Recent Improvements in Bariatric Surgery Outcomes

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Objective: Bariatric surgery is one of the fastest growing hospital procedures, but with a 40% complication rate in 2001. Between 2001 and 2005 bariatric surgeries grew by 113%. Our objective is to examine how 6-month complications improved between 2001 and 2006, using a nationwide, population-based sample.

Data/Design: We examined insurance claims in 2001–2002 and 2005–2006 for 9582 bariatric surgeries, at 652 hospitals, among a population of 16 million nonelderly people. Outcomes and costs were risk-adjusted using multivariate regression methods with hospital fixed effects.

Principal Findings: Between 2001 and 2006, while older and sicker patients underwent the surgery, the 180-day risk-adjusted complication rate declined 21% from 41.7% to 32.8%. Most of the improvement was in the initial hospital stay, where the risk-adjusted inpatient complication rate declined 37%, from 23.6% to 14.8%. Risk-adjusted rates of readmissions with complications declined 31%, from 9.8% to 6.8%. Risk-adjusted hospital days declined from 6 to 3.7 days, and risk-adjusted and inflation-adjusted payments declined 6%.

Improvements in complication rates and readmission rates were associated with a within-hospital 30% increase in hospital volume. Volume had no impact on costs. The use of laparoscopy, which increased from 9% to 71%, reduced costs by 12%, while gastric banding decreased costs by 20%. Laparoscopy had no impact on readmissions, but the increase in banding without bypass reduced readmissions.

Conclusions: Improvements in bariatric outcomes and costs were due to a mix of within-hospital volume increases, a move to a laparoscopic technique, and an increase in banding without bypass.

Key Words: bariatric surgery, obesity, postoperative complications, claims data

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Between 1996 and 2004, the number of hospitalizations with obesity diagnoses increased by 112%, while all other hospitalizations increased by only 13%.[1] As the obesity epidemic continues to grow, many obese patients are now turning to bariatric surgery to lose weight. Current research shows that there are potential long-term health benefits to bariatric surgery. A recent meta-analysis of the literature found that the percentage of excess weight loss was 47.5% under gastric banding, 68.2% under gastroplasty, 61.6% under gastric bypass, and 70.1% under bilopancreatic diversion or duodenal switch bypass. Moreover, diabetes was completely resolved in 76.8% of the patients. Hyperlipidemia was improved in 70% of the patients, while hypertension was resolved in 61.7% of the patients.[2] A recent study found that gastric bypass patients had an 89% reduced relative risk of death.[3] Another recent study found that 3% of gastric bypass patients younger than 40 died within 13.6 years, compared with 13.8% of obese patients that did not have bariatric surgery.[4]

Just in the 5 years from 2001 to 2005, we find that bariatric surgery grew by 113%, despite the surgery being an elective surgery with a high complication rate. In fact, a recent article in this journal by Encinosa et al found a 40% 6-month complication rate in 2001–2002.[5] However, considerable advances have been made in the surgical technique for bariatric surgery between 2001 and 2005, particularly due to surgeon learning-by-doing over the large volume of new surgeries performed, and also due to the move from open surgery to laparoscopic surgery. By reducing the size of the surgical incision and the trauma associated with the operative exposure, laparoscopy may reduce the rate of infection and complication, and allow the patient to recover quicker, saving costs in the long run. Using the same population-based insurance claims data in the original study (Encinosa et al, 2006), we examine how and why 6 month complication rates have changed between 2001 and 2006.

METHODS

Study Database

Our source of data is the MarketScan Commercial Claims and Encounter Database created by the Medstat Group, Inc., for 2001–2002 and 2005–2006.[6] The original study by Encinosa et al[5] used the 2001–2002 MarketScan data which contained about 6 million covered lives. The 2005–2006 data contains claims data for inpatient care and outpatient care for about 16 million enrollees under the age of 65 in employer-sponsored benefit plans for 45 large employers nationwide in 49 states. Overall, the MarketScan data

TABLE 1. Changes in the Types and Volume of Bariatric Surgeries: 2001 to 2006

Bariatric Procedures	2001–2002	2005–2006*
Laparoscopy	9.36%	71.00%
Banding, open (without bypass)	5.39%	2.94%
Banding, laparoscopic (without bypass)	0.08%	8.48%
Bypass, open	85.25%	26.07%
Bypass, laparoscopic	9.28%	62.52%
Annual Bariatric Volume terciles	**2001–02**	**2005–06**
Low volume < = 159	44.45%	32.11%
Medium volume 160–521	26.36%	35.57%
High volume >521	29.18%	32.32%
Average hospital volume	249	324

*All 2005 to 2006 values differ from 2001 to 2002 with $P < 0.01$.

consists of about 5% of the population with employer-sponsored health insurance coverage in the United States.

