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Laparoscopy Improves Short-term Outcomes After Surgery for Diverticular Disease

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Abstract

BACKGROUND & AIMS—Observational studies and small randomized controlled trials have shown that the use of laparoscopy in colon resection for diverticular disease is feasible and results in fewer complications. We analyzed data from a large, prospectively maintained, multicenter database (National Surgical Quality Initiative Program) to determine whether the use of laparoscopy in the elective treatment of diverticular disease decreases rates of complications compared with open surgery, independent of preoperative comorbid factors.

METHODS—The analysis included data from 6970 patients who underwent elective surgeries for diverticular disease from 2005 to 2008. Patients with diverticular disease were identified by International Classification of Diseases, 9th revision codes and then categorized into open or laparoscopic groups based on Current Procedural Terminology codes. Preoperative, intraoperative, and postoperative data were analyzed to determine factors associated with increased risk for postoperative complications.

RESULTS—Data were analyzed from 3468 patients who underwent open surgery and 3502 patients who underwent laparoscopic procedures. After correcting for probability of morbidity, American Society of Anesthesiology class, and ostomy creation, overall complications (including superficial surgical site infections, deep incisional surgical site infections, sepsis, and septic shock) occurred with significantly lower incidence among patients who underwent laparoscopic procedures compared with those who received open operations.

CONCLUSIONS—The use of laparoscopy for treating diverticular disease, in the absence of absolute contraindications, results in fewer postoperative complications compared with open surgery.

Keywords

Diverticulitis; Outcomes; Colectomy; Colorectal Surgery

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Conflicts of interest The authors disclose no conflicts.

This article has an accompanying continuing medical education activity on page e12. Learning Objective: Upon completion of these questions, successful learners will be able to review indications for, and treatment of, diverticular disease.

Diverticulitis is largely a disease of an aging population¹ and remains a significant problem in the United States, accounting for 312,000 hospital admissions, 1.5 million days of inpatient care, and 2.6 billion dollars per year.² These numbers likely will increase with the growing elderly population in the United States and other Western countries. Practice parameters for sigmoid diverticulitis from the American Society of Colon and Rectal Surgeons in 2006 recommend elective colon resection after one episode of complicated diverticulitis treated nonsurgically and that the decision to suggest elective sigmoid colectomy after recovery from acute diverticulitis should be made on a case-by-case basis.³ This largely is influenced by the practice of the surgeon performing the surgery. However, physicians must judge appropriately not only when to perform surgery but also which surgery to perform,⁴ as the optimal approach to these surgeries also remains controversial. Although several observational studies^{5,6} and randomized controlled trials⁷ have shown that a laparoscopic approach is feasible and may result in fewer complications, the approach remains largely the surgeon's decision. To date, there is no consensus regarding the optimal surgery and the American Society of Colon and Rectal surgeons continues to state that the laparoscopic approach is appropriate only in selected patients.³

The reason for the lack of widespread adoption of laparoscopy for the surgical treatment of elective colon surgery remains unclear. Since the first reported case by Redwine and Sharpe⁸ in 1991, evidence has mounted in support of offering laparoscopy to all patients requiring colon surgery who lack contraindications to laparoscopic surgery, by virtue of shown decreased risks of complications and decreased length of stay.⁹ Although most studies presented to date have shown fewer complications associated with a laparoscopic approach to diverticular surgery, these remain relatively small, single-center series or small randomized controlled trials. The detractors to laparoscopic colon surgery continue to argue that the evidence does not support a widespread adoption of this technique in the treatment of diverticular disease because this entity presents specific anatomic and technical challenges that are not applicable to other types of colon surgery.

The American College of Surgeons National Surgical Quality Initiative Program (NSQIP) is a large, prospective, multicenter database containing 4 years of patient data from more than 120 different private and academic hospitals. The purpose of this database was to allow for the accurate recording of short-term outcomes on a national scale. Several years of data are now available from this database and we have accessed this information to test the hypothesis that the use of laparoscopy in the elective treatment of diverticular disease decreases rates of complications compared with open surgery, independent of preoperative comorbid factors.

