CHAPTER 8

Effect of Bariatric Surgery on Long-term Mortality

Nicolas V. Christou, MD, PhD, FACS, FRCSC
Professor of Surgery, McGill University, Director, Section of Bariatric Surgery, McGill University Health Center, Montreal, Quebec, Canada

Lloyd D. MacLean, MD, PhD, FACS, FRCSC
Professor Emeritus, McGill University, Montreal, Quebec, Canada

In recent years, morbid obesity has emerged as a serious public health threat. After smoking, it is the leading cause of preventable, premature death in the United States. The World Health Organization has recognized an epidemic of obesity throughout most of the developed and developing world. The incidence of obesity in Canadian adults has grown over a 13-year period from 5.6% in 1985 to 14.8% in 1998. It is estimated that there are 400,000 deaths attributable to obesity secondary to poor diet and inactivity in the United States in the year 2000.

Obesity is associated with multiple complications and related comorbidities that lead to both physical and psychological problems. Surgery in the past was (appropriately) considered as a treatment of last resort. Anesthesia was dangerous and so was surgery. During the 1980s and 1990s, anesthesia for obese patients became significantly safer. With the advent of laparoscopic approaches and other technical advances, operations on the obese have become dramatically safer. In fact, no single category of patients has benefited more from laparoscopic surgery than the obese. The larger, deeper, fat-laden open incisions contributed substantially to the increased perioperative morbidity and mortality. It is only during the last 5 to 8 years that the danger, discomfort, and costs of surgery, previously much higher than for other treatments, have diminished, thus making bariatric surgery a more viable option. Bariatric surgery has been shown to be an effective method for producing weight loss.
in obese patients in both the short-term and long-term, and to be more effective than dieting in producing sustained weight loss.

The results of observational studies to the end of 2003, including those where the investigators adjusted for potential covariates, excluded unhealthy patients, or distinguished between intentional weight loss and unintentional weight loss, indicated that weight loss did not appear to influence longevity. Thus, regardless of how the data were “cleaned” or treated statistically, weight loss did not appear to either increase or decrease longevity. This literature, however, is plagued with methodological concerns including (1) the difficulty of assessing and accurately taking account of weight regain after weight loss; (2) the need to determine the methods by which the weight loss was achieved; (3) the assessment of dietary changes during follow-up; and (4) the use of body mass index (BMI, kg/m²) as a proxy for adiposity. The method that is most effective in producing substantial long-term weight loss is surgery. To date, no large, randomized, well-controlled clinical trial of obesity surgery with respect to efficacy in terms of mortality rate has been published. However, Drenick et al conducted an observational study among a group of 200 morbidly obese men who were followed up for a mean period of 7.5 years. About 25% of the men in the study died during the course of the study. According to these authors, life-table techniques comparing the mortality among the obese with that among men in the general population demonstrated a 12-fold excess mortality in the obese in the age group 25 to 34 years, and a 6-fold excess in the age group of 35 to 44 years.

TRIALS

When evaluating survival benefits of Roux-en-Y gastric bypass (RYGB), the mortality rate associated with the procedure is balanced against an anticipated long-term survival benefit associated with comorbidity reduction. The reported mortality associated with RYGB is less than 1 in 200; however, these estimates include in-hospital mortality only and are from selected case series or self-reported registries. In addition, while gastric bypass has been shown to improve quality of life and reduce the severity and importance of a number of comorbid conditions, until quite recently, no survival advantage had been documented with bariatric procedures. The early results of the Swedish Obese Study showed that the excess health risks associated with obesity may not be fully appreciated. An interim analysis of the data reported in 2001 showed that compared with weight stability, large intentional weight loss resulted in substantial reductions in the 2-year inci-
dence of several cardiovascular risk factors. After 8 years, there was still a reduced risk of developing diabetes in the surgical group, while the incidence of hypertension was equal in the 2 treatment groups. However, in the 6% subset of patients who underwent the gastric bypass procedure and lost significantly more weight than patients who underwent a purely restrictive operation, there were still significant decreases in both systolic and diastolic blood pressures at 8 years. This population-based longitudinal study comparing weight loss surgery with nonsurgical weight loss techniques plans to report on survival comparisons by the end of 2005.

