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Surgical Site Infections and Cost in Obese Patients Undergoing Colorectal Surgery

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Objectives: To measure the effect of obesity on surgical site infection (SSI) rates and to define the cost of SSIs in patients undergoing colorectal surgery.

Design, Setting, and Patients: This is a retrospective cohort study of 7020 colectomy patients using administrative claims data from 8 Blue Cross and Blue Shield insurance plans. Patients who had a total or segmental colectomy for colon cancer, diverticulitis, or inflammatory bowel disease between January 1, 2002, and December 31, 2008, were included.

Main Outcome Measures: We compared 30-day SSI rates among obese and nonobese patients and calculated total costs from all health care claims for 90 days following surgery. Multivariate logistic regression was performed to identify risk factors for SSIs.

Results: Obese patients had an increased rate of SSI compared with nonobese patients (14.5% vs 9.5%, respectively; $P<.001$). Independent risk factors for these infections were obesity (odds ratio = 1.59; 95% confidence interval, 1.32-1.91) and open operation as compared with a laparoscopic procedure (odds ratio = 1.57; 95% confidence interval, 1.25-1.97). The mean total cost was $31 933 in patients with infection vs $14 608 in patients without infection ($P<.001$). Total length of stay was longer in patients with infection than in those without infection (mean, 9.5 vs 8.1 days, respectively; $P<.001$), as was the probability of hospital readmission (27.8% vs 6.8%, respectively; $P<.001$).

Conclusions: Obesity increases the risk of an SSI after colectomy by 60%, and the presence of infection increases the colectomy cost by a mean of $17 324. Pay-for-performance policies that do not account for this increased rate of SSI and cost of caring for obese patients may lead to perverse incentives that could penalize surgeons who care for this population.

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SURGICAL SITE INFECTION (SSI) rate is now considered by policy makers to be one of the best available surrogate measures of quality in surgery. Hospital SSI rates will be publicly reported starting in 2012. Federal, state, and local pay-for-performance policies are increasingly incorporating SSI rates into their reimbursement algorithms, and health care providers are starting to be financially penalized when an SSI occurs.[1] While business strategies to monitor and reward low SSI rates are celebrated, it is important to note that risk factors for SSI are not factored into pay-for-performance policies. By far, the most common major SSI risk factor encountered is obesity—a condition that is increasing in prevalence and differentially affects certain minority populations. For example, the prevalence of this risk factor in the US population is 32% among white men, whereas it is 50% among black women.[2] Thus, depending on the effect of obesity as an intrinsic risk factor for SSI, pay-for-performance policies may be penalizing surgeons who disproportionately care for these high-risk populations.

See Invited Critique at end of article

We chose to study colectomy as a standardized procedure because the risk of SSI following this procedure is known to be greater than that following other abdominal procedures. In addition, there is substantial variation in the rate of SSI after colectomy, with rates ranging from 3% to 25% in the published literature.[3-5] The cost of an SSI is believed to be significant as patients with SSIs frequently have longer hos-

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pital stays and require outpatient wound care supplies and home nursing assistance.[6,7] However, to our knowledge, this cost has never been quantified from private insurance claims. Compliance with SSI-specific process measures (appropriate use of antibiotics, use of clippers for hair removal, and maintenance of normothermia) is believed to affect SSI rates[8]; however, recent evidence suggests that this influence is minor or even nonexistent.[9] We designed a study to quantify the rate of SSIs in obese and nonobese patients undergoing colectomy and to determine the cost of SSIs based on payments made by private insurance companies.

METHODS

DATA SET

The data set consisted of claims from members of 8 different Blue Cross and Blue Shield (BCBS) insurance plans (BCBS of Tennessee, BCBS of Hawaii, BCBS of Michigan, BCBS of North Carolina, Highmark, Inc of Pennsylvania, Independence Blue Cross of Pennsylvania, Wellmark BCBS of Iowa, and Wellmark BCBS of South Dakota) who met any of the following inclusion criteria from January 1, 2002, through December 31, 2008: (1) completed a health risk assessment with member height and weight; (2) had a claim with a diagnosis of obesity; (3) had a paid or denied claim for bariatric surgery; (4) had a paid or denied claim for a medication promoting weight loss; or (5) were older than 12 years and had a diagnosis of hyperlipidemia, type 2 diabetes mellitus, sleep apnea, gallbladder disease or surgery, or metabolic syndrome. These diagnoses were identified in the claims by *Current Procedural Terminology* (*CPT*) codes, diagnosis related groups, and *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnosis codes. The data set consisted of information on enrollee age and sex, enrollment dates, and claims for reimbursement for billable health care services, patient diagnoses as identified by *ICD-9-CM* codes and diagnosis related groups, and medical procedures classified by *CPT* codes and *ICD-9-CM* procedure codes. This study was exempt from institutional review board approval because the patient information was deidentified in accordance with the Health Insurance Portability and Accountability Act of 1996.