Material and Methods

Details of the American College of Surgeons NSQIP have been reported previously.¹⁰ It is an ongoing observational study in which trained, dedicated nurses prospectively collect preoperative, intraoperative, and postoperative information on patients undergoing major cardiac and noncardiac surgery under general, spinal, or epidural anesthesia for surgeries known to have significant complication rates. Each case contains 239 Health Insurance Portability and Accountability Act–compliant variables.⁹

For the purpose of this study, case identification consisted of patients entered into the NSQIP database from 2005 through 2008, which included all patients undergoing emergency and nonemergency cardiac and noncardiac surgery. Patients with diverticular disease were identified by International Classification of Disease, 9th revision codes and then categorized based on procedure type using Current Procedural Terminology (CPT) codes 44140, 44141, 44143, 44144, 44145, 44146 (open), and 44204, 44188, 44206, 44207,

44208 (laparoscopic) (Supplementary Table 1). We excluded all patients defined by the NSQIP to have undergone emergency surgery. This definition includes all patients who had surgery within 12 hours of admission.

Univariate analyses were performed to compare the postoperative, preoperative, and intraoperative variables between patients undergoing open procedures and patients undergoing laparoscopic operations using chi-square analysis and the Wilcoxon rank-sum test when appropriate. We included variables that were clinically significant and those that were associated significantly with outcome or treatment choice ($P < .10$) in the multivariate analyses. Multivariate logistic regressions were performed to estimate the relationship between treatment choice and outcomes (30-day mortality and overall complication), adjusting for all observed confounders.

Propensity score analyses were performed to attenuate the problem of potential selection bias and to adjust for nonrandom assignment of treatment. Selection bias could occur if surgeons choose the procedure based on perceived patient surgical risks and potential benefits gained from the procedure. Propensity scores were created based on all available preoperative variables, determining the probability of a patient being assigned to laparoscopic or open procedures. Propensity scores were divided into groups so that patients within each group had similar preoperative baseline risk factors. Propensity score groups were included as covariates in multivariate logistic regressions.

To assess whether laparoscopy and open procedures have different impacts on overall complications within morbidity probability groups and American Society of Anesthesiology (ASA) groups, our study population was categorized into 3 groups based on the predicted morbidity probability and 4 groups based on ASA classification. The probability of morbidity is a calculated score providing an estimation of the patient's risk of developing a postoperative complication.⁹ This score provides the ability to adjust for preoperative risk.^{10,11} Chi-square analyses were performed to evaluate the association between treatment choice and overall complication rate within each of these patient groups. All analyses were performed using SAS 9.2 software (SAS Institute, Cary, NC). Statistical significance was based on a P value of less than .05.

Results

Patient Demographics

From the NSQIP database we identified 8443 patients who were classified as having undergone 1 of the 11 procedures of interest. Of these, 1470 patients underwent emergency surgeries and were excluded. Three patients were omitted because of incomplete medical records; missing ASA classification, blood transfusion amount, and surgical time. This left 6970 patients to be included in our dataset. Of these patients, there were 3468 patients who underwent open procedures and 3502 patients who underwent laparoscopic procedures within the CPT codes listed previously.

Preoperative characteristics for both groups are shown in Table 1. Those patients undergoing laparoscopic surgeries were younger, had a lower body mass index, and had less comorbidities, including diabetes, severe chronic obstructive pulmonary disease, and history of myocardial infarctions. Patients undergoing laparoscopic procedures also were less likely to be ill at the time of surgery. This included a lower percentage of septic patients, a more favorable ASA class, and a lower preoperative probability of morbidity and mortality.

Postoperative/Intraoperative Characteristics

Next, we looked at different intraoperative and postoperative variables between the open and laparoscopic groups (Table 2). Overall, laparoscopic procedures were more likely to be performed in a clean/contaminated surgical field, as expected. We also found that surgical times were significantly longer with laparoscopic procedures, and that laparoscopic procedures were less likely to require a blood transfusion, although the incidence was low in both groups.

