ORIGINAL ARTICLE

Accelerated Growth of Bariatric Surgery With the Introduction of Minimally Invasive Surgery

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Hypothesis: An increase in national utilization of bariatric surgery correlates with the dissemination of laparoscopic bariatric surgery.

Design: Evaluation of Nationwide Inpatient Sample data from 1998 through 2002.

Setting: National database.

Patients: A total of 188 599 patients underwent bariatric surgery for the treatment of morbid obesity.

Main Outcome Measures: Annual total number of bariatric operations, the proportion of Roux-en-Y gastric bypass vs gastroplasty, the proportion of laparoscopic cases, postoperative length of stay, crude in-hospital mortality, and the number of institutions that perform bariatric surgery.

Results: Between 1998 and 2002, the number of bariatric operations increased from 12 775 cases to 70 256 cases. The rate of bariatric surgery increased from 6.3 to 32.7 procedures per 100 000 adults. Laparoscopic bariatric surgery increased from 2.1% to 17.9%. The number of bariatric surgeons with membership in the American Society for Bariatric Surgery increased from 258 to 631, and the number of institutions that perform bariatric surgery increased from 131 to 323. During this 5-year period, the annual rate of laparoscopic bariatric surgery increased exponentially (by 44-fold) compared with a linear growth in open bariatric surgery (by 3-fold).

Conclusions: Between 1998 and 2002, there was a 450% increase in the number of bariatric operations performed in the United States, a 144% increase in the number of American Society for Bariatric Surgery bariatric surgeons, and a 146% increase in the number of bariatric centers. The growth of laparoscopic bariatric surgery during this 5-year period greatly exceeds that of open bariatric surgery.

Arch Surg. 2005;140:1198-1202

SURGERY IS CURRENTLY THE only effective sustained weight loss option for patients with morbid obesity. In 1991, the National Institutes of Health Consensus Development Conference recommended that an operation, either vertical banded gastroplasty or Roux-en-Y gastric bypass, was an appropriate option for the treatment of morbid obesity.[1] The field of bariatric surgery has received increased publicity within the past several years, and the number of bariatric procedures performed in the United States has been increasing. The increased enthusiasm for bariatric surgery coincides with the development and dissemination of the laparoscopic approach to bariatric surgery. Randomized trials that compare laparoscopic vs open gastric bypass have demonstrated the clinical benefits of the laparoscopic approach, which may have lowered the threshold for patients to undergo surgery and primary physicians to refer their patients for a surgical option.[2,3]

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In a population-based study that examined the secular trends in bariatric surgery from 1990 to 1997, Pope et al,[4] using data from the Nationwide Inpatient Sample (NIS), reported that the number of bariatric procedures performed in the United States increased from 9189 in 1993 to 12 541 in 1997. The American Society for Bariatric Surgery (ASBS) has estimated that approximately 140 000 bariatric procedures will be performed in 2004, a calculation based on the increasing number of active ASBS members in the society. To our knowledge, no population-based study has examined the secular trends in the utiliza-

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Table. Bariatric Procedure Counts, Patient Characteristics, and Perioperative Outcomes After Bariatric Surgery in the United States, 1998-2002

Variable	1998	1999	2000	2001	2002
Procedures					
Total No. of procedures	12 775	22 184	29 699	53 685	70 256
Gastric bypass, %	78	91	88	90	92
Gastroplasty, %	22	9	12	10	8
Laparoscopy, %	2.1	13.5	13.6	15.8	17.9
Annual rate per 100 000 adults	6.3	10.8	14.2	25.3	32.7
Characteristics					
Median age, y	39	42	40	41	42
Female, %	82	82	86	84	84
White, %	81	85	78	81	81
Comorbidities, %					
Diabetes	14	17	17	18	21
Hypertension	35	39	37	37	44
Hyperlipidemia	5	3	3	6	7
Chronic liver disease	11	6	7	7	9
Sleep apnea	19	28	22	24	26
Outcomes					
Crude in-hospital mortality, %	0.8	0.4	0.5	0.3	0.5
Median length of stay, d	4	4	3	3	3

tion of bariatric surgery since the dissemination of laparoscopic bariatric surgery in 1998. In this study, we used administrative data from the NIS to evaluate trends in the utilization of bariatric surgery for the treatment of morbid obesity during the 5-year period between 1998 and 2002. We hypothesized that the growth in bariatric surgery is related in part to the dissemination of laparoscopic bariatric surgery.

