Outcomes After Open Versus Laparoscopic Gastric Bypass

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Abstract: In expert hands, laparoscopic gastric bypass (LGB) is associated with reduced morbidity and mortality compared with open bariatric surgery. The purpose of our study was to determine whether or not the results of LGB have been realized in the general US population. We used data from the nationwide inpatient sample to define differences in outcomes after LGB versus open techniques (OGB). We calculated hospital stay, in-hospital mortality, and major complications for both OGB and LGB. We noted a total of 26,940 gastric bypass procedures: LGB was coded in 16.3% and OGB in 83.7%. The mean hospital stay, mortality, wound, gastrointestinal, pulmonary, and cardiovascular complications were significantly lower after LGB ($P < 0.001$). After we adjusted for covariates, hospital stay, pulmonary morbidity, and mortality remained significantly lower after LGB ($P < 0.001$). In conclusion, LGB is associated with significantly lower mean hospital stay and with reduced morbidity and mortality as compared with OGB.

Key Words: bariatric, morbid obesity, gastric bypass, laparoscopic, population, nationwide inpatient sample

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The US Centers for Disease Control and Prevention have recently published data demonstrating a substantial increase in the number of estimated deaths attributable to obesity from poor diet and physical inactivity. These data indicate that obesity may soon overtake tobacco as the leading cause of death in the United States.[1] Obesity is a significant public health concern: as an estimated 20.9% of the US population is currently considered obese.[2] A number of treatment modalities including behavioral, drug, and surgical therapies have been devised. Yet, nonsurgical methods of weight reduction have met with little long-term success.

Given the relative ineffectiveness of nonsurgical treatment of obesity, surgery has become increasingly popular and has proven to be an effective and long-lasting approach to reduce obesity and its associated comorbidities. Gastric bypass has become the procedure of choice in the surgical management of morbid obesity.[3] Although this procedure is associated with excellent weight reduction, it is also associated with substantial morbidity and mortality.[4–7]

Laparoscopic gastric bypass (LGB) was developed to reduce the associated morbidity of this surgical procedure. Many studies have shown that laparoscopic techniques are associated with improved preservation of the immune system, reduced compromise of the pulmonary system, faster recovery, smaller wounds, and less postoperative pain, as compared with conventional gastric bypass (OGB).[8–10] Such studies, however, have come from highly experienced minimally invasive programs.[11] The aim of our study was to determine whether or not comparable beneficial results have been realized in the general US population.

In our study, we used administrative data from the nationwide inpatient sample (NIS), the largest source of all payer discharge information in the United States, to compare the outcomes after OGB versus LGB. The NIS database has been used in the past to compare differences in outcomes after other surgical procedures.[12] We looked for any population-based improvements in morbidity, mortality, and length of hospital stay (LOS) after LGB versus OGB.

MATERIALS AND METHODS

Database

We obtained hospital discharge data from the NIS, for January 2001 to December 2002, from the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. The NIS is a unique and powerful tool that contains the largest all-payer inpatient care database in the United States. It includes data from about 7 million hospital stays per year, from close to 1000 hospitals located in 35 states, roughly a 20% stratified sample of US community hospitals. The NIS and other discharge databases have been used extensively in the past to review trends in surgical care and outcomes,[13] volume outcome relationships,[14] and disparities in care.[15]

Patient and Procedure Selection

We identified all patients with International Classification of Diseases (ICD-9) diagnostic codes for morbid

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obesity (278.0, 278.00, 278.01, 278.1, 278.8)[7] who underwent a gastric bypass procedure (44.31, 44.39, 44.5, 44.69).[3] We excluded patients with a diagnosis of gastrointestinal neoplasm, peptic ulcer disease, or obstructive gastrointestinal disease.[7] Using the procedure codes 54.21, 54.23, and 54.51, we identified patients undergoing laparoscopic procedures.