We hypothesized that patients undergoing laparoscopic surgeries for diverticular disease would have lower overall complications than those patients undergoing an open surgery. Thus, we analyzed the rate of different postoperative complications in those patients undergoing either a laparoscopic or open resection for diverticular disease. With univariate statistics, we found that the incidence of overall complications, including superficial surgical site infections, deep incisional surgical site infections, organ space surgical site infections, pneumonia, pulmonary embolism, sepsis, septic shock, and deep venous thrombosis/thrombophlebitis, were all lower in the laparoscopic group (Figure 1). We also found that postoperative length of stay (7.8 vs 4.8 days; $P < .001$) and 30-day mortality were decreased significantly in patients undergoing laparoscopic procedures (Table 2).

Multivariate Analysis Shows That Laparoscopy Independently Decreases Complications

Subsequently, we examined the effect of laparoscopy on complications using a multivariate logistic regression model (Table 3). Controlling for preoperative variables showed that superficial surgical site infections, deep incisional surgical site infections, sepsis, and septic shock again occurred at a significantly lower incidence in patients undergoing laparoscopic procedures. We used propensity score matching in an effort to ensure the validity of our findings and correct for possible sources of error, including selection bias and to correct for nonrandomization. After applying propensity score analysis, we found similar significant reductions in postoperative complications in patients treated laparoscopically for their diverticular disease (Table 3).

Preoperative Factors That Contribute to Postoperative Complications

In addition to surgical approach, the multivariate analysis revealed other factors that contribute to postoperative complications (Table 4). Preoperative comorbidities such as chronic obstructive pulmonary disease, severe or moribund ASA classification, and obesity all correlated with an increased risk for postoperative complications. Surgical factors such as surgical approach (open), wound classification (dirty/infected), surgical time longer than 4 hours, and blood transfusion all correlated with increased risk of postoperative complications.

We also were interested in identifying factors that correlated with postoperative mortality (Table 5). We found no effect of surgical approach on mortality. Chronic steroid use increased risk for postoperative mortality as did a missing preoperative hematocrit level. Other factors in our model had little effect on risk for postoperative death.

Risk Stratification Reveals Laparoscopy Decreases Risk for Postoperative Complications

To test our hypothesis using another statistical test, we stratified patients according to their preoperative probability of morbidity and ASA class. We found that patients undergoing laparoscopic resection for their diverticular disease had lower overall complications in comparison with patients undergoing open surgeries in all groups of either probability of morbidity or ASA class (Figure 2).

Discussion

As the population of the United States and other Western countries ages, treatment of diverticular disease is projected to impose a larger stress on the health care system, fostering the need for optimal management modalities. Between the years of 1998 and 2005 there was a 38% increase in the rates of elective surgeries for diverticulitis.⁴ With emerging literature suggesting decreased length of stay and lower postoperative morbidity in regards to elective laparoscopic colon surgery, we hypothesized that laparoscopic treatment of diverticular disease would offer patients similar reductions in complications and overall length of hospital stay. We found that patients undergoing elective laparoscopic surgery for their diverticular disease had significantly lower overall postoperative complications including septic shock, sepsis, deep incisional surgical site infections, and superficial surgical site infections when compared with patients undergoing open surgeries. Previous small series and randomized controlled trials have published similar findings. This report is from a large, multi-institutional database showing that laparoscopy leads to fewer complications after elective surgery for diverticular disease. Moreover, this report further strengthens the evidence favoring the laparoscopic approach to colon surgery, without specific contraindications.

