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ORIGINAL ARTICLE

Obesity, Regardless of Comorbidity, Influences Outcomes After Colorectal Surgery—Time to Rethink the Pay-for-Performance Metrics?

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Abstract An elevated body mass index (BMI) is associated with increased morbidity and mortality after colorectal surgery. While coexistent comorbid conditions are captured in some determinations of case-severity, BMI itself is not factored into pay for performance (P4P) initiatives. From the National Surgical Quality Improvement Program database 2006–2011, obese (BMI ≥30 kg/m^2) and nonobese (BMI <30 kg/m^2) patients with and without comorbidity undergoing colorectal resection were identified. Pre- and intraoperative factors as well as postoperative outcomes were compared. Of 130,415 patients, 31.3 % were obese. 80.4 % of obese and 72.9 % of nonobese patients had comorbid conditions. Among obese patients, overall rates of surgical site infection (SSI), wound dehiscence, and various medical complications were significantly higher for those with comorbidity compared to those without (p<0.001 for all). Obese patients with comorbidity overall had greater risk of renal failure and urinary tract infection than nonobese patients. Regardless of comorbidity, obese patients more commonly had pulmonary embolism, failure to wean from the ventilator, overall SSI, and wound dehiscence. Comorbid factors associated with obesity influence outcomes; however, obesity itself in their absence is associated with worse outcomes. This supports inclusion of obesity as an independent determinant of case-severity, quality, and reimbursement after colorectal surgery.

Keywords Obesity · Colorectal · Outcomes · Pay for performance · Quality · Colorectal surgery · General surgery · Comorbidity · SSI · Complications · NSQIP

Introduction

The introduction of several pay-for-performance (P4P) initiatives in the last few years may threaten how care of challenging patients is reimbursed. This may hence affect how surgeons select patients for surgery, stranding higher risk patients without access to surgical care.[1,2] Obesity, defined as body mass index (BMI) ≥30 kg/m^2, is known to be associated with increased risk of surgical site infections (SSI), incisional hernias, and increased operative time after colorectal surgery.[3–5] Comorbidity and morbid obesity further increase these risks.[3] Increased SSI and wound dehiscence rates in obese patients are thought to be due to tissue devascularization and relative hypoxia in the surgical wounds as well as possible metabolic and microvascular pathologies coexistent with obesity.[6–8] Diabetes mellitus, which is more common in obese patients, is known to be associated with a greater risk for SSI.[9] SSI can increase hospital costs as well as outpatient costs.[10] While comorbidity is included in current determinants of disease severity, BMI alone is not. The detrimental aspects of an increased body mass index may be indirectly captured, but obesity in itself creates a surgical challenge, and this is not being adequately reflected. Whether obesity, per se, even in the absence of comorbidity is a determinant of adverse outcome after colorectal surgery has not been characterized. The presence of such an association would strongly support the inclusion of obesity itself in any risk stratification for postoperative complications and hence reimbursements, reporting and quality metrics, as well as P4P initiatives.

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The aim of this study is to examine whether obesity even in the absence of comorbidity adversely influences outcomes after colorectal surgery.

Methods

After institutional review board approval, all patients undergoing colon and rectal resection from 2006 to 2011 were identified from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database.[11,12] Obese (BMI ≥30 kg/m^2) and nonobese (BMI <30 kg/m^2) patients with and without comorbidity were compared. The presence or absence of any of the following: diabetes mellitus (DM), hypertension (HTN), chronic obstructive pulmonary disease (COPD), dyspnea, coronary artery disease/congestive heart failure (CAD/CHF, angina, prior myocardial Infarction, cardiac surgery, or percutaneous coronary intervention), cerebrovascular accident (CVA), neuropathy, hemiplegia, peripheral vascular disease (PVD; rest pain included), ascites, esophageal varices, malignancy (disseminated, recent chemotherapy or radiation therapy, central nervous system tumor), paraplegia/quadriplegia, renal failure (acute or chronic), excessive weight loss, steroid use, and bleeding disorder, was used to classify patients as having a comorbidity or otherwise. We compared four groups of patients: Group 1 BMI <30 kg/m^2 without comorbidity, group 2 BMI ≥30 kg/m^2 without comorbidity, group 3 BMI <30 kg/m^2 and comorbidity, and group 4 BM≥30 kg/m^2 and comorbidity.

