Perioperative Morbidity Associated With Bariatric Surgery

An Academic Center Experience

Robert W. O'Rourke, MD; Jason Andrus, BS; Brian S. Diggs, PhD; Mark Scholz, MPH; Donald B. McConnell, MD; Clifford W. Deveney, MD

Hypothesis: As the demand for bariatric surgery increases, it becomes increasingly important to define predictors of morbidity and mortality. We hypothesize that specific clinical variables predict postoperative morbidity after bariatric surgery.

Design, Setting, and Patients: This is a retrospective review of 452 patients undergoing inpatient bariatric surgery at an academic tertiary care institution.

Interventions: Patients underwent open or laparoscopic gastric bypass or biliopancreatic diversion with duodenal switch at Oregon Health & Science University, Portland, from 2000 to 2003. Patient data were prospectively entered into a database.

Main Outcome Measures: Postoperative morbidity and mortality were analyzed among all patients, and logistic regression was used to identify clinical predictors of morbidity.

Results: Major and minor morbidity rates were 10% and 13%, respectively; mortality was 0.9%. Age was associated with postoperative complications (odds ratio=1.056 for each additional year). Duodenal switch was also associated with higher morbidity than gastric bypass (odds ratio=2.149). Body mass index, sex, diabetes, surgical approach, and surgeon experience did not predict complications.

Conclusions: Increased age is a predictor of complications after bariatric surgery. Duodenal switch is also associated with a higher morbidity rate than gastric bypass. Surgeons should caution older patients (≥60 years) of a higher risk of postoperative complications, and a higher risk associated with duodenal switch. Large multicenter studies will be necessary to accurately define other clinical predictors of morbidity and mortality after bariatric surgery.

Arch Surg. 2006;141:262-268

Obesity is an epidemic in the United States; more than 20% of the population are obese and the prevalence of obesity is increasing.[1] In response to this growing health care crisis, the number of bariatric surgical procedures performed in the United States has increased markedly. Given the demand for bariatric surgery, along with increased public awareness of the morbidity and mortality associated with these procedures, it is important to identify patients at risk for complications after surgery. Patients who are obese represent challenging operative candidates; the presence of obesity-related comorbidities places them at higher risk for postoperative medical complications, including thromboembolic, pulmonary, and cardiac disease. Large intra-abdominal fat stores make bariatric operations technically demanding and potentially increase the risk of technical complications, including anastomotic leak. Despite awareness of these risks, specific clinical predictors of morbidity and mortality after bariatric surgery remain elusive, with much conflicting data in the literature.

Many factors are considered in evaluating a prospective bariatric patient's perioperative risk. Specific clinical factors include age, body mass index (BMI), and the presence of severe cardiac, pulmonary, or hepatic disease. Comorbidities such as sleep apnea and hypertension have been identified as predictors of complications in some studies,[2,3] but not others.[4] In addition, the choice of bariatric procedure may have an impact on perioperative risk; some investigators have attributed a higher perioperative morbidity and mortality to biliopancreatic diversion with duodenal switch (DS) compared with gastric bypass (GBP),[5] or long-limb GBP compared with standard GBP.[3] Differences in study size, study design, and patient populations among institutions may account for this conflicting literature.

Author Affiliations:
Department of Surgery, Oregon Health & Science University, Portland.

Table 1. Patient Age and BMI Distribution

BMI	Age <60 y, No. (%)	Age ≥60 y, No. (%)	All Ages, No. (%)
≤50	170 (40)	17 (55)	187 (41)
51-60	122 (29)	10 (32)	132 (29)
61-70	85 (20)	4 (13)	89 (20)
>70	44 (11)	0	44 (10)
All BMIs	421	31	452

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by the square of the height in meters).

Table 2. Distribution of Operations

	Open, No. (%)		Laparoscopic, No. (%)		All, No. (%)	
	GBP	DS	GBP	DS	GBP	DS
BMI						
≤50	72 (38)	25 (22)	78 (62)	12 (52)	150 (48)	37 (27)
51-60	55 (29)	33 (29)	38 (30)	6 (26)	93 (30)	39 (29)
61-70	41 (22)	37 (32)	8 (6)	3 (13)	49 (15)	40 (29)
>70	22 (11)	19 (17)	1 (1)	2 (9)	23 (7)	21 (15)
Age, y						
<60	174 (92)	104 (91)	121 (97)	22 (96)	295 (94)	126 (92)
≥60	16 (8)	10 (9)	4 (3)	1 (4)	20 (6)	11 (8)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of the height in meters); DS, duodenal switch; GBP, gastric bypass.