Claims Definition of Bariatric Surgery

As in the Encinosa et al study,[5] we identified the 2 main types of bariatric surgeries, banding/gastroplasty and gastric bypass, by the following CPT-4 codes: 43842 and 43843 (gastric banding or gastroplasty without gastric bypass); 43846 (Roux-en-Y gastric bypass); and 43845 and 43847 (other types of gastric bypass). In 2005, laparoscopic bariatric CPT-4 codes were introduced for bypass: 43644 and 43645. To identify laparoscopic banding or gastroplasty without gastric bypass between 2005 and 2006, we used the new 2005–2006 ICD-9-CM procedure codes 4468 and 4495. Before 2005, we identified bariatric surgeries that were performed laparoscopically by CPT-4 codes 43651–43659 (stomach laparoscopy) or 44200–44209 (intestinal laparoscopy). See Table 1 for the types of bariatric surgeries used over time.

Study Timeline

Index bariatric surgeries included in the analysis are(1) bariatric surgeries that took place from February 1, 2001, to July 1, 2002 (17 months), and from February 1 to July 1 in 2005 and 2006 (two 5 month periods), and (2) where the patient did not have a previous bariatric surgery during the 30 days before admission. We also excluded bariatric surgeries with any primary or secondary diagnoses codes for stomach or intestinal cancer. Between 2001 and 2002, this resulted in a final sample of 2522 index bariatric surgeries taking place at 308 hospitals nationwide. Between 2005 and 2006, we have a final sample of 7060 bariatric surgeries at 532 hospitals.

Complications and Outcomes

We use the 12 postoperative complications specifically related to bariatric surgery as found in Encinosa et al (2006). These complications were based on a meta-analysis of complications in the bariatrics literature.[7,8] Readmissions refer to any stay longer than 24 hours at an inpatient hospital, beginning within 180 days after the index discharge. Outpatient hospital visits include postoperative same-day visits to an inpatient hospital, outpatient hospital, or an ambulatory surgery center. ER visits are emergency room visits. Office visits include office visits or home health care visits.

Statistical Methods

Using a logit multivariate regression analysis, the complication rates across the 2 periods (2001–2002 and 2005–2006) were risk-adjusted for the following covariates: gastric banding without bypass, number of comorbidities, sex, age, insurance plan type, region, year, and the quarter of the year to control for seasonal patterns in infections. We used in the risk adjustment model of Encinosa et al (2006), based on the number of comorbidities the patient has out of 30 comorbidities (not including obesity). The log of health care expenditures was also risk-adjusted for the above covariates. Health care expenditures include all payments made to physicians and hospitals for all services during the 6 months after surgery. The log of expenditures was then retransformed into dollars using the Duan smearing estimator to adjust for the bias arising under the log-retransformation.[9] All statistical tests of significance were based on bootstrapping of the standard errors using Stata 9.2. Finally, we used linear multivariate regression analyses with hospital random effects to examine the impact of volume and laparoscopy on outcomes and the log of expenditures. The overall hospital bariatric volume for each year was obtained from the Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases.[10] The HCUP volume data merged to about 40% of our MarketScan data. Thus, the hospital volume analyses are conducted on a subset of 3841 surgeries.

RESULTS

Changes in the Surgery

Between 2001 and 2006, the overall population rate of bariatric surgery per 100,000 covered lives increased from 26.8 to 43.7. The average annual bariatric volume for the hospitals in our sample increased 30% from 249 to 324 (see Table 1). Moreover, the number of surgeries that were completed laparoscopically increased from 9.4% to 71.0%. Banding without bypass increased more than 50% from 5.47% (=5.39 + 0.08) to 11.42% (=2.94 + 8.48) and became predominantly performed via laparoscopy between 2005 and 2006. However, most of the shift to laparoscopy was in gastric bypass, making up more than 88% of the laparoscopic cases from 2005 to 2006.