Outcomes

From hospital discharge records, we abstracted in-hospital mortality data after both OGB and LGB. (The NIS does not include information after discharge, so all outcomes are based on in-hospital data.) To evaluate morbidity, we identified relevant complications using standard ICD-9 codes. We grouped morbidity into 4 categories: wound, gastrointestinal, pulmonary, and cardiovascular complications.[12] We defined LOS as the difference between the hospital's admission and discharge dates.

Statistics

Statistical analyses were performed using SAS version 9.13 (SAS Institute Inc, Cary, NC) unless otherwise noted. We calculated crude rates for LOS, morbidity, and mortality; then we compared them for both OGB and LGB using χ^2 analyses and Student *t* tests. To calculate an index of comorbid conditions, we used the Deyo modification of the Charlson comorbidity index.[16] In our analysis, we adjusted for potential confounders such as age, sex, race, income, comorbidity score, payer, hospital gastric bypass volume, hospital teaching status, hospital bed-size, and hospital rurality. To examine the risk-adjusted association between the dependent variables (LOS, morbidity, and mortality) and the independent variables (OGB and LGB), we used multiple regression and logistic regression models. In addition, to correct for a possible clustering effect, which is commonly seen in the setting of large variations in surgical outcomes, we analyzed the data for clustering using STATA 8.0 Software (College Station, TX).

RESULTS

Demographics

During our 2-year study period, a total of 26,940 patients underwent either LGB or OGB. Of these patients, 4382 (16.3%) underwent LGB; the remaining 22,558 (83.7%) underwent OGB. The mean age of the total cohort was 41.5 ± 11.3 years; 83.2% were female. Differences in age, sex, race, and income for OBG versus LGB patients are detailed in Table 1. LGB patients were more likely to be female (85.5%), have a higher income, have private insurance (88.8%), and have lower Deyo Charlson comorbidity scores. LGB was more likely to be performed at teaching versus nonteaching hospitals (53.1%) ($P < 0.01$).

TABLE 1. Patient and Hospital Characteristics for LGB Versus OGB

Characteristics	LGB	OGB	*P*
Age	41.4 ± 10.5 y	41.5 ± 11.3 y	< 0.0001
Female sex	85.5%	82.7%	< 0.0001
White race	80.1%	80.6%	NS
Income > $45,000	61.5%	54.9%	< 0.001
Private payer	88.8%	80.5%	< 0.001
Bypass volume	259.8 ± 186.3	261.9 ± 282.4	NS
Teaching hospital	53.1%	50.9%	< 0.01
Large hospital	62.2%	63.2%	NS
Urban hospital	99.2%	94.9%	NS
Deyo Charlson	0.34 ± 0.57	0.38 ± 0.62	< 0.0001

In-hospital Mortality

The crude mortality rate after all gastric bypass procedures was 0.72%. The mortality rate after LGB was 0.27%; after OGB, 0.81% ($P < 0.0001$) (Table 2).

In-hospital Morbidity

According to our univariate analysis, LGB patients had significantly fewer wound complications (1.35%) versus OGB patients (1.98%, $P < 0.005$). We noted a similar significant reduction in gastrointestinal complications for the LGB patients (4.52%) versus OGB patients (5.33%, $P < 0.05$). LGB patients also had fewer pulmonary complications (2.60%) and cardiovascular complications (1.92%) compared with the OGB group (5.36%, $P < 0.0001$) and (3.02%, $P < 0.0001$), respectively (Table 2).

Hospital LOS

For the entire cohort, LOS averaged 4.5 ± 7.5 days (range, 0 to 347 d). The mean LOS after LGB was 3.1 ± 4.2 days; after OGB, 4.8 ± 8.0 days ($P < 0.0001$) (Table 2).

Risk-adjusted End Points

In our multiple regression analyses controlling for potential confounders (including age, sex, race, income, comorbidity score, payer, hospital gastric bypass volume, hospital teaching status, hospital bed-size, and hospital rurality), LGB patients demonstrated reduced LOS, mortality, and pulmonary complications (Table 3). The odds ratio for mortality was 2.3 for OGB (versus LGB); for pulmonary complications, 2.07 for OGB (versus LGB). Although statistically significant in the univariate analysis, LGB did not independently predict a reduced likelihood of cardiovascular, wound, or gastrointestinal complications.

