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Outcomes and Use of Laparoscopic Versus Open Gastric Resection

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ABSTRACT

Background and Objectives: The advantages of laparoscopy over open surgery are well established. Laparoscopic resection for gastric cancer is safe and results in equivalent oncologic outcomes when compared with open resection. The purpose of this study was to assess the use of laparoscopy to treat gastric cancer and the associated outcomes.

Methods: The American College of Surgeons National Surgical Quality Improvement Project (NSQIP) dataset was queried for patients with gastric cancer (ICD-9 Code 151.0–151.9) from January 2005 through December 2012. Logistic regression was used to evaluate the 30-day morbidity and mortality of open gastrectomy (CPT code 43620-2, 43631-4) versus that of the laparoscopic procedure on the stomach (CPT code 43650), while adjusting for preoperative risk factors.

Results: A total of 4116 patients with gastric cancer were identified and divided by surgical approach into 2 groups: open gastrectomy (n = 3725; 90.5%) and laparoscopic procedure on the stomach (n = 391; 9.5%). After adjustment for preoperative risk factors, complications were significantly fewer in laparoscopic versus open gastric resection (odds ratio [OR] 0.61, 95% confidence interval [CI] = 0.45–0.82; P = .001). After adjusting for preoperative risk factors, there was no statistically significant difference in mortality with laparoscopic compared to open gastric resection (OR 0.74; 95% CI = 0.32–1.72; P = .481).

Conclusion: Laparoscopy is underused in the treatment of gastric cancer. Given that laparoscopic gastric resection has a lower morbidity in comparison to open resection, steps should be made toward advancing the use of laparoscopy for gastric cancer.

Key Words: Gastric cancer, Laparoscopic gastrectomy, Laparoscopic perioperative outcomes.

INTRODUCTION

More than 22,000 Americans receive a diagnosis of gastric cancer annually, of which nearly 11,000 progress to disease-related mortality.[1] Surgical treatment of gastric cancer was pioneered by Billroth in the 1880s.[2] Total gastrectomy for gastric cancer was first performed successfully in America by Brigham in 1898.[3] The following decades saw the development of efforts to maximize survival and minimize the invasiveness of the procedure. The first reported laparoscopic distal gastrectomy (LDG) was performed by Kitano in 1992; since that time, the procedure has gained in popularity, albeit slowly, because of diminished surgical morbidity.[4] Laparoscopic total gastrectomy (LTG), with its greater complexity, took longer to gain traction. In addition to surgical advances, developments in perioperative care and multimodal therapy have contributed to the gains in survival observed in patients with gastric cancer over the past 4 decades.[5]

Several studies have compared short- and long-term outcomes of laparoscopic gastrectomy with those of traditional open gastrectomy for gastric cancer. Lee and Hans[6] found LDG to be associated with fewer perioperative complications, decreased length of hospital stay, and longer operative time than open distal gastrectomy (ODG). Huscher et al[7] reported no difference in long-term survival between LDG and ODG. Meta-analyses by Zeng et al[8] and Wang et al[9] confirmed that LDG and LTG were commensurate to their open counterparts in mortality and oncologic outcomes.

Despite evidence that laparoscopic resection of gastric cancer is safe and effective, the use of the approach remains low.[8] Open gastrectomy remains the preferred approach for many surgeons, potentially due to concerns of increased operative difficulty, port site recurrence, and decreased adequacy of lymph node dissection that they do

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not feel is as feasible with a laparoscopic approach. The reason for this could be due to surgeon comfort level, and lack of experience with advanced laparoscopic procedures. There is a learning curve for LDG and LTG, as for any procedure. However, increased use of LDG and LTG may lead to improved outcomes with a higher quality of life for patients with gastric cancer.

The purpose of this study was to compare the outcomes of laparoscopic and open gastrectomy for gastric cancer reported in a national database.

MATERIALS AND METHODS

The American College of Surgeons National Surgical Quality Improvement Project (NSQIP) dataset was queried for patients treated for gastric cancer (ICD-9 Code 151.0–151.9) from January 2005 through December 2012. The surgical procedures undergone by the 4116 patients identified were classified into 2 groups: open gastrectomy (CPT code 43620-2, 43631-4) and laparoscopic procedure on the stomach (CPT code 43659). Demographic characteristics, overall morbidity, and complications were compared by χ^2 tests for categorical variables and 2-sided t tests for continuous variables. Seventeen preoperative risk factors were compared between the 2 groups.