METHODS

Discharge data from the NIS from 1998 through 2002 were obtained from the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality. The NIS is the largest all-payer inpatient care database in the United States, containing data from 5 million to 8 million hospital stays from approximately 1000 hospitals sampled, which represents approximately 20% of US community hospitals. The NIS includes public hospitals and academic medical centers. We obtained information from the NIS database on the annual total number of bariatric operations, the proportion of Roux-en-Y gastric bypass vs gastroplasty, the proportion of laparoscopic cases, patient characteristics (age, sex, and race) and comorbidities, postoperative length of stay, crude in-hospital mortality, and the number of institutions that perform bariatric surgery. Approval for the use of the HCUP patient data was obtained from the institutional review board of the University of California, Irvine Medical Center, and the HCUP.

Using the HCUP database, we analyzed all discharge abstract data for patients who underwent bariatric surgery from January 1, 1998, through December 31, 2002. All hospitalizations during which a bariatric procedure was performed for the treatment of morbid obesity were identified using appropriate diagnosis and procedure codes as specified by the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*). The principal *ICD-9-CM* diagnosis codes for obesity and morbid obesity were 278.0, 278.00, 278.01, 278.8, and 278.1, which included a subcategory of obesity and a subclassification of morbid obesity. The principal *ICD-9-CM* procedure codes for Roux-en-Y gastric bypass were 44.31 and 44.39, which included a subcategory of gastroenterostomy without gastrectomy and a subclassification of high gastric bypass. The principal *ICD-9-CM* procedure code for gastroplasty was 44.69. No specific *ICD-9-CM* code exists for laparoscopic bariatric surgery. Therefore, to estimate the number of bariatric procedures performed laparoscopically, we identified all discharge abstracts that included an *ICD-9-CM* code for diagnostic laparoscopy, laparoscopic lysis of adhesions, or laparoscopic cholecystectomy (54.21, 54.51, 51.23).

We calculated the population-based rates of bariatric surgery for each year with the number of bariatric surgical procedures obtained from the NIS database and the US Census data. For the denominator, we used adult (age >17 years) population estimates from the US Census. To estimate the number of surgeons who performed bariatric surgery, we obtained from the ASBS the number of regular members from 1998 through 2002. A regular member was defined as a general surgeon who practiced bariatric surgery and who was a diplomat of the American Board of Surgery or a fellow of the American College of Surgeons or the Royal College of Surgeons. Statistical analysis was performed using Stata statistical software, version 6.0 (Stata Corp, College Station, Tex). Trends in utilization of bariatric surgery across time were evaluated for significance using logistic regression analysis. The characteristic growth pattern (linear vs exponential) of laparoscopic and open bariatric surgery was analyzed using the annual rate of bariatric surgery as the dependent variable and year as the independent variable. $P<.05$ was considered statistically significant.

RESULTS

RATES OF BARIATRIC SURGERY

From 1998 to 2002, a total of 188 599 patients underwent bariatric surgery for the treatment of morbid obesity. The growth in the field of bariatric surgery is reflected by an increase in the number of bariatric operations from 12 775 procedures in 1998 to 70 256 procedures in 2002 (**Table**).

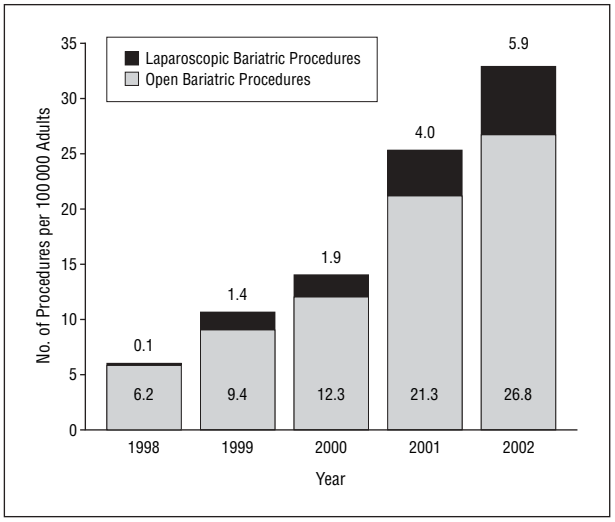

Figure 1. Annual rate of laparoscopic vs open bariatric procedures per 100 000 adults, 1998-2002.

