

Prospective Evaluation of Roux-en-Y Gastric Bypass as Primary Operation for Medically Complicated Obesity

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• **Objective:** To determine prospectively the results of Roux-en-Y gastric bypass (RYGB) used as the primary weight-reducing operation in patients with medically complicated ("morbid") obesity. The RYGB procedure combines the advantages of a restrictive physiology (pouch of 10 mL) and a "dumping physiology" for high-energy liquids without requiring an externally reinforced (banded) stoma.

• **Patients and Methods:** Between April 1987 and December 1998, a total of 191 consecutive patients with morbid obesity (median weight, 138 kg [range, 91-240 kg]; median body mass index, 49 kg/m² [range, 36-74 kg/m²]), all of whom had directly weight-related morbidity, underwent RYGB and prospective follow-up.

• **Results:** Hospital mortality was 0.5% (1/191), and hospital morbidity occurred in 10.5% (20/191). Good long-term weight loss was achieved, and patients adapted well to the required new eating habits. The mean \pm SD weight

loss at 1 year after operation (113 patients) was 52 \pm 1 kg or 68% \pm 2% of initial excess body weight. By 3 years postoperatively (74 patients), weight loss was still 66% \pm 2% of excess body weight. Overall, 53 (72%) of 74 patients had achieved and maintained a weight loss of 50% or more of their preoperative excess body weight 3 years after the operation. In addition, only 1 (1%) of 98 patients had persistent postoperative vomiting 1 or more times per week.

• **Conclusion:** We believe that RYGB is a safe, effective procedure for most patients with morbid obesity and thus may be the current procedure of choice in patients requiring bariatric surgery for morbid obesity.

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BMI = body mass index; NIH = National Institutes of Health; NSAID = nonsteroidal anti-inflammatory drug; RYGB = Roux-en-Y gastric bypass

Medically complicated obesity (so-called morbid obesity) is a national health crisis.¹⁻³ It is estimated that 6% of women and 2% of men in the United States have morbid obesity.² Medical and economic implications of such prevalence of morbid obesity are devastating not only to the public but also for private and governmental health policy.⁴ The importance of operative interventions for this serious health issue culminated in a 1991 National Institutes of Health (NIH) Consensus Conference on the role of surgery for obesity; this consensus conference offi-

cially acknowledged the efficacy of bariatric surgery in producing the benefits of short- and long-term weight loss.^{5,6}

For editorial comment, see page 669.

Currently, there are 2 primary, NIH-"sanctioned" operative approaches—vertical banded gastroplasty⁷ and Roux-en-Y gastric bypass (RYGB).⁸ Our previous experience initially with a nonbanded gastroplasty⁹ and subsequently with vertical banded gastroplasty¹⁰ proved unsatisfactory in maintenance of weight loss, with less than 50% of patients losing at least half of their excess body weight. Additionally, because of an increased prevalence of postoperative heartburn and vomiting, we adopted RYGB in 1989 as our primary procedure for the typical patient with morbid obesity. This report summarizes our long-term experience with this surgical approach. Our goals and criteria of success were based on the ability of RYGB to achieve and maintain a loss of at least 50% of the excess body weight without having substantial adverse effects such as maladaptive eating, vomiting, or stomal ulcers.¹¹

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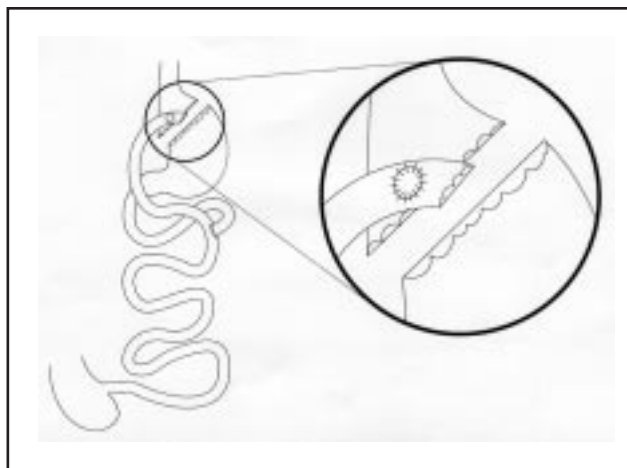


Figure 1. Vertical disconnected Roux-en-Y gastric bypass. Note the anatomic separation of the very small volume pouch of cardia (about 10 mL) from the remainder of the stomach.

PATIENTS AND METHODS

Patients

From April 1987 through December 1998, 359 patients selected for weight reduction surgical procedures because of serious weight-related morbidity underwent RYGB. During this time interval, 120 patients underwent reoperative bariatric surgery and were excluded. In addition, since 1993, another group of 48 patients with super obesity (weight $\geq 225\%$ above ideal body weight or body mass index [BMI] >50 kg/m²) underwent a more radical modification of RYGB that establishes a malabsorptive component.¹² These patients with super obesity were also excluded from this analysis to ensure a homogeneous patient population with a standardized operation.