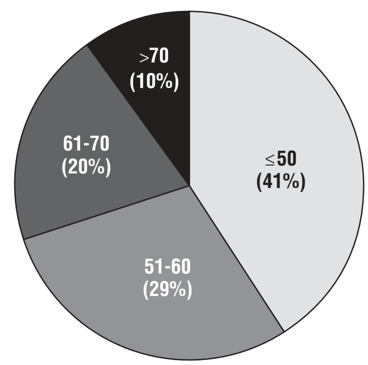

Figure 1. Distribution of all operations among body mass index (calculated as weight in kilograms divided by the square of the height in meters) groups.

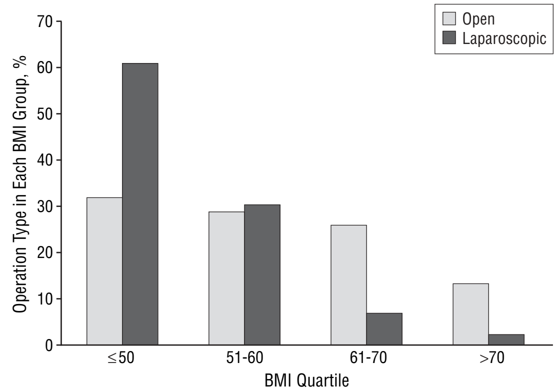

Figure 2. Distribution of open and laparoscopic operations among body mass index (BMI) (calculated as weight in kilograms divided by the square of the height in meters) groups.

We have prospectively entered patient clinical data into a computerized database since the inception of our bariatric program. We performed a retrospective review of all of our patients undergoing bariatric surgery, in an effort to identify predictors of morbidity and mortality, with the goal of defining clinical predictors that would allow risk stratification of candidates for bariatric surgery.

METHODS

Open bariatric surgery has been performed at Oregon Health & Science University, Portland, since April 2000. Laparoscopic bariatric surgery was begun in January 2003. Currently, 3 surgeons perform these operations (R.W.O., D.B.M., and C.W.D.). Operations performed include both laparoscopic and open GBP, biliopancreatic diversion with DS, and gastric band placement (LapBand; Inamed Inc, Santa Barbara, Calif). Patients with a gastric band were excluded from analysis because our experience with this procedure is currently limited. Patients undergoing revisionary bariatric surgery were likewise excluded from analysis. Preoperative, perioperative, and short-term and long-term postoperative data were collected on all patients and entered into a computerized database.

Gastric bypass involves the creation of a gastric pouch 20 to 30 cm^3, with a biliary limb of 70 cm and a Roux-en-Y limb of 100 cm. Duodenal switch was performed with a common channel of 100 cm and an alimentary limb of 250 cm, with a longitudinal lateral gastrectomy. Both operations were performed via either open or laparoscopic approaches. Reinforcement of staples lines, with devices such as fibrin glue or pericardial strips, was not used in any patients. The choice of operation and approach was based on patient and surgeon preference. Patients who required conversion from laparoscopic to open operation were analyzed using intent-to-treat analysis and categorized as patients undergoing laparoscopic surgery.

Postoperative care included prophylaxis for venous thromboembolism in all patients, including both low-molecular-weight heparin and sequential compression devices during the hospital stay. Postoperative contrast studies were not obtained routinely, or in most patients. Leaks were diagnosed based on clinical signs and symptoms, including abdominal pain, tachycardia, and hypoxia. Contrast studies were obtained only in select patients for whom the diagnosis was equivocal. Our threshold for reexploration to diagnose leaks was low.

Patients were stratified into 4 BMI groups and 2 age groups (<60 years and ≥60 years). Distribution of patients among age groups and BMI categories is presented in **Table 1**. Distribution of patients in BMI and age categories among surgical approach groups (open or laparoscopic) and operation type groups (GBP or DS) is presented in **Table 2** and shown in **Figure 1** and **Figure 2**.

Clinical variables studied include (1) age, (2) BMI, (3) sex, (4) operation type (GBP or DS), (5) approach (open or laparoscopic), (6) surgeon experience, and (7) specific comorbidities. Surgeon experience was analyzed by categorizing each operation into a given surgeon's first 50 cases, second 50 cases, and 100th or greater cases for operation type and approach separately.

