Review Article

# Bariatric Surgery for Obesity and Diabetes

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**Abstract**

With the imminent threat of a global health crises of obesity and diabetes or "diabesity" as it is referred to today, healthcare professionals urgently need an effective range of treatment options for management of these two epidemics. After many decades in obscurity, bariatric surgery has emerged as an impressive treatment of obesity and type 2 diabetes. The field of bariatric surgery has seen a rapid evolution over the last 30 years and current procedures are safe, effective, less invasive, and relatively cost- effective. Bariatric procedures produce durable weight loss, long -term remission of type 2 diabetes, and beneficial effects on other comorbidities; they lead to a significant reduction in mortality in the long term. The adverse events after surgery are not uncommon but in majority of cases are not fatal. Bariatric surgery is costly, but cost-efficacy analysis consistently shows that the additional years of lives gained through bariatric surgery can be obtained at a reasonable and affordable cost. However, universal surgical treatment of obesity is not achievable with the world's current healthcare and surgical resources.

The conclusion of this review is that although bariatric surgery is a good addition to management of obesity and diabetes, these epidemics must be addressed by more comprehensive and long- term health policy efforts and appropriate research to determine the most effective ways of prevention and nonsurgical alternatives to treat obesity and type 2 diabetes.

**Keywords:** Bariatric surgery, diabetes, obesity

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## Introduction

The prevalence of obesity is rising worldwide. The World Health Organization estimated that in 2005, 1.6 billion adults were overweight and 400 million were obese.[1] Obesity is defined by a body mass index (BMI) of 30 kg/m$^2$ or more. BMI is calculated as weight in kilograms divided by the square of height in meters. The rate of obesity varies in different countries, with one-third of adults in some of the well- developed countries being obese.[2] In a developing country such as Iran, the rate of obesity is 20%.[3,4] In the United States (US) the rate of obesity in men and women are almost similar (33.3 and 35.3%, respectively), while in Iran obesity is more frequent in women than men (30% vs. 17%, respectively). Morbid obesity defined as BMI > 40 kg/m$^2$ affects 4.7% and 1.3% of adults in the US and Iran, respectively.[2,4] Obesity is associated with life-threatening complications such as heart disease, diabetes, hypertension, and cancer and increased risk of death.[5]

Studies have shown a close relationship between excess of intake of nutrients and derangements of molecular and cellular mediators of immunity and inflammation. This concept describes the chronic low-grade inflammatory response to obesity, as one of the potential unifying mechanisms behind the pathogenesis of obesity- associated diseases.[6,7] The role of gut microbiota and duodenal loop hormones and gastrointestinal-brain axis is well appreciated,[7,8] and bariatric surgery disrupts this vicious cycle and would be effective to reduce the complications of obesity.

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Medical management of a chronic disease such as obesity, which carries substantial physical, emotional, and economic burdens, requires an effective armamentarium. However, the clinician does not have much choice for medical management of obesity. Sibutramine was withdrawn from the market due to its cardiovascular complications and only two drugs, orlistat and phentermine are currently approved for the treatment of obesity.[9] Recently, it has been shown that exenetide treatment leads to significant weight loss in obese adults without diabetes.[10] Many studies have shown that highly supervised dietary interventions may also cause significant weight loss; however, all medical treatments of obesity fail to achieve the mean weight loss of more than 10% of body weight and unfortunately weight regain following these forms of treatment is almost universal.[11–14] The mean maintenance of weight loss after interventions for obesity is 54% (25% – 88%) after one year,[10] and < 25% after two years.[14]

The high failure rates of medical treatment, along with the rising prevalence of obesity and escalation of its life-threatening complications, has led to the wide use of bariatric surgery;[15] in addition, this kind of surgery is the most successful treatment for achieving long- term weight loss in adults with morbid obesity,[5] which is why bariatric surgery is to date the most effective treatment for morbid obesity, with close to 350,000 bariatric operations performed worldwide until 2008.[16]

### Outcomes

Outcomes of bariatric surgery have been widely studied and those of clinical importance are summarized in this article.