Logistic regression was used to evaluate 30-day morbidity and mortality, with adjustment for preoperative risk factors. Secondary outcomes (mortality and any complications) were further analyzed by logistic regression. We report the odds ratio (OR) with 95% confidence interval (CI) for nonadjusted analyses and for those adjusted for covariates. Covariates included were those significantly related to outcome at an α level of .05 in univariate analyses. Forward–backward selection algorithms included the same variables in all cases. Significance was set at $P < .05$. All calculations were performed with SAS version 9.2 software (SAS Institute Inc., Cary, North Carolina, USA).

RESULTS

A total of 4116 patients with gastric cancer were identified: group 1, open gastrectomy (n = 3725; 90.5%), and group 2, laparoscopic procedure on the stomach (n = 391; 9.5%). Age was similar in both groups: open, 66.4 years, and laparoscopic, 66.7 years ($P = .678$). Continuous and categorical preoperative risk factors were compared between the 2 groups. Continuous preoperative risk factors are listed in **Table 1**, and categorical preoperative risk factors are listed in **Table 2**.

Table 1.
Continuous Preoperative Risk Factors

Continuous Factor	Laparoscopy	Open	P
Age (years)	66.4 (12.8)	66.7 (13.4)	.678
BMI (kg/m^2)	28.3 (6.6)	26.6 (6.1)	**<.0001**
Height (meters)	1.7 (0.1)	1.7 (0.1)	.082
Comorbidities	1.6 (1.2)	1.8 (1.3)	**.001**
Sodium	139.5 (2.9)	139.4 (2.9)	.382
BUN	16.5 (7.1)	16.1 (8.0)	.313
Creatinine	1.0 (0.6)	1.0 (0.6)	.616
Albumin	3.9 (0.5)	3.7 (0.7)	**<.0001**
Total bilirubin	0.6 (0.4)	0.6 (0.7)	.201
AST	25.9 (14.3)	25.7 (19.3)	.821
Alkaline phosphatase	79.8 (46.0)	82.2 (44.0)	.405
WBC	6.7 (2.2)	7.0 (2.9)	**.014**
Hematocrit	37.7 (5.0)	36.0 (5.5)	**<.0001**
Platelet count	245.1 (80.6)	257.5 (98.7)	**.006**
PTT	29.4 (5.6)	29.5 (5.6)	.692
INR	1.0 (0.2)	1.1 (0.3)	.187
PT	12.7 (2.9)	12.5 (2.4)	.496

Data are expressed as the mean (SD), unless another unit is shown. Bold indicates a statistically significant difference between study groups. AST aspartate aminotransferase; BMI, body mass index; BUN, blood urea nitrogen; PT, prothrombin time; PTT, partial thromboplastin time; WBC, white blood cell (count).

Regarding continuous preoperative risk factors, compared with the open gastrectomy group, the laparoscopic group had a significantly higher body mass index (BMI; 28.3 kg/m^2 vs 26.6 kg/m^2; $P < .0001$), preoperative serum albumin (3.9 vs 3.7; $P < .0001$), and hematocrit (37.7 vs 36.0; $P < .0001$), but a lower number of comorbidities (1.6 vs 1.8; $P = .001$), and preoperative white blood cell (6.7 vs 7.0; $P = .014$) and platelet (245.1 vs 257.5; $P = .006$) counts. Regarding categorical preoperative risk factors, the laparoscopic group had a significantly lower incidence of weight loss (10.5% vs 16.0%; $P = .004$) and had received radiation therapy more frequently (5.0% vs 2.4%; $P = 0.010$).

Thirty-day mortality was 3.7% in the open and 2.0% in the laparoscopic group ($P = .096$). Postoperative complications are listed in **Table 3**. The overall 30-day morbidity rates were 32.8% for the open and 21.0% for the laparoscopic group ($P < .0001$). Specific complications that were more frequent in the open-resection group were pneumonia, reintubation, urinary tract infection, sepsis, and septic shock. There were

Table 2.
Categorical Preoperative Risk Factors

Categorical Factor	Laparoscopy (n = 391)	Open (n = 3725)	P
Shortness of breath	36 (9.2)	440 (11.8)	.126
COPD	17 (4.3)	210 (5.6)	.288
Current pneumonia	0 (0)	6 (0.2)	.461
Ascites	1 (0.3)	34 (0.9)	.178
Esophageal varices	0 (0)	5 (0.2)	.501
History of CHF	5 (1.3)	32 (0.9)	.403
History of MI	1 (0.4)	27 (0.9)	.363
History of PCI	20 (7.1)	246 (7.9)	.633
History of cardiac surgery	22 (7.8)	213 (6.8)	.539
History of angina	0 (0)	23 (0.7)	.148
Hypertension	233 (59.6)	2084 (55.9)	.167
History of PVD	4 (1.4)	56 (1.8)	.645
Rest pain	0 (0)	5 (0.2)	.501
On dialysis	2 (0.5)	25 (0.7)	.710
Hemiplegia	3 (1.1)	30 (1.0)	.868
History of TIA	7 (2.5)	95 (3.0)	.595
History of CVA	9 (3.2)	83 (2.7)	.600
CNS tumor	0 (0)	2 (0.1)	.671
Paraplegia	0 (0)	6 (0.2)	.461
Wound infection	2 (0.5)	28 (0.8)	.595
Steroid use	6 (1.5)	78 (2.1)	.457
Weight loss	41 (10.5)	595 (16.0)	**.004**
Bleeding disorder	10 (2.6)	147 (3.9)	.173
Chemotherapy	15 (5.3)	223 (7.2)	.248
Radiotherapy	14 (5.0)	75 (2.4)	**.010**
Previous operations	6 (2.2)	40 (1.4)	.241