Prospective follow-up data were collected on the study group of 191 patients to determine the success of the operative procedure in terms of weight loss, patient satisfaction, and lifestyle. This group of patients consisted of 142 women and 49 men with a median age of 42 years (range, 18-70 years). Their median preoperative weight was 138 kg (range, 91-240 kg). The median BMI was 49 kg/m² (range, 36-74 kg/m²), and mean percentage of body weight above ideal body weight (calculated from standard weight data tabulated by the Metropolitan Life Insurance Company) was 121% (range, 60%-231%).

All patients underwent an extensive preoperative assessment by a multidisciplinary team, including a psychologist, endocrinologist, internist, dietitian, and surgeon. All patients undergoing RYGB, including the 6 with BMI between 36 and 39 kg/m², had concomitant, directly weight-related medical conditions, including 168 (88%) with severe lower back or lower extremity large-joint de-

generative arthropathy, 82 (43%) with hypertension, 76 (40%) with type 2 diabetes mellitus, 69 (36%) with sleep apnea, and 27 (14%) with asthma. No operations were performed for cosmetic reasons.

All patients had failed multiple previous nonsurgical attempts at long-term weight reduction; however, 164 (86%) had been able to lose weight (median, 24 kg [range, 4-103 kg]) with previous diets but had only been able to maintain the weight loss for a median of 6 months (range, 1-120 months). Prospective surgical candidates also received 2 pamphlets (developed by our group)—one explained the operation, its rationale, and the changes in lifestyle and eating habits to be expected postoperatively, and a second described in depth the dietary plan to be followed for the first 3 months postoperatively. In addition, a trial of behavior modification counseling was initiated whenever possible.

Patients underwent a psychological evaluation as an integral part of their screening. Patients were asked about current psychosocial stressors, symptoms of depression (mood, sleep, sociability, hopelessness, self-esteem, memory, concentration, and libido), symptoms of anxiety, availability of social support, anticipated lifestyle changes, reasonable outcome expectations, substance abuse, and psychiatric history. Patients with an active Axis I psychiatric disorder were recommended first to receive treatment for their psychiatric comorbidity and then to be reevaluated in 3 to 6 months.

Operative Procedure

The technical aspects of vertical disconnected RYGB (Figure 1) have been described previously.¹³ The cardia of the stomach was stapled across vertically leaving a small proximal gastric pouch of 10 mL. Early in our experience (the first 66 patients), we only applied 2 complete rows of staples once across the cardia without physically separating the partitioned gastric pouches. By the 3-year follow-up, 2 patients had developed partial staple line dehiscence; thereafter, all patients had the proximal pouch of cardia physically isolated from the bypassed distal stomach by transecting the cardia between 2 linear 90-mm staplers fired vertically across the gastric cardia. A side-to-side cardiojejunostomy was performed with an intraluminal end-to-end stapler to a 150-cm Roux-en-Y limb of proximal jejunum; we have used a somewhat longer Roux-en-Y limb (150 cm) in an attempt to maximize weight loss without obligating severe fat malabsorption.¹² The anastomosis was reinforced with an outer layer of interrupted seromuscular-type 3-0 silk sutures. It has been our practice to place a perianastomotic closed-suction drain for 3 to 5 days postoperatively. A cholecystectomy was performed routinely (by 3 of the 4 surgeons involved) if not already done

Table 1. Weight Loss After Vertical Disconnected Roux-en-Y Gastric Bypass in 39 Patients With Complete Follow-up at Each Time Point*

Parameter	Postoperative year				
	0	1	2	3	4
Weight (kg)	146 (127-165)	95 (83-103)	90 (78-90)	94 (79-104)	95 (82-110)
Weight loss (kg)	...	51 (44-62)	56 (44-70)	52 (40-63)	51 (36-62)
Excess body weight lost (%)	...	68 (53-73)	72 (60-80)	66 (50-76)	63 (48-73)
Patients with $\geq 50\%$ excess body weight lost (%)	...	90	87	74	72

*Values are median (interquartile range) unless indicated otherwise.

because of the high subsequent incidence of gallstone formation with extreme weight lost.¹⁴ A tube gastrostomy (removed 6 weeks later) was placed in the defunctionalized distal gastric remnant. Perioperative low-dose subcutaneous heparin, 2 doses of a broad-spectrum intravenous antibiotic (cefazolin), and sequential calf compression devices were used routinely as was postoperative epidural analgesia whenever possible.

