Original articles

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SURGICAL ENDOSCOPY and Other Interventional Techniques

National trends in utilization and outcomes of bariatric surgery

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Abstract
Background: Because of the growing interest in surgery to treat morbid obesity, this study examined changes in the utilization and in-hospital outcomes of bariatric surgery in the United States over a 10-year period.
Methods: Data were obtained from the Nationwide Inpatient Sample, the largest all-payer discharge database in the United States. International Classification of Disease (ICD-9) codes were used to identify all bariatric procedures performed for adults from 1990 to 2000. Population-based rates of surgery for each year were calculated by applying sampling weights and U.S. Census data. Secular trends in annual rates of surgery, changes in patient characteristics, and in-hospital mortality and complications were analyzed.
Results: From 1990 to 2000, the national annual rate of bariatric surgery increased nearly six fold, from 2.4 to 14.1 per 100,000 adults ($p = 0.001$). There has been more than a ninefold increase in the use of gastric bypass procedures (1.4 to 13.1 per 100,000; $p < 0.001$). This represents an increase from 55% of all bariatric procedures in 1990 to 93% of such procedures in 2000 ($p < 0.001$). The rates of in-hospital mortality were low (0.4% overall), but increased slightly over time (0.2% in 1990 to 0.5% in 2000; $p = 0.009$). There is no significant difference in adjusted mortality for the past 8 years, but a slight rise did occur over the full 10-year period. The rates for reoperation (1.3%) and pulmonary emboli (0.3%) remained stable. The rates for respiratory failure associated with bariatric surgery declined from 7.7% in 1990 to 4.5% in 2000 ($p < 0.001$). Over this time, the mean length of hospital stay declined from 6.0 to 4.1 days ($p < 0.001$).
Conclusions: The annual rate of bariatric surgery in the United States increased nearly six fold between 1990 and 2000, with little change in in-hospital morbidity and mortality. This appears to be driven largely by the increasing popularity of gastric bypass procedures.

Key words: Obesity — Surgery — Epidemiology — Trends

The prevalence of obesity in the U.S. population is increasing at an alarming rate [29, 30, 32, 33]. Nearly one-third (30.5%) of the U.S. population is currently considered obese, as defined by the National Institutes of Health (NIH). The prevalence of obesity (body mass index [BMI] ≥ 30) more than doubled, from 13.3% to 30.9% between 1960 and 2000. The main rise in obesity prevalence has occurred in the past 20 years [9]. The prevalence of extreme obesity (BMI ≥ 40) rose from 2.9% to 4.7% from 1988 to 2000. This represents a dramatic rise from 0.8% in 1960 [9, 10]. Recent mortality figures indicate that poor diet and physical inactivity may soon surpass tobacco as the leading cause of death [3]. These trends have increased awareness of the health risks associated with obesity among health care providers, health policymakers, and the general public.

Conventional methods of weight loss such as diet and exercise have been ineffective in achieving sustained weight loss in the morbidly obese population. In fact, the best weight loss programs have been able to maintain a sustained excess body weight loss of only 10% [35, 37, 43, 49]. This small reduction in excess body weight has little if any effect on obesity-related comorbidities in the morbidly obese population.

The only treatment that produces significant, sustained excess body weight loss is bariatric surgery. Several studies of surgical weight loss have demonstrated reductions in obesity-related morbidity, including diabetes, hypertension, obesity hypoventilation, sleep apnea, and gastroesophageal reflux [1, 2, 5–7, 12–16, 18, 24, 39–41, 45, 46, 48]. Public awareness of the benefits of bariatric surgery has been fueled by increased media attention and by the successful treatment of several high-profile celebrities. This interest has been further advanced by the development of laparoscopic approaches to various bariatric procedures.

Secular trends in the use of bariatric surgery in the U.S. have not been examined despite this newfound

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popularity. High-volume experienced centers have published case series of the relatively low perioperative risks associated with both open and laparoscopic bariatric surgery. A goal of this study was to discern whether similar results are achieved in the broader population.

