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Optimizing Surgical Care of Colon Cancer in the Older Adult Population

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Abstract

Objective—We have undertaken the current study to evaluate factors that correlate with postoperative complications in older patients undergoing surgery for colon cancer.

Patients and Methods—The database of the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) from years 2005 to 2008 was accessed. Patients age 65 and older were included according to Current Procedural Terminology and International Classification of Disease-9 codes. Preoperative and operative variables were examined and postoperative complications assessed using a combination of univariate and multivariate statistical models. Propensity score matching was used to control for nonrandomization of the database.

Results—We found that patients undergoing laparoscopic (n = 2113) and open (n = 3801) surgery for the diagnosis of colon cancer were similar in age and gender. However, patients undergoing laparoscopic surgery were generally at lower risk for developing postoperative complications (16.1% vs. 25.4%, $P < 0.005$). Statistical models controlling for preoperative and operative variables demonstrated patients with elevated body mass index (odds ratio [OR] = 1.26), a history of chronic obstructive pulmonary disease (OR = 1.63), over age 85 (OR = 1.35), a surgery lasting longer than 4 hours (OR = 1.48), or having undergone an open operation (OR = 1.53) to have increased risk for developing postoperative complications. Propensity score match analysis confirmed these results.

Conclusions—Identification of preoperative factors that predispose patients to postoperative complications could allow for the institution of protocols that may decrease these events. Furthermore, expanding the role of laparoscopy in the treatment of older patients with colon cancer may decrease rates of postoperative complications.

In 2006, more than 12% of the United States' population was over the age of 65.¹ It has been projected that by 2050 there will be more than 20 million people over the age of 85 living in the United States. This has at least 2 implications for those interested in colon

cancer. Given that age is a significant risk factor for developing colon cancer, it is likely that we will see more patients with this disease.² Second, surgeons will have to operate on colon cancer patients who are on average older than current and who have more comorbid illnesses due to their advanced age. Therefore, optimizing surgical approach to this patient population remains a critical goal.

There is growing evidence that age may not represent an independent risk factor for poor outcomes in patients undergoing either surgical or medical therapy for colon cancer.^{3–7} In fact, a National Cancer Institute Surveillance Epidemiology and End Results-based population study reported a high quality of life in individuals whose disease was in remission at or beyond 3 years, regardless of age.⁸ Data such as these support the notion that we must strive to improve both medical and surgical outcomes in older adult patients with colon cancer.

Many studies have investigated the oncologic outcomes of patients undergoing laparoscopic surgery for colon cancer.^{9–14} None have found negative effects of surgical approach on oncologic outcomes. Furthermore, the surgical approach has generally been shown to have small to no effect on short-term outcomes such as complications, quality of life, and length of stay. However, the surgical standard of care for treatment of patients with colon cancer remains undefined.

The American College of Surgeons (ACS) has developed the National Surgical Quality Improvement Program (NSQIP), which tracks short-term outcomes of patients who undergo general and vascular procedures at participating institutions.^{15,16} Others have used this database effectively to demonstrate that patients undergoing laparoscopic colon resections have improved short-term outcomes over those patients treated through open surgery.^{17,18} However, none have looked exclusively in older patients with the diagnosis of colon cancer.

Anecdotally, we have found that laparoscopy improves short-term outcomes in the older adult patient population with multiple comorbidities. Therefore, we undertook this study of the NSQIP database to determine whether laparoscopy is associated with a decreased rate of complication in older patients undergoing surgery for colon cancer. We further wished to identify factors other than operative approach that correlate with complications in this group of patients.