Patients underwent intense nutritional counseling during their hospitalization with our hospital dietitians and began a strict dietary protocol. On postoperative day 3, we initiated progressive 24-hour trials of 30 mL/h of clear liquids, 60 mL/h of clear liquids, 60 mL/h of full liquids (milk-based products, low-residue cereals), and, finally, pureed foods (60-90 mL [2-3 oz] 6 times a day). Patients were dismissed from the hospital with instructions to eat 60 to 90 mL of pureed foods 6 times a day and were encouraged to sip low-energy liquids between meals. A detailed dietary pamphlet explained the recommended progression of diet. The diet was gradually advanced to regular food as tolerated over the next 11 to 12 weeks. Patients were instructed by both our clinic- and hospital-based dietitians in more effective eating habits, such as stopping further oral intake when a feeling of fullness was noted, chewing food extremely well to the point of a pulplike consistency, extending meal times to a 30-minute period, and avoiding high-energy liquids and especially ice cream.

Follow-up

A surgeon assessed patients at 6 weeks postoperatively and again at 3 months in conjunction with an internist and a dietitian specializing in obesity therapy. Medical and dietary follow-up was conducted at the Mayo Clinic with patients from the Olmsted County, Minnesota, region and whenever possible, with patients from more remote locations. Those who could not return because of travel constraints were strongly encouraged to return for at least a 3-month postoperative visit. Local physicians were sent detailed instructions on the long-term nutritional adverse

effects of gastric bypass with suggestions for postoperative nutritional surveillance. Standardized questionnaires were mailed to all patients 3, 6, 12, 18, 24, 36, and 48 months postoperatively. Data were collected prospectively. Patients who failed to return their questionnaires were contacted either by a repeated mailing of another questionnaire or, when necessary, by direct telephone interview.

Despite our attempts, complete follow-up data at 1, 2, and 3 years were available in only 113 (80%) of 141 patients contacted at 1 year, 90 (80%) of 112 patients at 2 years, and 74 (76%) of 98 patients at 3 years, even with repeated efforts at patient contact. These percentages, however, are higher than many other weight maintenance studies.^{15,16} We acknowledge the limitations of self-reported weights on these questionnaires, but because of our referral-type practice, we had to accept these limitations. Partial or intermittent follow-up was obtained in the rest of the patients, except for 1 patient who was completely lost to follow-up.

Weight Loss Data

To allow comparison with multiple previous reports and to provide objective data for evaluation, we analyzed weight in kilograms, BMI, excess body weight (in kilograms), and percentage of ideal body weight. Weight loss is expressed as kilograms of weight lost, percentage of excess body weight lost, and most importantly as percentage of patients who lost 50% or more of their excess body weight, which was our preoperative goal (Table 1).

Weight parameters during follow-up are presented in 2 ways: as all available data at each time point (Figure 2) and as data from the 39 patients in whom complete follow-up data were available at each time point throughout the study (1, 2, 3, and 4 years postoperatively; Table 1). The latter method of using only complete data avoids biases introduced by patients who failed to complete follow-up forms. The 2 patients who underwent reoperation for a partial staple line dehiscence 12 and 24 months postoperatively were included in the analysis.