TABLE 2. Univariate Mortality, Morbidity, and LOS Outcomes

Outcomes	LGB	OGB	*P*
Mortality	0.27%	0.81%	< 0.0001
Wound complications	1.35%	1.98%	< 0.005
Gastrointestinal complications	4.52%	5.33%	< 0.05
Pulmonary complications	2.60%	5.36%	< 0.0001
Cardiovascular complications	1.92%	3.02%	< 0.0001
LOS	3.12 + 4.4 d	4.75 + 9.2 d	< 0.0001

TABLE 3. Multivariate Mortality, Morbidity, and LOS Outcomes

Risk-adjusted Analyses*	Odds Ratio (Confidence Interval)	P
Mortality	2.25 (1.02, 4.93)	< 0.05
Wound complications	1.26 (0.91, 1.74)	NS
Gastrointestinal complications	1.11 (0.92, 1.35)	NS
Pulmonary complications	2.07 (1.62, 2.64)	< 0.0001
Cardiovascular complications	1.17 (0.90, 1.54)	NS
LOS	1.20 (0.75, 1.64)	< 0.0001

*Regression analyses demonstrating odds ratio for outcome after OGB.

Table 4 summarizes the results of our regression analysis for mortality, after we adjusted for covariates and corrected for clustering. A lower hospital volume of gastric bypass procedures, older patient age, male sex, a nonprivate payer, a lower estimated median household income, and an urban hospital location were significantly correlated with increased mortality (Table 4). A lower hospital volume of gastric bypass procedures was also significantly associated with increased LOS and increased morbidity after we adjusted for other potential covariates independent of gastric bypass approach.

TABLE 4. Logistic Regression for Mortality

Demographic	Odds Ratio (Confidence Interval)	P
Surgical approach		
OGB	Referent	< 0.05
LGB	0.45 (0.22, 0.91)	
Sex		
Male	Referent	< 0.0001
Female	0.35 (0.24, 0.52)	
Increased age	1.08 (1.06, 1.10)	< 0.001
Race		
White	Referent	NS
Black	1.08 (0.58, 2.02)	
Other	0.92 (0.49, 1.72)	
Income		
$1-$24,999	Referent	
$25,000-$34,999	0.44 (0.20, 0.93)	< 0.05
$35,000-$44,999	0.34 (0.16, 0.74)	< 0.01
> $45,000	0.48 (0.23, 0.99)	< 0.05
Payer		
Private	Referent	
Medicaid	6.94 (3.77, 12.77)	< 0.0001
Medicare	2.26 (1.33, 3.85)	< 0.001
Other	1.16 (0.41, 3.26)	NS
Bypass volume		
25th Quartile	Referent	
50th Quartile	0.50 (0.30, 0.84)	< 0.001
75th Quartile	0.31 (0.18, 0.55)	< 0.001
100th Quartile	0.17 (0.07, 0.43)	< 0.001
Teaching hospital		
Teaching	Referent	NS
Nonteaching	1.13 (0.76, 1.67)	
Bed-size		
Small	Referent	NS
Medium	1.10 (0.52, 2.34)	
Large	1.52 (0.75, 3.08)	
Hospital location		
Rural	Referent	< 0.05
Urban	2.91 (1.01, 8.36)	
Comorbidity		
Deyo Charlson	1.17 (0.96, 1.42)	NS

DISCUSSION

Our study revealed significant differences in patient outcomes after LGB versus OGB in the treatment of morbid obesity. Using a representative sample of US hospital discharge abstracts, we showed that LGB has significant advantages over traditional OGB. LGB is characterized by a reduced LOS, fewer in-hospital postoperative complications, and decreased mortality. Differences in pulmonary complications, mortality, and LOS remained significant after we adjusted for covariates (including age, sex, race, income, comorbidity score, payer, gastric bypass volume, hospital teaching status, hospital bed-size, and hospital rurality).