Although elective laparoscopic colon surgery recently has been lauded,⁹ the recommendation of laparoscopic surgery specifically for diverticulitis has yet to meet similar acclaim. The reasons for the hesitancy to adopt laparoscopic colon surgery specifically for diverticulitis have been reported previously; sigmoid diverticulitis and its complications often cause dense pericolic and mesenteric inflammation and adhesions, distorting anatomic planes, making surgical dissection difficult and potentially hazardous.¹² In addition to extensive mesocolic and para-colic dissection and large-vessel ligation, there remains the removal of diseased colon and apprehension regarding anastomosis performance.⁶ Earlier experiences with open surgery found that elective resection for diverticulitis carried a higher morbidity than similar resections performed for neoplastic disease,¹³ and early laparoscopic experiences found higher conversion rates compared with the same resections for other indications.^{14–16} However, later experiences found that laparoscopic colon resection for diverticular disease was feasible and safe^{17,18} and most more recent studies cited conversion rates between 20%⁶ and 26%,¹² which is not dissimilar for current large series reports of conversion rates for neoplastic disease.¹⁹ The aforementioned series included cases of complicated diverticulitis and found that increased conversion was related to the presence of a fistula or abscess requiring preoperative drainage. These results were corroborated by Sher et al,²⁰ who also found higher conversion rates in those patients with more advanced class of disease classification as per Hinchey et al.²¹ However, regardless of reasons for reluctance or uncertainty, the results of this multicenter database would suggest that laparoscopy decreases overall complications and provides support for its universal acceptance as the procedure of choice for diverticular disease warranting surgical intervention.

Longer operating room times and thus increased surgical costs have been another reason for the lack of adoption of laparoscopic colon resection. Indeed, earlier studies by Pfeifer et al²² and Saba et al²³ found significant increases in cost associated with laparoscopic colon resection. However, recent data challenge this finding. Studies looking at cost analysis at institutions with considerable laparoscopic experience have reported decreased costs when taking into account length of stay, which would be a function of efficient surgical teams, limiting complications and conversion rates.^{24,25} Our results corroborate these outcomes, showing that although surgical times are slightly longer, this is offset by the significant reduction in postoperative length of stay. Also, the difference in surgical times is on the

order of minutes, and as laparoscopic experience increases among surgeons, surgical time likely will continue to decrease.²⁶

Our results also identify multiple preoperative/intraoperative variables that, on multivariate analysis, portend an increased risk of overall complications. Although many of these variables may be expected, some are not as explicit, such as a history of severe chronic obstructive pulmonary disease. Some of these variables are addressed when comparing open and laparoscopic surgery, including blood transfusions. Thus, the benefits of laparoscopic surgery with regards to complication rates appear to befit many of the preoperative and intraoperative variables that alone are risk factors for complications.

We acknowledge the limitations of this study. First, the patients included in this dataset were identified from the American College of Surgeons NSQIP database, which is an amalgamation of patients from 199 voluntary institutions. These institutions are disproportionately large academic hospitals with high-volume colon and rectal surgery centers. Unfortunately, we cannot correct for differences in hospital variables (procedure volume, number of beds, specialized centers), or differences in operating surgeon (procedure volume, fellowship training). The data are gathered prospectively and we believe reflects a more accurate description of real-world practices than that of a randomized controlled trial. In addition, only 30-day outcomes can be measured, which relies on nurse data extractors and phone call follow-up evaluation. These nurse extractors are hospital specific and often are unable to follow up with patients who are admitted to other hospitals to pursue future care.

Another significant limitation exists in the nonrandom assignment of patients to the type of surgical approach. Although we attempted to control for preoperative and intraoperative factors that may have affected our results, there most certainly are disease states and variables, as well as clinical judgment of the operating surgeon for which we cannot devise an acceptable control. Furthermore, we have tried to eliminate those patients who underwent an emergency surgery. However, this includes only those patients who undergo surgery within 12 hours of admission. Given the high rate of dirty/infected wounds in the study (Table 2) we assume that some patients failed attempted medical management and required surgery in a less than ideal situation. We have attempted to control for these differences using multiple statistical methods including propensity score adjustment (Table 4) and stratification according to variables known to increase complications (Figure 2). Despite the obvious differences between the 2 groups, laparoscopy was found to decrease the rate of postoperative complications independently.

