Cost-effectiveness of Gastric Bypass for Severe Obesity

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PURPOSE: To estimate the cost-effectiveness of gastric bypass in the treatment of severe obesity.
SUBJECTS AND METHODS: We performed a cost-effectiveness analysis of gastric bypass versus no treatment from the payer perspective. We discounted quality-adjusted life-years (QALYs), life-years, and cost during the patient's lifetime. Our target group comprised women and men aged 35 to 55 years with a body mass index between 40 and 50 kg/m^2, and who did not have cardiovascular disease and in whom conservative bariatric therapies had been unsuccessful.
RESULTS: The base case cost-effectiveness ratios ranged from $5000 to $16,100 per QALY for women and from $10,000 to $35,600 per QALY for men, depending on age and initial body mass index. In a few subgroups of older, less obese men, variation in parameters such as loss of excess weight, obesity-related quality of life, complication rates, and perioperative mortality affected the cost-effectiveness ratios. Parameter variation did not result in meaningful changes in the remaining patients.
CONCLUSION: Gastric bypass is a cost-effective alternative to no treatment, providing substantial lifetime benefits in patients who are severely obese. **Am J Med. 2002;113:491–498.** ©2002 by Excerpta Medica, Inc.

In the United States, the prevalence of severe obesity in men and women aged 18 to 64 years increased by 114% between 1991 and 1999 (1,2). Yet few treatments have been effective in severely obese patients, typically identified as having a body mass index >40 kg/m^2. Dietary therapy, even together with exercise and behavior therapy, is rarely successful in these patients (3). Weight loss medications such as orlistat and sibutramine have shown modest efficacy (4,5), and their effects on long-term maintenance of weight loss are unknown. Frequent complications and severe adverse effects characterized early surgical procedures such as jejunoileal bypass.

Gastric bypass is one of two main forms of bariatric surgery (6) that is tolerated better and performed widely. It limits food intake by dividing the stomach to form a small gastric pouch, and induces malabsorption by creating an anastomosis from the pouch to the jejunum. The alternative surgical procedure, vertical banded gastroplasty, has similar costs as gastric bypass but is less effective (7–11) and was not considered in our analysis. We sought to determine the cost-effectiveness of gastric bypass in the treatment of severe obesity in patients without cardiovascular disease in whom conservative bariatric therapies were repeatedly unsuccessful.

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METHODS

Decision Model and Sample

We used a deterministic decision model (12) to compare the lifetime expected costs and outcomes between gastric bypass and no treatment of severe obesity from the payer perspective (Figure 1). Patients in each arm were assigned to health outcomes by rates, instead of drawn from distributions. The cost-effectiveness ratio was determined by dividing the difference in total lifetime medical cost by the difference in quality-adjusted life-years (QALYs). Cost and QALYs were discounted at 3% to reflect the principle that events in the future are less valuable than immediate costs and benefits. Base case parameter estimates represent our best judgment from the literature and discussions with experts. When ambiguous, we chose model attributes and estimates that favored no treatment.

The target group comprised a relatively healthy subset of men and women who were severely obese (class 3), defined as having a body mass index >40 kg/m^2. Subjects were 35 to 55 years in age, and body mass index was between 40 and 50 kg/m^2. We limited analysis to nonsmoking patients who did not have cardiovascular disease, drug addictions, and major psychological disorders. As recommended by treatment guidelines (6), we included only those subjects who had been unable to maintain clinically meaningful weight loss despite several attempts at conservative therapies (e.g., dieting, exercise, behavior therapy, and pharmacotherapy). To assess variation within this group, we characterized risk subgroups by age, sex, and initial body mass index. Differences in longevity and average cost and length of stay motivated the differentiation.