Most of the surgical procedures in the Swedish Obese Study are vertical banded gastroplasty (VBG) and adjustable gastric banding. Both procedures are associated with less initial excess weight loss compared with RYGB. Benotti et al29 reported on 5178 patients with morbid obesity who underwent surgical treatment in 12 different centers, and stated that “operative and late mortality rates were quite similar to observed death rates for non-obese men and women between 25–64 years of age.” MacDonald et al30 studied 232 morbidly obese patients with non–insulin-dependent diabetes and followed up 154 patients who underwent a gastric bypass and 78 patients who did not have surgery (personal preference or insurance issues). The mean follow-up in the operated group was 9 years and in the nonoperated group, 6.2 years. The mortality rate in the nonoperated group was 28%, compared with 9% for the surgical group (including perioperative deaths). This retrospective study detailed an annual mortality of only 1.0% among 154 patients who underwent RYGB, compared with 4.5% in the 78 morbidly obese patients referred for RYGB who did not undergo the operation \( (P < .001) \).

Multiple prospective randomized trials were done comparing VBG, the predominant bariatric procedure in the United States in the 1980s, to gastric bypass. Most notably, the randomized controlled trial reported by Sugerman et al31 demonstrated clearly superior maintenance of weight loss at 3 years after gastric bypass compared with VBG. This and other similar randomized controlled trials led to the gradual shift in practice patterns during the 1990s, wherein gastric bypass became the predominant bariatric surgical procedure performed.32 There are no randomized controlled trials comparing nonsurgical medical management of morbid obesity with gastric bypass. There are multiple reasons why this is the case. Most institutional review boards would have difficulty approving the “placebo” arm (ie, no surgery) for the morbidly obese patient given the current state of knowledge of the known and potential beneficial effects of surgery on long-term survival. This concept is reinforced
by 2 key studies published recently that demonstrate the survival advantage of bariatric surgery.

Flum and Dellinger\textsuperscript{33} performed a population-based retrospective cohort study using the Washington State Comprehensive Hospital Abstract Reporting System database and the Vital Statistics database. They found that the 30-day mortality rate associated with bariatric surgery (in patients aged 18-65 years) was nearly 2%. Importantly, in this study, almost half of the deaths within 30 days occurred after discharge from the hospital. They found significantly higher rates of death in males (\textsim 2 times more likely) and older patients (the odds of 30-day mortality increased with increasing age). They also found a significant association between surgical inexperience and outcome with surgeons performing fewer than 20 procedures.\textsuperscript{B} Ten-year survival after the bariatric procedure was high (91.2\%), and survival curves adjusted for gender and comorbidity index demonstrated significant comparative benefit in survival for operated patients ($P = .004$). At 15 years of follow-up, 16.3\% of non-operated patients had died, compared with 11.8\% of patients who had the bariatric procedure. When patient survival was compared starting at 1 year after hospitalization, the hazard for death was significantly less for operated patients than for those who did not have the procedure (HR,\textsuperscript{C} 0.67; 95\% confidence interval [CI], 0.54-0.85). Among patients younger than 40 years, by 13.6 years (the longest common point of follow-up for operated and nonoperated patients younger than 40), only 3\% of those who had the bariatric procedure had died compared with 13.8\% of morbidly obese patients who did not have the procedure.

Christou et al\textsuperscript{34} carried out an observational 2-cohort study that compared the morbidity and mortality of a cohort of morbidly obese patients treated with bariatric surgery with that of matched morbidly obese controls who had not been treated surgically. The inception time of the bariatric cohort was the time of admission for surgery. The inception time for the control group was the date of surgery of the matched bariatric patients. A maximum of 6 controls were identified for each bariatric patient. A total of 1118 patients underwent bariatric surgery for the treatment of morbid obesity at the McGill University Health Center between January 7, 1986, and June 8, 2002. The unique health insurance numbers of these patients were used to retrieve their information from the provincial health insurance database of the Regie de l’assurance maladie du Quebec (RAMQ). The RAMQ database includes information regarding all health care utilization claims, including those for hospitalizations, physician visits, prescription medications, and other paramedical
services. It is a single-payer system and captures all health expenditures and clinical outcomes. For example, if a patient dies in the province of Quebec, a physician must certify the death and submit an invoice to RAMQ, which is recorded in the database. This single-payer system ensures 100% clinical follow-up for both patient cohorts. Data concerning weight loss parameters for the surgically treated patients were extracted from the McGill University Health Center bariatric surgery patient registry. This registry is maintained in a prospective manner for all patients undergoing bariatric surgery.

Of the 1118 patients in the bariatric surgery cohort, 83 patients were excluded because data from their RAMQ file showed that within 6 months before bariatric surgery, they had been diagnosed and hospitalized with one of the chronic conditions or diseases listed in Table 1.