PATIENTS AND METHODS

The details of the ACS NSQIP have been previously described.¹⁵ The ACS NSQIP provides risk-adjusted outcomes data to participating hospitals for the purpose of quality improvement. The program focuses on 30-day postoperative outcomes, including mortality and 21 categories of morbidity. Data collection at each participating institution is performed by a dedicated surgical clinical reviewer (SCR) with support and oversight from an ACS NSQIP Nurse Coordinator. The SCR, using medical chart extraction and other methods, collects detailed data on patient demographics, comorbidities, preoperative laboratory values, operative variables, and postoperative outcomes including 30-day complications, 30-day mortality, reoperation, and length of stay. Full descriptions of the qualifications, training, and auditing of data collection personnel, case inclusion criteria, sampling and data collection strategy, and variable and outcome definitions are available online from the ACS NSQIP website.¹⁹

In brief, the ACS NSQIP captures and reports 30-day morbidity and mortality outcomes for a sample of operations performed at participating institutions. In an attempt to limit bias in case selection, the NSQIP has developed a systematic sampling algorithm called the 8-day cycle. The number of patients included from each of the forty 8-day cycles per year is

dependent upon the surgical volume of the participating institution. The SCR at a high-volume hospital will capture the first 40 operations in the 8-day cycle thereby including 1640 patients per high-volume center. All patients from each 8-day cycle are captured at low-volume hospitals, which have to include at least 900 patients per year. A full description of the temporal sampling procedure as well as case inclusion and exclusion criteria can be obtained in the ACS NSQIP data user guide.¹⁹ Participant use files (PUF) containing 240 HIPAA (Health Insurance Portability and Accountability Act) compliant variables for each patient included from each participating site are made available yearly by the ACS. The 2008 PUF contains 271,368 cases submitted from 211 participating institutions. The 2005 to 2006 and 2007 PUFs contain 152,490 and 211,407 cases submitted by 183 sites, respectively. These files are available free of cost to individuals from participating institutions. The human subjects committee at the University of Wisconsin reviewed the database and deemed it to be exempt from Institutional review board review.

All 635,265 patients in the NSQIP database between 2005 and 2008 including all undergoing emergency and nonemergency cardiac and noncardiac surgery were considered for inclusion into this study. Patients undergoing open colon surgery were selected using the principal Current Procedural Terminology (CPT) codes 44140, 44141, 44145, 44146, 44147, 44150, and 4416. Those patients undergoing laparoscopic colon surgery were selected using the CPT codes 44204, 44205, 44206, 44207, 44208, and 44210. From these groups, patients undergoing surgery for colon cancer were selected using International Classification of Disease, 9th edition codes 153, 153.1, 153.2, 153.4, 153.5, 153.6, 153.7, 153.8, and 153.9. Those who underwent emergency operations or classified as American Society of Anesthesiology (ASA) class 5 were excluded. Other exclusion criteria included ventilator dependence, preoperative sepsis, comatose, and age less than 65.

Patients were dichotomized throughout our study into open or laparoscopic resection based on CPT codes. Outcome variables included 30-day mortality and 30-day complications (any—yes/no; and by category). Control variables include demographics (gender, race, age), as well as preoperative health status and comorbidities, perioperative variables, and preoperative laboratory values. Age was treated as both continuous and categorical variables (1, 65–75 years; 2, 75–85 years; and 3, 85+ years). Preoperative comorbidities included body mass index (BMI) (continuous—calculated from height and weight; categorical—underweight [BMI <18.5], normal [BMI = 18.5–24.9 kg/m²], overweight [BMI = 25–29.9 kg/m²], obese [BMI = 30–49 kg/m²], and superobese [BMI >50 kg/m²]),²⁰ diabetes mellitus (no/oral hypoglycemic agents or insulin), history of smoking in the year before surgery (no/yes), intake of more than 2 alcoholic drinks in the 2 weeks before surgery (no/yes), functional category (independent/totally or partially dependent), history of chronic obstructive pulmonary disease (COPD) (no/yes), current pneumonia (no/yes), presence of difficult or labored breathing (dyspnea no/yes), history of coronary artery disease (no/yes), history of peripheral vascular disease (no/yes), history of neurologic disease (no/yes), currently on dialysis (no/yes), use of steroids for chronic condition (no/yes), >10% weight loss in the 6 months prior to surgery (no/yes), ascites (no/yes), history of esophageal varices documented within 6 months of surgery (no/yes), history of congestive heart failure within 30 days of surgery (no/yes), history of bleeding disorders (no/yes), history of chemotherapy exposure in ≤30 days prior to surgery (no/yes), and presence of open wound/wound infection preoperatively (no/yes). Other control variables include the ASA category (1: no/mild; 2: severe; 3: life threatening) as well as intraoperative variables including surgical wound category (1: clean/contaminated; 2: contaminated; 3: dirty/infected), intraoperative blood transfusion (1: none; 2: 1–2; 3: ≥3), and length of operation (1: <4 hours, 2: 4–6 hours; and 3: >6 hours). Preoperative laboratory variables included creatinine (low, <1.2 mg/dL; high, >1.2 mg/dL; or missing), serum sodium (low, <135 mmol/L; normal, 135–145 mmol/L; high, >145 mmol/L; or missing), serum alkaline phosphatase (low, <125 U/L; high,