Table 3. Length of Stay

	Length of Stay*	*P* Value
Operation		
GBP	5 (4-6)	.001
DS	6 (5-7)	
Approach		
Open	6 (5-7)	.001
Laparoscopic	4 (3-5)	
Operation/approach		
Laparoscopic GBP	4 (3-4)	.001†
Laparoscopic DS	4 (3-5)	
Open GBP	5 (5-7)	
Open DS	6 (5-8)	
Age, y		
<60	5 (4-6)	.004
≥60	7 (5-7)	
BMI		
≤50	5 (4-6)	<.001
>50	6 (5-7)	

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of the height in meters); DS, duodenal switch; GBP, gastric bypass.

*Values are median and interquartile range; significance from Mann-Whitney *U* test, or Kruskal-Wallis test for categorical (>3) variables.

†Each laparoscopic category is significantly different from its corresponding open category. Open gastric bypass is significantly different from open duodenal switch. No significant differences exist between laparoscopic gastric bypass and laparoscopic duodenal switch.

Excess weight loss at 1 year was calculated for all patient groups and operation types, as well as for patients with and without complications. Each patient's measured percentage of excess weight loss at various follow-up times was fit to a 2-parameter nonlinear curve (percentage of excess weight loss=A[1−exp(−t/b)]). The 2 parameters are projected asymptotic percentage excess weight loss (A) and a measure of how rapidly the weight was lost (b) over time (t). Each group's projected percentage of excess weight loss and time scale for weight loss was defined as the average of the respective individual parameters for the patients in that group.

The primary outcome of interest was major complications. Secondary outcomes were minor complications and length of stay. Complications (morbidity) were divided into major and minor categories. Major complications included the following: anastomotic leak, pulmonary embolus, internal or ventral hernia or bowel obstruction requiring reoperation, fascial dehiscence, hemorrhage requiring reoperation or more than 1 unit of transfusion, and other major complications including death due to fulminant *Clostridium difficile* colitis (n=1), myocardial infarction (n=3), and stroke (n=1). Additionally, anastomotic leak was studied as a separate outcome. Minor complications included wound infection, bleeding requiring 1 unit or less of transfusion, pneumonia, and central venous catheter infections.

Differences in the distribution of patients between BMI and age groups, operation type, and approach were analyzed by χ^2 tests. Univariate analysis of categorical variables (major complication, minor complication, and anastomotic leak) revealed counts and relative percentages and test significance with χ^2 tests or the Fisher exact test as appropriate based on the magnitude of the cell counts. Univariate analysis of continuous variables (length of stay) revealed median and interquartile range and test significance using Mann-Whitney *U* tests. A multivariate analysis of major complications was performed using logistic regression treating BMI and age as continuous variables. For all tests, a significance level of .05 was used to determine statistical significance.

RESULTS

A total of 452 patients underwent open or laparoscopic GBP or DS surgery at Oregon Health & Science University from April 14, 2000, through December 23, 2003. The mean and median age of all patients were 44 and 45 years , respectively. The mean and median BMI of all patients were 55 and 52, respectively. Of these patients, 372 (82%) were women, and 80 (18%) were men. The distribution of patients among age groups and BMI groups is presented in Table 1.

The distribution of procedures and approach among BMI groups and age groups is presented in Table 2. The distribution of all procedures among BMI groups is shown in Figure 1. The distribution of open and laparoscopic approaches among BMI groups is shown in Figure 2. Selection bias certainly exists with respect to selection of patients for operation and choice of a laparoscopic or open approach; specifically, fewer older patients were offered surgical therapy, and those who underwent surgery were more likely to have a lower BMI than younger patients (Pearson correlation coefficient=−0.12; *P*=.01). Also, fewer patients with higher BMI underwent laparoscopic operations, especially early in our laparoscopic experience (ratio of odds of open approach=1.089 [95% CI, 1.063-1.117] for each point of BMI; *P*<.001).

Median operating room times were 160 minutes, 195 minutes, 210 minutes, and 251 minutes for open GBP, open DS, laparoscopic GBP, and laparoscopic DS, respectively. Thirteen patients required conversion from laparoscopic to an open operation, 8 in the GBP group and 5 in the DS group. Four of these patients suffered a major complication, one of whom died as a result of a leak at the gastrojejunostomy after GBP. The remaining 3 patients who suffered a major complication underwent DS; the complications included a leak at the duodenoileostomy, a fascial dehiscence requiring reoperation, and a gastric outlet obstruction owing to a twisted gastric conduit requiring reoperation. Conversion did not independently predict morbidity in the logistic regression model, although the number of patients who underwent conversion was small and may have prevented detection of a difference in morbidity rates.