This does not imply that the disease condition was not present. It simply means that the patient (for whatever reason, but not because of affordability) did not see a physician or visit a hospital for the condition. If a patient had repeat bariatric surgery, the index surgery was used as the inception date, and the subsequent surgery was included in the morbidity assessment.

The RAMQ database was queried to identify a maximum of 6 control subjects for each bariatric patient. The inclusion criteria for the controls were a diagnosis of morbid obesity according to the International Classification of Diseases, Ninth Revision (ICD-9) codes (278.00, 278.01) for treatment in a hospital, treatment by a physician, or as an indication for a prescription, as well as never having

<table>
<thead>
<tr>
<th>Condition/Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood and blood-forming organs</td>
</tr>
<tr>
<td>Cancer</td>
</tr>
<tr>
<td>Cardiovascular and circulatory disorders</td>
</tr>
<tr>
<td>Digestive disorders</td>
</tr>
<tr>
<td>Endocrinologic disorders</td>
</tr>
<tr>
<td>Genitourinary disorders</td>
</tr>
<tr>
<td>Infectious diseases</td>
</tr>
<tr>
<td>Musculoskeletal disorders</td>
</tr>
<tr>
<td>Nervous System disorders</td>
</tr>
<tr>
<td>Psychiatric and Mental disorders</td>
</tr>
<tr>
<td>Respiratory disorders</td>
</tr>
<tr>
<td>Skin disorders</td>
</tr>
</tbody>
</table>
had surgery for the treatment of severe obesity (44.31, 44.39). Each bariatric patient was caliper matched to controls with respect to the (1) date of the first diagnosis of morbid obesity, which was within 2 years; (2) age, which was within 5 years; and (3) gender. A total of 6210 controls were identified, of which 464 were excluded because according to their RAMQ file, they had been hospitalized for one of the chronic conditions listed above within 6 months before the surgery date of their matched bariatric patient. The final study sample included 1035 bariatric surgery patients and 5746 matched controls.

For the open RYGB, patients were given 2 g of sodium cefazolin intravenously and 7500 units of unfractionated heparin subcutaneously with induction of anesthesia. Exposure was obtained through an upper midline incision. Blunt finger dissection was used to encircle the cardia of the stomach at the angle of His and the lesser curvature of the stomach approximately 2 cm distal to the gastroesophageal junction. At this point, a 2-cm window was made along the lesser curvature of the stomach. A previously placed 32F bougie was held against the lesser curve, and a 25-mm EEA (Ethicon Endosurgical) was used to create a circular opening into the stomach.

The PI-90 instrument (US Surgical) was passed through this opening (with the help of a #28 chest tube), positioned in a vertical orientation against the bougie, and fired. A second firing of the PI-90 created a quadruple row of staples, and the stomach was completely separated between the staple lines. A roux limb of jejunum (50-300 cm long, depending on BMI and the date of the surgery) was brought up in a retrocolic, retrogastric fashion, and an end-to-side gastrojejunostomy was fashioned with a 3-0 PDS (Ethicon Endosurgical) single continuous suture around an 18-gauge nasogastric tube. The end result was a gastric pouch 1.2 cm in diameter and 5 to 7 cm long with a calculated volume ($\pi r^2 \times$ height) of approximately 7 to 8 mL (approximately the size of a thumb). The jejunojejunostomy was completed, and the mesenteric defects were closed. The nasogastric tube was removed after a satisfactory methylene blue and air bubble leak test. A small suction drain was placed next to the gastrojejunostomy and brought out through a separate stab wound incision, up to 1998. No drains were used afterwards. The fascia was closed with a #2 Maxon double suture in a continuous fashion. The subcutaneous tissue was irrigated and carefully dried with clean sterile sponges that had not touched skin.

Clips were used to close the skin, and an occlusive dressing was applied. Two more doses of cefazolin were given after surgery, and 7500 units of subcutaneous heparin was continued until patient discharge. Patients were placed on a cardiac monitor after surgery.
and ambulated later on the day of surgery. Ice chips and water were given orally the night of the operation, initially limited to no more than 60 mL per hour. The following morning, if there was no tachycardia greater than 120 beats per minute, tachypnea, or fever, the patients were given a clear fluid diet and advanced to a full fluid diet as tolerated. Discharge followed on the third or fourth postoperative day. The first appointment to the bariatric clinic was given for 2 weeks after surgery.