#### *Weight loss*

Bariatric surgery leads to a significant reduction in weight in all adults.[17] Two randomized controlled trials have reported mean percent initial weight loss of 20% and 21.6% in surgical groups, compared to 1.4% and 5.5% in nonsurgical groups, respective-

ly.[18,19] The large prospective Swedish study reported that after 10 years, weight loss of 25% of body weight had been successfully maintained in surgical subjects, compared to 1.5% in nonsurgical patients.[20]

*Cardiovascular disorders*

Bariatric surgery in morbidly obese subjects decreases the thickness of the left ventricle, the overall ventricular mass, improves cardiac performance,[21] and leads to progressive regression of left ventricular hypertrophy.[22] Both coronary microvascular function and peripheral vascular dilator function improve after bariatric surgery.[23] Two review papers have found that all of the cardiovascular risk factors are improved or even resolved after bariatric surgery.[24,25] It has been predicted that progression of atherosclerosis slows down and the 10- year risk of cardiac events could decline by up to 50% in patients undergoing bariatric operations.[25]

*Diabetes mellitus*

The worldwide prevalence of type 2 diabetes is rising following the rapidly increasing frequency of obesity and it has been shown that the annual incidence rate of diabetes has reached almost 1% in some populations.[26] More than 60% of diabetics are obese and treatment of the combination of obesity and type 2 diabetes, or "diabesity" is now a public health priority;[27] a meta- analysis showed that 78% of diabetic patients had complete resolution and 62% remained in remission more than two years after operation.[28] A prospective randomized controlled trial showed 73% remission of diabetes in those who underwent surgery, compared to 13% in the control group.[18] Another randomized study showed that the proportion of patients with a glycated hemoglobin level of 6% or less, after 12 months of intervention, was 12% in intensive medical therapy, 42% after gastric bypass, and 37% following sleeve gastrectomy.[29] Improvement and resolution of diabetes is mostly related to weight loss after surgery; however, the plasma concentration of incretine hormones increases by three to five fold and insulin secretion and glucose tolerance improve after the operation, changes which are not seen after an equivalent weight loss by diet.[30]

*Hypertension:*

One month after bariatric surgery, up to 25% show resolution and 36% have improvement in hypertension.[30] Obesity surgeries improve or resolve hypertension in most patients (37% – 53%) and reduce the need for medications (18% – 36%).[31–33]

*Dyslipidemia*

Bariatric surgery greatly improves secondary hypercholesterolemia and the mixed form of dyslipidemia and causes an increase in HDL cholesterol levels as well. The above changes occur in 12% – 47% of patients.[34,35] Discontinuation of medications may reach 40% after one year, more likely in those who take fibrates than in those who take a combination of statins and fibrates.[34] Up to a 59% reduction in use of hyperlipidemia medication has also been reported.[36]

*Renal disorders*

Overall kidney dysfunction improves in the first year after surgery and may prevent the development of obesity- related glumerulopathy.[37] Albuminuria improves and in patients with established renal disease, 20% resolution, improvement, or stabilization have been observed.[38,39]

*Digestive disorders*

Different surgeries for obesity have varying effects on gastroesophageal reflux disease. Adjustable gastric banding and, in particular, the Roux-en -Y gastric bypass decreases[40] and sleeve gastrectomy increases reflux symptoms.[41] Bariatric surgery improves steatosis, necroinflammatory activity, and hepatic fibrosis in patients with obesity and nonalcoholic steatohepatitis.[42]

*Musculoskeletal disease*

Bariatric surgery causes between 32% – 100% subjective improvement or resolution of joint pain or osteoarthritis at one year. Joint pain improves in particular in load-bearing joints such as the ankle, hip, and knee.[43] The rates of osteoporosis and rheumatic disease also decrease following obesity operations.[44]

*Psychologic disorders*

Significant reduction in depression and improvement in sexual desire, arousal, lubrication, satisfaction, and total sexual function have been reported.[45]

*Cancer*

Overall evaluation of the effect of bariatric surgery on the rates of various cancers in obese subjects may require a few decades after worldwide implementation of these operations. After 13 years of follow- up, a Swedish study reported a significant decrease in the incidence of first cancer in women.[46]