STUDY POPULATION

We identified 7020 patients in the data set aged between 18 and 64 years who underwent a partial or total colectomy (identified by *CPT* and *ICD-9-CM* procedure codes) for a diagnosis of colon cancer, diverticulitis, or inflammatory bowel disease (identified by *ICD-9-CM* diagnosis codes). Patients older than 65 years were excluded because their BCBS coverage was only supplemental and some of the charges associated with the colectomy were covered by Medicare. Patients were defined as obese if they had a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) greater than or equal to 30 (documented in patients with completed health risk assessment data) and/or an *ICD-9-CM* diagnosis of obesity (*ICD-9-CM* code 278, V85.35-V85.39, or V85.4). One patient was excluded because of a traumatic injury diagnosis code in addition to the diagnoses previously listed. Postoperative infections were identified by *ICD-9-CM* codes for superficial, deep, or organ space infections (abdominal abscess). Although we determined the patients' cost of care for 90 days, we defined postoperative infection as an infection that occurred within 30 days after the operation.

COST ANALYSIS

Cost associated with colectomy was calculated from the paid claims for total hospital, emergency department, home health, and outpatient pharmacy services starting on the day of surgery and continuing for 90 days following the surgical procedure. The diagnosis related group–standardized payments were used to calculate inpatient costs. In the event that this was not available, the sum of line items for the admission was used to approximate inpatient costs. Physician payments were standardized by *CPT* code. Pharmacy payments were derived from the amount paid by the insurance plan. If a claim had a missing or nonpositive payment amount after the algorithm described earlier was followed, the payment was imputed from the claims with nonmissing payments based on the insurance plan, code (diagnosis related group, *CPT*, or *ICD-9-CM* procedure code), and year. Eight percent of the facility line item claims had to be imputed, while all the other files had 2% or fewer imputed values.

STATISTICAL ANALYSIS

The main outcomes of interest were development of SSI, length of stay, total cost, and overall cost attributable to an SSI (during the 90 days after operation). We determined simple descriptive statistics, and logistic regression was performed to identify risk factors for the development of SSIs. We selected variables for the logistic regression based on availability in the claims database. Detailed patient and procedural factors including American Society of Anesthesiologists classification and wound classification were not available. All statistical analysis of costs used log-transformed values. We used SAS version 9.13 statistical software (SAS Institute, Inc, Cary, North Carolina) for all analyses. $P < .05$ was considered statistically significant.

RESULTS

CHARACTERISTICS OF THE STUDY POPULATION

We identified 7020 patients who underwent either a segmental or total colectomy for colon cancer, diverticulitis, or inflammatory bowel disease between January 1, 2002, and December 31, 2008. A total of 1243 patients met the criteria for being obese at the time of colectomy. Significantly more women (52.6%) than men (47.4%) were obese (**Table 1**). Colectomy for diverticulitis was more common in the obese patients than in the nonobese patients, but the other diagnoses did not differ (Table 1).

EFFECT OF OBESITY ON SSI

The overall SSI rate was 10.3%, and obese patients had an increased rate of SSIs compared with nonobese patients (14.5% vs 9.5%, respectively; $P < .001$) (Table 1). On multivariate analysis, obesity was the strongest predictor of SSI (odds ratio = 1.59; 95% confidence interval, 1.32-1.91) after adjustment for laparoscopy, diagnosis, sex, and age (**Table 2**). Open colectomy as compared with laparoscopic colectomy was also associated with an increased risk of SSI (odds ratio = 1.57; 95% confidence interval, 1.25-1.97).

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Table 1. Characteristics of the Study Patients by Obesity Status

Characteristic	All (N=7020)	Obese (n=1243)	Nonobese (n=5777)	*P* Value
Age, mean (range), y	54.1 (18-64)	52.3 (18-64)	54.5 (18-64)	<.001
Sex, No. (%)				<.001
Male	3707 (52.8)	589 (47.4)	3118 (54.0)	
Female	3313 (47.2)	654 (52.6)	2659 (46.0)	
Diagnosis, No. (%)				<.001
Colon cancer	3909 (55.7)	643 (51.7)	3266 (56.5)	
Diverticulitis	2817 (40.1)	558 (44.9)	2259 (39.1)	
Inflammatory bowel disease	294 (4.2)	42 (3.4)	252 (4.4)	
Laparoscopic colectomy, No. (%)	1273 (18.1)	204 (16.4)	1069 (18.5)	.08
Surgical site infection, No. (%)	726 (10.3)	173 (14.5)	553 (9.5)	<.001