Data are expressed as the number of patients (% of total group). Bold indicates a statistically significant difference between study groups. CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CNS, central nervous system; CVA, cerebrovascular accident; MI, myocardial infarction; PCI, percutaneous coronary intervention (e.g., angioplasty); TIA, transient ischemic attack; PVD, peripheral vascular disease.

Table 3.
Thirty-day Mortality and Complications

Complications	Laparoscopic (n = 391)	Open (n = 3725)	P
Death	8 (2.0)	137 (3.7)	.096
Wound infection	5 (1.3)	64 (1.7)	.520
Wound dehiscence	3 (0.8)	53 (1.4)	.287
Pneumonia	13 (3.3)	258 (6.9)	**.006**
Reintubation	10 (2.6)	190 (5.1)	**.026**
PE	3 (0.8)	41 (1.1)	.542
Renal failure	0 (0)	11 (0.3)	.282
Renal insufficiency	4 (1.0)	23 (0.6)	.345
UTI	8 (2.0)	156 (4.2)	**.039**
Cardiac arrest	3 (0.8)	43 (1.2)	.489
MI	2 (0.5)	44 (1.2)	.231
Transfusion	6 (1.5)	85 (2.3)	.339
DVT	5 (1.3)	56 (1.5)	.727
Sepsis	13 (3.3)	256 (6.9)	**.007**
Septic shock	7 (1.8)	166 (4.5)	**.012**
Return to OR	24 (6.1)	273 (7.3)	.387

Data are expressed as the number of patients experiencing each complication (% of total group). Bold indicates a statistically significant difference between study groups. DVT, deep venous thrombosis; MI, myocardial infarction; OR, operating room; PE, pulmonary embolism; UTI, urinary tract infection.

no significant differences in the rates of other complications evaluated, including wound infection, pulmonary embolism, and return to the operating room.

Complications were significantly fewer with laparoscopic than with open gastric resection (OR 0.54; 95% CI = 0.42–0.70; $P < .001$). After adjusting for preoperative risk factors, including the difference in BMI, this estimate was only slightly attenuated (OR 0.61; 95% CI = 0.45–0.82; $P = .001$). After adjusting for preoperative risk factors, there was no statistically significant difference in mortality after laparoscopic compared to open gastric resection (OR 0.74, 95% CI = 0.32–1.72; $P = .481$).

DISCUSSION

This study demonstrated that laparoscopic gastric procedures had fewer complications than open procedures in patients with gastric cancer. This finding supports those reported from previous institutional experiences and meta-analyses. Specific complications that were observed less frequently with laparoscopic procedures were pneumonia, reintubation, urinary tract infection, sepsis, and septic shock. Even after adjusting for preoperative risk factors, including BMI and comorbidities, there was a lower complication rate with laparoscopic gastric resection. In addition, there was no statistically significant difference in mortality with laparoscopic versus open gastrectomy.

The literature on both LDG and LTG supports decreased morbidity after laparoscopic versus open gastric resection. Regarding LDG, Zeng et al[8] demonstrated among 3411 patients that overall postoperative morbidity was less after LDG versus ODG (relative risk = 0.58; $P < .00001$). In addition, Lee and Han[6] demonstrated a more frequent incidence of postoperative pulmonary complications in the ODG versus the LDG group ($P = .043$). Regarding LTG, Weng et al[9] published a meta-analysis of 2313 patients demonstrating a lower postoperative morbidity for LTG versus OTG (relative risk 0.79; $P = 0.007$). Most of these studies are from Asian countries, but similar decreases in morbidity are noted in Western countries. Kelly et al[10] published a case–control study of 174 patients, of whom half underwent laparoscopic and the other half open gastrectomy, including both distal subtotal and total gastrectomy. Laparoscopic versus open gastrectomy was associated with decreased minor complications in the early (27% vs 16%) and late (17% vs 7%) postoperative periods ($P < .01$). Major complications and 30-day mortality were similar between the 2 operative groups. Although this study does not distinguish between distal and total gastrectomy because of the limitations inherent in CPT coding, the literature and this study both support less morbidity after laparoscopic versus open gastric resection.