*Polycystic ovary syndrome*

Bariatric surgery may resolve this disease with decrease in hirsutism and serum androgen concentrations. Restoration of regular menstrual cycles and ovulation had paralleled weight loss after the operation.[47]

*Obstructive sleep apnea*

Appropriate resolution of obstructive apnea after bariatric surgery has been demonstrated in many studies[48] and up to 53% of patients have discontinued the use of continuous positive airway procedure in the first year following surgery.[49]

*Quality of life*

Bariatric surgery, at least in the short-term, improves quality of life and psychosocial functions in a substantial proportion of patients.[50] However, some studies indicate no improvement or a reversion to baseline levels of psychosocial distress.[51]

*Life expectancy*

In nonsmoker obese women and men, life expectancy may be reduced by 7.1 and 5.8 years, respectively as compared to normal weight subjects.[52] Bariatric surgery increases longevity in morbidly obese patients and causes a 45% global reduction in total mortality.[53]

## Complications

*Mortality*

The thirty- day mortality for bariatric surgery ranges from 0.1% to 2%.[16] The most important factors in mortality rate are the skill of the bariatric surgeon and type of surgery. More recent data have shown improved mortality not exceeding 0.3%,[54] which is mostly

due to laparoscopic approaches, better anesthesia, and improved monitoring and supervision. Total late mortality (30 days to two years) is around 0.35%.[5]

Adverse effects of bariatric surgery depend mainly on operational procedure. In general, 10% – 20% of patients may experience early (during 90 days of postoperative period) or late complications. Rates of major complications of bariatric surgery are shown in Table 1.[17,55]

### Trends in bariatric procedures

Over the last two decades, two procedures that have gained popularity are gastric banding (prototype restrictive operation) and gastric bypass (prototype malabsorptive procedure), accounting for 49% and 52% of total bariatric operations, respectively worldwide.[16] Sleeve gastrectomy, duodenal switch, and biliopancreatic diversion together account for < 10% of all bariatric surgeries, with the first procedure fast gaining popularity among bariatric surgeons. A recent meta-analysis has indicated that laparoscopic surgery may be a safer procedure than open bariatric operation.[56] Comparative studies have shown that bariatric procedures with more dramatic clinical benefits may carry greater risks of complications.[17,57] The comparisons of some of attributes of three major bariatric procedures are shown in Table 2.

### Cost-effectiveness

Economic costs of obesity include direct (behavioral and pharmacologic treatment and management of obesity-related comorbidities) and indirect (loss of work productivity, disability, and loss of years of productive life) costs. Number of obese patients multiplied by the sum of direct and indirect costs generates an enormous total spending of 2% – 7% of total world healthcare costs.[57,58] Studies have shown that aggregates of direct costs of obese individuals are 36% – 42% higher than nonobese subjects.[57,59] Annual indirect cost of obesity has been estimated at 64 billion for USA.[59]

Although surgical operations are more costly than noninvasive management, the more significant weight loss, improvement of obesity-related comorbidities, longevity, and enhanced quality of life make bariatric surgery cost-effective compared to nonsurgical treatment, with reasonable increment costs for any gained quality-adjusted life year (QALY).[60] In patients with diabetes mellitus, obesity surgery may impose an initial economic investment, but will save money in a relatively short period of time.[52]

### Indications for bariatric surgery

The 1991 National Institutes of Health of the United States statement indicated that all patients with BMI over 40 kg/m$^2$ and those with a BMI of 35 – 40 kg/m$^2$ with significant comorbidities, interfering with their lifestyles, were candidates for surgical treatment.[61] This statement has become the most generally accepted guideline for determining indications for bariatric surgery for those with BMI 35 – 40 kg/m$^2$, with comorbidities. Patients with type 2 diabetes have the most frequent indications of surgery. Recently, few medical societies have increased indications of bariatric surgery to include patients with BMI 30 – 34 kg/m$^2$ with a comorbid condition that can be cured or markedly improved by substantial and sustained weight loss.[62]