>125 U/L; or missing), white blood cell count (WBC low, <4.5 K/ μ L; normal, 4.5–11 K/ μ L; high, >11 K/ μ L; and missing), hematocrit (low, <38%; high, >38%; and missing), blood urea nitrogen (BUN low, <40 mg/dL; high, >40 mg/dL; or missing), serum glutamic oxaloacetic transaminase (low, <40 U/L; high, >40 U/L; or missing), albumin (low, <2.4 g/dL; normal, 2.5–3.39 mg/dL; high, >3.4 mg/dL; or missing) and platelets (low, <50 K/ μ L; normal, 50–400 K/ μ L; high, >400 K/ μ L; or missing).

Outcomes of interest were complications occurring within 30 days of the procedure and death occurring within 30 days of the procedure. All surgical outcomes and potential control variables were compared between the surgical approach groups using χ^2 tests for categorical variables and Wilcoxon rank sum tests for continuous variables. All variables that were found to be associated with surgical outcomes at a significance level of 0.10 in these univariate analyses were included in the multivariable model. Preoperative albumin and serum glutamic oxaloacetic transaminase categories were excluded from the final model to minimize the potential effect of multicollinearity.

To partially adjust for the nonrandom assignment of surgical approach, a propensity score model was constructed based on multivariate logistic regression using all the preoperative patient characteristics, comorbidities, and laboratory values. Propensity scores were divided into quintiles so that patients in the laparoscopic and open surgical approach groups had a similar distribution of preoperative baseline risk factors within each quintile.^{18,21} The propensity score variable was included in the final multivariable model (along with control variables that remained significant at $P = 0.1$) to examine the association between the surgical approach and morbidity and mortality as has been previously used by Bilimoria et al.¹⁸ Interaction terms involving the propensity score quintiles and other factors did not contribute to the overall quality of the multivariable model.

The NSQIP database includes a variable that estimates risk for either morbidity or mortality for each patient (probmorb and probmort, respectively). These variables were not included in the multivariable analyses. However, unadjusted subgroup analyses were performed to assess whether laparoscopy had a significant association with postoperative complications within 3 probability of morbidity groups: ≤ 0.2 , 0.2–0.4, and ≥ 0.4 ; 3 age groups: 65–75, 75–85, and ≥ 85 ; and 3 ASA categories: no/mild illness (ASA 1–2), severe illness (ASA 3), and life-threatening illness (ASA 4) using a χ^2 test. Statistical significance was considered with $P < 0.05$. All analyses were performed using SAS 9.1.3 for Windows (SAS Institute; Cary, NC).