To determine secular trends, we used administrative data from the Nationwide Inpatient Sample, the largest source of all-payer discharge information in the United States that can be evaluated. Specifically, we sought to determine how much population-based rates of surgery for morbid obesity changed between 1990 and 2000. We also examined trends in patient characteristics and in-hospital outcomes over this period.

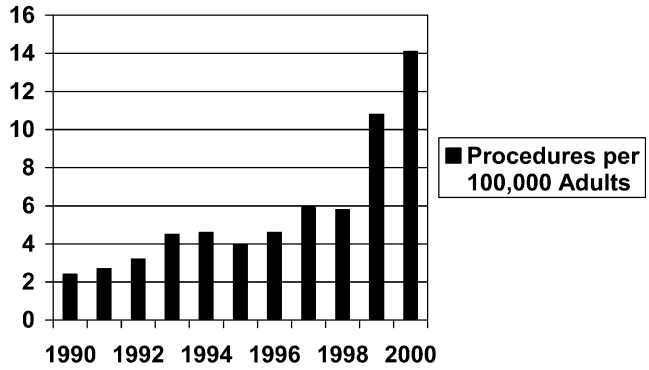

Fig. 1. Bariatric procedures performed annually in the United States from 1990 to 2000. (Procedures/100,000 adults)

Materials and methods

Database

Discharge data from the Nationwide Inpatient Sample (NIS) for the years 1990 to 2000 were obtained from the Healthcare Cost and Utilization Project of the Agency for the-Healthcare Research and Quality. The NIS data consist of all patient-level discharge abstracts from a 20% stratified probability sample of acute care, nonfederal hospitals in the United States (approximately 1,000 hospitals in 2000) [21].

Patient selection

We used International Classification of Diseases (ICD-9) procedure and diagnosis codes to identify all hospitalizations during which a bariatric surgical procedure was performed. Bariatric surgery discharges were identified by the presence of a code for gastric bypass (44.31, 44.39) and/or gastroplasty (44.69) and an accompanying ICD-9 diagnostic code for obesity (278.0, 278.00, 278.01, 278.1, 278.8). For discharges coded for both gastric bypass and gastroplasty (less than a 4% average overlap), gastric bypass was assumed. To increase the homogeneity of the cohort, we excluded all patients with a diagnostic code for an abdominal neoplasm (150.0 through 159.9).

Statistical analysis

We calculated the national population-based rate of bariatric surgery for each year from 1990 to 2000. The annual number of procedures performed in the United States (numerator) was estimated using sampling weights provided with the NIS data. Adult (age, >17 years) population estimates (denominator) were obtained from the U.S. Census.

Demographic characteristics (patient age, gender, and comorbidities) and perioperative outcomes (in-hospital mortality, pulmonary embolus, reoperations, respiratory complications, and median length of stay) were evaluated from the NTS cohort for each year. The Charlson comorbidity index was used to measure severity of illness [8, 42]. This index is a weighted score of patient comorbidity based on ICD-9 diagnostic codes for prior myocardial infarction (412), peripheral vascular disease (440.0 to 443.9), chronic pulmonary disease (415.0, 416.8, 416.9, 491, 491 to 494, 496), dementia (290.0 to 290.9, 331.0, 331.2), diabetes mellitus (250.0 to 250.39), diabetes mellitus with complications (250.4 to 250.99), mild liver disease (571.2, 571.5, 571.6, 571.8, 571.9), severe liver disease (572.2 to 572.4, 456.0 to 456.29), chronic renal failure (585.0 to 586.9, V420, V451, V56.0 to V56.9), various cancers (140.0 to 171.9, 174.0 to 195.9, 200.0 to 208.8, 273.0 to 273.3, V104.6), and metastatic solid tumor (196.0 to 199.9). Complications were identified by the presence of the discharge abstract of specific ICD-9 codes for pulmonary embolus (415.1); reoperation for hemorrhage, anastamotic leak, abscess, or dehiscence (54.11, 54.12, 54.19, 54.61); and respiratory complications including prolonged mechanical ventilation for more than 96 h (96.72), tracheostomy (519.0, 519.00, 519.01, 519.02, 519.09, 31.1, 31.2, 31.21, 31.29, 96.55, 97.23), pneumonia (519.8, 997.3), respiratory failure (518.5, 518.81, 518.82, 518.84), and respiratory arrest (799.1).