Table 2. Logistic Regression of Risk Factors for Surgical Site Infection

Risk Factor	OR (95% CI) Univariate	OR (95% CI) Multivariate
Obesity	1.61 (1.34-1.93)	1.59 (1.32-1.91)
Open operation	1.59 (1.27-2.00)	1.57 (1.25-1.97)
Diagnosis		
Colon cancer	0.97 (0.83-1.13)	1 [Reference]
Diverticulitis	0.98 (0.84-1.15)	0.98 (0.83-1.15)
Inflammatory bowel disease	1.34 (0.95-1.90)	1.27 (0.88-1.84)
Female	1.03 (0.89-1.21)	1.02 (0.87-1.19)
Age >55 y	0.99 (0.98-1.00)	1.00 (0.99-1.01)

Abbreviations: CI, confidence interval; OR, odd ratio.

Table 3. Cost and Length of Stay by Obesity Status

Outcome	Mean (95% CI) Obese	Mean (95% CI) Nonobese
Cost, $	16 642 (15 239-18 045)[a]	16 347 (15 692-17 002)
Length of stay, d	8.5 (8.1-8.8)[b]	8.2 (8.0-8.3)

Abbreviation: CI, confidence interval.
[a] $P = .50$.
[b] $P = .13$.

EFFECT OF OBESITY AND SSI ON COST OF COLECTOMY

The mean (SE) cost of colectomy was $16 399 ($280). Colectomy in obese patients cost approximately $295 more than in nonobese patients, regardless of whether the patient developed a postoperative SSI ($P = .50$) (**Table 3**). On average, development of a postoperative SSI increased the cost of colectomy by $17 324 (**Table 4**). Patients with an SSI compared with those without an SSI had longer hospital stays (mean, 9.5 vs 8.1 days, respectively; $P < .001$) and markedly higher rates of hospital readmission (27.8% vs 6.8%, respectively; $P < .001$). For patients with SSIs, the most common diagnosis at the time of readmission was SSI (56.1% of readmissions), while patients without SSIs were most frequently readmitted for gastrointestinal symptoms or dehydration (57.4% of readmissions). In the event that a readmission occurred, the median length of the readmission stay was longer in patients with SSIs than in those without SSIs (7.0 vs 5.0 days, respectively; $P < .001$).

Table 4. Cost and Length of Stay by Development of Postoperative Surgical Site Infections

Outcome	Mean (95% CI) Patients With SSI	Mean (95% CI) Patients Without SSI
Cost, $		
Total	31 933 (29 607-34 258)[a]	14 608 (14 018-15 197)
Subtype		
Inpatient	26 307 (24 045-28 569)	11 029 (10 488-11 507)
Ambulatory	4174 (3617-4730)	3120 (2934-3305)
Emergency department	587 (416-759)	184 (148-220)
Home care	1294 (1062-1526)	253 (225-280)
Pharmacy	699 (575-824)	463 (435-492)
Length of stay, mean (95% CI), d	9.5 (9.0-10.0)[a]	8.1 (8.0-8.2)

Abbreviations: CI, confidence interval; SSI, surgical site infection.
[a] $P < .001$.

COMMENT

Surgical site infections are increasingly the target of governmental and private efforts to improve quality in surgical care.[8] Provisions that would cease payment for surgeons and hospitals in the event a patient develops a postoperative SSI have even been proposed. Such pay-for-performance programs will unfairly penalize hospitals and health care providers who disproportionately care for obese and other high-risk patients. Because the prevalence of obesity is substantially higher in certain minority subgroups such as black women, we warn of the discriminatory implications of unadjusted pay-for-performance policies.[2]

In this study, we found that for patients undergoing colectomy, obesity increases the risk of developing a postoperative SSI by 60%. We also identified open procedures to be a higher risk for SSI, similar to other SSI studies. In our study, patients with an SSI incurred approximately $17 000 more in claims than patients who did not develop an SSI. Much of the increased cost stems

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from the markedly increased rate of hospital readmission in patients with SSIs. While it has long been assumed that colorectal SSIs are costly, this is the first comprehensive study to our knowledge of the total cost of SSIs using a non-Medicare insurance claims database.[6,7,10] Thus, the difference in cost between patients with and without SSIs reflects the true financial impact of these complications as compared with prior studies that focused on the same hospital admission charges. Furthermore, our findings also suggest that much of the additional expense of caring for obese patients stems from SSI-related costs, a portion of which may be attributed to the increased length of stay and hospital readmission rate noted in patients with SSIs. Patients with SSIs had a higher chance of being readmitted; when they were readmitted, the stay was on average 2 days longer.