Gastric Bypass Probabilities and Rates

Gastric bypass is associated with the risk of perioperative death and complications such as deep venous thrombosis

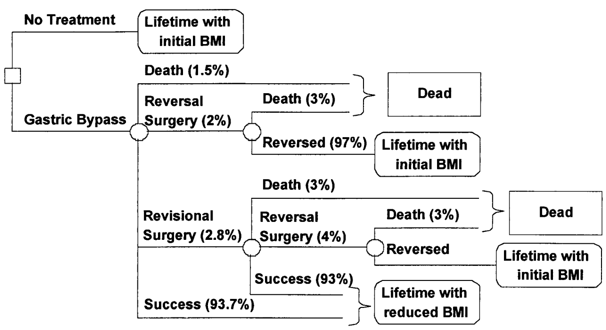

Figure 1. Deterministic decision model comparing lifetime expected costs and outcomes between gastric bypass and no treatment of severe obesity from the payer perspective. If no treatment was chosen, we estimated the patient's lifetime medical costs for the treatment of selected obesity-related diseases, life expectancy, and quality-adjusted life expectancy conditional on age, sex, and initial body mass index (see Tables 3 and 4). If surgery was chosen, the patient bore the cost and burden of the initial surgery and its complications. Surviving patients may require corrective surgery within a year of the initial surgery. We assumed that at the end of that year, the patient had died, returned to the original weight, or lost weight. If the procedure was reversed, we further accumulated lifetime cost and health outcomes as in the no-treatment group, except that quality of life was halved for the remainder of the patient's life because of the psychological burden of treatment failure. Successful patients incurred additional costs and burden from weight loss–related events, namely treatment for cholelithiasis and abdominoplasty. We assumed that 5 years after the initial surgery, the weight loss of successful patients stabilized, and we similarly estimated lifetime cost and health outcomes based on age, sex, and reduced body mass index. BMI = body mass index.

and wound infection (Figure 1, Table 1). Rarely, patients cannot restrict their diet sufficiently following the procedure and develop intractable dumping syndrome requiring reversal surgery. Revisional surgery is necessary with complications such as staple line disruption or dehiscence and may sometimes need to be followed with reversal surgery. Nearly a quarter of patients require treatment for incisional hernia within 2 years after hospital discharge. Revisional and reversal procedures are associated with higher complication rates (13,14). Therefore, we set the complication rates following corrective procedures to be twice that of rates after initial surgery. The modeling of each arm incorporated the rates of complications and their timing.

We considered gastric bypass to be successful if the patient survived and did not undergo a reversal procedure, regardless of complications. Some successful patients require treatment for cholelithiasis 2 years after discharge and abdominoplasty 5 years after discharge. Each patient was assumed to return for follow-up care with a general practitioner and a dietitian three times a year for 3 years if the surgical procedure was successful, and for 1 year if the procedure was reversed. Because malabsorption increases the risk of nutritional deficiencies, successful patients take two multivitamins, two tablets of $FeSO_4$ (325 mg), and 1000 mg of calcium carbonate every day, and vitamin B_{12} 1000 μg intramuscularly every month, for the rest of their lives. Some studies recommend taking ursodiol during the weight loss period to prevent cholelithiasis (15,16), which we did not follow because of limited evidence.

We based our estimates for weight loss and complication rates on those from a study by Pories et al. (17), which involved a large sample (608 patients) and 14 years of follow-up with a 96.3% follow-up rate. Loss of excess weight was the amount of weight lost divided by the total amount of excess weight before the intervention, and was expressed as a percentage. Excess weight was defined as the weight above a body mass index of 22 kg/m^2. Pories et al. estimated a mean percentage loss of excess weight of about 58% five years after surgery. We abstracted the rates of deep venous thrombosis and pulmonary embolism from the International Bariatric Surgery Registry, given that their estimation required a large sample (18,19). The rates of abdominoplasty and reversal surgery were obtained from the Adelaide Study (9), a randomized clinical trial that compared the outcomes of gastric bypass with those of vertical banded gastroplasty over 5 years. These two rates were unavailable elsewhere in the literature.

Life Expectancy

Using data from the Framingham Heart Study, Thompson et al. estimated life expectancy across age, sex, and body mass index (20), considering only mortality associated with coronary heart disease and stroke, and excluding patients with an initial history of these conditions. We applied a simple linear approximation to their estimates to assess the effects of obesity on life expectancy.