Secular trends were tested for statistical significance using logistic regression for dichotomous variables (gender, procedure type, in-hospital mortality, pulmonary embolus, reoperations, and respiratory complications), with year as a continuous independent variable. Nonparametric rank-sum tests were used to test secular trends for continuous dependent variables (patient age, comorbidities, and median length of hospital stay).

Multiple logistic regression was used to calculate adjusted mortality rates for each year [23]. Age and gender were selected as covariates for the final model following stepwise comparison of nested models.

Population sampling weights from NIS were applied to all statistical computations to account for the stratified, clustered survey design. Significance for all tests was set at a p value less than 0.05. All p values are two-tailed. All the analyses were performed using statistical computer software (STATA 7.0, STATA Corporation, College Station, TX, USA).

Results

Patient characteristics

Patient age increased over the study period, and there were significantly more patients with one or more major comorbidites (17.9–27.6%; $p < 0.001$). No gender trends were observed over the 10-year study period.

Rates of surgery

From 1990 to 2000, the national annual rate of bariatric surgery increased almost sixfold, from 2.4 to 14.1 per 100,000 adults ($p < 0.001$) (Fig. 1). The rate more than doubled in the first 7-year period (2.4 per 100,000 adults in 1990 to 5.9 per 100,000 adults in 1997), then more than doubled again in the final 2 years (5.8 to 14.1 per 100,000 adults in 1998 to 2000; $p < 0.001$). There was a definite shift toward the use of gastric bypass procedures over this 10-year period. The use of gastric bypass significantly increased from 1.4 to 13.1 per 100,000 adults, whereas gastroplasty utilization declined (Fig. 2). As a proportion of all bariatric procedures, gastric bypass increased from 55% in 1990 to 93% in 2000.

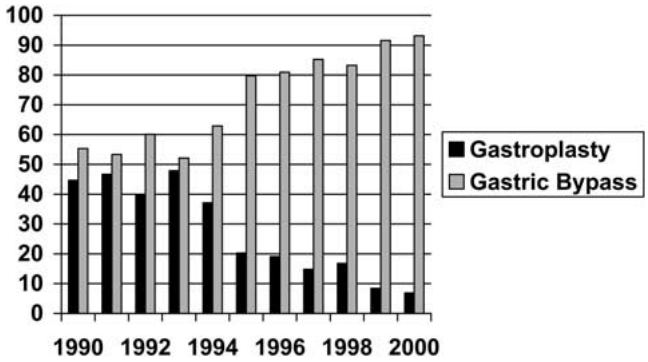

Fig. 2. Distribution of gastroplasty vs gastric bypass performed annually in the United States from 1990 to 2000. (procedures/100,000 adults)

In-hospital outcomes

Unadjusted in-hospital mortality showed a slight upward trend from 0.2% in 1990 to 0.5% in 2000 ($p = 0.006$). There was no significant difference in adjusted mortality for the final 8 years, but we did find a slight rise over the full 10-year period ($p = 0.009$).

The rates for reoperation (1.2%) and pulmonary emboli (0.3%) remained stable. The rates for respiratory failure associated with bariatric surgery, which include prolonged ventilation, tracheostomy, pneumonia, respiratory failure, and respiratory arrest, declined from 7.7% in 1990 to 4.5% in 2000 ($p < 0.001$). Over this time, the mean length of hospital stay declined from 6 to 4.1 days ($p < 0.001$).