Thirty-five percent of the patients who underwent VBG were subsequently converted to open RYGB because of complications, including outlet obstruction (58%), failure to lose weight (33%), and miscellaneous reasons (9%).

Since February 2002, we have been performing RYGB laparoscopically with the use of 5 ports. We perform a hand-sewn gastrojejunostomy by using a modification of Higa’s technique. This ensures that the operation is very similar to the open RYGB, especially the creation of the very small, vertically oriented gastric pouch. The time frame of this study captured the first 21 laparoscopic RYGB patients for this analysis. Large population-based studies, which more accurately reflect realistic community outcomes, thus far have not specifically targeted laparoscopic RYGB since it remains a relatively new procedure. Outcomes of large (30-1000 patients) series of laparoscopic RYGB are reported in a recent review by Schneider et al. Most series have similar patient populations, with a female preponderance (>70%), a mean age in the mid 40s with an age range from the teenage years to the seventh decade, and a mean BMI near 50 kg/m² (range, 35-70 kg/m²). Operating time generally ranges from 2 to 4 hours, and appears to increase with increasing BMI but decreases with experience. Conversion rates to laparotomy are less than 5%. Although there appears to be significant variability in the methods for detecting and reporting complications, both early and late complication rates (3.3%-15% and 2.2%-27%, respectively) are reasonably low. Operative mortality has ranged from 0 to 0.5%.

The RAMQ database was searched for all claims for health care services by persons in both cohorts for the 5-year period after the date of inception. The ICD-9 codes were used to classify the conditions leading to the utilization of health services. Morbidity was assessed by using the incidence of new diagnoses during the follow-up period. Health care utilization during the follow-up period was measured by the number of hospitalizations, total hospital stay, and outpatient physician visits. The hospitalization and subsequent care required for the bariatric surgery was included in the total estimates of the bariatric cohort.
Weight loss for the bariatric surgery cohort was estimated with the use of the percent change in BMI and the percent excess weight loss. The percent change in BMI was calculated as:

$$100\% \times \frac{\text{BMI}_0 - \text{BMI}_i}{\text{BMI}_0}$$

where $\text{BMI}_i$ is the BMI at the last follow-up, and $\text{BMI}_0$ is the BMI at the time of surgery. The percent excess weight loss was calculated as:

$$100\% \times \frac{W_0 - W_i}{\text{EW}_0}$$

where $W_0$ is the weight in kilograms at the time of surgery, $W_i$ is the weight in kilograms at the last follow-up, and $\text{EW}_0$ is the excess weight at the time of surgery. Excess weight was estimated according to the formula described by Deitel and Greenstein\(^3\)\(^8\) and is based on the Metropolitan Tables for middle-frame individuals.

There were no significant differences in age, gender, or follow-up. The statistical significance of weight loss in the bariatric surgery cohort was assessed with the paired Student $t$ test and was described by using the mean change and 95% CIs for the cohort. There were significant reductions in the mean percent initial excess weight loss ($67.1\%, P < .001$) and in the percent change in BMI ($34.6\%, P < .001$), as shown in the Table 2.\(^1\) The percent initial excess weight

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>SD</th>
<th>Min – Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (kg)</td>
<td>136.4</td>
<td>28.4</td>
<td>77 – 284</td>
</tr>
<tr>
<td>Initial BMI</td>
<td>50.0</td>
<td>8.2</td>
<td>36 – 90</td>
</tr>
<tr>
<td>Ideal body weight (kg)</td>
<td>64.1</td>
<td>8.4</td>
<td>14 – 114</td>
</tr>
<tr>
<td>Initial excess weight (kg)</td>
<td>72.4(^K)</td>
<td>23.8</td>
<td>29 – 205</td>
</tr>
<tr>
<td>Excess BMI</td>
<td>26.5</td>
<td>7.8</td>
<td>12 – 66</td>
</tr>
<tr>
<td>Final weight (kg)</td>
<td>88.8</td>
<td>22.9</td>
<td>42 – 199</td>
</tr>
<tr>
<td>Final BMI</td>
<td>32.6</td>
<td>7.3</td>
<td>16 – 62</td>
</tr>
<tr>
<td>% Initial excess weight loss</td>
<td>67.1</td>
<td>23.7</td>
<td>1 – 130</td>
</tr>
<tr>
<td>% Initial BMI reduction</td>
<td>34.6</td>
<td>12.1</td>
<td>1 – 65</td>
</tr>
<tr>
<td>Overall follow-up (y)</td>
<td>5.3</td>
<td>3.8</td>
<td>1 – 16</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, Body mass index; SD, standard deviation; Min, minimum; Max, maximum.
loss was significantly higher in patients who had undergone an open RYGB (68.7% ± 23.1%) compared with VBG, especially those VBG patients who were not converted to RYGB (57.3% ± 24.8%, $P = .0000^{M}$). VBG patients who were converted to RYGB achieved percent excess weight loss of 66.3% ± 22.6%, equivalent to de novo RYGB patients.