RESULTS

Our data analysis for this study includes 5914 patients over the age of 65 who underwent either laparoscopic ($n = 2113$) or open ($n = 3801$) surgery for the diagnosis of colon cancer from 2005 to 2008. Table 1 presents the demographic and preoperative comorbidity data for the study population. In general, the patients who were operated on using the laparoscopic approach had less comorbidity. The average probability of morbidity, a score calculated by the ACS, was found to be significantly lower at 0.19 in those patients undergoing the laparoscopic approach compared with 0.21 in those undergoing open surgery ($P < 0.005$).

Next we examined operative and postoperative variables of the 2 groups using univariate statistical approaches (Tables 1 and 2). We found that patients in the laparoscopic group had fewer intra-operative transfusions (95% of the patients in this group had no transfusions) on average and had a shorter length of stay (6.7 vs. 8.7 days, $P < 0.005$). We also found that operative times were longer in the laparoscopic group (129.9 vs. 144.9 minutes, $P < 0.005$). Not surprisingly, we found the rate of overall complications (16.1 vs. 25.4, $P < 0.005$) and

mortality (2.1% vs. 3.7%, $P < 0.005$) to be significantly lower in the laparoscopic group. In addition, many of the individual complications occurred less often in the laparoscopic group (Fig. 1).

We performed a multivariable logistic analysis to control for preoperative and intraoperative factors other than surgical approach that likely contribute to the postoperative outcomes (Table 3).

Factors that correlated with an increased risk of complications included open surgery, increased age (over 75), increased BMI, history of alcohol use, functional status less than totally independent, history of COPD, presence of ascites, dirty or infected wound, ASA score of 2 or 3, and operation lasting between 4 and 6 hours. These results were confirmed when we incorporated propensity scores to partially control for the nonrandom assignment of the laparoscopic approach (Table 3).

We also performed a multivariable logistic regression analysis both with and without incorporating propensity scores to identify factors correlated with an increased risk for postoperative mortality (Table 4). We found that age more than 75, preoperative weight loss, nonindependent functional status, presence of preoperative dyspnea, presence of ascites, ASA of 3, and intraoperative transfusion of 1 to 2 units were associated with an increased risk of mortality in the first 30 days following a surgery for colon cancer. Surgical approach did not correlate with risk for postoperative mortality.

Although the multivariate analysis is compelling, it cannot be considered sufficient as there will be features of every patient that a surgeon will use to decide what operation to perform. To try to address this form of bias, we stratified the patients according to factors known to increase complications: probability of morbidity, age, and ASA category.^{17,18,22,23} Figure 2 demonstrates that complications were significantly decreased in the laparoscopic group in each of the stratified subsets.

DISCUSSION

We sought to determine if laparoscopy provides benefits to older patients undergoing surgery for colon cancer. Using 3 different statistical techniques we have found that laparoscopy is associated with a decrease in postoperative complications in the older patient population. In addition, we have found that age over 75, increased BMI (greater than 25 kg/m²), history of COPD, and prolonged operation time were also associated with postoperative morbidity. In contrast, laparoscopy did not independently correlate with reduced postoperative mortality.

Laparoscopic colectomy has been shown to be an oncologically safe technique for treating patients with resectable colon cancer through multiple randomized controlled trials (RCT).^{9–14} However, the laparoscopic technique has not been readily accepted as a new treatment standard. This slow acceptance is likely due to the fact that these RCTs have not uniformly demonstrated significant benefits over open surgery.^{9–14,24} Only the Barcelona trial by Lacy et al found a significant reduction in perioperative morbidity in the laparoscopic colectomy group (relative risk, 0.49; $P = 0.001$), with a significant reduction in wound infections and persistent ileus.²⁴ Interestingly, none of the other RCTs corroborated these results. However, most have demonstrated moderate reduction in hospital stays in those patients undergoing a laparoscopic approach. Our current study demonstrates a significant reduction in length of stay as well as postoperative complications in older adult patients undergoing a laparoscopic colectomy for cancer compared with older adult patients undergoing open surgery. The reason for this contradiction with most of the RCTs has many possible explanations.