Complications and Outcomes

Postoperative complications that were included as 'surgical' were surgical site infection (SSI), wound dehiscence, perioperative bleeding, and reoperation. 'Medical' complications included pulmonary embolism (PE), urinary tract infection (UTI), pneumonia, failure to wean from the ventilator, myocardial infarction (MI), cerebrovascular accident (CVA), and acute renal failure (ARF) and 30-day mortality.

Statistics

Descriptive statistics such as frequencies of comorbidities were computed for all categorical variables. Differences in groups were assessed using chi-squared or Fisher's exact tests. Quantitative variables were summarized using mean, median, and standard deviation as well as Student's *T*-test or the one-way ANOVA were used to compare groups. A p value of 0.05 was considered statistically significant. SPSS 21 statistical software was used for analyses.

Results

Patient Characteristics

Of 133,535 total patients undergoing colorectal resection, 130,415 adults had complete data, 1.7 % were aged >90 years (mean age 61.3 years for those ≤89), and 47.7 % were male (Table 1). The most common procedure was an open partial colectomy (26.4 % of patients), with colorectal cancer (26.4 %) and diverticular disease (20 %) the most common diagnoses. Laparoscopy was performed in 35.4 % of patients. The most common comorbidities were HTN (50.4 %) and DM (14.7 %). We excluded 2.3 % of patients (n=3161) who had missing information on BMI from analyses. Of the remaining, 40,853 were obese; most of these had comorbidities (80.4 %, n=32,833). Nonobese patients made up 67.1 % (n=89,562) of the study population, and comorbidities were also relatively common in this group (72.9 %, n=65,260) (p<0.001). Nonobese patients had greater tobacco use than obese patients. Obese and nonobese patients without comorbidity tended to be younger. Nonobese patients more commonly underwent emergency operations than obese patients as did those with comorbidities. Obesity, regardless of comorbidity, was associated with increased operative time (p<0.001).

Surgical Complications

The most common surgical complication was SSI, present in 13.6 % of patients overall (Table 2). Regardless of the presence or absence of comorbidity, obese patients were more likely to have SSI and wound dehiscence than nonobese patients. Obese patients with comorbidity were more likely to have superficial and deep SSI than nonobese patients with comorbidity. When compared to obese patients without comorbidity, obese patients with comorbidity had greater rate of organ space SSI. While obese patients with comorbidity had a higher rate of organ space SSI than nonobese patients when they underwent open surgery, this complication was similar for both groups undergoing laparoscopic procedures. When patients were divided into five classes according to BMI, patients in the group with a BMI ≥35 have the highest risk for SSI overall (19.8 % BMI ≥35 vs. 11.4 % BMI ≤18, p<0.001) and wound dehiscence (3.0 vs. 1.9 %, p<0.001). It seems that increasing obesity has a cumulative effect on poor outcomes regarding wound complications.

Medical Complications and Outcomes

Obesity irrespective of comorbidity was associated with increased pulmonary embolism, and failure to wean from the ventilator (Table 3). The presence of comorbidity in obese patients was associated with pneumonia, UTI, MI, ARF, and CVA when compared to obese patients without comorbidity.

Table 1 Patient demographics

Characteristic	No comorbidity		Comorbidity present		*p* value[a]
	Nonobese (group 1; *N*=24,302)	Obese (group 2; *N*=8020)	Nonobese (group 3; *N*=65,260)	Obese (group 4; *N*=32,833)	
Age (mean years±SD)	54.5±15.1[b]	52.0±12.8[b]	64.6±15.6[c]	62.2±13.0[c]	<0.001
Gender (female)	13,049 (53.7 %)[b]	4106 (51.2 %)[b]	33,157 (50.8 %)[c]	17,520 (53.4 %)[c]	<0.05
Surgical technique (laparoscopic)	11,242 (46.3 %)	3732 (46.5 %)	20,686 (31.7 %)	10,547 (32.1 %)	>0.05
Emergency	1560 (6.4 %)[b]	374 (4.7 %)[b]	12,427 (19.0 %)[c]	5680 (17.3 %)[c]	<0.001
Operative time (mean minutes±SD)	166.6±86.7[b]	184.0±89.3[b]	162.9±91.9[c]	179.5±96.4[c]	<0.001