Excess weight loss was 54% at 1 year for all patients, and did not differ significantly among operation type (GBP or DS), approach (laparoscopic or open), or patient groups with and without complications. Length of hospital stay was analyzed between BMI groups, age groups, operation types, and approach (**Table 3**). Length of stay was longer in patients who had open surgery when compared with patients who had laparoscopic surgery and in patients who underwent DS compared with patients who underwent GBP, regardless of approach. Each laparoscopic category is significantly different from its corresponding open category (both GBP and DS). Open GBP is significantly different from open DS. No significant differences exist between laparoscopic GBP and laparoscopic DS. Patients who were considered heavy (BMI ≥50) had a longer length of stay than patients whose weight was considered light, regardless of approach or operation. Finally, older patients (≥60 years old) had a longer length of stay, regardless of approach or operation, compared with younger patients (Table 3).

Table 4. Perioperative Complications

	Open GBP, No. (%)		Open DS, No. (%)		Laparoscopic GBP, No. (%)		Laparoscopic DS, No. (%)	
	Major	Minor	Major	Minor	Major	Minor	Major	Minor
BMI								
≤50	4/72 (6)	9/72 (13)	2/25 (8)	2/25 (8)	4/78 (5)	1/78 (1)	3/12 (25)	1/12 (8)
50-59	5/55 (9)	10/55 (18)	5/33 (15)	8/33 (24)	4/38 (11)	1/38 (3)	2/6 (33)	0/6 (0)
60-69	6/41 (15)	5/41 (12)	4/37 (11)	10/37 (27)	0/8 (0)	1/8 (13)	1/3 (33)	0/3 (0)
≥70	0/22 (0)	7/22 (32)	4/19 (21)	4/19 (21)	0/1 (0)	0/1 (0)	1/2 (50)	1/2 (50)
Age								
<60 y	13/174 (7)	30/174 (17)	12/104 (12)	19/104 (18)	8/121 (6.6)	3/121 (2.5)	6/22 (27)	2/22 (9)
≥60 y	2/16 (13)	1/16 (6)	3/10 (30)	5/10 (50)	0/4 (0)	0/4 (0)	1/1 (100)	0/1 (0)
Total	15/190 (7.9)	31/190 (16.3)	15/114 (13.2)	24/114 (21)	8/125 (6.4)	3/125 (2.4)	7/23 (30)	2/22 (1.1)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of the height in meters); DS, duodenal switch; GBP, gastric bypass.

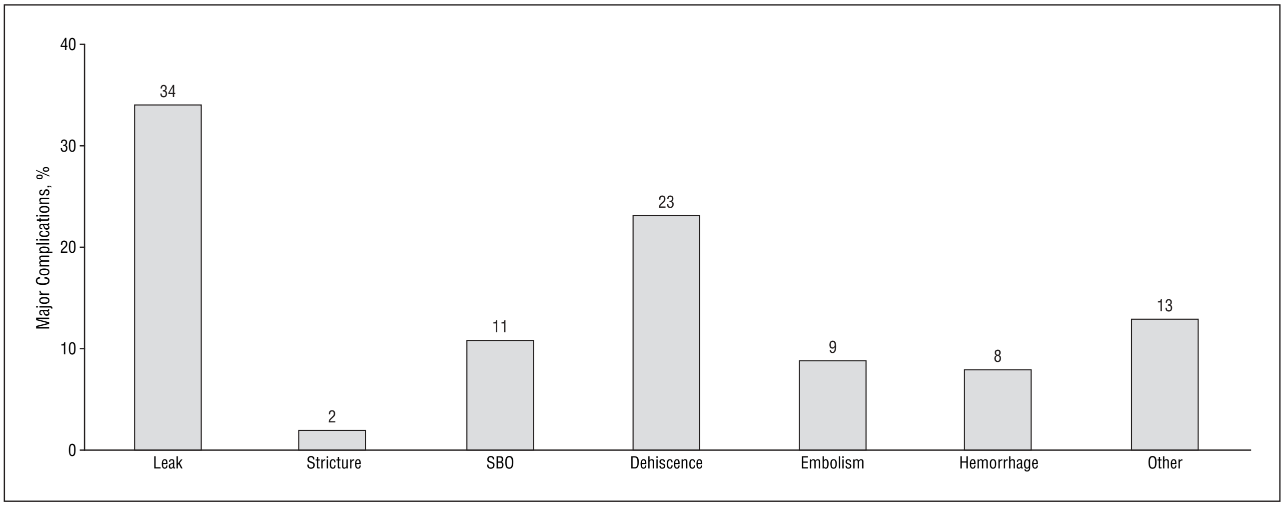

Figure 3. Distribution of major complications. SBO indicates small-bowel obstruction; other includes myocardial infarction (n=3), stroke (n=1), and *Clostridium difficile* colitis (n=1).