Discussion

The rates for bariatric surgery use in the United States increased more than ninefold between 1990 and 2000, from 2.4 to 14.1 per 100,000 adults. The use of gastric bypass has been the primary driving force in this trend.

We first observed more than a twofold increase in the use of bariatric surgery from 1990 to 1997 [38]. A similar trend over the same period also was reported in a national study from Sweden [26]. The in-hospital mortality rates were similar in both studies. Remarkably, the rate of bariatric surgery use in the United States more than doubled again in the following 3-year period.

There was a decrease in the use of bariatruic surgery from 1994 to 1995 in both the United States and Sweden. This decline correlates with the introduction and popularization of fenfluramine-phentermine (fen-phen). Fenfluramine prescriptions grew from 50,000 per year in 1994 to more than 1 million in 1995 [17]. Fenfluramine was removed from the market in 1997, the same year a sharp rise in bariatric surgery utilization was observed. A second dramatic rise in utilization of bariatric surgery occurred in 1999, which can be attributed to increased media attention to the procedure, largely driven by a laparoscopic approach and celebrity patients.

The in-hospital mortality rate rose slightly over the 10-year period, but this increase was not statistically significant for the final 8 years. We did find a slight in-hospital mortality increase over the full 10-year period. This may reflect the "learning curve" of some surgeons performing bariatric surgery for the first time. The in-hospital outcomes for bariatric surgery were similar to those reported in large published clinical series. The operative mortality rates in large clinical series were 0.24% for vertical banded gastroplasty [28] and 0.4% after both gastric bypass and biliopancreatic diversion [44, 47], with a range from 0% to 2% in published reports [1, 3, 4, 11, 18–20, 22, 24, 25, 27, 34, 36, 41, 48, 50].

The in-hospital complications rates identified from NIS were consistent with published rates for bariatric procedures [1, 4, 19, 22, 25, 27, 39, 41, 47, 50]. Perioperative outcomes such as pulmonary emboli and reoperations remained stable, whereas respiratory complications improved over this time. Pulmonary emboli occurred in approximately 0% to 0.4% of patients, which is similar to the rates of 0% to 0.5% in large published series [1, 22, 39, 41, 50]. Published reoperation rates ranged from 1% to 2.8% whereas we observed rates of 1% to 1.6% [1, 25, 39, 41].

The use of administrative data imposed several limitations. The NIS data capture only in-hospital data, whereas most clinical series capture both in-hospital and out patient outcomes after surgery. Hence, adverse outcomes after discharge were not captured in our study.

Our results most likely underestimate the true number of bariatric procedures performed the over the 10-year study period because of absent ICD-9 codes and the coding practices at various institutions. Many bariatric procedures, particularly laparoscopic procedures, have no designated ICD-9 codes. Nonspecific codes such as "other gastroenterostomy bypass" (44.31) required that the accompanying diagnostic code for obesity be captured for inclusion in this study. These code combinations are highly dependent on the coding practice of the institutions and the number of comorbidity codes that may be preferentially used by some institutions. Also, the number of comorbid conditions experienced by many of these patients may fill the maximum number of diagnostic codes allowed, essentially forcing the elimination of the diagnostic code for obesity.

Finally, information regarding patients' baseline operative risk difficult to ascertain from administrative data, limiting our ability to adjust for case mix differences.

There appears to be a definite shift to the use of gastric bypass procedures for the treatment of obesity. The ability to perform bariatric surgery laparoscopically has fueled a renewed interest in obesity surgery among surgeons and the public. Gastric banding, approved by the Food and Drug Administration, may shift interest back to restrictive procedures if efficacious. The development of innovative endoscopic bariatric procedures or promising weight loss drugs could dramatically alter these trends.

Conclusions

Utilization of bariatric surgery in the United States increased nearly sixfold from 1990 to 2000. This trend appears to be linked to an increase in the use of gastric bypass. The development of minimally invasive bariatric procedures along with increased public awareness and a growing prevalence of obesity may continue to increase bariatric surgery utilization further.

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