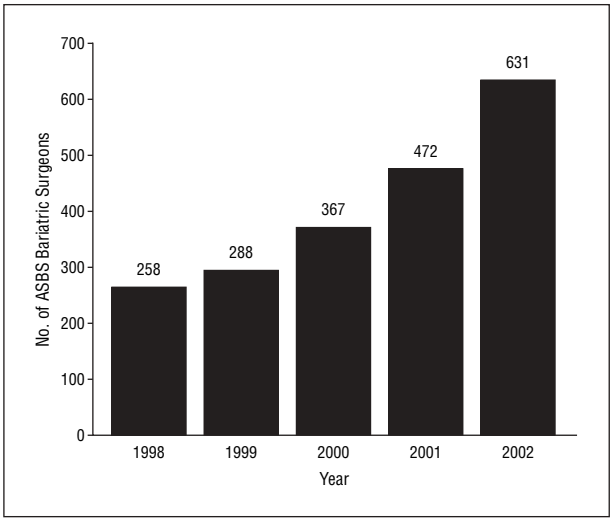

Figure 2. Number of bariatric surgeons with membership to the American Society for Bariatric Surgery (ASBS), 1998-2002.

Most bariatric operations consisted of Roux-en-Y gastric bypass, with a rate that increased from 78% in 1998 to 92% in 2002. The annual rate of bariatric surgery increased from 6.3 procedures per 100 000 adults in 1998 to 32.7 procedures per 100 000 adults in 2002 ($P<.001$) (**Figure 1**). Figure 1 also depicts the annual rate of bariatric surgery according to technique (laparoscopic vs open). There was an exponential growth in the annual rate of laparoscopic bariatric surgery from 0.1 procedure per 100 000 adults in 1998 to 5.9 procedures per 100 000 adults in 2002, whereas there was linear growth in the annual rate of open bariatric surgery from 6.2 procedures per 100 000 adults in 1998 to 26.8 procedures per 100 000 adults in 2002. The proportion of laparoscopic cases increased from 2.1% in 1998 to 17.9% in 2002.

PATIENT CHARACTERISTICS AND OUTCOMES

Between 1998 and 2002, the median age for patients who underwent bariatric surgery ranged from 39 to 42 years, and 82% to 86% of patients were women. The proportion of procedures performed in white patients ranged from 78% to 85%. The proportion of comorbidities is listed in the Table. The median length of stay ranged from 3 to 4 days. The crude in-hospital mortality was 0.8% in 1998 and 0.5% in 2002.

NUMBER OF BARIATRIC SURGEONS

The number of bariatric surgeons with membership to the ASBS increased over time (**Figure 2**): 258 members in 1998, 288 members in 1999, 367 members in 2000, 472 members in 2001, and 631 members in 2002. This represents a 144% increase in the number of bariatric surgeons who belong to the ASBS during the 5-year period.

NUMBER OF BARIATRIC CENTERS

Between 1998 and 2002, the number of bariatric centers participating in the HCUP project increased: 131 (13%) of 984 institutions performed bariatric surgery in 1998, 145 (15%) of 984 institutions in 1999, 151 (15%) of 994 institutions in 2000, 185 (19%) of 986 institutions in 2001, and 323 (32%) of 995 institutions in 2002.

COMMENT

The accelerated growth in the field of bariatric surgery within the past 5 years has corresponded with the dissemination of laparoscopic bariatric surgery. Using the NIS administrative database, we found 450% growth in the number of bariatric operations being performed in the United States between 1998 and 2002. Liu et al[5] reported similar findings and found that the number of bariatric procedures performed in California had increased by 4115% between 1990 (149 cases) and 2000 (6281 cases). Courcoulas et al[6] also reported that the prevalence of gastric bypass surgery in Pennsylvania increased by 100% each year between 1999 and 2001. In this study, we calculated the population-based rate of bariatric surgery using the US Census data and found that the rate of bariatric surgery increased more than 4-fold between 1998 and 2002 (6.3 to 32.7 procedures per 100 000 adults). Before 1998, the population-based rate of bariatric surgery had reached a plateau of 5.3 to 6.3 procedures per 100 000 adults between 1994 and 1997 (**Figure 3**).[4] Between 1998 and 2002, most bariatric procedures were Roux-en-Y gastric bypass, which increased from 78% in 1998 to 92% in 2002. During the same period, the estimated proportion of laparoscopic bariatric procedures increased from 2.1% to 17.9%. Although the rate of both laparoscopic and open bariatric surgery is growing, the growth of laparoscopic bariatric surgery approximates an exponential regression model, whereas the growth of open bariatric surgery approximates a linear regression model. Finally, the number of institutions that perform bariatric surgery has increased from 13% to 32% during this 5-year period.