Data on morbidity and mortality over the 5-year follow-up period are shown in Table 3. The incidence of chronic conditions was defined as the ratio of the number of new diagnoses during the 5-year follow-up period over the total number of patients included in the cohort at inception. Relative risks with 95% CIs and exact significance tests were used to assess the difference in morbidity rates between the 2 groups. Relative risks were calculated by using the bariatric cohort as the exposed group and the control cohort as the reference. Therefore, relative risk estimates less than unity indicate a protective or beneficial association for the bariatric cohort. Incidence density rates for cause-specific hospitalizations were calcu-

### Table 3.
Five-Year Morbidity and Mortality

<table>
<thead>
<tr>
<th>Condition/Disease</th>
<th>Bariatric Surgery</th>
<th>Controls</th>
<th>Relative Risk Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Blood and blood forming organs</td>
<td>4</td>
<td>0.39</td>
<td>41</td>
</tr>
<tr>
<td>Cancer</td>
<td>21</td>
<td>2.03</td>
<td>487</td>
</tr>
<tr>
<td>Cardiovascular and circulatory</td>
<td>49</td>
<td>4.73</td>
<td>1530</td>
</tr>
<tr>
<td>Digestive</td>
<td>377</td>
<td>36.43</td>
<td>1414</td>
</tr>
<tr>
<td>Endocrinologic</td>
<td>98</td>
<td>9.47</td>
<td>1566</td>
</tr>
<tr>
<td>Genitourinary</td>
<td>77</td>
<td>7.44</td>
<td>551</td>
</tr>
<tr>
<td>Infectious diseases</td>
<td>90</td>
<td>8.70</td>
<td>2140</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>50</td>
<td>4.83</td>
<td>682</td>
</tr>
<tr>
<td>Nervous system</td>
<td>25</td>
<td>2.42</td>
<td>228</td>
</tr>
<tr>
<td>Psychiatric and mental</td>
<td>45</td>
<td>4.35</td>
<td>470</td>
</tr>
<tr>
<td>Respiratory</td>
<td>28</td>
<td>2.71</td>
<td>651</td>
</tr>
<tr>
<td>Skin</td>
<td>38</td>
<td>3.67</td>
<td>305</td>
</tr>
<tr>
<td>Mortality</td>
<td>7</td>
<td>0.68</td>
<td>354</td>
</tr>
</tbody>
</table>

Abbreviation: CI, Confidence interval.
lated as events per 1000 person-years of follow-up. Rate ratios with 95% CIs and exact significance tests were used to assess the between-cohort differences with respect to the cause-specific hospitalization rates. In comparison with controls, bariatric surgery patients had significantly lower incidence rates for all the chronic conditions listed with the exception of those related to blood and blood-forming organs. The most notable risk reduction was observed for the incidence of malignancies, cardiovascular and circulatory conditions including hypertension, endocrinologic conditions including type 2 diabetes, infectious diseases, and respiratory conditions. The bariatric surgery patients were at increased risk for digestive disorders during the 5-year follow-up when compared with controls.

The crude mortality rate in the bariatric surgery cohort was 0.68% compared with 6.17% for controls (relative risk, 0.11; 95% CI, 0.04–0.27). Mortality in the surgical group includes perioperative deaths (0.4%). Since relative risks were calculated with the bariatric cohort as the exposed group and the control cohort as the reference, another way to describe the mortality data is as follows. Surgery that produces a sustained excess weight loss of 67% results in a relative risk reduction of mortality of 89%. The between-cohort difference with respect to mortality was also assessed with the log-rank test for comparison of Kaplan-Meier survival curves. The Kaplan-Meier survival analysis (Fig 1) confirms that the mortality rate in the bariatric surgery cohort was significantly lower than that of controls ($P < .001$). A similar survival advantage with bariatric surgery has been reported by Flum and Delinger. 33

The selection of patients on the basis of their exposure or treatment, without knowledge of the outcome, the inclusion only of patients who were at risk for the ascertained morbidity indicators (ie, excluding those with a history of the outcomes), and matching the controls with respect to the duration of disease and age were key elements of the study’s design. These elements make the current study an excellent simulation of a prospective cohort study and a valid representation of a “real-life” situation.