First, the current study uses data collected prospectively from multiple institutions. The use of laparoscopy or open surgery was not assigned in a randomized manner. The lack of randomization gives rise to clear selection bias that is demonstrated in both Tables 1 and 2. We have attempted to control for this bias using a multivariable logistic regression analysis, which includes preoperative variables as well as an analysis in which we incorporated a propensity score that partially controls for the nonrandom assignment of surgical therapy. Both of these analyses found laparoscopy to be associated with a lower rate of complications independent of other preoperative factors (Table 3). In addition to the multivariable logistic regression analysis, we stratified patients according to factors known to increase risk for postoperative complications (Fig. 2). The results of all analyses allow us to conclude that laparoscopy is associated with a lower risk for complications independent of other preoperative factors for which we can control.

Other explanations for differences between our results and the published trials may include unintended age bias of the RCTs. These trials excluded patients with significant cardiac and/or pulmonary comorbidities and as a result, tended to include mostly younger patients. This is reflected in the mean age of patients in these trials (69 in the COST and CLASSIC trial and 71 in the COLOR trial).^{9,11,25} Furthermore, the COLOR trial excluded patients with a BMI >30 kg/m².¹¹ Therefore, the discrepancy between our results and those of the previously published studies may reflect different inclusion criteria regarding risk factors for postoperative complications, including age, pre-existing comorbidities, and BMI. Moreover, these RCTs were designed to detect oncologic outcomes such as disease-free and overall survival. Postoperative complications were secondary outcomes measured in these studies. Therefore, the currently published studies are not conclusive in their failure to detect differences in short-term outcomes between patients undergoing laparoscopic and open colon surgery.

Correlation between improvement in 30-day outcomes and improved quality of life cannot be accomplished by the current study. However, others have shown that advancing age and postoperative complications do correlate with discharge to a skilled nursing facility.²⁶ These authors also found that discharge to the skilled nursing facility correlated with a higher 30-day, 90-day, and 1-year mortality rate.²⁶ Therefore, any technique that can reduce the rate of complications in this patient population should be favored. The strength of the current study is that we have limited our analysis to patients over 65. We have further used multiple tests to partially control for the lack of randomization. Additionally, patients from more than 200 different hospitals with varied experiences and expertise are included. These factors taken in sum provide validity and broad applicability to our conclusions.

The main limitations of our study are related to the source of the data. The ACS NSQIP is a voluntary program and the 211 participating sites do not represent a statistically valid national sample of hospitals in the United States. However, it includes a mixture of both teaching and nonteaching hospitals thereby providing a snapshot of what is happening in surgical practice today. Additionally, the database contains many clinical variables, but essentially no information on patient socioeconomic status. Furthermore, the ACS NSQIP does not track measures of postoperative physiologic recovery, which may vary by surgical approach, including time to first bowel movement or stoma output, time to oral diet, and time to independent ambulation.

The operative approach was dichotomized into open and laparoscopic colectomy based on CPT codes, and we were unable to determine the rate of conversion to open surgery. Conversion to an open operation may contribute to higher rates of complications. Furthermore, the coding of these converted operations is up to the discretion of the operating surgeon. If laparoscopic cases converted to open were actually coded as an open operation

and these patients had a higher rate of complications, the patients would have been captured in this study and included in our open group biasing our results in favor of the laparoscopic approach. However, others have not found higher rates of complications in patients who have had a laparoscopic operation converted to open.²⁷

Hospital identifiers as well as geographic information are not included in the Participant Use Data File. Therefore, it is not possible to determine the association of hospital procedure volume on surgical outcomes using this database. There is a similar paucity of surgeon-level variables, and the database does not include information on surgeon experience or surgeon procedure volume. However, no study has ever demonstrated a clear correlation with surgeon volume and complications in colon surgery. Small differences in mortality after colon surgery have been correlated with institutional volumes.²⁸ Therefore, how this lack of data contributes to bias remains unclear.