Group 1 BMI <30 kg/m^2 without comorbidity. Group 2 BMI ≥30 kg/m^2 without comorbidity. Group 3 BMI <30 kg/m^2 with comorbidity. Group 4 BMI ≥30 kg/m^2 with comorbidity

[a] *p* values relate to comparisons between all groups

[b] Statistically significant difference between nonobese and obese patients without comorbidities (groups 1 and 2)

[c] Statistically significant difference between nonobese and obese patients with comorbidities (groups 3 and 4)

Thirty-day postoperative mortality was significantly higher in obese patients with comorbidity when compared to obese patients without comorbidity (4.2 vs. 0.3 % $p<0.001$, respectively) (Table 3).

Discussion

Colorectal surgery is safe in obese patients, but is associated with an increased risk of several complications, particularly those related to the surgical wound.[13] Surgeons are familiar with the increased technical complexity and resultant risks for complications when performing operations in obese patients as compared to those who are nonobese. While the comorbid factors that are often associated with obesity are included in determinations of risk severity, obesity itself is, however, not considered a risk factor in current assessments of anticipated adverse perioperative outcomes. This inevitably has knock-on effects on reporting and quality metrics, as well as P4P initiatives. Thus, a determination of whether or not obesity, regardless of comorbidity, modulates outcomes after colorectal surgery and thus impinges on resource utilization has potential implications for health-care planning and policies. Our study found that current risk assessment strategies that include comorbidity alone, would account for the increased risk for perioperative bleeding, reoperation, renal failure, urinary tract infection, MI, and CVA in obese patients with comorbidity. However, obese patients without comorbidity, who constituted 6.1 % of the study population and 19.6 % of obese patients undergoing colorectal surgery, were also at higher risk for such complications as SSI, wound dehiscence, failure to wean from the ventilator, and PE than nonobese patients. This suggests that current assessment strategies may be under-

Table 2 Surgical complications

Complication	No comorbidities		Comorbidity present		*p* value[a]
	Nonobese (group 1; *N*=24,302)	Obese (group 2; *N*=8020)	Nonobese (group 3; *N*=65,260)	Obese (group 4; *N*=32,833)	
Superficial SSI	1559 (6.4 %)[b]	764 (9.5 %)[b]	4623 (7.1 %)[c]	3596 (11.0 %)[c]	<0.001
Deep SSI	248 (1.0 %)[b]	133 (1.7 %)[b]	991 (1.5 %)[c]	803 (2.4 %)[c]	<0.001
Organ space SSI	793 (3.3 %)	284 (3.5 %)	3072 (4.7 %)	1624 (4.9 %)	>0.05
Overall SSI	2494 (10.3 %)[b]	1141 (14.2 %)[b]	8319 (12.7 %)[c]	5776 (17.6 %)[c]	<0.001
Dehiscence	182 (0.70 %)[b]	103 (1.3 %)[b]	1204 (1.8 %)[c]	874 (2.7 %)[c]	<0.001
Perioperative bleeding	469 (1.9 %)	147 (1.8 %)	5130 (7.9 %)[c]	2313 (7.0 %)[c]	<0.05
Reoperation	1040 (4.3 %)	1342 (4.3 %)	5103 (7.8 %)[c]	2776 (8.5 %)[c]	<0.05

Group 1 BMI <30 kg/m^2 without comorbidity. Group 2 BMI ≥30 kg/m^2 without comorbidity. Group 3 BMI <30 kg/m^2 with comorbidity. Group 4 BMI ≥30 kg/m^2 with comorbidity

[a] *p* values relate to comparisons between all groups

[b] Statistically significant difference between nonobese and obese patients without comorbidities (groups 1 and 2)

[c] Statistically significant difference between nonobese and obese patients with comorbidities (groups 3 and 4)