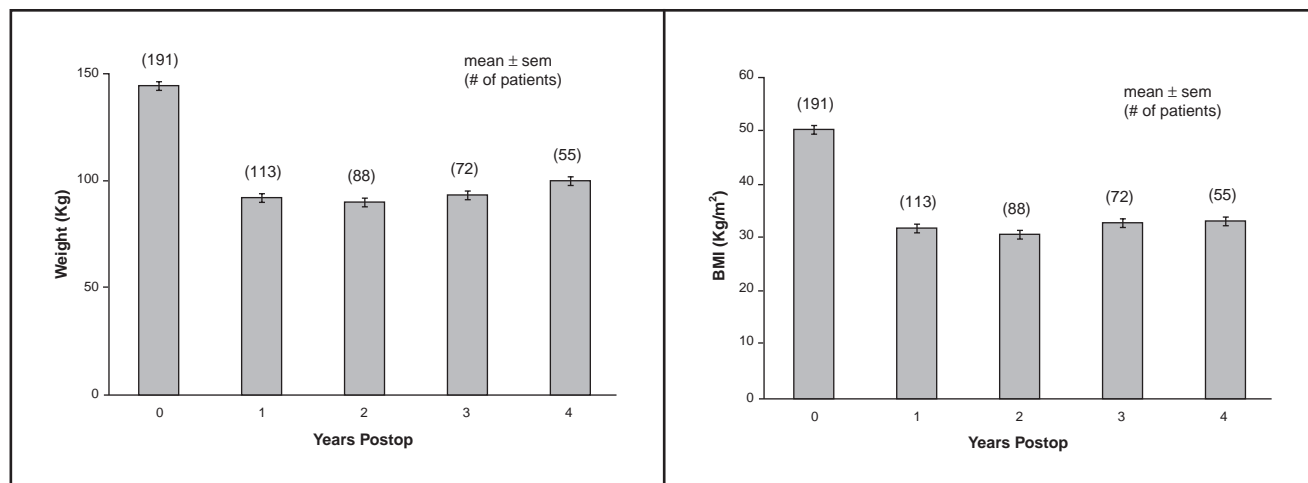


Figure 2. Body weight of entire group for whom complete or partial weight data were available before and after vertical disconnected Roux-en-Y gastric bypass. Left, Changes in absolute weight. Right, Changes in body mass index (BMI).

Statistical Analysis

The distributions of actual weight values, BMI, and excess body weight were summarized as medians (interquartile ranges) (Table 1). Weight loss at 1, 2, 3, and 4 years postoperatively was summarized as median values (25th and 75th percentiles) for kilograms lost and percentage of excess body weight lost.

RESULTS

Perioperative Mortality/Morbidity

There was 1 hospital death (0.5%), a man with known sleep apnea who died suddenly on the fourth postoperative day. Autopsy revealed no pulmonary embolus or intra-abdominal cause, and we presume he developed a cardiac arrhythmia. Hospital morbidity included pneumonia in 3 patients (1.6%), wound infection in 11 (5.8%), and congestive heart failure, pulmonary embolus, transient gastrointestinal bleeding, and need for splenectomy at time of operation in 1 patient each (0.5%). Although 2 patients (1.0%) were reoperated because of the suspicion of an anastomotic leak, only 1 patient (0.5%) proved to have an anastomotic leak; this patient was treated successfully by external drainage without need for further operative therapy. Two minor technical, tube-related complications occurred—in 1 patient, the gastrostomy tube was inadvertently removed on the first postoperative day requiring reoperation; in a second patient, the perianastomotic drain fractured at the junction with the intraperitoneal segment on removal. The median duration of hospitalization was 8 days with a range of 4 to 64 days. With our more recent experience, average stays have been reduced to about 5 days. The patient staying 64 days was a 70-year-old woman without severe postoperative complications but whose dis-

charge was delayed because she needed temporary nursing home placement for physical rehabilitation of her preoperative physical disability.

Long-term Mortality/Morbidity

One patient died during the follow-up. This 24-year-old woman with lupus erythematosus (on long-term corticosteroid therapy) and congenital hip arthropathy underwent a total hip arthroplasty 1 year after her RYGB; 6 years later (7 years after RYGB), she developed an infected hip prosthesis with gluteal, iliopsoas, and medial thigh abscesses and died from sepsis after open drainage. Long-term morbidity included small bowel obstruction in 8 patients (5 of whom required reoperation [5%]), partial staple line disruption in 2 (prior to anatomically separating the proximal pouch of cardia from the defunctionalized bypassed stomach), and cholecystitis requiring cholecystectomy in 1 of the 3 patients who did not undergo a cholecystectomy at the time of RYGB. Ventral hernias developed in 32 patients (17%), of whom 26 underwent operative repair after their weight had stabilized (usually 12-24 months postoperatively). Presumed stomal stenosis at the cardiojejunostomy was dilated in 2 patients with relief of the symptoms. Rehospitalization was necessary because of dehydration in 2 patients early after discharge and because of diabetic ketoacidosis, pulmonary embolus, constipation/impaction, anorexia, and gastrointestinal bleeding from an anastomotic ulcer at the cardiojejunostomy secondary to use of nonsteroidal anti-inflammatory drugs (NSAIDs) in 1 patient each; the ulcer in the lattermost patient rapidly healed with discontinuation of the NSAIDs. No other patient developed a stomal ulcer or other ulceration of the pouch of cardia or of the Roux limb.

Weight Loss

The majority of the absolute weight loss, when including all patients evaluated, occurred in the first postoperative year with an average weight loss of 52 ± 2 kg (Figure 2). There was a tendency to regain some weight (about 2-4 kg) between the second and third years postoperatively. However, the patients attained a mean BMI of 34 ± 1 kg/m² at 4 years (n=55) postoperatively, decreased from a mean BMI of 49 ± 5 kg/m² preoperatively (n=191).

When considering only those patients in whom data were available at each time point (year 1, 2, 3, and 4), similar findings were noted (Table 1). When expressed differently, patients followed up at 1, 2, 3, and 4 years postoperatively lost a median of 68%, 72%, 66%, and 63% of their excess body weight, respectively. When evaluated critically against our goal of losing at least 50% of excess body weight, among those followed up at 1, 2, 3, and 4 years postoperatively, 90%, 87%, 74%, and 72% attained this goal, respectively.