We have attempted to develop statistical models, which control for multiple factors that likely contribute to postoperative complications and mortality. However, we recognize that a real bias remaining in these data is that many surgeons offer surgical procedures based on clinical experience. This clinical “gestalt” is not directly captured in the NSQIP database, and although portions of the physician-patient decision-making process may be captured in our propensity score model, we are clearly limited in our ability to describe its influence on patient outcomes. We have attempted to reduce this bias by using multiple statistical techniques to determine whether laparoscopy may benefit patients independent of comorbidity. To this end, we have used a logistic regression analysis with and without a propensity score, which partially controls for the nonrandom treatment assignment. We have also stratified patients according to variables known to increase risk for postoperative complications and evaluated the overall rate of complications in patients undergoing open or laparoscopic surgery for colon cancer. All of these analyses have found that laparoscopy is correlated with a decreased rate of postoperative complications in older adults undergoing surgery for colon cancer.

We have found several pre- and intraoperative factors that correlate with short-term complications and have found that laparoscopy correlates with a decreased rate of complications independent of these other factors, even in the oldest of the old. Identification of higher risk patients preoperatively and optimizing their medical care may result in a decrease in postoperative complications. Additional consideration to operative approach may also contribute to decreasing complications. Future investigations will focus on multidisciplinary management of these patients to optimize short- and long-term outcomes. Implementation of preoperative systems to optimize care of older adult patients undergoing surgery for colon cancer may contribute to a decrease in both complication and mortality rate following colon cancer surgery. Improvement in postoperative outcomes may enhance postoperative quality of life in this particular group of patients.

This study is the first to examine outcomes from the NSQIP database in patients more than 65 undergoing surgery for colon cancer. Analyses such as these will prove critical as the population of the United States continues to age. Surgeons will have to operatively approach an older group of patients with multiple preoperative comorbidities. It is clear from these data that preoperative health and functional status as well as operative approach contribute to short-term outcomes.

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FIGURE 1.

Univariate analysis of complications in patients undergoing open or laparoscopic surgery for colon cancer. The rate of overall complications was lower in patients undergoing laparoscopic surgery. * $P < 0.05$.

FIGURE 2.

Patients were stratified according to probability of morbidity groups: 1, ≤ 0.2 ; 2, 0.2 to 0.4; and 3, ≥ 0.4 ; 3 age groups: 1, 65 to 75; 2, 75 to 85; and 3, ≥ 85 ; and 3 ASA categories: 1, no/mild; 2, severe, and 3, life-threatening probability of morbidity. Differences between the open and laparoscopic groups were tested with a χ^2 at each point and found to be statistically significant with $P < 0.05$.

TABLE 1

Univariate Analysis of Demographics, Preoperative Comorbidities, and Intraoperative Characteristics

	Open (n = 3801)	Laparoscopic (n = 2113)	P
Gender			
Female (%)	55.9	53.8	0.130
Age (mean, yr)	77.4	77.1	0.053
65–75 (%)	37	38.1	
75–85(%)	43.4	44.7	
85+ (%)	19.5	17.2	0.080
BMI (mean)	27.4	27	0.120
Underweight (%)	3.4	2.5	
Normal weight (%)	34.1	34.9	
Overweight (%)	32.4	36	
Obese (%)	28	25.4	
Missing (%)	2.1	1.2	0.001
Race (%)			
White	77.9	80.1	
Black	8.8	6.3	
Other	13.3	13.5	0.003
Diabetes (%)			
Oral agents/insulin	19.8	19.6	0.860
Current smoker (%)	9.5	7.9	0.040
Alcohol use (%)	2.6	3.2	0.190
Functional status (%)			
Independent	88.7	93.5	<0.005
COPD (%)	10.1	7.5	0.001
Current pneumonia (%)	0.5	0.3	0.290
Dyspnea (%)	21.4	18.2	0.004
CAD (%)	18.9	18.4	0.620
PVD (%)	2.5	1.7	0.040
Neurological dysfunction (%)	13.8	11.9	0.030
Current dialysis (%)	0.6	0.5	0.590
Steroid use (for any chronic condition) (%)	2.9	3.4	0.350
Weight loss (>10% in last 6 mo)(%)	7.9	3.6	<0.005
Ascites (%)	2.3	0.5	<0.005
Esophageal varices (%)	0.3	0.09	0.100
CHF (%)	2.7	1.3	<0.005
Bleeding disorder (%)	6.3	5.3	0.11
Transfusion (>4 U within 72 h) (%)	0.58	0.14	0.010
Chemotherapy (<30 d preoperative) (%)	0.9	0.4	0.050
Radiation therapy (within 90 d of operation) (%)	0.5	0.2	0.12
Probability of morbidity (mean)	0.21	0.19	<0.005