Table 3 Medical complications

Complication	No comorbidities		Comorbidity present		p value[a]
	Nonobese (group 1; N=24,302)	Obese (group 2; N=8020)	Nonobese (group 3; N=65,260)	Obese (group 4; N=32,833)	
Pulmonary embolism	92 (0.4 %)[b]	63 (0.8 %)[b]	523 (0.8 %)[c]	346 (1.1 %)[c]	<0.001
Urinary tract infection	618 (2.5 %)	218 (2.7 %)	2788 (4.3 %)[c]	1496 (4.6 %)[c]	<0.05
Pneumonia	253 (1 %)	82 (1 %)	3105 (4.8 %)[c]	1324 (4 %)[c]	<0.001
Failure to wean	181 (0.7 %)[b]	80 (1 %)[b]	4386 (6.7 %)[c]	2548 (7.8 %)[c]	<0.05
Myocardial infarction	27 (0.1 %)	4 (0.05 %)	626 (1 %)[c]	254 (0.8 %)[c]	<0.05
Cerebrovascular accident	17 (0.1 %)	5 (0.1 %)	364 (0.6 %)	161 (0.5 %)	>0.05
Acute renal failure	31 (0.1 %)	13 (0.2 %)	757 (1.2 %)[c]	594 (1.8 %)[c]	<0.001
Length of stay (mean days±SD)	6.1±5.1	6.1±4.3	9.0±9.3	9.2±10.1	>0.05
30-day mortality	77 (0.3 %)	22 (0.3 %)	3438 (5.3 %)[c]	1376 (4.2 %)[c]	<0.001

Group 1 BMI <30 kg/m^2 without comorbidity. Group 2 BMI ≥30 kg/m^2 without comorbidity. Group 3 BMI <30 kg/m^2 with comorbidity. Group 4 BMI ≥30 kg/m^2 with comorbidity

[a] p values relate to comparisons between all groups

[b] Statistically significant difference between nonobese and obese patients without comorbidities (groups 1 and 2)

[c] Statistically significant difference between nonobese and obese patients with comorbidities (groups 3 and 4)

evaluating risks for this group of patients. This adversely impacts quality and outcome assessment as well as P4P initiatives, thereby potentially unfairly penalizing surgeons and hospitals that treat a greater proportion of these patients.

Obese patients were at greater risk for wound complications such as SSI and dehiscence regardless of the presence of comorbidity. Obesity has previously been shown to be associated with increased superficial and deep SSI.[6] Redundant adipose tissue and its propensity for poor vascularity likely contribute to poor healing and an increased risk of infection, and as such, this finding is not surprising. Obesity (particularly BMI >35) has also been identified as a risk factor for wound dehiscence as well as incisional hernia occurrence.[3,4,8,13] With regards to organ space SSI, this occurred with a higher rate in obese patients with comorbidities when compared to obese patients without comorbidities (p=0.015). This may be because organ space SSI is more closely associated with anastomotic leakage to which patients with comorbidity are likely more prone.[14,15] Another factor that may influence these results is operative site, as has been previously reported.[16] Proctectomy is associated with an increased rate of SSI (especially in the obese), and particularly deeper infections.[6] Since nonobese patients with comorbidities had more proctectomies in our study, this may have influenced the finding of a similar rate of organ space SSI for obese and nonobese patients. While obese patients with comorbidity had a higher rate of organ space SSI than nonobese patients when they underwent open surgery, this complication was similar for both groups undergoing laparoscopic procedures. It is possible that this is because laparoscopy negates some of the effects of obesity on organ space SSI.

Nonobese patients with comorbidity, were found to be more likely to undergo reoperation (8.5 vs. 4.3 % p=0.002). This may be due to the higher proportion of emergency operations in this group.

Increased failure to wean from the ventilator and PE were associated with obesity regardless of comorbidity. Obesity increases the work of breathing, and the presence of an active preoperative medical condition may further increase this risk.[17] Further, morbidly obese patients display greater pulmonary atelectasis after surgery than nonobese patients.[18] The association between PE and obesity has also previously been reported.[3]

Obese patients with comorbidity had increased rates of pneumonia, renal failure, UTI, and CVA when compared to obese patients without comorbidity. The association between obesity particularly in the presence of comorbidity and urinary and renal complications has previously been demonstrated.[19–21] The results here show a small, statistically significant difference in the rate of UTIs between the obese and nonobese patients with comorbidities (4.3 vs. 4.6 %, p= 0.044). Although this may have doubtful clinical relevance, it is valuable in recognition of the increased risk attributed to obesity alone and therefore the inclusion of UTI as a performance marker. Length of stay and 30-day mortality were greater in the obese patients with comorbidities, when compared to those without. This is secondary to the overall increased complications that occur in these complex patients. The occurrence of increased medical and surgical complications in obese patients with comorbidities makes them at higher risk for operations than other surgical patients. Mortality and increased time in the hospital puts significant financial strain on health systems.