Changes in the Patient Pool

Compared with 2001 to 2002, patients with higher severity case mix underwent bariatric surgery between 2005 and 2006 (see Table 2). Between the 2 periods, patient age increased, with a greater proportion being over age 50 (44% vs. 28%). Moreover, we see a shift away from patients being covered by fee-for-service and point-of-service health maintenance organizations (HMOs) and more covered by preferred provider organizations and capitated HMOs. We also see a demographic shift away from the East and Central to the West and South. These 2 shifts were likely because of the changes in insurance coverage policies towards bariatric surgery, since the distribution of regional location did not change for the overall pool of covered

TABLE 2. Descriptive Statistics of Index Bariatric Surgeries

	2001–2002	2005–2006*
Banding and gastroplasty without bypass	5.47%	13.95%
Gastric bypass	94.53%	86.05%
Number of comorbidities		
Zero comorbidities (other than obesity)	66.42%	54.07%
One comorbidity	27.24%	25.03%
Two or more comorbidities	6.34%	20.91%
Female	85.29%	80.82%
Male	14.71%	19.18%
Age 18–39	42.19%	29.83%
Age 40–49	29.38%	26.56%
Age 50–64	28.43%	43.61%
Capitated HMO	26.65%	28.94%
Point-of-service HMO	14.27%	9.94%
PPO	35.69%	48.17%
Fee-for-service	23.39%	12.96%
Northeast	11.02%	6.83%
West	15.50%	27.69%
South	31.01%	38.75%
Central	42.47%	26.72%
N	2522	7060

*All 2005 to 2006 values differ from 2001 to 2002 with $P < 0.01$.
PPO indicates preferred provider organization.

lives between the periods, and since the overall enrollment in capitated HMOs declined from 23% to 11.4% in the overall pool of covered lives.

Improved Outcomes

Despite the increase in patient health severity case mix, outcomes improved. Overall, not shown, the 180-day death rate remained low and statistically unchanged, 0.2% in 2001–2002 and 0.05% in 2005–2006. The 180-day risk-adjusted complication rate declined 21% from 41.7% to 32.8%, and the 30-day complication rate dropped by 24%, from 33.7% to 25.5% (see Table 3). Most of the improvement was in the initial hospital stay, where the risk-adjusted inpatient complication rate declined 37% from 23.6% to 14.8%. Of the 12 complications, 5 complications declined in prevalence: complications of the anastomosis, abdominal hernias, infections, respiratory failure, and pneumonia. The risk-adjusted infection rate had the largest decline, 58%. Seven had no change after risk adjusting: marginal ulcer, dumping, hemorrhage, wound dehiscence, DVT/pulmonary embolism, acute myocardial infarction, and stroke.

Risk-adjusted rates of readmissions with complications declined 31%, from 9.8% to 6.8%. Same-day outpatient hospital visits post discharge declined from 14.8% to 13.26%. Changes in office visits and emergency room visits with complications were not statistically significant. Over the 6 months, total risk-adjusted hospital days declined from 6 to 3.7 days.

These improved outcomes led to reduced costs. Overall, risk-adjusted, inflation-adjusted hospital payments declined 6%, from $29,563 to $27,905, in 2006 dollars. The hospital payments for patients with complications declined from $41,807 to $38,175. The total hospital payments for those with the most expensive outcome, readmissions, also declined substantially, from $80,001 to $69,960. Hospital payments for those patients without any readmissions also dropped, from $26,578 to $23,115.

Sources of the Improvements

Finally, we estimate the effect of volume and laparoscopy on outcomes and costs (see Table 4). An increase in hospital bariatric volume reduced the rate of complications. Essentially, an increase from bottom tercile of volume (159 surgeries) to the top tercile of volume (521 surgeries) reduced the odds ratio of having a complication by 29%. Similarly, laparoscopy reduced the odds ratio of having a complication by 30%. Note that banding without bypass had no impact on complications. However, much of the decline in postoperative hospitalizations (such as readmissions) with complications was driven by a move to banding. Although high volume decreased the odds ratio of postoperative visits with a complication by 29%, banding reduced it by 40%. Next, note that volume had no impact of hospital payments. Laparoscopy reduced payments by 12%, whereas banding reduced payments by 20%. Finally, note that the variable "Period 2005–2006" was not statistically significant in the 2 outcome regressions, implying that volume, laparoscopy, and banding explained all of the improvement in outcomes (not explained by changes in the other demographic covariates of Table 2, such as age) over the period. However, the variable "Period 2005–2006" was still statistically significant in the payment regression, indicating that there was some other factor that we did not account for that was reducing hospital costs over the time period.