	Open (n = 3801)	Laparoscopic (n = 2113)	P
<0.2 (%)	59.2	63.7	
0.2–0.4 (%)	35.5	33.8	
>0.4 (%)	5.3	2.5	<0.005
Probability of mortality (mean)	0.03	0.02	<0.005
<0.2 (%)	98	99.2	
0.2–0.4 (%)	1.4	0.6	
>0.4 (%)	0.6	0.2	0.001
ASA categories			
No/mild (%)	30.4	39.3	
Severe (%)	60.7	55.3	
Life threatening (%)	8.9	5.4	<0.005
Wound categories			<0.005
Clean/contaminated (%)	92.3	95.7	
Contaminated (%)	5.7	3.7	
Dirty/infected (%)	2	0.05	
No. units of RBC transfused (%)			<0.005
None	87.8	95.1	
1–2	10.7	4.5	
≥ 3	1.5	0.4	
Operative time (mean, h)	129.9	144.9	<0.005
<4 h (%)	93.1	93.2	
4–6 h (%)	6	6.2	
>6 h (%)	0.9	0.6	0.57

BMI indicates body mass index; ASA, American Society of Anesthesiology; COPD, chronic obstructive pulmonary disease; CAD, coronary artery disease; PVD, peripheral vascular disease; CHF, congestive heart failure; RBC, red blood cell.

TABLE 2

Univariate Analysis of Outcome Variables

	Open (n = 3801)	Laparoscopic (n = 2113)	<i>P</i>
Postoperative stay (d)	8.7	6.7	<0.005
<4 (%)	3.7	19.6	
4–10 (%)	75.6	69.6	
>10 (%)	20.6	10.8	<0.005
Return to OR (%)	5.7	5.1	0.31
Any postoperative complication (%)	25.4	16.1	<0.005
Postoperative mortality (%)	3.7	2.1	<0.005

OR indicates odds ratio.

TABLE 3
Multivariate Analysis Demonstrates Several Factors That Predict Complications Within 30 Postoperative Days

Parameter	Comparison	Logistic Regression			Propensity Score Adjusted		
		Odds Ratio	95% CI	95% CI	Odds Ratio	95% CI	95% CI
Open operation	Lap	1.53	1.33	2.77	1.53	1.32	1.76
Age							
75–85	65–75	1.18	1.01	1.34	1.18	1.01	1.37
>85	65–75	1.35	1.11	1.64	1.35	1.11	1.63
BMI							
<18	<25	0.91	0.62	1.34	0.90	0.61	1.32
25–29.9	<25	1.22	1.04	1.43	1.23	1.04	1.44
30–49	<25	1.26	1.05	1.49	1.23	1.04	1.44
ETOH							
Yes	No	1.52	1.05	2.19	1.54	1.07	2.23
Totally/partially							
Dependent	Independent	1.50	1.22	1.85	1.47	1.19	1.83
COPD							
Yes	No	1.84	1.49	2.27	1.82	1.47	2.83
Ascites							
Yes	No	1.71	1.11	2.65	1.66	1.07	2.58
Wound							
Dirty/infected	Clean/contaminated	1.92	1.22	3.02	1.91	1.21	3.01
ASA							
2 (severe)	1 (no/mild)	1.29	1.10	1.52	1.29	1.09	1.52
3 (life threatening)	1 (no/mild)	1.65	1.26	2.16	1.64	1.26	2.15
Operative time							
4–6 h	<4 h	1.48	1.15	1.90	1.48	1.15	1.90
>6 h	<4 h	1.65	0.85	3.21	1.64	0.84	3.19