Patients who underwent both elective and emergency surgery were included in this study. We found that within both the subgroups of patients who did or did not have comorbidity, nonobese patients had a significantly higher rate of emergency operative surgery than obese patients. Despite this, obese patients were still more likely to have worse outcomes than nonobese patients which further corroborate the negative effect of obesity regardless of comorbidity on outcomes.

Whether or not P4P initiatives actually improve quality and delivery of care is debatable.[22] The Premier Hospital Quality Improvement Demonstration (HQID) was introduced in 2003 and rewards hospitals for being in the top 20 % of hospitals for performance in outcomes. The Hospital Inpatient Quality Reporting Program (IQR) pays hospitals that successfully report designated quality measures a higher annual update to their payment rates or a reduction in the annual market basket update for hospitals that did not successfully report.[23] Particularly important outcomes examined by both of these policies are pneumonia, heart failure, MI, and SSI. Public reporting of these outcomes without adequate accounting for confounding variables such as obesity and comorbidity can reduce the reputation (and potentially patient referral) of centers that routinely treat high-risk patients. Non-reporting of perceived poor outcomes can lead to a reduction of payments to hospitals, thereby compounding the problem. Obese patients are particularly at risk for complications—surgery is technically challenging, takes more time, access is worse, exposure, and reach is more difficult.[18] Even in patients without comorbidity, colorectal surgery is a particular problem since it predisposes to SSI. As SSI is a poor outcome and may be seen as a measure of surgical quality, all factors that impinge on this outcome (as also others) hence need to be included.

Identifying patients at risk for SSI is important for preoperative patient counselling and in anticipating postoperative complications. Steps that have been shown to reduce the overall risk of SSI include hair removal with electric clippers, IV antibiotics at induction, surgical scrub for 2–5 min, and avoidance of perioperative hyperglycaemia.[24] A recent review of evidence-based non-pharmacological strategies to reduce the risk of SSI in colorectal surgery[25] supported the abandonment of preoperative showers with chlorhexidine, the use of chlorhexidine-alcohol skin preparation, perioperative maintenance of normothermia, use of laparoscopy when feasible, and consideration of the use of perioperative hyperoxia.

The findings of this study that evaluates a previously poorly explored area are important since the results may have potential implications for health-care planning. Since the study includes carefully accrued data for a large patient cohort, with standardized definitions for the various variables, the results are likely generalizable. Some limitations however need to be considered. The retrospective nature of the study, the selection of the participating hospitals, and the lack of an assessment of the degree of obesity as a determinant of the influence the nature and extent of complications are potential disadvantages. Despite these limitations, the finding that obesity in itself determines outcomes after colorectal surgery is relevant to the surgical community and may support the advocacy of its inclusion in any assessment of patient and operative severity. Our findings may be expected to be similar across operations for other GI surgery. For the purpose of this study, however, we chose to evaluate a homogeneous group of patients and considering that colorectal surgery is widely considered a high outlier for SSI, included only patients in this cohort for evaluation. Further, in an era of increased personalization of treatment, it is valuable to examine risks specific to a subspecialty. Current determinations of anticipated outcomes after colorectal surgery in obese patients without comorbidity likely underestimate risks in this group of patients. This may adversely influence not only determinations of surgeon and hospital performance and quality but also reputation and reimbursements including P4P initiatives.

Conflict of Interest Authors have nothing to disclose.

Authors' Contributions Iyare O. Esemuede and Ravi P. Kiran made substantial contributions to the conception and design of the project as well as acquisition, analysis, and interpretation of data. Iyare O. Esemuede, Ravi P. Kiran, Alice Murray, Steven A. Lee-Kong, and Daniel L. Feingold made significant contributions to drafting and revising the article. Final approval of the version to be published was done by all four authors.

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