Medical Comorbidity

Although a detailed evaluation of medical comorbidity was not the primary focus of this study, we noted a decrease in usage of antihypertensive medications from 36% to 16% of patients, insulin from 12% to less than 1%, and need for anti-inflammatory medications from 33% to 9%.

Subjective Patient Satisfaction

A qualitative evaluation of outcome is summarized in Table 2. Overall, of the 98 patients followed up at 3 years postoperatively, 91 (93%) considered themselves satisfied and improved. Early postprandial satiety was maintained in 82 patients (84%). Interestingly, overall appetite was decreased in 112 patients (82%) at 1 year postoperatively, and this persisted at 3 years postoperatively. Virtually all patients were able to eat regular food. At 3 years, the most common foods that were not well tolerated by patients included milk (23%), steak (14%), and hamburger (10%). Adverse gastrointestinal symptoms, including constipation, heartburn, and vomiting, were quite unusual although diarrhea occurred once or more per week in 22% of patients.

DISCUSSION

Our results with RYGB as our primary bariatric operation for morbid obesity are quite positive compared with the alternatives of medical management in which long-term (>2 years) maintenance of medically significant weight loss is less than 5%.¹⁷ When compared with the results described in 2 previous reports from our institution with a nonbanded gastric stapling (vertical gastroplasty)⁹ and subsequently with a banded gastroplasty (vertical banded

Table 2. Subjective Evaluation of Patient Outcome*

Parameter	Postoperative year	
	1 (n=113†)	3 (n=98†)
Postprandial early satiety	97 (86)	82 (84)
Appetite‡		
Decreased	93 (82)	79 (81)
Unchanged	17 (15)	14 (14)
Increased	3 (3)	2 (2)
Diet of regular food	112 (99)	97 (99)
Foods poorly tolerated		
Milk	28 (25)	23 (23)
Steak	18 (16)	14 (14)
Hamburger	14 (12)	10 (10)
Pork	6 (5)	4 (4)
Bread	9 (8)	6 (6)
Fruits	3 (3)	4 (4)
Gastrointestinal symptoms		
Diarrhea ($\geq 1 \times /wk$)	30 (27)	21 (22)
Constipation	12 (11)	10 (10)
Heartburn	14 (12)	11 (11)
Vomiting	4 (4)	1 (1)

*Values are number (%) of patients.

†Number of patients with complete follow-up at specified time interval.

‡Compared with preoperative appetite.

gastroplasty),¹⁰ the current success with a primary, vertical, disconnected RYGB is encouraging and more appropriately justifies the operative risk and operative costs. At 4 years postoperatively, among patients available for follow-up, more than 70% had lost and maintained loss of more than 50% of their excess body weight. With this weight loss came a decrease in medical weight-related comorbidity and increased patient satisfaction.

Currently, 2 basic bariatric operations are sanctioned by the NIH Consensus Conference—vertical banded gastroplasty⁷ and RYGB.⁸ Vertical banded gastroplasty was designed and first described by Mason in 1982.⁷ This operation, attractive in theory, was designed and adopted because it is technically easy, requires creation of no formal anastomoses, and involves no partial or total bypass of any gastrointestinal segment. Although some centers have reported good long-term results in weight loss,^{18,19} many others have not been able to reproduce such good results.^{11,20-24} Indeed, our results¹⁰ with 70 patients proved unsatisfactory with only 38% of patients having maintained a weight loss of at least 50% of excess body weight at 3 years postoperatively. Moreover, the anatomy of vertical banded gastroplasty appears to predispose to symptoms of gastroesophageal reflux disease,²⁵ staple line disruption,²⁴ mechanical or functional stomal obstruction,²⁶ and a maladaptive eating disorder. This maladaptive eating seems to be related to a very high incidence (up to 50%) of

vomiting of solid foods causing the subjects to alter their diet to liquid or semisolid foods, often of high energy content; with this dietary change, their weight often paradoxically increases.

Roux-en-Y gastric bypass was designed initially by Mason and Ito in 1969²⁷ and later modified by others²³ to maintain a restrictive anatomy (small proximal gastric reservoir which restricts the volume of ingestible food) but also to establish a "dumping physiology" should the patient ingest a liquid of high energy density (which would pass unimpeded through the stoma of the vertical banded gastroplasty). This high-energy liquid would dump directly into the Roux-en-Y limb of the gastric bypass, thereby eliciting all the symptoms of dumping—nausea, sympathetic cutaneous discharge, abdominal cramping, and eventually diarrhea, which might act as an impetus to behavior modification. Our experience is that this dumping is quite impressive during the first postoperative year but becomes progressively less prominent thereafter. Nevertheless, the majority of patients maintain their weight loss.