With the advantages of laparoscopic gastric bypass clearly apparent to patients and physicians, more phy-

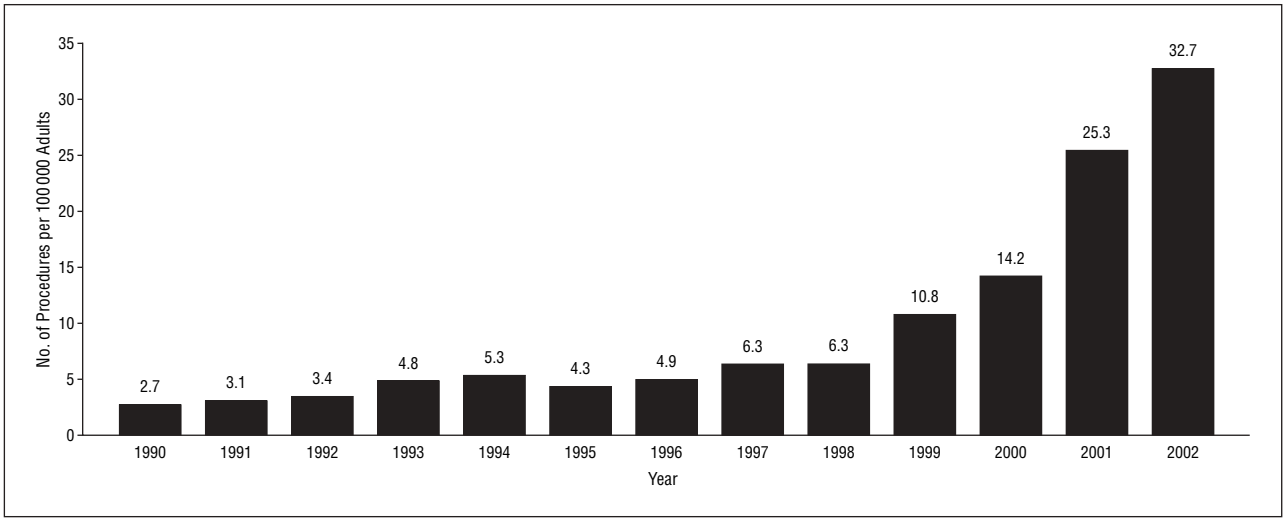

Figure 3. Annual rate of bariatric procedures per 100 000 adults, 1990-2002. Data from 1990-1997 were derived from Pope et al.[4]