Overall follow-up times were 419 days (mean) and 356 days (median), with an interquartile range of 115 to 660 days. The overall rate of major and minor perioperative complications was 10% and 13%, respectively. The distributions of major and minor complications among BMI and age groups are presented in **Table 4**. The distribution of major complications among all patients is shown in **Figure 3**.

Logistic regression analysis identified age and the DS operation type as predictors of major postoperative morbidity. Duodenal switch was associated with a higher risk of major morbidity than GBP (odds ratio, 1.967, $P=.05$). Age also predicted postoperative morbidity, with an odds ratio of 1.056 for each additional year of age. Discriminant analysis was performed on 5-year age intervals in an attempt to identify a specific age associated with a dramatic increase in risk, but the number of patients in each subset was too small to identify a specific age cutoff associated with a statistically significant dramatic increase in risk. No other variables tested showed a statistically significant association with increased morbidity (**Table 5**).

Mortality was 0.9% (n=4). There were too few deaths to allow for identification of predictors of mortality using a logistic regression model. Causes of death were myocardial infarction (n=1), fulminant *C difficile* colitis (n=1), and anastomotic leak (n=2).

The distribution of anastomotic leaks among age, BMI, and operation categories is presented in **Table 6**. Leaks were analyzed separately as a categorical variable using the Fisher exact test. Duodenal switch was associated with a higher leak rate than GBP ($P=.03$) (Table 6). Two of 9 leaks associated with DS occurred at the lateral gastrectomy staple line, 1 in a patient who underwent open DS, and 1 in a patient who underwent laparoscopic DS but required conversion to an open procedure. The remainder of leaks associated with DS occurred at the duodenoileostomy. All of the 7 leaks associated with GBP occurred at the gastrojejunostomy with the exception of 1 patient who underwent laparoscopic GBP who experienced a leak at the jejunojejunostomy. There was no statistically significant difference in leak rates between laparoscopic and open groups, or among BMI or age groups.

COMMENT

The growing demand for bariatric surgery warrants careful evaluation of outcomes. Bariatric procedures are tech-

Table 5. Logistic Regression Analysis for Major Complications

	P Value	Odds Ratio	95% CI Lower	95% CI Upper
BMI	.14	1.027	.991	1.065
Age	.01	1.055	1.016	1.097
Sex (female vs male)	.43	1.401	.612	3.205
Approach				
Open vs laparoscopic	.73	1.176	.456	3.031
Open vs conversion	.26	2.580	.490	13.586
Operation (DS vs GBP)	.03	2.369	1.090	5.145
Arthritis	.69	1.170	.541	2.529
Asthma	.80	1.123	.469	2.685
Congestive heart failure	.21	.248	.028	2.194
Coronary artery disease	.51	1.531	.433	5.414
Depression	.88	.948	.470	1.914
Diabetes	.55	1.248	.608	2.561
GERD	.87	1.060	.521	2.158
Hypertension	.98	1.011	.472	2.165
Lipid disorder	.55	1.310	.540	3.177
Sleep apnea	.11	1.851	.866	3.957
Venous stasis disease	.52	.590	.119	2.930
Surgeon experience (operations)				
51-100 vs 1-50	.39	1.471	.611	3.542
101+ vs 1-50	.73	1.283	.306	5.382
Surgeon experience (approach)				
51-100 vs 1-50	.44	.706	.291	1.713
101+ vs 1-50	.07	.307	.085	1.104

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of the height in meters); CI, confidence interval; DS, duodenal switch; GBP, gastric bypass; GERD, gastroesophageal reflux disease.