Other variables included in the model but not predictive of postoperative complications include: gender, preoperative weight loss, diabetes, smoking, pneumonia, dyspnea, CAD, PVD, neurological disorder, preoperative dialysis, preoperative steroid use, esophageal varices, CHF, bleeding disorder, preoperative chemotherapy, presence of wound infection, WBC, Hct, Na, Creat, Alk Phos, surgical wound category, and transfusion.

BMI indicates body mass index; ASA, American Society of Anesthesiology; CI, confidence interval; COPD, chronic obstructive pulmonary disease; ETOH >2 alcoholic drinks per day in 2 weeks before admission.

TABLE 4

Multivariate Analysis Demonstrates Several Factors That Predict Mortality Within 30 Postoperative Days

Parameter	Comparison	Logistic Regression			Propensity Score Adjusted		
		Odds Ratio	95% CI	CI	Odds Ratio	95% CI	CI
Open operation	Lap	1.23	0.85	1.77	1.18	0.82	1.69
Gender							
Male	Female	1.53	1.10	2.11	1.55	1.12	2.15
Age							
75–85	65–75	1.84	1.19	2.83	1.82	1.18	2.81
>85	65–75	3.69	2.32	5.87	3.63	2.28	5.77
Weight							
Loss	No	1.75	1.09	2.79	1.51	0.93	2.44
Totally/partially							
Dependent	Independent	2.08	1.42	3.04	1.86	1.26	2.75
Dyspnea	No	1.58	1.11	2.24	1.55	1.09	2.21
Ascites	No	4.01	2.15	7.46	3.37	1.78	6.38
WBC							
Normal	Low 4.5	1.22	0.62	2.39	1.15	0.59	2.27
>11	Low 4.5	2.31	1.09	4.90	1.91	0.88	4.14
Missing	Low 4.5	0.62	0.09	4.44	0.68	0.09	4.79
Na							
Normal	<135	0.62	0.40	0.96	0.65	0.42	1.01
>145	<135	0.31	0.07	1.40	0.31	0.07	1.37
Missing	<135	0.14	0.03	0.57	0.14	0.04	0.58
Creatinine							
>1.2	<1.2	1.32	0.92	1.91	1.30	0.90	1.88
Missing	<1.2	4.51	1.70	11.96	3.59	1.32	9.77
Alkaline phosphatase							
>125	<125	2.53	1.62	3.97	2.31	1.46	3.64
missing	<125	1.45	0.98	2.15	1.59	1.06	2.37
ASA							
2 (severe)	1 (no/mild)	1.59	0.98	2.58	1.56	0.96	2.52

Parameter	Comparison	Logistic Regression			Propensity Score Adjusted		
		Odds Ratio	95% CI	CI	Odds Ratio	95% CI	CI
Transfusion	3 (life threatening)	2.58	1.41	4.72	2.48	1.36	4.54
	1 (no/mild)						
	None	1.84	1.23	2.76	1.83	1.22	2.74
	1–2 units						
	>3 units	2.56	0.98	6.67	2.54	0.97	6.62

Other variables included in the model but not predictive of mortality include: BMI, COPD, CAD, neurological disorder, CHF, bleeding disorder, preoperative chemotherapy, preoperative wound infection, Hct, surgical wound category, and length of operation.

ASA indicates American Society of Anesthesiology; CI, confidence interval, WBC, white blood cell count.