Sensitivity Analysis

First, our use of categorical variables for volume may mask the level of the nonlinearity in the relationship between outcomes and volume. However, our results are robust when we use an alternative spline specification for continuous volume and control for outlier hospitals. Second, because 60% of our sample had hospital volume missing, our results may be biased. To test this, we used the HCUP National Inpatient Sample (NIS), a nationally representative sample of the hospitals in the United States, with complete volume data. With 88,930 bariatric surgeries in the NIS, we ran a logit regression on inpatient complications with similar covariates as used in Table 4. The estimated odds ratio of a complication was 0.80 for medium volume and 0.69 for high volume, with a P value less than 0.01. This mirrors our results of 0.78 and 0.71 in Table 4. Thus, our volume results in Table 4 appear to be robust and not biased because of missing volume. Similarly, the odds ratio in the NIS for laparoscopy is 0.69, compared with 0.70 in Table 4. The odds ratio for banding in the NIS is 0.69, compared with 0.82 in Table 4. Thus, although our laparoscopy effect is robust, we may have underestimated the banding effect. The NIS does not contain readmissions and payments, so we could not test the robustness of those regressions.

Next, we cannot ascertain if the volume effect on outcomes in Table 4 is really due to a volume effect (possibly such as surgeon learning-by-doing as volume increases), or if it is simply reverse causation: the volume is increasing at a

TABLE 3. Risk Adjusted Changes in Bariatric Outcomes and Utilization Over Time

	Unadjusted		Risk Adjusted	
	2001–2002	2005–2006	2001–2002	2005–2006
Inpatient complication rate	21.93%	15.31%*	23.60%	14.81%*
30-day overall complication rate	32.39%	26.31%*	33.68%	25.45%*
180-day overall complication rate	39.57%	33.64%*	41.69%	32.81%*
Specific 180-day complications				
Anastomosis complications	12.29%	9.48%*	13.01%	9.26%*
Marginal ulcer	0.99%	2.05%*	1.81%	2.05%
Abdominal hernia	7.10%	4.83%*	7.19%	4.81%*
Dumping, vomiting, diarrhea, etc.	19.59%	19.34%	21.44%	18.63%
Hemorrhage	1.67%	2.06%	1.96%	1.94%
Wound dehiscence	1.78%	2.32%	2.19%	2.15%
Infection	5.59%	3.32%*	7.16%	3.03%*
Deep vein thrombosis/pulmonary embolism	2.34%	2.47%	2.50%	2.40%
Respiratory failure	3.05%	2.42%†	4.27%	2.15%*
Pneumonia	4.08%	3.26%†	5.02%	3.01%‡
Postoperative acute myocardial infarction	0.32%	0.40%	0.46%	0.37%
Postoperative stroke	0.00%	0.08%	—	0.10%
Readmission with complication	7.18%	7.59%	9.78%	6.79%*
Emergency room visit with complication	1.31%	1.86%†	1.44%	1.79%
Outpatient hospital visit with complication	14.23%	13.48%	14.78%	13.26%*
Office visit with complication	11.22%	11.11%	12.61%	10.60%
180-day total hospital days (days)	6.0	4.0*	6.1	3.7*
180-day total hospital payments ($)	31,016	27,591‡	29,563	27,905*
180-day inpatient physician payments ($)	3308	3151	3383	3128

The rates are risk adjusted using a logit regression with the covariates of Table 2 and with yearly quarter dummies. The days and payments are risk adjusted using a log-linear regression with the covariates of Table 2. Dollars are in 2006 dollars. Levels of statistical significance in the risk adjusted results are based on bootstrapped standard errors for the differences between years.

*Significantly different from the 2001–2002 complication rate at the 99% level.

†Significantly different from the 2001–2002 complication rate at the 90% level.

‡Significantly different from the 2001–2002 complication rate at the 95% level.

hospital because people know it has inherently low complications and are thus attracted to it. We will try to control for this reverse causality. Since our sample in Table 4 is too small to control for hospital fixed effects, we use the NIS sample of 88,930 surgeries with hospital fixed effects. The fixed effects method estimates a separate indicator term for each hospital, thus controlling for any attribute of the hospital unchanged over the time period. Such a fixed attribute could be the inherent quality of the hospital's surgeons. Thus, without fixed effects, any observed volume effect on outcomes might simply be an effect between hospitals, where a high volume hospital has better outcomes than a low volume hospital simply because it has better skilled surgeons. With hospital fixed effects, this fixed quality of the hospital is captured, and so any remaining observed volume effect is now within-hospital, indicating that the hospital is also improving outcomes over time within-hospital (ie, volume drives quality). With the NIS data, using a hospital fixed effects logit regression on inpatient complications, we find that the odds ratios for a complication are 0.82 for medium volume and 0.69 for high volume, with a P value less than 0.01. Thus, we find that the volume effect on complications is a within-hospital effect over time. This within-hospital effect on complications could possibly be surgeon learning-by-doing, but our data limitations do not allow us to verify whether this is the case.