Table 6. Anastomotic Leaks

	Open GBP	Open DS	Laparoscopic GBP	Laparoscopic DS
No. (%)	4 (2.1)	7 (6.1)	3 (2.4)	2 (8.7)
BMI				
≤50	0	2	2	2
51-60	3	3	1	0
61-70	1	2	0	0
>70	0	0	0	0
Age, y				
<60	4	6	3	2
≥60	0	1	0	0

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of the height in meters); DS, duodenal switch; GBP, gastric bypass.

nically challenging operations applied to high-risk patients. Mortality rates for gastric bypass average 0.5% at high-volume centers, with overall complication rates ranging between 7% to 14%.[6-8] Low volume centers and inexperienced surgeons may have higher mortality and major complication rates.[9] Clinical variables such as BMI, age, sex, and comorbid conditions have been suggested as potential predictors of perioperative morbidity and mortality. However, data supporting the utility of such predictors in risk stratification are conflicting. The issues of surgeon experience and the application of laparoscopy to bariatric procedures further complicate such assessments. It is difficult to compare studies from different centers because others have shown that surgeons at academic centers operate on higher-risk patients than surgeons in private practice settings, and document higher complication rates associated with these higher-risk patients.[10] Analyses that control for such differences in patient populations will become increasingly important as data from both academic and private practice centers are compared. Identification of specific predictors of morbidity and mortality associated with bariatric surgery is critical as this field expands and public attention directed at surgical outcomes increases.

To contribute to the growing body of literature that attempts to define predictors of morbidity after bariatric surgery, we examined 452 patients who underwent open or laparoscopic GBP or DS over a 4-year period at a tertiary care academic referral center. We studied a panel of clinical variables using logistic regression analysis, including age, BMI, sex, operation, surgical approach, and medical comorbidities, and found that increased age and the DS operation type independently predicted complications after bariatric surgery.

This study found age to be a significant predictor of complications after bariatric surgery. Others have found age to predict mortality after gastric bypass.[4] While some investigators have suggested a specific age limit as an absolute contraindication to bariatric surgery, we do not employ such limits for our patients. We nevertheless approach older patients with caution, especially in light of recent data that suggest that the benefits of bariatric surgery with respect to longevity may wane in older patients[9] Our data suggest that older patients should be counseled regarding a higher morbidity rate, and careful scrutiny is warranted in patient selection with consideration and optimization of all medical comorbidities. Such patients should be offered bariatric surgery only after a program has accumulated significant experience in lower-risk patients.

In our study, we also demonstrate a higher major morbidity rate and anastomotic leak rate with DS compared with GBP. Others with considerable experience with DS have also reported high morbidity and mortality rates in noncomparative studies; a review of more than 700 patients who underwent open DS surgery over a 10-year period at the University of Southern California, Los Angeles, had a 1.9% mortality rate.[11] Kim et al[5] reported a series of patients who underwent laparoscopic and open DS with morbidity rates of 23% and 17% and mortality rates of 7.6% and 3.5%, respectively. Our data support the contention that DS is a technically challenging operation with a higher complication rate than GBP. The addition of a lateral gastrectomy to a duodenoileostomy and ileoileostomy may increase the risk of staple line leaks. Two of 9 leaks associated with DS in this series occurred at the lateral gastrectomy, which supports this contention. In addition, DS is often applied to a subset of patients with higher BMI. These factors may, in part, account for the higher morbidity associated with this operation. The potential benefits of DS, including the ability to eat larger meals and greater total weight loss, must be carefully balanced with the increased rate of morbidity and mortality associated with this surgery.

The failure of BMI to predict morbidity in this study is of interest. Patients who are heavy certainly present technical challenges, and many surgeons feel that high BMI defines a group of high-risk patients. However, data supporting this contention are sparse. Noncomparative studies have shown that bariatric surgery can be accomplished safely in patients with high BMI, with morbidity and mortality rates approaching those seen in patients who are not heavy.[12,13] Others have shown that BMI is not an independent predictor of morbidity after bariatric surgery when controlling for other variables.[2,4,14] In our study, BMI did not predict major complications in the logistic regression model, although when analyzed using univariate analysis, there was a trend ($P<.1$) toward significance ($P=.09$, Kendall-Tau test). Despite the uncertainty surrounding BMI as an independent predictor of morbidity, BMI is an important consideration in patient selection. Patients with higher BMI present technical challenges, especially when approached laparoscopically. In fact, while Schwartz et al[14] found that BMI did not predict complications, BMI did correlate with longer operative times and higher conversion rates. In addition, while some studies show that high BMI does not independently predict morbidity, it is likely that such patients represent a carefully selected subgroup; surgeons most likely select patients with higher BMIs with more favorable body habitus (ie, gynecoid rather than android) and fewer comorbidities. Such selection bias is even more significant in laparoscopic series. Central obesity and android body habitus may therefore be a better predictor of risk than BMI; in support of this theory, at least 1 group has shown that male sex, typically associated with central android obesity, is an independent predictor of morbidity after bariatric surgery.[4] Although sex did not predict complications in our study, only 18% of our patients were male; studies of larger numbers of male patients might reveal an effect of sex on morbidity.