The fact that we cannot accurately determine the rate of conversion of a laparoscopic procedure to an open surgery also introduces a concerning limitation. Unfortunately, no CPT code exists for conversion from a laparoscopic to an open surgery. In this article we have included in the laparoscopic group all patients coded as having undergone a laparoscopic surgery regardless of secondary and tertiary CPT codes. Likewise, all patients coded as having undergone an open surgery were included in the open group regardless of the secondary and tertiary codes. Although we could attempt to estimate conversion based on these secondary and tertiary fields, there is no way to fully know the intent of the operating surgeon. For example, the surgeon involved in a procedure coded as an open surgery with a laparoscopic code in the secondary field may have had the intent of performing only a diagnostic laparoscopy. Including such a case as a conversion would not be valid. Likewise, a procedure coded as a laparoscopic surgery with a laparotomy in the secondary field might be included as a conversion. However, it would not be possible to know why the surgery was converted or know the intent of the laparotomy. Therefore, we have chosen to analyze the data only using the primary CPT codes because we believe it is the most accurate

analysis introducing the least amount of bias on our part. Clearly, this choice could affect our data both negatively and positively. Conversion to open colectomy has been reported to carry a higher morbidity, longer hospital stay, and higher cost in some series.^{27,28} However, other series have not found higher complication rates for patients requiring conversion and have postulated that increased experience with laparoscopic colon resection would reduce the overall numbers of conversion.¹² This has been confirmed in multiple other series that have found that the learning curve associated with decreased conversion rates varied between 11 and 70 cases per surgeon.^{26,29–33} Therefore, as skill and comfort with the laparoscopic technique improves, conversion rates may continue to decrease, resulting in lower rates of postoperative complications.³⁴ However, we recognize from practices such as ours and those of our colleagues that as skill with the technique increases, the willingness to apply the technology broadly increases. Anecdotally, this results in a conversion rate that is relatively stable over time. How the broad application of laparoscopy to the surgical treatment of diverticulitis affects the overall rate of postoperative complications remains to be seen.

Conclusions

We have presented compelling evidence that the use of laparoscopy for elective colon surgery should be the recommended surgical approach for the treatment of diverticular disease. In addition, we have found that factors such as chronic obstructive pulmonary disease, increasing ASA, and increasing body mass index significantly contribute to postoperative complications. The identification of preoperative risk factors and optimizing surgical approach will lead to decreased postoperative complications and improved short-term outcomes. Future studies should focus on the effect of the broad application of laparoscopy to colon surgery on postoperative complications. Such a study would allow for the identification of groups of patients at high risk and provide insight into potential interventions that might decrease postoperative morbidity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Abbreviations used in this paper

ASA	American Society of Anesthesiology
CPT	Current Procedural Terminology
NSQIP	National Surgical Quality Initiative Program

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Figure 1. Univariate analysis of complications in those patients undergoing either laparoscopic or open surgeries for diverticular disease. All differences noted are statistically significant. DVT, deep venous thrombosis; SSI, surgical site infection.

Figure 2.

Rates of complications in those patients undergoing either laparoscopic or open surgeries for diverticular disease stratified according to risk predictors. (A) Patients were stratified into 3 groups of probability of morbidity. Differences in rates of complications were statistically significant. (B) Patients were stratified according to ASA classification. Differences in rates of complications were statistically significant.

Table 1

Preoperative Characteristics

	Open (n = 3468)	Laparoscopic (n = 3502)	P value
Male sex, %	46.9	49.1	.066
Mean age, y	59.2	55.6	<.0001
<40, %	7.1	9.6	
40–49, %	17.5	22.7	
50–59, %	27.3	30.1	
60–69, %	24.9	24.1	
70–79, %	15.5	10.9	
80+, %	7.7	2.7	
Mean BMI	29.2	28.9	<.0001
Underweight, %	2	0.7	
Normal weight, %	23.7	23	
Overweight, %	34.2	38.9	
Obese, %	37.7	36	
Super obese, %	0.9	0.5	
Missing, %	1.5	0.8	
Race			<.0001
Black, %	6.9	3.4	
White, %	79.2	83.5	
Other, %	14	13.2	
Current smoker, %	25.5	19	<.0001
Diabetes, %	10.7	7	<.0001
Ventilator-dependent, %	0	0.1	<.0001
History of severe COPD, %	5.3	2	<.0001
Functional health status			
Independent, %	94.7	99.2	<.0001
Current pneumonia, %	0	0.3	.0009
History of myocardial infarction, %	0.6	0.1	.0006
Currently on dialysis, %	0.7	0.1	<.0001
Chronic steroid use, %	4.5	1.9	<.0001
>10% loss of body weight, %	4.7	2	<.0001
Systemic sepsis			<.0001
None, %	89.6	98.1	
SIRS, %	7.8	1.4	
Sepsis, %	2.4	0.4	
Septic shock, %	0	0.2	
Other procedure before surgery, %	0.95	0.17	<.0001