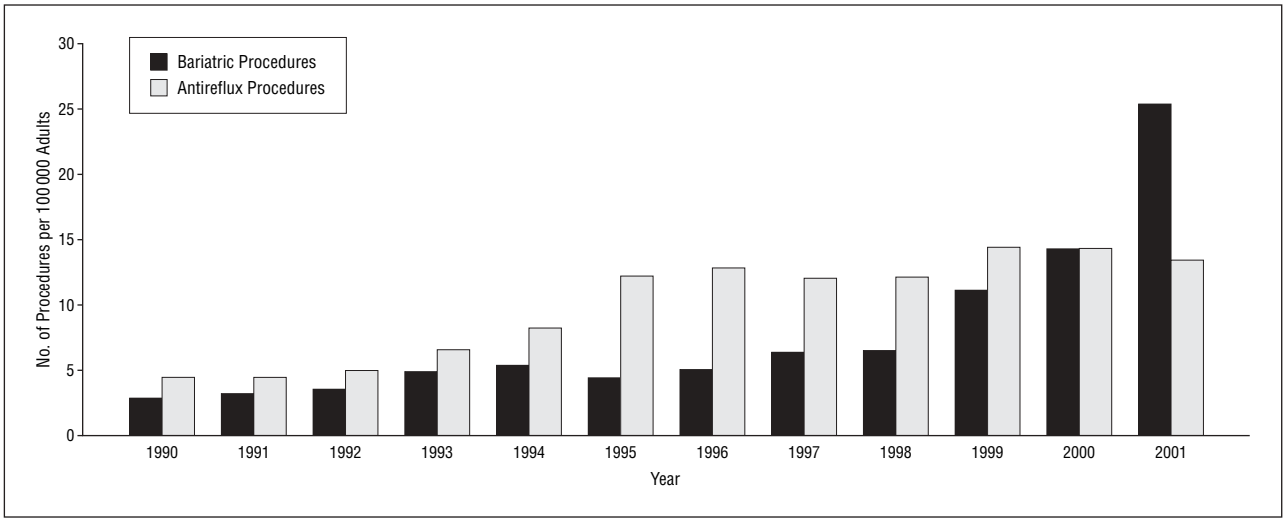

Figure 4. Annual rate of bariatric procedures vs antireflux procedures per 100 000 adults, 1990-2001. Data for the annual procedures of antireflux surgery from 1990 to 1997 were derived from Finlayson et al.[7] Data for the annual procedures of antireflux surgery from 1998 to 2001 were derived from Root et al.[8] Data for the annual procedures of bariatric surgery from 1990 to 1997 were derived from Pope et al.[4]

sicians are likely to refer their patients for a surgical option, and patients are more willing to undergo surgery for treatment of morbid obesity. Approximately 8 million adults in the United States are categorized as morbidly obese, but only 1 in every 600 of these individuals underwent open bariatric surgery in 1997.[4] With the development of laparoscopic bariatric surgery, many patients who were morbidly obese but were not interested in open surgery became motivated to pursue the surgical option. The exponential growth in bariatric surgery since the development of laparoscopic bariatric surgery is similar to the growth observed for cholecystectomy and antireflux surgery with the development of their respective laparoscopic techniques (**Figure 4**).[7-10] Between 1990 and 1997, Finlayson et al[7] reported that the population-based annual rate of antireflux surgery increased from 4.4 to 12.0 per 100 000 adults and that the proportion of laparoscopic antireflux procedures increased from 0.5% to 64%. A substantial increase in utilization of antireflux surgery occurred between 1993 and 1995, and by 1996, laparoscopic antireflux surgery exceeded that of open antireflux surgery (58% vs 42%, respectively).[7]

In our study, the initial increase in the annual number of bariatric procedures performed in the United States occurred in 1999. By 2001, the population-based rate of bariatric surgery per 100 000 adults was almost double that of antireflux surgery in the United States (Figure 4).[8] Overall, we observed an increase in both the annual rate of laparoscopic and open bariatric surgery; however, the increase in the annual rate of laparoscopic bariatric surgery approximates an exponential regression model, whereas the increase in the annual rate of open bariatric surgery approximates a linear regression model (44-fold increase vs 3-fold increase). Although most patients currently seeking bariatric surgery are requesting the laparoscopic approach, not all patients qualify for the laparoscopic technique and not all surgeons are comfortable with performing laparoscopic bariatric surgery. Because of the complexity of laparoscopic bariatric surgery, we estimate that it will

take more than 6 to 8 years from the initial increase in the rate of bariatric surgery before the number of laparoscopic bariatric procedures will exceed that of the open bariatric procedures.

Other factors probably contribute to the growth of bariatric surgery. The medical community now recognizes that morbid obesity is a chronic illness and that surgery can substantially reduce obesity-related illnesses and improve one's quality of life. Favorable reports regarding the efficacy of bariatric surgery compared with medical therapy, particularly in reducing diabetes and hypertension, are influential. Also, the well-publicized increase in the prevalence of obesity in the United States leads patients to seek surgical alternatives.