Costs

We included medical costs (in U.S. 2001 dollars) associated with the initial surgery, treatment of complications, follow-up care, and treatment of obesity-related diseases, such as coronary heart disease, stroke, type 2 diabetes, hypercholesterolemia, and hypertension. All cost estimates were adjusted for inflation; the Medical Care Component of the Consumer Price Index for All Urban Consumers was used to adjust prices, when necessary. Expected lifetime medical cost estimates were obtained from the published literature (20). For the majority of the remaining costs, estimates of nationally representative hospital charges (Table 1) were obtained from the Healthcare Cost and Utilization Project (21). These sex-specific estimates were consistently higher in men, except for perioperative death. We overestimated treatment

Table 1. Input Variables and Sources* Used in the Model

Procedure or Outcome (ICD-9-CM Code)	Rate (%)	Charges ($)		Length of Stay (days)		Length of Recovery (days)	Reference
		Men	Women	Men	Women		
Gastric bypass (44.31)	–	26,100	20,500	5.20	4.40	45	–
Minor wound infection†	8.7	192	192	0	0	0	17
Major wound infection (998.6)	3.0	20,600	19,200	7.80	8.00	14	17
Deep venous thrombosis (128)	2.6	8700	8100	5.70	5.36	14	19
Pulmonary embolism (78)	1.0	14,700	13,900	6.47	6.34	14	19
Cholelithiasis (51.22)	11.4	27,100	22,700	8.10	7.00	14	17
Incisional hernia (53.51)	24.0	13,200	12,500	4.10	4.10	14	17
Abdominoplasty (86.83)	39.0	13,600	12,200	3.90	2.50	14	9
Revision surgery (44.69)	2.8	38,500	25,600	10.40	7.60	30	17
Reversal surgery (44.69)	2.0	38,500	25,600	10.40	7.60	∞	9
Perioperative death (249)	1.5	27,600	29,000	6.90	6.80	14	17
Follow-up visit‡	–	150	150	–	–	–	–
Supplements†$	–	68	68	–	–	–	–

* Charges and lengths of stay were mostly taken from the Healthcare Cost and Utilization Project database derived from the 1997 medical claims survey (21). Codes indicate the ICD-9-CM number for each procedure, except for deep venous thrombosis and pulmonary embolism, which are Clinical Classification Software codes, a tool developed at the Centers for Medicare and Medicaid Services for clustering patient diagnoses and procedures into a manageable number of clinically meaningful categories, and for perioperative death, which is a diagnosis-related group code. Length of recovery was assessed by expert opinion.
† From reference (22).
‡ From R. Atkinson, MD, Clinical Nutrition Clinic, written communication, 2001.
$ Refers to the annual supply of multivitamins, iron supplements ($FeSO_4$ 320 mg), calcium supplements, and vitamin B_{12} injections.
ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*.

costs because charge reimbursement rates were usually less than 100%. We obtained the cost of medications and follow-up visits from a source on wholesale drug prices (22) and a local source (R. Atkinson, MD, Clinical Nutrition Clinic, written communication, 2001).

Quality of Life

We assumed that a person who loses weight has the same quality of life as someone who is at that reduced weight. To estimate the effects of obesity on quality of life, we stratified a nationally representative sample of nonsmoking adults by sex (23). Within each stratum, we used a multivariate linear regression model to estimate years of healthy life (24), which revealed the negative relation between health-related quality of life and body mass index (Table 2) and provided the basis for QALY estimates. Quality-adjusted life expectancy was also adjusted for treatment burden and perioperative mortality.

We reduced quality of life by 200% for time spent in the hospital and by 50% for time spent in recovery, assuming that being in hospital was a state "worse than death," represented by a quality of life less than zero, and that recovery time decreased quality of life by half. We also assumed that patients never recovered completely from reversal surgery because of its psychological effects. For successful procedures, the 6-week recovery period was associated with adverse effects of dietary adjustment, often characterized by vomiting and dumping syndrome.

Table 2. Health-Related Quality of Life, by Sex, Age, and Body Mass Index*

Body Mass Index (kg/m²)	Age (years)									
	Men					Women				
	35	45	55	65	75	35	45	55	65	75
25	0.929	0.912	0.886	0.85	0.805	0.908	0.889	0.857	0.813	0.755
30	0.903	0.88	0.853	0.823	0.79	0.875	0.846	0.811	0.77	0.722
35	0.877	0.848	0.821	0.797	0.775	0.842	0.804	0.765	0.727	0.688
40	0.851	0.816	0.789	0.77	0.76	0.809	0.761	0.719	0.684	0.654
45	0.825	0.784	0.756	0.743	0.745	0.775	0.718	0.673	0.641	0.621
50	0.799	0.752	0.724	0.717	0.73	0.742	0.675	0.627	0.598	0.587

* On a 0 (death) to 1 (perfect health) scale.