	Open (n = 3468)	Laparoscopic (n = 3502)	P value
Chemotherapy for malignancy, %	0.8	0.3	.0031
Radiotherapy for malignancy, %	0.3	0.1	.0199
Preoperative hematocrit level	33.9	31.6	<.0001
Low, %	34.7	19.7	
High, %	61.5	73.5	
Missing, %	3.8	6.8	
Preoperative serum albumin level			<.0001
<3.3, %	16.9	5.1	
3.3, %	47.8	49.9	
Missing, %	35.4	45	
ASA class			<.0001
None, %	3.9	7.3	
Mild, %	55.9	70.9	
Severe, %	36.5	20.9	
Life-threatening/moribund, %	3.8	0.9	
Probability of morbidity	0.18	0.14	<.0001
Probability of mortality	0.014	0.005	<.0001

BMI, body mass index; COPD, chronic obstructive pulmonary disease; SIRS, systemic inflammatory response syndrome.

Table 2

Postoperative/Intraoperative Variables

	Open (n = 3468)	Laparoscopic (n = 3502)	P value
Wound class			<.0001
Clean/contaminated, %	59.3	76.2	
Contaminated, %	20.6	18.6	
Dirty/infected, %	20.1	5.1	
Mean surgical time, <i>h</i>	2.75	2.94	<.0001
3 h, %	65.3	56.1	
3–4 h, %	19.6	27.5	
4–5 h, %	8.7	11.6	
>5 h, %	6.4	4.8	
Blood transfusion, %			<.0001
None, %	93.1	99.1	
1–2 U, %	5.5	0.8	
3 U, %	1.2	0.1	
Superficial SSI, %	11.9	6.3	<.0001
Deep incisional SSI, %	2.0	0.7	<.0001
Organ space SSI, %	3.5	2.2	<.0001
Pneumonia, %	2.6	0.9	<.0001
Pulmonary embolism, %	0.8	0.3	.0039
Sepsis, %	4.5	2.2	<.0001
Septic shock, %	2.5	0.6	<.0001
DVT/thrombophlebitis, %	1.2	0.5	.0007
Overall complications, %	21.7	11.0	<.0001
30-day postoperative mortality, %	1.1	0.4	.0004
Mean postoperative length of stay, days	7.8	4.8	<.0001

DVT, deep venous thrombosis; SSI, surgical site infection.

Table 3

Multivariate Logistic Regression of Treatment Effect on Complication Groups

Complication outcomes	Comparison	Unadjusted logistic regression		Propensity score adjusted logistic regression	
		Odds ratio	95% CI	Odds ratio	95% CI
Superficial SSI	Lap vs open	0.51	0.423–0.615	0.508	0.422–0.613
Deep incisional SSI	Lap vs open	0.442	0.267–0.732	0.45	0.271–0.747
Organ space SSI	Lap vs open	0.734	0.532–1.015	0.732	0.529–1.013
Pneumonia	Lap vs open	0.715	0.449–1.136	0.742	0.466–1.184
Pulmonary embolism	Lap vs open	0.503	0.234–1.078	0.487	0.226–1.047
Sepsis	Lap vs open	0.662	0.485–0.902	0.659	0.483–0.901
Septic shock	Lap vs open	0.429	0.249–0.74	0.44	0.255–0.762
DVT/thrombophlebitis	Lap vs open	0.633	0.337–1.19	0.613	0.325–1.159

DVT, deep venous thrombosis; Lap, laparoscopic; SSI, surgical site infection.