The results of the current study show that for up to 16 years after bariatric surgery, patients experience significant and sustained weight loss. This result is expected and compatible with those reported in other studies. The results showing reduced mortality, reduction in the development of new comorbid conditions, and reduced health care utilization after surgery in combination with the demonstrated effectiveness in weight loss are unique findings of the current study.
The effects of morbid obesity on the risk for hypertension, coronary artery disease and vascular disorders, coronary artery disease and vascular disorders, diabetes, cancer, and respiratory conditions have been well documented. In the current study, patients having undergone bariatric surgery had a significantly reduced risk of developing cancer, cardiovascular disease, endocrinologic disorders, infectious diseases, musculoskeletal disorders, and respiratory conditions.

The increased risk for gastrointestinal disorders in the surgery cohort was expected and we feel serves as an internal consistency check of the analysis. After surgery, some patients experience stenosis of the vertical banded outlet, stenosis of the gastrojejunostomy, stomal ulcers, gastro-gastric fistula, small bowel obstructions, incisional hernias, dumping syndrome, and diarrhea. Thus, one expects to see increased physician visits and hospitalizations for treatment of these conditions.

Morbid obesity increases the risk for mortality. The above study demonstrates that in patients being treated with bariatric surgery, the risk of 5-year mortality is reduced by 89%. This is a significant observation since it not only suggests the role of morbidity as a
risk factor for early mortality, but also provides evidence that surgical treatment for obesity produces a significant reduction in mortality. We feel that the improved weight loss due to the efficacy of RYGB and the conversion of the failed VBG patients to RYGB, which resulted in a sustained initial excess weight loss of at least 68% compared with a 25% initial excess weight loss in the Swedish Obese Study, accounts for the observed significant reduction in mortality in our study. Most of the surgical procedures in the Swedish Obese Study are VBG and adjustable gastric banding. Both procedures are associated with less initial excess weight loss compared with RYGB. Benotti et al reported on 5178 patients with morbid obesity who underwent surgical treatment in 12 different centers, and stated that “operative and late mortality rates were quite similar to observed death rates for non-obese men and women between 25–64 years of age.”

A potential weakness of the current study is the lack of data regarding weight loss in the controls. Severely obese patients are not likely to lose weight over a 5-year period without surgery. If they did lose weight over the 5-year period, similar to the operated patients, then the hypothesis would have to be modified—specifically, that weight loss surgery exerts its therapeutic effects by a mechanism other than weight loss.

The strengths of the current study are related to the design and the selection of the cohorts. The exclusion of patients with a history of the ascertained outcomes allows the estimation of true incidence and removes potential selection bias and confounding. Matching the cases and controls with respect to age, gender, and duration of disease further reduces the possibility of confounding from these factors, since both are potentially associated with the morbidity indices studied and with an increased risk for mortality. The random selection of controls from an administrative database reduces selection bias and bias by indication that would have been introduced if hospital-based controls were used.

**CONCLUSION**

Data are accumulating from long-term observational trials, population-based studies, and randomized controlled trials that surgery for obesity does favorably affect mortality in severely obese patients. These studies include the observed decreased mortality over a 6- to 9-year period, from 28% to 9%, in obese type 2 diabetics not operated on as compared with those who underwent gastric bypass. The population-based study of Flum and Dellinger is particularly impressive when comparing non-surgically treated con-
trols with surgically treated obese patients, all of whom were younger than 40 years. Only 3% of the patients who underwent gastric bypass died compared with 13.8% in the control group. The study of Christou et al\textsuperscript{34} provides data available from a single-payer system that provided 100% follow-up concerning mortality for both the patients operated on as well as the controls. The mortality rate in the bariatric surgery cohort was 0.68% compared with 6.17% in the control obese patients, which is a reduction in relative risk of 89%. The patients operated on also had significant risk reductions for the development of cardiovascular, cancer, endocrine, infectious, psychiatric, and mental disorders compared with controls. There was no difference in relative risk for developing hematologic complications, and there was a greater risk in the surgically treated patients to develop digestive disease comorbidities.

Although more extensive risk-benefit assessments may be useful in providing more detailed data regarding the impact of surgery for obesity, the current studies herein reported provide evidence supporting the use of this surgery, particularly gastric bypass, in the management of seriously obese patients.

REFERENCES