RESULTS

Base Case Analysis

In all risk subgroups, the cost-effectiveness ratios of gastric bypass versus no treatment were favorable, at less than $50,000 per QALY. In four risk subgroups representing the upper and lower bounds of the cost-effectiveness ratios (Tables 3 and 4, Figure 2), the ratios ranged from about $5000 to $16,100 per QALY for women and from about $10,000 to $35,600 per QALY for men, depending on age and initial body mass index. These variations suggest that gastric bypass is more cost-effective among women and those with a higher initial body mass index. However, because the reduction in lifetime medical cost was not greater than the cost of treatment in any risk subgroup, this analysis did not show that gastric bypass was cost saving.

Sensitivity Analysis

Because estimates of treatment effectiveness were based on case series and subject to patient selection bias, we set the lower bound of percentage loss of excess weight to 38%, more than one-third less than the base case estimate. Thus, the cost-effectiveness ratio for a 45-year-old man with a body mass index of 40 kg/m^2 was $57,200 per QALY and for a woman of the same age and body mass index was $28,000 per QALY (Figure 3). Further analysis suggested that the 38% estimate increased the cost-effectiveness ratio beyond $50,000 per QALY for a few subgroups of older, less obese men.

Most insurers reimburse a fraction of charges. For example, the median reimbursement rate at the University of Wisconsin Hospitals and Clinics is 67%, which, in a 45-year-old woman with a body mass index of 40 kg/m^2, would lower the cost-effectiveness ratio from $14,000 to $7300 per QALY. Such a shift is intuitive because a decrease in the reimbursement rate reduces all charge-based cost estimates for gastric bypass surgery but has no effect on the lifetime cost estimates derived from the literature.

Long-term severe obesity may have residual effects on health. Consequently, the risk of obesity-related disease for a person who loses weight may not equal the risk for someone who is less obese. Because the estimations of life expectancy and expected lifetime medical costs did not account for such residual effects, our base case estimates may have favored weight loss. To investigate the sensitivity of our results to residual effects, we incorporated these effects into the model. We performed one-way and two-way sensitivity analyses that assumed that weight loss did not affect life expectancy or the onset of obesity-related disease. To assess the sensitivity of the cost-effectiveness ratios to a decrease in the effect of obesity on quality of life, we decreased the obesity-related regression coefficients by 25%. In each analysis, the resulting ratios remained below $50,000 per QALY, except in a few subgroups of older, less obese men.

Table 3. Effectiveness and Costs in Base Case Estimates, by Risk Subgroup at Age 35 Years*

Body Mass	Life Expectancy (years)				Quality-Adjusted Life Expectancy (QALY)				Total Cost ($)				Cost-effectiveness Ratio			
	Gastric Bypass		No Treatment		Gastric Bypass		No Treatment		Gastric Bypass		No Treatment		Cost Per Life-Year ($)		Cost Per QALY ($)	
Index (kg/m^2)	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
40	23.00	24.63	22.97	24.72	19.56	19.82	18.51	18.21	68,600	59,000	38,500	35,300	844,700	—	28,600	14,700
50	22.83	24.46	22.52	24.46	18.87	18.88	16.83	16.03	75,000	64,800	53,200	48,500	70,300	9,130,000	10,700	5700

* Absent values indicate that the cost-effectiveness ratio (cost per life-year) is negative, signifying that gastric bypass incurred higher cost with lower effectiveness than did no treatment of severe obesity. All values are discounted at 3%.

QALY = quality-adjusted life-year.

Table 4. Effectiveness and Costs in Base Case Estimates, by Risk Subgroup at Age 55 Years*

Body Mass Index (kg/m^2)	Life Expectancy (years)				Quality-Adjusted Life Expectancy (QALY)				Total Cost ($)				Cost-effectiveness Ratio			
	Gastric Bypass		No Treatment		Gastric Bypass		No Treatment		Gastric Bypass		No Treatment		Cost Per Life-Year ($)		Cost Per QALY ($)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
40	16.44	18.58	16.15	18.49	13.32	13.94	12.48	12.62	77,600	69,600	47,900	48,200	100,200	248,500	35,600	16,100
50	16.22	18.41	15.51	18.08	12.81	13.23	11.17	10.88	85,300	77,000	63,500	64,100	30,700	38,900	13,300	5400

* All values are discounted at 3%.
QALY = quality-adjusted life-year.