Roux-en-Y gastric bypass does have some limitations that need to be acknowledged and explored further. In theory, the Roux-en-Y limb of jejunum is "unprotected" from contact with gastric acid since the pancreatobiliary secretions enter the functional gut 150 cm downstream. Stomal ulcers at this anastomosis have been reported by others and can be painful, bleed, or obstruct the stoma.²⁸ With our described technique of vertical gastric partitioning and creation of a very small (<15 mL) proximal gastric pouch of cardia,¹³ acid-induced stomal ulcers should not develop because we have measured both resting and stimulated acid secretion from the proximal pouch of gastric cardia and found virtually no acid present.²⁹ Indeed, with our technique, we had only 1 patient develop a stoma ulcer, which resolved when he discontinued use of NSAIDs.

Another potential concern of gastric bypass is the possibility of vitamin and mineral deficiencies. Cyanocobalamin (vitamin B₁₂) requires gastric acid, R-factor, and intrinsic factor for normal absorption within the ileum. The altered anatomy of RYGB disrupts this necessary interaction.³⁰ Nevertheless, with supplementation of free cyanocobalamin, deficiencies are rare.³¹ Although we have no objective data on which to base our recommendations of supplemental cyanocobalamin (1000 µg intramuscularly monthly) other than the demonstrated decreased absorption,³⁰ we believe that supplements prevent potential serious neurologic and hematologic problems caused by vitamin B₁₂ deficiency. Similarly, bypass of the stomach and duodenum hinders normal absorption of ingested iron; yet, significant iron deficiency in our experience and that of others³² is unusual except in women with heavy menstrual

losses of iron. Oral supplementation is usually sufficient, but on occasion we have administered intravenous iron dextran to attain satisfactory levels. While we encourage use of calcium supplements (much of the oral calcium is absorbed in the duodenum), we currently have little evidence that RYGB predisposes to calcium deficiency or metabolic bone disease.

Despite these considerations, the weight loss accompanying RYGB brings a notable decrease in weight-related morbidity. Our results support previous research which has shown an improvement in health status after significant weight loss. MacDonald et al³³ have documented the beneficial effects of RYGB on type 2 diabetes mellitus; indeed, with appropriate weight loss, the need for insulin therapy should be eliminated, as patients in our study experienced. Similarly, the need for antihypertensive medications decreased in our study as in others.³⁴ Weight-related degenerative joint arthropathy is a notable problem that greatly reduces mobility in these patients. At their preoperative weights, most patients would have been unrealistic candidates for necessary joint replacements. However, after successful bariatric surgery, total joint arthroplasties have been well tolerated; 14 patients have undergone 20 arthroplasties with excellent results.³⁵ At their lower postoperative weights, their functional joint expectancy should increase as well. Other common weight-related medical conditions that benefit from bariatric surgery are sleep apnea, severe lymphovenous stasis disorders of the lower extremities, recurrent giant ventral hernias, and certain dyslipidemias.

Based on these accepted operations, newer bariatric operations (some of which induce a greater weight loss) have been designed. Scopinaro et al^{36,37} developed the partial biliopancreatic bypass which, in addition to a less drastic gastric restriction, also diverts the digestive pancreatobiliary secretions to the distal ileum, thus obligating a maldigestion/malabsorption anatomy. Weight loss is impressive (>80% of excess body weight), but in our experience¹² and that of others,³⁸ the metabolic sequelae of the induced fat malabsorption are prohibitive. A current malabsorptive procedure being used by some groups is the duodenal switch with modified biliopancreatic diversion; results in terms of weight loss appear good, but patients require close observation for development of nutrient, mineral, and vitamin deficiencies.³⁹ We have developed a modification of both the RYGB and the partial biliopancreatic diversion¹² specifically for the subgroup of patients with extreme morbid obesity (super obesity, ie, ≥225% ideal body weight and/or BMI >50 kg/m²). Our results with this very long limb RYGB have been good with 62% of patients losing at least half of their excess body weight, but we continue to assess these patients

closely for potential metabolic sequelae. Recently, several groups have been able to carry out a modified gastric bypass laparoscopically using minimal-access techniques.^{40,41} We have been reluctant to embrace this technique because it is technically a somewhat difficult operation, and, in our opinion, more formal study is needed to determine if the safety of the procedure is comparable to that of the RYGB.

The newest bariatric procedure being used widely in Europe is the laparoscopically placed, adjustable gastric band.⁴² This operation is a form of "adjustable" gastroplasty, and although its original technical design had some defects,⁴³ the results with the current modification appear quite encouraging.⁴⁴⁻⁴⁶ Nevertheless, the question of whether a switch of diet to high-energy liquids or semisolid foods negates the initial benefits of the minimal access procedure to insert the adjustable gastric band remains unanswered.