### Estimation of work load

It has been estimated that it would take 5500 surgeons doing 400 cases a year, each for 10 years to attempt bariatric surgery for every 22 million obese Americans.[63] Another estimation could be provided for a developing country such as Iran. The rates of BMIs > 40 and 35 – 40 kg/m$^2$ in approximately 40 million Iranians ≥ 20 years of age are 1.3% and 3.8%, respectively.[4] Therefore, 520,000 subjects with BMI > 40 kg/m$^2$ and 106400 type 2 diabetic patients with BMIs between 35 – 40 kg/m$^2$ require obesity operations. This will require 157 surgeons doing 400 cases a year, each for 10 years to undertake bariatric surgery for every 626400 obese Iranians. In the capital city of Tehran with an approximately 12 million population, the relative figure is even higher. In a sample population of Tehranians, aged ≥ 20 years, 213 (1.66%) had BMI > 40 kg/m$^2$,[3] and 88 subjects with type 2 diabetes had BMI of 35 – 40 kg/m$^2$;[64] therefore, a total of 301 (2.35%) have indications for bariatric surgery. Extrapolating these data to 7,800,000 Tehranians ≥ 20 years of age indicates that 183,300 obese subjects may require bariatric operations, and 46 surgeons should hence perform 400 cases a year, each for 10 years, to provide surgical treatment for all obese Tehranians.

**Table 1.** Rate of major complications of bariatric surgery

| Adverse Events | |
|---|---|
| **Early (first 90 days) (%)** | **Late (%)** |
| Vomiting | |
| Wound infection (2.12.9–) | Stomal stenosis (4.7) |
| Anastomotic leak, peritonitis, or abscess (1.42.0–) | Bowel obstruction (3.2) |
| Gastrointestinal hemorrhage (1.11.9–) | Incisional hernia (0.5) |
| Bowel obstruction (0.51.7–) | Cholelithiasis (625%–) |
| Pulmonary embolus (0.41) | Malabsorption (6%) |
| Thromboembolism (1.0) | |
| Other infections (1.4) | |

**Table 2.** Comparison of some of characteristics of the principal bariatric procedures

| Characteristic | Gastric Banding | Gastric Bypass | Sleeve Gastrectomy |
|---|---|---|---|
| Side effects | + | ++ | + |
| Safe | +++ | ++ | ++ |
| Effective | ++ | ++ | ++ |
| Minimally invasive | +++ | ++ | ++ |
| Durable | +++ | +++ | --- |
| Reversible easily | Yes | No | No |

Adopted from ref. 17 and 56.

## Discussion

Many studies have discussed the importance of noncommunicable chronic diseases,[3,4] in particular obesity and diabetes, and their risk factors in many parts of Iran.[65–69]

Given the lack of long-term success with dieting, limited pharmacologic options, and the invasive nature of bariatric surgery, the current treatment options for obesity and diabetes have a long way to go to achieve the goals of appropriate management. However, bariatric surgery has shown to be the most effective treatment for morbid obesity and diabetes with BMI $\geq$ 35 kg/m$^2$. Bariatric surgery is associated with substantial and durable weight loss and favorable metabolic effects far beyond those achieved by lifestyle modifications and pharmacologic treatments, along with significant reduction in comorbidities associated with obesity and type 2 diabetes. Bariatric surgery has been documented for rapidly increasing longevity and reducing healthcare costs over time and hence should be made available to as many patients as possible. However, data available show that bariatric surgery cannot provide the impact necessary for reduction in healthcare and economic costs on a worldwide scale. The numbers of surgeons needed for the global figures of operations estimated are not achievable with the world's current healthcare and surgical resources.

Obesity and diabetes epidemics must be addressed by long-term, concerted policy efforts worldwide. Appropriate changes in lifestyle along with healthy eating, regulation of food supply, public education, healthy commuting through walking or biking need gradual infrastructure change and, last but not least, the motivation and incentives in various societies. Current research horizons should be widened to encompass novel and effective nonsurgical treatments for obesity and type 2 diabetes.

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