According to the International Bariatric Surgery Registry, mortality is 0.17% in severely obese patients. Regardless of this discrepancy, gastric bypass remained cost-effective, except in some older, less obese men, even after doubling the base case estimate to 3% and after increasing all complication rates by 25%.

In the sensitivity analysis of the discount rate, we removed lifetime medical costs from the model, which was equivalent to assuming that weight loss had no effect on lifetime medical costs, and increased the discount rate from 3% to 5%. The cost-effectiveness ratio remained favorable in all women and in some men in the upper body mass index ranges, suggesting that the significance of discount rate variation was concentrated among less obese men, if present.

Given the repeated finding of sensitivity among older, less obese men, we assessed how variation in loss of excess weight and the reimbursement rate altered the cost-effectiveness ratio among 55-year-old men with a body mass index of 40 kg/m^2, the oldest and least obese male risk subgroup. The two-way analysis (Figure 4) showed that a loss of excess weight greater than 46% was sufficient for a $50,000 per QALY cutoff under the base case reimbursement rate. If the reimbursement rate was less than 67%, the ratio was less than the cutoff for all loss of excess weight estimates considered. Therefore, the cost-effectiveness of gastric bypass among older, less obese men depended on whether loss of excess weight was greater than 46% or the reimbursement rate was less than 67%.

Gastric bypass was not cost-effective in patients under all potential parameter estimates. Parameter variation increased the cost-effectiveness ratio among some older, less obese men. This sensitivity to parameter variation was attributed to increased cost and length of treatment, and lower disutility associated with obesity. Variation in parameters did not have a noteworthy effect on the cost-effectiveness ratio among women.

DISCUSSION

Our results suggest that gastric bypass is not cost saving from the payer perspective. However, the cost-effectiveness ratio estimates compare favorably with those of other accepted interventions and appear robust to parameter variation, especially among women and younger, more obese men (25). In comparison with no treatment, gastric bypass is a cost-effective alternative.

Our study sample comprised subjects who were severely obese but who did not have the chronic medical conditions typically associated with obesity. Results may have been different if we had included patients with comorbid conditions such as diabetes, heart disease, and hypertension. Among such patients, the perioperative risks would be greater, but so would the benefits of weight

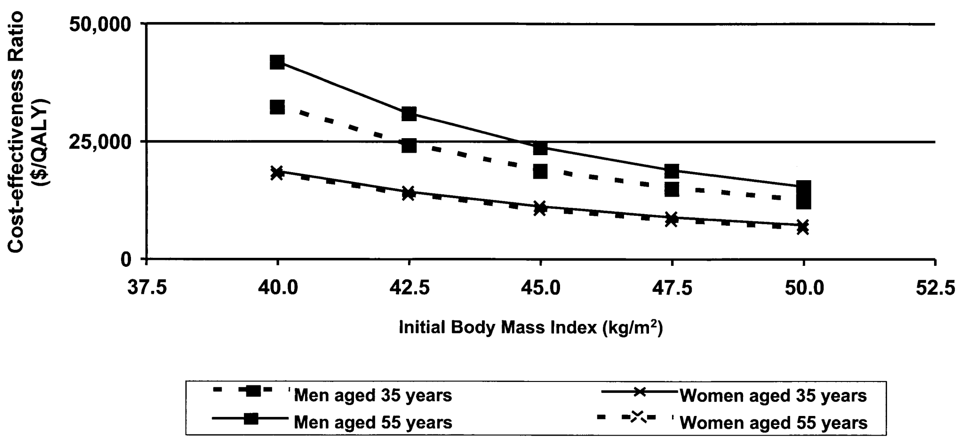

Figure 2. Analysis of four risk subgroups representing the upper and lower bounds of the cost-effectiveness ratios. These results suggest that gastric bypass is more cost-effective among women and those with a higher initial body mass index. QALY = quality-adjusted life-year.

loss. The importance of weight loss in patients with chronic conditions is appreciated by the National Institutes of Health Consensus Development Conference Panel (1), which lowered the recommended threshold for surgery from a body mass index of 40 kg/m^2 to 35 kg/m^2 in these patients.