In an effort to meet the high demand for bariatric surgery, there has been an increase in both the number of surgeons who perform bariatric surgery and the number of centers that offer bariatric surgery. Many institutions and surgical societies, such as the ASBS, are offering bariatric surgery workshops. In our study, we found that membership to the ASBS has increased by 144% between 1998 and 2002 and that the number of institutions that perform bariatric surgery increased by 146%. According to the NIS database, approximately one third of the hospitals now perform bariatric surgery. Similarly, the number of academic institutions that perform bariatric surgery has increased from 64 centers in 1999 to 84 centers in 2002 (data from the University HealthSystem Consortium Clinical Database).[11]

There are limitations to this study. Our method for estimating the proportion of laparoscopic cases probably underestimates the true rate of laparoscopic bariatric surgery. However, this should not affect our finding that the proportion of laparoscopic bariatric surgery has increased during this period. The NIS database is compiled from discharge abstract data and is limited to in-hospital mortality without outpatient follow-up data. For example, deaths that occur after discharge would not be captured in this database. Therefore, our calculation of the mortality rate probably underestimates the true mortality. We analyzed bariatric surgery data only up to the year 2002 because the data for 2003 or later are not currently available, but we reasoned that the rate of bariatric surgery will continue to increase along with an increasing proportion of laparoscopic cases. Finally, membership in the ASBS likely underrepresents the number of surgeons who perform bariatric surgery. Despite these limitations, this study provides a large sample size and is the first, to our knowledge, to characterize the growth of bariatric surgery at the national level in conjunction with the rapid expansion of laparoscopic bariatric surgery. Since the data set is available for multiple years, the growth of bariatric surgery can be examined using a regression model.

In conclusion, the utilization of bariatric surgery has increased more than 4-fold between 1998 and 2002, corresponding with an increase in the number of institutions that provide bariatric surgery and an increase in the number of surgeons who perform bariatric surgery. The observed increase in bariatric surgery rates is related in part to an increase in utilization of the laparoscopic technique by surgeons and greater acceptance by patients of the minimally invasive option. The transition from open to laparoscopic bariatric surgery after 2002 will likely continue because of the high patient demand for laparoscopic bariatric surgery, the identification of morbid obesity in the United States as a health care priority, more favorable reports of laparoscopic bariatric surgery, and the introduction of laparoscopic adjustable silicone gastric banding in the United States. Without a long-term, effective nonsurgical treatment for morbid obesity on the horizon, the rate of bariatric surgery will continue to increase and the procedure will become one of the most commonly performed gastrointestinal operations.

Accepted for Publication: February 2, 2005.
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Previous Presentation: This study was presented at the Annual Meeting of the American Society for Bariatric Surgery; June 15, 2004; San Diego, Calif.
Additional Information: The information contained in this article was based on the NIS database, which is sponsored by the Agency for Healthcare Research and Quality (Rockville, Md).

REFERENCES

1. Consensus Development Conference Panel. Gastrointestinal surgery for severe obesity. *Ann Intern Med.* 1991;115:956-961.
2. 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;234:279-289.
3. Lujan JA, Frutos MD, Hernandez Q, et al. Laparoscopic versus open gastric bypass in the treatment of morbid obesity: a randomized prospective study. *Ann Surg.* 2004;239:433-437.
4. Pope GD, Birkmeyer JD, Finlayson SR. National trends in utilization and in-hospital outcomes of bariatric surgery. *J Gastrointest Surg.* 2002;6:855-861.
5. Liu JH, Etzioni DA, O'Connell JB, et al. Inpatient surgery in California. *Arch Surg.* 2003;138:1106-1112.
6. Courcoulas A, Schuchert M, Gatti G, Luketich J. The relationship of surgeon and hospital volume to outcome after gastric bypass surgery in Pennsylvania: a 3-year summary. *Surgery.* 2003;134:613-623.
7. Finlayson SRG, Laycock WS, Birkmeyer JD. National trends in utilization and outcomes of antireflux surgery. *Surg Endosc.* 2003;17:864-867.
8. Root J, Paya M, Stevens CM, Nguyen NT. Utilization of laparoscopic antireflux surgery for gastroesophageal reflux [abstract]. *Surg Endosc.* 2004;18(suppl):S274.
9. Escarce JJ, Chen W, Schwartz JS. Falling cholecystectomy thresholds since the introduction of laparoscopic cholecystectomy. *JAMA.* 1995;273:1581-1585.
10. Finlayson SRG, Birkmeyer JD, Laycock WS. Trends in surgery for gastroesophageal reflux disease: the effect of laparoscopic surgery on utilization. *Surgery.* 2003;133:147-153.
11. Nguyen NT, Paya M, Stevens CM, Mavandadi S, Zainabadi K, Wilson SE. The relationship between hospital volume and outcome in bariatric surgery at academic medical centers. *Ann Surg.* 2004;240:586-594.