The obesity epidemic is increasingly taxing the entire American health care system. In 1998, it was estimated that direct and indirect costs of obesity and obesity-related health problems accounted for 9.1% of the total US medical expenditure.[11] However, information about the true cost of caring for these patients is limited. We demonstrated that obesity is a major risk factor for colorectal SSIs. Previously, a European study of patients undergoing clean general surgery procedures (colorectal operations were excluded) demonstrated that the development of nosocomial infections in surgical patients leads to increased hospital stays and longer time to return to work—the overall cost was estimated to be £90 000 in 1998.[7] More recently, using crude calculations, it was estimated that colorectal patients with SSIs incur about $6200 in home health care costs.[4] In this study using an insurance claims database, we estimated that patients with SSIs cost $17 000 more than patients without SSIs.

Public reporting of hospital quality data has been initiated by both the Centers for Medicare and Medicaid Services and commercial health care plans. Simultaneously, pilot programs focused on pay for reporting and pay for performance have also commenced.[12] While interest in these initiatives has intensified in the health care marketplace, data to support improved care as a result of pay for performance are limited.[1] In fact, pay for performance can paradoxically exacerbate health care disparities by discouraging physicians and hospitals from treating high-risk populations such as obese patients. Because there is consideration for including postcolectomy wound infections in pay-for-performance programs, we designed this study to define the SSI rate in a large and geographically diverse population undergoing colon resections, describe the risk factors, and determine the additional cost associated with caring for patients with SSIs.

There are a few limitations of this study. First, administrative databases generally underestimate SSI rates (3.7%-5%)[6] as compared with prospective studies (15%-40%).[4,5] Although the SSI rate in our study is lower than those in prospective reports, it is markedly higher than rates determined from other hospital databases. We speculate that inclusion of both inpatient and outpatient claims significantly increased our ability to detect SSIs. It is increasingly recognized that a significant number of colorectal SSIs are diagnosed in the outpatient setting. Because we identified SSIs based on claims data, we are not able to distinguish organ space infections from anastomotic leaks. A portion of the SSIs that we identified are likely the result of anastomotic disruption. These events may be driving a significant portion of the increased cost in patients with SSIs. Second, our study has no information about compliance with SSI-related process measures (appropriate dosing of antibiotics and use of clippers for hair removal) and specific details about the procedures (wound classification and operation duration). However, new studies have called into question the true effect of these process measures in improving hospital SSI rates.[9] The determination of obese vs nonobese patients is similarly limited to those who have an obesity diagnosis code or have BMI information through health risk assessment questionnaires. This likely underestimates the number of obese patients in the data set, as some patients who are not diagnosed as being obese or do not have BMI information available may still be obese. (In contrast, those with a diagnosis of obesity are unlikely to be nonobese.) Given this misclassification, our results are likely a conservative estimate of the effects of obesity; in reality, the differences in SSI rates and costs between obese and nonobese patients are likely even greater than those described in this study. Another limitation is the accuracy of the cost data specific to SSI. While other ongoing care costs in patients with SSI may be included, the cost we report is the true cost realized to the payer for a patient with an SSI compared with those without an SSI. Finally, information about patient comorbidities in the data set is limited. There is no information about many of the patient characteristics frequently associated with increased risk of SSIs such as cigarette smoking, preoperative sepsis, nutritional status, or emergency operation. These limitations are intrinsic to claims data and, in our opinion, are outweighed by the strengths of the data set, its size, and exact paid claims data included instead of charge data.

The costs to society of SSIs are far greater than we can estimate in this study, as patients with SSIs have delayed return to daily activities after surgery and have increased risk of long-term complications such as ventral hernias and stoma complications. A prospective study is necessary to quantify these costs. We conclude that patients undergoing colorectal surgery who develop SSIs, many of whom are obese, tax the health care system. Pay-for-performance policies in surgery should account for the increased risk of infection and cost of caring for this population. Failure to consider these differences could lead to perverse incentives that may penalize surgeons who care for obese patients and may even affect obese patients' access to colorectal surgery.

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INVITED CRITIQUE

Preventing Unintended Consequences of Quality Measurement

Wick and colleagues[1] report an important study in which they used a large administrative database to examine the association between obesity and surgical site infection (SSI) in patients undergoing colectomy. The authors interpret their results within the context of an increasing call for public reporting of infection rates and incorporation of SSI into pay-for-performance policies, cautioning that such programs may incentivize surgeons to preferentially operate on nonobese patients. The authors' message is clear, timely, and appropriate. We would like to further highlight 2 pertinent issues: preventing unintended consequences and the source of data for quality evaluation.

We agree with the authors that public reporting of unadjusted SSI rates may result in surgeons cherry-picking patients perceived to be at low risk, thus resulting in an increased disparity in receipt of surgical care for higher-risk patient populations. One potential solution to prevent this unintended consequence is to report outcomes that are risk adjusted for relevant patient factors such as obesity. Surgeons can then be reassured that an obese patient's increased risk of SSI is being taken into account by adjusting for obesity in the analysis.

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