We also included only patients who had been repeatedly unsuccessful at conservative interventions, which is in agreement with clinical guidelines (6) that failure of diet, exercise, and behavior therapy is an eligibility requirement for bariatric surgery. Failure of pharmacotherapy, however, is not a requirement, although it is common practice to attempt all conservative treatments before undergoing invasive procedures.

Laparoscopic forms of gastric bypass are becoming more common (26,27) and are potentially more effective, albeit more costly. However, more long-term follow-up data are needed on safety and effectiveness.

Our analysis had several limitations. Several obesity-related costs were excluded because of insufficient evidence. We applied the payer perspective, which ignores nonmedical costs such as decreased productivity, lost wages, and other indirect costs associated with comorbid conditions. We incorporated medical costs associated with treatment and with the lifelong treatment of obesity-related diseases such as coronary heart disease, stroke, type 2 diabetes, hypercholesterolemia, and hypertension. Some obesity-related diseases such as cancer and musculoskeletal conditions were also excluded from our analysis, as were nonobesity-related medical costs incurred by increased longevity and the effects of weight loss on conception and childbirth. Beyond patient outcomes, we dis-

Figure 3. One-way analysis of 45-year-old men and women with body mass index of 40 kg/m^2. For all parameters, we conducted a bidirectional analysis, except for life expectancy and expected lifetime medical costs. Gains in life expectancy and savings of expected lifetime medical costs were potentially less because of residual effects. Obesity-related quality of life refers to the obesity parameters in the regression analysis. QALY = quality-adjusted life-year.

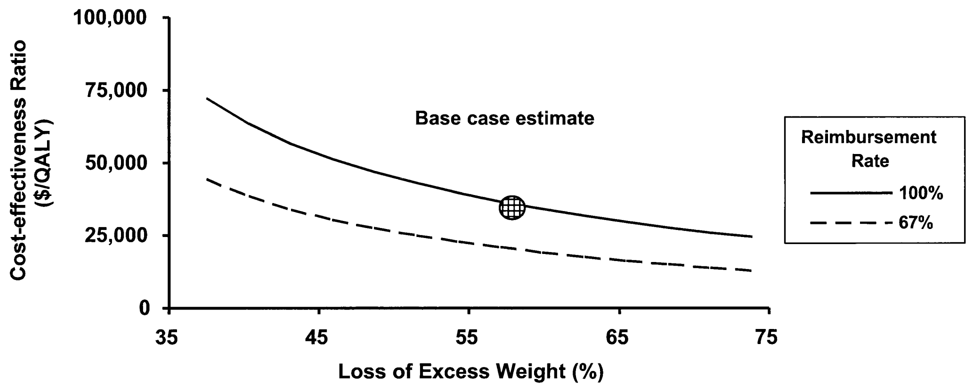

Figure 4. Two-way analysis of 55-year-old men with body mass index of 40 kg/m^2. QALY = quality-adjusted life-year.

regarded the effects of treatment on family members and the community. The inclusion of these factors would likely have strengthened the importance of weight loss and increased the cost-effectiveness of gastric bypass.

In our model, the effectiveness of gastric bypass to induce weight loss was based on published results estimated using case series. Patient selection bias and potential publication bias may have inflated the loss of excess weight estimate. In response, we chose a conservative base case estimate from the literature (17) and applied a much-reduced loss of excess weight estimate in the sensitivity analysis. We also assumed that those who had lost weight had the same quality of life as did those who had always been at that lower weight, even though some have reported that quality of life after weight loss surpassed that of the general population (28,29).

In conclusion, gastric bypass is a cost-effective alternative to no treatment of severe obesity from the payer perspective. However, bariatric surgery is often considered a cosmetic procedure by health maintenance organizations. We recognize that the decision to undergo bariatric surgery must be individualized because of the associated risks, and patients should understand the long-term commitment that the treatment entails. Given the numerous health consequences of severe obesity and its increasing prevalence, gastric bypass has the potential to improve health dramatically and at a reasonable cost.

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