No specific medical comorbidities of obesity predicted complications in this study. Others have found specific obesity-related comorbidities that predict postoperative morbidity, including hypertension, sleep apnea, and others.[2,3,15] The literature is conflicting regarding the utility of such comorbidities in predicting morbidity. Controlling for the severity of different obesity-related comorbidities (such as number and dosages of antihypertensive medication and continuous positive airway pressure settings for sleep apnea) among patients and between studies is difficult, and variability in the severity of such comorbidities may, in part, account for the conflict in the literature regarding these variables as predictors of morbidity. Detailed analyses of specific comorbidities graded for severity may resolve this confusion, but no specific comorbidities have been shown to consistently and reliably predict postoperative morbidity among patients who have undergone bariatric surgery.

The application of laparoscopy to bariatric surgery warrants comment. Laparoscopic procedures are generally thought to be more technically challenging than open procedures, and the types and incidences of complications differ between laparoscopic and open GBP.[6] In addition, surgeon experience is an important variable that influences outcome, especially in laparoscopic series.[2,16,17] The laparoscopic component of our bariatric program is relatively young, more than 100 cases at the time this article was written. Numerous reports suggest that the learning curve for laparoscopic bariatric operations may consist of more than 150 cases. Despite this, our anastomotic leak rates for laparoscopic cases are similar to that associated with our open surgery cases, and similar to leak rates reported in other large series of laparoscopic bariatric surgeries.[6-8] In addition, surgeon experience did not predict morbidity in the logistic regression model, although this may be owing to the fact that the majority of laparoscopic cases in our series were in any given surgeon's first 100 cases. Even though surgeon experience was not a predictor of morbidity in this series, other published data[2,16,17] suggest that it is prudent to analyze a given surgeon's or center's early experience in bariatric surgery separately from later experience, especially when considering laparoscopic series. It is important to note that 4 of 13 patients who underwent conversion from a laparoscopic to open approach in our series suffered major complications. While there are too few patients in this category to draw conclusions of statistical significance, this is a higher morbidity rate than the entire patient population. In addition, 3 of 5 patients undergoing DS who required conversion suffered a major complication, which is testament to the technical challenges inherent in this operation.

The philosophy regarding the prevention and management of leaks is uniform among the surgeons participating in this study. There are few data supporting the use of fibrin glue or pericardial strips to reinforce staple lines to prevent leaks, and the surgeons participating in this study do not use such devices. We did not obtain routine postoperative contrast studies because we find that the results of such studies are often equivocal and concerned with false negatives. Leaks are diagnosed clinically and our threshold for reexploration, either laparoscopically or open, is low.

There are several limitations to this study. First, the retrospective nature of this study design limits the conclusions that can be drawn. Selection of operation type was not randomized and determined primarily by patient preference. Our group considers GBP the procedure of choice for most patients. In general, DS was applied preferentially to patients with higher BMI who specifically requested the procedure based on sparse data from others suggesting that very obese (BMI >50) patients may lose more weight with DS than with GBP.[18] The selection of DS in our practice is therefore primarily based on patient preference. Our willingness to apply DS to patients who are heavier is more apparent among open procedures. We were less likely early in our experience to apply laparoscopic DS to patients who were heavy, although a trend toward application of DS to patients with higher BMI is seen in the laparoscopic group as well (Table 2). A randomized trial comparing GBP with DS would answer many questions regarding comparable efficacy with respect to weight loss and morbidity and mortality rates, but such a trial presents inherent problems in study design.

In addition, selection bias certainly exists with respect to age, BMI, and medical status—older patients and patients with higher BMI or significant comorbidities were carefully selected and therefore are probably lower-risk patients than those of similar age, BMI, or medical status drawn randomly from the population. Careful patient selection likely reduces the effect of these variables on complication rates, and unselected older patients are probably exposed to an even greater risk of morbidity than that demonstrated in this study. Similarly, unselected patients with high BMI might demonstrate a statistically significant higher complication rate, in contrast to our results which show no effect of BMI on morbidity or mortality. Finally, larger studies might identify other clinical predictors of morbidity that this small study was unable to demonstrate.