Table 4

Multivariate Logistic Regression of Treatment Effect on 30-Day Morbidity

Parameter	Comparison	Unadjusted logistic regression		Propensity score adjusted logistic regression	
		Odds ratio	95% CI	Odds ratio	95% CI
Lap	No vs yes	0.543	0.468–0.629	0.541	0.467–0.628
History of severe COPD	Yes vs no	1.472	1.077–2.012	1.623	1.157–2.276
Preoperative systemic sepsis	Yes vs no	1.007	0.743–1.365	1.178	0.809–1.714
Prior surgery within 30 days	Missing vs no	1.388	1.143–1.684	1.426	1.158–1.756
ASA classification	Mild vs none	1.303	0.899–1.889	1.312	0.905–1.903
	Severe vs none	1.852	1.226–2.799	1.88	1.243–2.842
	Moribund vs none	2.234	1.186–4.206	2.241	1.188–4.225
Blood transfusion	1–2 vs none	1.493	1.08–2.066	1.49	1.076–2.064
Wound classification	Contam vs clean/contam	1.237	1.044–1.467	1.241	1.047–1.471
	Dirty/infected vs clean/contam	1.205	0.973–1.492	1.215	0.981–1.506
Surgical time	3 v 3–4 h	1.174	0.996–1.384	1.179	1–1.39
	3 v 4–5 h	1.708	1.387–2.103	1.708	1.387–2.104
	3 v >5 h	1.934	1.503–2.49	1.934	1.502–2.49
BMI	Obese vs normal	1.433	1.187–1.731	1.457	1.192–1.782
	Super obese vs normal	2.285	1.194–4.373	2.464	1.259–4.822
Probability of morbidity	Lap vs open	5.172	0.957–27.945	0.541	0.467–0.628

NOTE. Variables included in the model but not significant include: history of myocardial infarction, chronic steroid use, ventilator dependency, more than 10% weight loss in the previous 6 months, diabetes mellitus, sex, current smoker, age, BMI, and ostomy creation at time of surgery. BMI, body mass index; contam, contaminated; COPD, chronic obstructive pulmonary disease; Lap, laparoscopic.

Table 5

Multivariate Logistic Regression of Treatment Effect on 30-Day Mortality

Parameter	Comparison	Unadjusted logistic regression		Propensity score adjusted logistic regression	
		Odds ratio	95% CI	Odds ratio	95% CI
Laparoscopic	Open	1.319	0.607–2.865	1.376	0.634–2.985
Preoperative hematocrit level	<38% vs 38%	1.099	0.48–2.518	1.133	0.494–2.599
Radiotherapy	Missing vs 38%	5.839	1.365–24.974	9.365	1.962–44.7
Chronic steroid use	Yes vs no	18.498	1–342.016	16.593	0.982–280.256
ASA classification	Yes vs no	2.761	1.179–6.462	2.642	1.129–6.184
	Mild vs none	0.437	0.051–3.769	0.344	0.04–2.989
	Severe vs none	0.839	0.09–7.818	0.582	0.063–5.423
	Moribund vs none	1.767	0.139–22.463	1.245	0.098–15.757
Wound classification	Contam vs clean/contam	0.858	0.343–2.149	0.848	0.339–2.126
	Dirty/infected vs clean/contam	1.769	0.769–4.071	1.769	0.762–4.108
Age, y	<40 vs 80+	0.124	0.014–1.119	0.174	0.018–1.657
	40 vs 80+	0.045	0.005–0.384	0.06	0.007–0.525
	50 vs 80+	0.068	0.017–0.27	0.08	0.019–0.326
	60 vs 80+	0.257	0.108–0.613	0.293	0.121–0.729
	70 vs 80+	0.032	0.13–0.703	0.302	0.127–0.716
Race	Other vs black	0.152	0.027–0.84	0.138	0.025–0.766
	White vs black	0.482	0.175–1.33	0.476	0.169–1.34
Propensity score treatment	1st vs 4th			0.244	0.02–3.003
	2nd vs 4th			0.314	0.033–2.973
	3rd vs 4th			20.51	0.714–5.886

NOTE. Variables included in the model but not significant include: preoperative albumin level, chemotherapy, dialysis, preoperative functional status, chronic obstructive pulmonary disease, history of myocardial infarction, preoperative sepsis, prior surgery within 30 days, ventilator dependency, more than 10% weight loss preoperatively, body mass index, probability of morbidity, and ostomy creation at time of surgery.