To our knowledge, this is the first publication describing significant advantages for the general population of LGB in the United States. Previous data demonstrated similarly significant advantages of LGB in case series from large specialty referral centers.[4–7,10–11] But those single-center data were limited by local physician and hospital factors, so they may not accurately reflect actual practices or results across the country. Given the complexity of the LGB technique, similarly excellent results have been thought to be improbable in all settings. Yet the results of this study do confirm a significant advantage of LGB for morbidly obese patients in a variety of practice settings across the country. In addition, surgeons using laparoscopic bypass are doing so with relatively good results, despite the fact that this procedure is both new and complex.

Our finding of significant advantages for LGB versus OGB is consistent with previously published prospective and retrospective data. Retrospective reviews indicated reduced mortality rates, reduced wound complication rates, and fewer hernias after LGB.[17] Similarly, prospective randomized trials demonstrated the improved safety and cost-effectiveness of LGB in expert centers. LGB has also been associated with improved pulmonary function and reduced pain.[10] We similarly noted fewer pulmonary complications after LGB. Explanations for the superior outcomes with minimally invasive techniques include better preservation of the immune system, faster recovery, and less postoperative pain.[8,9]

Given the advantages of minimally invasive surgery, use of such procedures has been slowly increasing. Today, laparoscopic approaches to cholecystectomy are considered the standard of care. Yet use of minimally invasive techniques for other conditions has not been embraced as enthusiastically as laparoscopic cholecystectomy.[12] For example, minimally invasive approaches to appendicitis are still performed much less frequently than open procedures. Only 16% of the patients in our study underwent LGB for morbid obesity. Although use of LGB for morbid obesity has been increasing steadily since the 1990s, these numbers still remain low. Underuse of minimally invasive techniques may be due to the additional expertise and technology required, especially for difficult procedures such as gastric bypass. Further data demonstrating the safety, effectiveness, and superiority of LGB should ultimately result in its increased use. Our data will add to the growing body of evidence pointing to LGB as a superior procedure to OGB; thus, we believe that this study is a significant contribution to the field of bariatric surgery.

The strengths of population-based data include large sample sizes and thus the applicability of the results to a wide group of patients. Large sample sizes permit analysis of difficult questions, allowing more finite conclusions. For this reason, statistical errors based on type 2 error are less likely. Given that our data represent practice patterns across a roughly 20% stratified sample of nonfederal US hospitals, our results are likely generalizable to a variety of practice settings across the country. Our vital and mortality findings were also consistent with those of other previously published population-based studies.[3,7] Nonetheless, further data are needed to demonstrate equal effectiveness and similar long-term results before definitive conclusions can be made for LGB, particularly as more providers learn and adopt this technique.

The significant advantages of our study are counterbalanced by limitations of population-based data, including potential inaccuracies of data coding (resulting in misclassification bias) and the limited amount of medical information available (ie, records do not contain information regarding body mass index). Outcomes such as LOS and mortality are unlikely to be miscoded, but the inability to directly compare body mass index for both sampling arms remains a significant limitation of our study: selection bias cannot be excluded. Another limitation is the lack of a defined ICD-9 procedure code for LGB and the inability to identify laparoscopic conversions. As with other laparoscopic procedures, a universal code for gastric bypass is not part of the ICD-9 coding manual. Therefore, we used all laparoscopy modifiers to develop a large enough sample to perform a comparison and found that over 16% of all gastric bypass procedures were performed with a laparoscopic technique. In addition, conversion rates are estimated to be a relatively small percentage of all LGB procedures.[18]

In conclusion, our study confirmed a significant reduction in LOS, morbidity, and mortality after LGB (versus OGB). These population-based data strengthen the previously reported prospective analyses from well-established minimally invasive centers. The generalized benefits of LGB, which we demonstrated during our 2-year study period, further support the position of LGB as the preferred surgical technique for morbid obesity. Increased use of LGB by qualified surgeons should result in improved outcomes across the country.

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