In summary, RYGB has proven effective in obtaining a durable weight loss in more than 70% of morbidly obese patients evaluated 4 years postoperatively. With the weight loss, type 2 diabetes mellitus disappeared, medication-dependent hypertension decreased, patients previously too heavy to undergo needed joint replacement became candidates for orthopedic procedures, and overall quality of life improved. Currently, vertical disconnected RYGB remains our procedure of choice to treat patients with morbid obesity.

REFERENCES

- Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among US adults: the National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA*. 1994; 272:205-211.
- Martin LF, Hunter SM, Lauve RM, O'Leary JP. Severe obesity: expensive to society, frustrating to treat, but important to confront. *South Med J*. 1995;88:895-902.
- Balsiger BM, Luque-de Leon E, Sarr MG. Surgical treatment of obesity: who is an appropriate candidate? *Mayo Clin Proc*. 1997; 72:551-558.
- Rippe JM. The obesity epidemic: challenges and opportunities. *J Am Diet Assoc*. 1998;98(suppl 2):S5.
- Consensus Development Conference Panel. NIH conference: gastrointestinal surgery for severe obesity. *Ann Intern Med*. 1991;115: 956-961.
- Brolin RE. Update: NIH consensus conference: gastrointestinal surgery for severe obesity. *Nutrition*. 1996;12:403-404.
- Mason EE. Vertical banded gastroplasty for obesity. *Arch Surg*. 1982;117:701-706.
- Sugerman HJ, Kellum JM, Engle KM, et al. Gastric bypass for treating severe obesity. *Am J Clin Nutr*. 1992;55(2, suppl):560S-566S.
- Hocking MP, Kelly KA, Callaway CW. Vertical gastroplasty for morbid obesity: clinical experience. *Mayo Clin Proc*. 1986;61:287-291.
- Nightengale ML, Sarr MG, Kelly KA, Jensen MD, Zinsmeister AR, Palumbo PJ. Prospective evaluation of vertical banded gastroplasty as the primary operation for morbid obesity. *Mayo Clin Proc*. 1991;66:773-782.
- Capella JF, Capella RF. The weight reduction operation of choice: vertical banded gastroplasty or gastric bypass? *Am J Surg*. 1996; 171:74-79.
- Murr MM, Balsiger BM, Kennedy FP, Mai JL, Sarr MG. Mal-absorptive procedures for severe obesity: comparison of pancreaticobiliary bypass and very very long limb Roux-en-Y gastric bypass. *J Gastrointest Surg*. 1999;3:607-612.
- Sarr MG. Vertical disconnected Roux-en-Y gastric bypass. *Dig Surg*. 1996;13:45-49.
- Pi-Sunyer FX. Short-term medical benefits and adverse effects of weight loss. *Ann Intern Med*. 1993;119:722-726.
- Wadden TA, Frey DL. A multicenter evaluation of a proprietary weight loss program for the treatment of marked obesity: a five-year follow-up. *Int J Eat Disord*. 1997;22:203-212.
- DePue JD, Clark MM, Ruggiero L, Medeiros ML, Pera V Jr. Maintenance of weight loss: a needs assessment. *Obes Res*. 1995;3: 241-248.
- Van Itallie TB. "Morbid" obesity: a hazardous disorder that resists conservative treatment. *Am J Clin Nutr*. 1980;33(suppl):358-363.
- Carr ND, Harrison RA, Tomkins A, et al. Vertical banded gastroplasty in the treatment of morbid obesity: results of three year follow up. *Gut*. 1989;30:1048-1053.
- Sweet WA. Vertical banded gastroplasty: stable trends in weight control at 10 or more years. *Obes Surg*. 1994;4:149-152.
- Sugerman HJ, Starkey JV, Birkenhauer R. A randomized prospective trial of gastric bypass versus vertical banded gastroplasty for morbid obesity and their effects on sweets versus non-sweets eaters. *Ann Surg*. 1987;205:613-624.
- Sugerman HJ, Londrey GL, Kellum JM, et al. Weight loss with vertical banded gastroplasty and Roux-Y gastric bypass for morbid obesity with selective versus random assignment. *Am J Surg*. 1989; 157:93-102.
- Linner JH. Comparative effectiveness of gastric bypass and gastroplasty: a clinical study. *Arch Surg*. 1982;117:695-700.
- Pories WJ, Caro JF, Flickinger EG, Meelheim HD, Swanson MS. The control of diabetes mellitus (NIDDM) in the morbidly obese with the Greenville Gastric Bypass. *Ann Surg*. 1987;206:316-323.
- MacLean LD, Rhode BM, Forse RA. Late results of vertical banded gastroplasty for morbid and super obesity. *Surgery*. 1990;107:20-27.
- Balsiger BM, Murr MM, Sarr MG. Gastroesophageal reflux after intact vertical banded gastroplasty: correction by conversion to Roux-en-Y gastric bypass. *J Gastrointest Surg*. In press.
- Behrns KE, Smith CD, Kelly KA, Sarr MG. Reoperative bariatric surgery: lessons learned to improve patient selection and results. *Ann Surg*. 1993;218:646-653.
- Mason EE, Ito C. Gastric bypass. *Ann Surg*. 1969;170:329-339.
- MacLean LD, Rhode BM, Nohr C, Katz S, McLean AP. Stomal ulcer after gastric bypass. *J Am Coll Surg*. 1997;185:1-7.
- Behrns KE, Smith CD, Sarr MG. Prospective evaluation of gastric acid secretion and cobalamin absorption following gastric bypass for clinically severe obesity. *Dig Dis Sci*. 1994;39:315-320.
- Smith CD, Herkes SB, Behrns KE, Fairbanks VF, Kelly KA, Sarr MG. Gastric acid secretion and vitamin B12 absorption after vertical Roux-en-Y gastric bypass for morbid obesity. *Ann Surg*. 1993; 218:91-96.
- Brolin RE, Gorman JH, Gorman RC, et al. Are vitamin B12 and folate deficiency clinically important after Roux-en-Y gastric bypass? *J Gastrointest Surg*. 1998;2:436-442.
- Brolin RE, Gorman JH, Gorman RC, et al. Prophylactic iron supplementation after Roux-en-Y gastric bypass: a prospective, double-blind, randomized study. *Arch Surg*. 1998;133:740-744.