DISCUSSION

In 2002, 83% of bariatric surgeries were covered by private insurance.[11] In Encinosa et al (2006), we provided the first population-based analysis of 6-month bariatric surgery outcomes, complications, utilization, and costs by examining a 3% sample of the privately-insured across 49 states between 2001 and 2002. The 180-day complication rate of 39.60% was higher than the usual 10% to 20% range for complications found in the literature.[7,8] In this update, we find that although older and sicker patients underwent bariatric surgery between 2005 and 2006 compared with 2002, with the number of comorbidities per patient more than doubling, the 180-day risk-adjusted complication rate declined 21% from 41.7% to 32.8%. Moreover, risk-adjusted rates of readmissions with complications declined 31%, from 9.8% to 6.8%.

These improvements over time may be because of: (1) increased use of laparoscopy; (2) increased use of banding without bypass; or (3) within-hospital increases in hospital volume. We found that improvements were due to all 3 reasons. First, the improvement in 180-day complications was due to laparoscopy and within-hospital increases in hospital volume, with the hospital volume in our sample growing by 30% over this period. However, laparoscopy had no impact on readmissions and ER visits with complications.

TABLE 4. Estimated Effects of Volume and Laparoscopy on Bariatric Outcomes and Costs

Variables	180-day Complications Logit Odds Ratios	Post-op Hospital Visit With Complication Logit Odds Ratios	Log (hospital payments) OLS Coefficients
Medium volume	0.783* (0.013)	0.840 (0.108)	−0.011 (0.732)
High volume	0.710† (0.003)	0.706† (0.005)	−0.058 (0.134)
Laparoscopy	0.699† (0.000)	0.956 (0.685)	−0.120† (0.000)
Banding, no bypass	0.824 (0.159)	0.601† (0.004)	−0.201† (0.000)
Period 2005–2006	0.851 (0.127)	0.833 (0.134)	0.070* (0.022)

N = 3841. All models include hospital random effects. *P* values are in parentheses. The reference groups are low volume, non-laparoscopic, and period 2001–2002. The regressions also control for the covariates of Table 2: number of comorbidities, female, ages 18–39, 40–49, and 50–64, capitated HMO, point-of-service plan, PPO, fee-for-service, regions, and yearly quarters.

In the middle columns, "post-op hospital visit" refers to any readmission, ER visit, or outpatient hospital visit with a complication. "OLS" is ordinary least squares regression.

*Significantly different from the reference group at the 95% level.

†Significantly different from the reference group at the 99% level.

‡Significantly different from the reference group at the 90% level.

Both within-hospital increases in hospital volume and a move to banding reduced such postoperative visits. Within-hospital increases in hospital volume did not impact 180-day payments. Laparoscopy reduced payments by 12% and banding reduced payments by 20%. Thus, overall, improvements in bariatric outcomes and costs were due to a mix of within-hospital increases in hospital volume, a move to a laparoscopic technique, and a move to banding.

There are a few limitations of our study. First, we could not track death outside of the hospital. Thus, our low death rate was only for deaths observed in the hospital. A second limitation of our study is that we did not know the patient's body mass index. Patients with a higher body mass index may be at a greater risk of complications. Another limitation of this article is that although the MarketScan data is national, the data is not nationally representative because it over-represents the South and under-represents the West. For example, although 36% of the US population resides in the South, 51% of the MarketScan population resides in the South. Also, we could not track surgeons within and between hospitals to verify that the effect of within-hospital volume increases on outcomes was a result of surgeon learning-by-doing.

Future research should examine other factors that improved outcomes after 2006. Did the introduction of the ASBS Center of Excellence certification program (after our study period) result in further improvements? Future research should also examine the recent move to laparoscopic banding and gastric-balloons. In fact, gastric-balloons are even less invasive than laparoscopy since they can be placed endoscopically. Moreover, many of these less invasive techniques are being performed at outpatient centers. Future research should study this shift from inpatient to outpatient. Finally, as the costs of bariatric surgery declined by 5% between 2001 and 2006, it appears that more HMOs funded bariatric surgery than in 2001. Future research should examine these trends in the insurance market. Moreover, we found that some of the decline in costs between 2001 and 2006 could not be explained by our model. Future research should examine other effect on costs, such as increased bariatric hospital price competition.

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