We noted an 11.8% decrease (32.8% open and 21.0% laparoscopic) in 30-day morbidity with laparoscopic compared to open gastric cancer resection. Aside from the immediate effects discussed in this study, this difference also adds long-term morbidity to patients' lives, such as delays in returning to work and in resuming normal activities of daily living. These long-term quality-of-life effects were not addressed in this study. In addition, the effect on healthcare costs of the morbidities after these procedures is not specifically addressed by the database. It is important to determine both the long-term effects on patients and the overall increase in healthcare costs, when considering the differences in morbidity between these 2 procedures.

No statistically significant difference in mortality after laparoscopic versus open gastrectomy was demonstrated in this study or in the literature. For LDG, Memon et al[11] performed a meta-analysis of 4 studies, comparing 162 patients. They found that the difference in mortality rates between LDG and ODG was not statistically significant (OR = 0.94; $P = 0.936$). Similar findings were identified for total gastrectomy. Haverkamp et al[12] performed a meta-analysis of LTG versus OTG and found that in 8 studies, in-hospital mortality rates for LTG and OTG were comparable (0.9 and 1.8%, respectively). Xiong et al[13] confirmed this finding in their meta-analysis of 15 studies, reporting that LTG and OTG had similar rates of mortality (OR = 0.74; $P = 0.61$).

This study highlights the low utilization rate of laparoscopy for the treatment of gastric cancer. In this NSQIP database study, only 10% of gastric resections were performed laparoscopically. The reasons that surgeons chose to perform open gastric rather than laparoscopic resection cannot be determined from the dataset, but the decision may have been related to personal laparoscopic training and experience or to patient-specific factors. However, adjustments were made in the data analysis to account for differences in comorbidities among patients. The number of centers performing open versus laparoscopic gastric cancer resections also could not be determined from the database. This information would be helpful in identifying the factors that prevent the use of laparoscopic gastric resection in certain centers and thus could contribute to improved perioperative outcomes and long-term benefits to patients by supporting the minimally invasive approach in centers where it is not favored at present.

In contrast to open procedures, there is no differentiation in coding between the types of laparoscopic gastric procedures that enable comparison of wedge, distal, and total gastrectomies. The utilization rate of laparoscopy for malignant gastric resection is low, in contrast to the penetrance of laparoscopic gastric procedures for benign disease, such as gastric bypass and sleeve gastrectomy. Roux-en-Y gastric bypass is a technically complex procedure, but >90% are performed laparoscopically.[14] The high rate of utilization of laparoscopy for complex bariatric applications suggests extending the use of the approach to procedures for gastric cancer. In light of the decreased morbidity with laparoscopic versus open resection, it is difficult to definitively conclude from this study the reasons that laparoscopic resection for gastric cancer is underused. Possible reasons that have been discussed herein include surgeons' discomfort with advanced laparoscopy and concerns about compromising oncologic outcomes. Steps toward ameliorating these hindrances include providing surgeons the opportunity for advanced laparoscopic training courses and educating them on the benefits of laparoscopy in these clinical situations through continued research and presentation at both regional and national conferences.

Limitations of this study include the inability to directly compare specific types of gastric resection for open versus laparoscopic approaches. This limitation is secondary to the minimal CPT coding options for laparoscopic gastric procedures. Selecting only patients with the diagnosis of gastric cancer can at least exclude those patients who underwent wedge resection of benign lesions, as this procedure is not the standard of care for gastric cancer resection. However, it is difficult to exclude patients in the laparoscopic CPT code group who have not undergone resection, but rather have had a palliative procedure, such as a gastrojejunostomy or placement of a gastrostomy tube, or have undergone a biopsy. CPT coding alternatives to more evenly distinguish between open and laparoscopic gastric cancer resection include "laparoscopic partial gastrectomy" and "laparoscopic total gastrectomy." The addition of these CPT coding options within the database would improve the ability to compare and analyze perioperative outcomes in patients who undergo open versus laparoscopic procedures for gastric cancer.

Additional limitations include the absence of data that show the extent of lymph node dissection and neoadjuvant or adjuvant therapy. These data would comment on the oncologic impact of laparoscopic versus open gastric cancer resection, which cannot be determined from the database used in this study. Information such as pathologic diagnosis is not available in this dataset, which focuses primarily on perioperative morbidity and mortality. However, this information would be helpful in accounting for any differences in outcomes.

CONCLUSION

Laparoscopy is underused in the treatment of gastric cancer. Laparoscopic gastric resection has lower morbidity in comparison to open resection, and steps should be made toward advancing the use of laparoscopy for gastric cancer.

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