CONCLUSIONS

This study examined morbidity and mortality among 452 patients who underwent bariatric surgery over a 4-year period and found that patient age predicted complications after surgery. Surgeons should counsel older patients about their higher risk for complications after bariatric surgery. This, combined with data suggesting that older patients may not benefit in terms of increased lifespan from bariatric surgery as much as younger patients, suggests that the risk-benefit ratio of bariatric surgery among older patients is not as favorable. In addition, DS is associated with a higher morbidity rate than GBP and surgeons should consider this when counseling patients regarding their choice of surgery. Larger prospective studies will be necessary to accurately define other clinical predictors of morbidity and mortality after bariatric surgery.

Accepted for Publication: May 4, 2005.

Correspondence: Robert W. O'Rourke, MD, Department of Surgery, Oregon Health & Science University, L223A, 3181 SW Sam Jackson Park Rd, Portland, OR 97239 (orourkro@ohsu.edu).

REFERENCES

1. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. *JAMA*. 2004;291:2847-2850.
2. Perugini RA, Mason R, Czerniack DR, et al. Predictors of complication and suboptimal weight loss after laparoscopic GBP. *Arch Surg*. 2003;138:541-546.
3. Fernandez AZ, DeMaria EJ, Tichansky DS, et al. Experience with over 3,000 open and laparoscopic bariatric procedures: multivariate analysis of factors related to leak and resultant mortality. *Surg Endosc*. 2004;18:193-197.
4. Livingston EH, Huerta S, Arthur D, Lee S, De Shields S, Heber D. Male gender is a predictor of morbidity and age a predictor of mortality for patients undergoing gastric bypass surgery. *Ann Surg*. 2002;236:576-582.
5. Kim WW, Gagner M, Kini S, et al. Laparoscopic vs open biliopancreatic diversion with duodenal switch: a comparative study. *J Gastrointest Surg*. 2003;7:552-557.
6. Podnos YD, Jiminez JC, Wilson SE, Stevens M, Nguyen NT. Complications after laparoscopic gastric bypass. *Arch Surg*. 2003;138:957-961.
7. DeMaria EJ, Sugerman HJ, Kellum JM, Meador JG, Wolfe LG. Results of 281 consecutive total laparoscopic Roux-en-Y gastric bypasses to treat morbid obesity. *Ann Surg*. 2002;235:640-647.
8. Nguyen NT, Goldman C, Rosenquist CJ, et al. Laparoscopic versus open gastric bypass: a randomized study of outcomes, quality of life, and costs. *Ann Surg*. 2001;234:279-291.
9. Flum D, Dellinger EP. Impact of gastric bypass operation on survival: a population-based analysis. *J Am Coll Surg*. 2004;199:543-551.
10. Lopez J, Sung J, Anderson W, et al. Is bariatric surgery safe in academic centers? *Am Surg*. 2002;68:820-823.
11. Anthone GJ, Lord RV, DeMeester TR, Crookes PF. The duodenal switch operation for the treatment of morbid obesity. *Ann Surg*. 2003;238:618-627.
12. Moose D, Lourie D, Powell W, et al. Laparoscopic Roux-en-Y gastric bypass: minimally invasive bariatric surgery for the superobese in the community hospital setting. *Am Surg*. 2003;69:930-932.
13. Kreitz K, Rovito P. Laparoscopic Roux-en-Y gastric bypass in the megaobese. *Arch Surg*. 2003;138:707-709.
14. Schwartz ML, Drew RL, Chazin-Caldie M. Laparoscopic Roux-en-Y gastric bypass: preoperative determinants of prolonged operative times, conversion to open gastric bypasses, and postoperative complications. *Obes Surg*. 2003;13:734-738.
15. Cooney RN, Haluck RS, Ku J, et al. Analysis of cost outliers after gastric bypass surgery: what can we learn? *Obes Surg*. 2003;13:29-36.
16. Oliak D, Ballantyne GH, Weber P, Wasielewski A, Davies RJ, Schmidt HJ. Laparoscopic Roux-en-Y gastric bypass: defining the learning curve. *Surg Endosc*. 2003;17:405-408.
17. Schauer P, Ikramuddin S, Hamad G, Gourash W. The learning curve for laparoscopic Roux-en-Y gastric bypass is 100 cases. *Surg Endosc*. 2003;17:212-215.
18. MacLean LD, Rhode BM, Nohr CW. Late outcome of isolated gastric bypass. *Ann Surg*. 2000;231:524-528.