (53.6)
Race	
White	171,743 (79.9)
Black	19,225 (8.9)
Other	24,073 (11.2)
Ethnicity	
Hispanic	27,182 (12.6)
Non-Hispanic	183,632 (85.4)
Unknown	4,227 (2.0)
Median income quartile	
1 (low)	52,119 (24.2)
2	55,784 (25.9)
3	52,646 (24.5)
4 (high)	54,492 (25.3)
Principal payer	
Medicare	106,968 (49.7)
Medicaid	13,320 (6.2)
Commercial	82,242 (38.2)
Self	6,337 (3.0)
Other	6,174 (2.9)
Comorbidities	
0	33,781 (15.7)
1	44,578 (20.7)
2+	136,682 (63.6)
Colon cancer	67,414 (31.4)
Rectal cancer	5,687 (2.6)

Characteristic	**Data**
IBD	12,047 (5.6)
Diverticulitis	72,411 (33.7)
Chronic steroid use	2,623 (1.2)
Bed size	
Small	9,699 (4.5)
Medium	90,041 (41.9)
Large	115,301 (53.6)
Owner and setting	
Investor owned	30,655 (14.3)
Rural, not for profit	6,983 (3.3)
Urban, not for profit	177,403 (82.5)
Emergency admission	81,124 (37.7)
Total	215,041 (100.0)

Data are presented as n (%), unless otherwise indicated.
IBD, inflammatory bowel disease; IQR, interquartile range.

Table 3

Rates of Same-Day Procedures Associated with Selected Patient and Hospital Characteristics

Characteristics	Procedure category,* %						No. of procedures			
	Any	Surgical	Nonsurgical	Colon	Abdomen	Other	0	1	2	3+
State										
California	72.3	68.3	26.5	36.6	49.6	29.4	27.2	28.7	18.8	25.3
Florida	74.8	69.0	31.0	35.9	51.0	33.8	24.8	29.2	19.5	26.5
New York	78.7	71.8	40.0	37.4	54.5	41.7	20.9	26.1	19.6	33.4
Comorbidities										
0	68.6	64.1	24.5	28.3	49.7	26.7	31.2	30.6	18.4	19.8
1	70.5	65.5	26.9	30.9	50.0	29.3	29.2	29.9	18.1	22.8
2+	77.8	72.1	34.9	40.5	52.3	37.8	21.6	27.0	19.8	31.6
Bed size										
Small	73.1	67.3	30.6	37.3	48.7	33.0	26.5	28.4	20.1	25.0
Medium	73.4	68.0	29.6	36.4	49.1	32.1	26.1	29.4	19.4	25.1
Large	76.2	70.9	33.3	36.7	53.4	36.2	23.5	27.1	19.0	30.4
Owner/setting										
Investor owned	73.7	68.0	29.0	37.7	48.1	31.7	25.8	30.0	19.6	24.6
Rural, NFP	78.2	71.4	35.0	41.1	50.1	37.2	21.5	29.8	22.3	26.4
Urban, NFP	74.9	69.7	31.9	36.2	52.1	34.7	24.7	27.8	19.1	28.6
Total	74.9	69.5	31.6	36.6	51.4	34.3	24.7	28.1	19.2	27.9

*Categories of additional procedures are not mutually exclusive. Each patient can count toward none, some, or all of the same-day procedure buckets. NFP, not for profit.