33. MacDonald KG Jr, Long SD, Swanson MS, et al. The gastric bypass operation reduces the progression and mortality of non-insulin-dependent diabetes mellitus. *J Gastrointest Surg.* 1997;1:213-220.
34. Carson JL, Ruddy ME, Duff AE, Holmes NJ, Cody RP, Brolin RE. The effect of gastric bypass surgery on hypertension in morbidly obese patients [published correction appears in *Arch Intern Med.* 1994;154:1770]. *Arch Intern Med.* 1994;154:193-200.
35. Parvizi J, Trousdale RT, Sarr MG. Total joint arthroplasty after bariatric surgery for morbid obesity. *J Arthroplasty.* In press.
36. Scopinaro N, Gianetta E, Civalleri D, Bonalumi U, Bachi V. Bilio-pancreatic bypass for obesity, II: initial experience in man. *Br J Surg.* 1979;66:618-620.
37. Scopinaro N, Gianetta E, Adami GF, et al. Bilio-pancreatic diversion for obesity at eighteen years. *Surgery.* 1996;119:261-268.
38. Sugerman HJ, Kellum JM, DeMaria EJ. Conversion of proximal to distal gastric bypass for failed gastric bypass for superobesity. *J Gastrointest Surg.* 1997;1:517-525.
39. Marceau P, Hould FS, Simard S, et al. Bilio-pancreatic diversion with duodenal switch. *World J Surg.* 1998;22:947-954.
40. Wittgrove AC, Clark GW. Laparoscopic gastric bypass, Roux-en-Y: experience of 27 cases, with 3-18 months follow-up. *Obes Surg.* 1996;6:54-57.
41. Schauer PR, Ikramuddin S, Gourash WF. Laparoscopic Roux-en-Y gastric bypass: a case report at one-year follow-up. *J Laparoendosc Adv Surg Tech A.* 1999;9:101-106.
42. Schlumpf R, Lang T, Schob O, et al. Treatment of the morbidly obese patient with laparoscopic adjustable gastric banding. *Dig Surg.* 1997;14:438-443.
43. O'Brien PE, Brown WA, Smith A, McMurrick PJ, Stephens M. Prospective study of a laparoscopically placed, adjustable gastric band in the treatment of morbid obesity. *Br J Surg.* 1999;86:113-118.
44. Forsell P, Hallerback B, Glise H, Hellers G. Complications following Swedish adjustable gastric banding: a long-term follow-up. *Obes Surg.* 1999;9:11-16.
45. Belachew M, Legrand M, Vincent V, Lismonde M, Le Docte N, Deschamps V. Laparoscopic adjustable gastric banding. *World J Surg.* 1998;22:955-963.
46. Chelala E, Cadiere GB, Favretti F, et al. Conversions and complications in 185 laparoscopic adjustable silicone gastric banding cases. *Surg Endosc.* 1997;11:268-271.