Table 4

Univariate and Multivariable Results and Model Performance for Outcomes Using Each Same-Day Procedure Category

Model	Observed rate Additional procedure?		Odds ratio (95% CI)	C-statistic*	Likelihood ratio test†
	No, %	Yes, %			
Mortality					
Baseline‡	5.0	NA	NA	0.840	NA
Any	1.7	6.2	2.14 (1.99–2.30)	0.844	497.50§
Surgical	2.6	6.1	1.45 (1.37–1.54)	0.842	175.45§
Nonsurgical	3.1	9.3	2.36 (2.26–2.46)	0.852	1,587.80§
Colon	3.2	8.2	1.51 (1.44–1.57)	0.843	329.25§
Abdomen	4.7	5.4	1.01 (0.97–1.06)	0.840	0.46
Other	3.0	9.0	2.33 (2.23–2.43)	0.852	1,545.15§
No. of procedures				0.854	1,778.23§
0	NA	1.5	Ref		
1	NA	3.0	1.46 (1.34–1.59)		
2	NA	4.9	1.97 (1.81–2.15)		
3+	NA	10.3	3.60 (3.32–3.90)		
Wound disruption					
Baseline‡	1.6	NA	NA	0.723	NA
Any	0.8	1.9	1.58 (1.42–1.75)	0.726	76.42§
Surgical	0.9	1.9	1.40 (1.27–1.53)	0.725	52.78§
Nonsurgical	1.3	2.3	1.37 (1.28–1.47)	0.727	77.90§
Colon	1.2	2.3	1.37 (1.27–1.47)	0.726	71.26§
Abdomen	1.4	1.8	1.12 (1.05–1.20)	0.723	10.48
Other	1.3	2.3	1.44 (1.34–1.54)	0.728	106.11§
No. of procedures				0.732	201.43§
0	NA	0.7	Ref		

Model	Observed rate Additional procedure?		Odds ratio (95% CI)	C-statistic*	Likelihood ratio test†
	No, %	Yes, %			
1	NA	1.2	1.26 (1.11–1.43)		
2	NA	1.7	1.56 (1.37–1.77)		
3+	NA	2.7	2.04 (1.82–2.30)		
Wound infection					
Baseline‡	5.6	NA	NA	0.647	NA
Any	3.3	6.3	1.47 (1.39–1.55)	0.652	212.76§
Surgical	3.6	6.4	1.40 (1.33–1.47)	0.652	195.30§
Nonsurgical	4.9	7.1	1.27 (1.22–1.32)	0.650	137.41§
Colon	4.7	7.0	1.22 (1.17–1.27)	0.649	96.20§
Abdomen	4.5	6.6	1.32 (1.27–1.37)	0.651	196.96§
Other	4.8	7.1	1.30 (1.25–1.35)	0.651	173.23§
No. of procedures				0.660	521.39§
0	NA	3.3	Ref		
1	NA	4.7	1.23 (1.16–1.31)		
2	NA	5.8	1.42 (1.33–1.52)		
3+	NA	8.4	1.87 (1.76–1.98)		
Respiratory complications					
Baseline‡	12.9	NA	NA	0.802	NA
Any	4.9	15.5	2.20 (2.10–2.30)	0.808	1,383.56§
Surgical	6.7	15.6	1.64 (1.58–1.71)	0.805	737.91§
Nonsurgical	8.7	21.9	2.32 (2.26–2.39)	0.816	3,408.87§
Colon	8.5	20.5	1.73 (1.68–1.78)	0.808	1,342.36§
Abdomen	11.5	14.1	1.11 (1.08–1.14)	0.802	51.84§
Other	8.4	21.3	2.30 (2.24–2.37)	0.816	3,387.65§
No. of procedures				0.824	5,354.68§
0	NA	4.3	Ref		

Model	Observed rate Additional procedure?		Odds ratio (95% CI)	C-statistic*	Likelihood ratio test†
	No, %	Yes, %			
1	NA	8.0	1.43 (1.35–1.50)		
2	NA	13.2	2.17 (2.05–2.29)		
3±	NA	25.1	4.17 (3.97–4.38)		

No patients fell into this category.

*Internally validated using bootstrapping with 100 replications.

†Comparison of model with adjustment for same-day procedures to baseline model.

‡Model with adjustment for patient and hospital factors, but not same-day procedures.

§$p < 0.001$ after correction for multiple comparisons.

NA, Not applicable.