Overview of the Epidemiology of Obesity and the Early History of Procedures to Remedy Morbid Obesity

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Obesity may be defined by weight, body mass index (BMI) (calculated by dividing weight in kilograms by height in meters squared), and percentage of body fat, although no categorization is universally accepted. The cause is multifactorial, with genetic, environmental, socioeconomic, and behavioral or psychological influences.

Health conditions caused or exacerbated by obesity include hypertension, diabetes mellitus (DM), sleep apnea and obesity hypoventilation, back and joint problems, cardiovascular disease, pseudotumor cerebri, thromboembolic disease, and others. Malignancies occur with increased incidence in persons who are obese and include breast, endometrial, and colonic neoplasms. Numerous recent studies, increasingly reported in the lay press, emphasize the increasing incidence of obesity in the United States, with concomitant increases in the related morbidity and mortality. An estimated 64.5% of American adults (>120 million people) are overweight or obese, an increase from 45% in 1960.1 The incidence of juvenile obesity has doubled in the last 20 years, affecting an estimated 15% of children between 6 and 19 years old.2 Obesity is widely recognized as one of the primary national health issues and has been predicted to soon surpass smoking as the leading cause of preventable mortality in the United States. Health care costs associated with obesity are incalculable. Costs for DM alone are estimated at $100 billion annually. The incidence of DM has increased parallel with that of obesity, from 9 million adult cases in 1991 to 15 million in 2001.3

DEFINITION OF OBESITY

Obesity is strictly defined as an excessive accumulation of body fat. The BMI has become the most commonly accepted measurement. A BMI exceeding 25 is considered overweight, while obesity is defined as a BMI of 30 or more. A BMI of 35 or more with serious comorbidity, or a BMI of 40 or more, is considered morbid obesity. Other definitions of morbid obesity include more than 45.2 kg (>100 lb) over the ideal body weight as defined by the 1983 Metropolitan Life Insurance Height and Weight tables or a body weight exceeding 200% of the ideal body weight.

While most obese people are overweight, not all overweight individuals are obese. Included in this latter group would be very muscular athletes, such as weightlifters or football players, who do not have excess body fat. Methods of calculating body fat include underwater weighing, measuring total body water using isotopic dilution, measuring total body potassium level, bioelectrical impedance analysis, and measurements using computed tomography or magnetic resonance imaging. These techniques are not widely used in assessment of obesity owing to expense, technical difficulty, and lack of sufficient validation.4 Circumference and skinfold thickness measurements are more practical because of simplicity; however, these measurements are more useful to determine regional fat distribution rather than total body fat. Waist circumference as an indicator of excess abdominal or visceral fat has been associated with dyslipidemia, hypertension, and glucose intolerance.5

PREVALENCE

While estimates may vary between studies, there is general agreement that the prevalence of obesity has increased steadily...
over the last 2 to 3 decades in the United States and worldwide. The National Center for Health Statistics in 1999 reported that 61% of adults in the United States were overweight (BMI ≥ 25) and that 26% were obese (BMI ≥ 30). Prevalence rates differ with sex, age, race or ethnicity, and socioeconomic status. American women have a higher prevalence of obesity than men. African American and Mexican American women and men have higher rates of obesity than white women and men (Third National Health and Nutrition Examination Survey [NHANES III], 1988-1994). While the prevalence of obesity tends to be lower in less well-developed countries, it is higher in lower socioeconomic and less educated groups in the United States. 

Of great concern is the increased US prevalence of childhood and adolescent obesity. Rates of obesity among children aged 6 to 11 years increased from 4% in the National Health Examination Survey for 1963-1965 to 13% in 1999 (NHANES-IV). There was a similar increase in adolescents aged 12 through 19 years from 5% for 1966-1970 to 14% in 1999. As in adults, prevalence rates are highest for Hispanic and Native American children of both sexes and for African American females. Genetic, socioeconomic, environmental, and dietary influences are all implicated. The incidence of type 2 DM in adolescents has increased in proportion to the increase in obesity, with an average BMI of 38 in patients who have newly diagnosed DM in this age group.

HEALTH EFFECTS OR COMORBIDITIES

The hallmark study by Drenick et al in 1980 clearly demonstrated excess mortality in a group of 200 morbidly obese males followed up for a mean of 7½ years. During the course of the study, 25% of the group died. There was a 12-fold excess mortality compared with the general population in the 25- to 34-year-old group and 6-fold excess mortality in the 35- to 44-year-old group. Cardiovascular disease was the most common cause of death, while injuries (trauma, eg, motor vehicle, falls, industrial injuries, and others) were surprisingly frequent. Overweight (>110% of the ideal body weight) nonsmoking men in the Framingham study had 30-year mortality rates as high as 3.9 times that of normal-weight men.

Diabetes Mellitus

The association of obesity and type 2 DM is well known. The increase in prevalence of obesity over the last decade has been accompanied by a 25% increase in prevalence of DM, which increases dramatically with a BMI exceeding 25. Diabetes mellitus is a major cause of stroke, blindness, renal failure, lower extremity amputations, and ischemic cardiac disease. The mortality rate from cardiovascular disease is substantially higher for patients with DM than without DM.

There is an increased risk of DM in many groups that also have an increased prevalence of obesity, such as African Americans, Hispanics, Native Americans, and those of low socioeconomic status. There is evidence to support independent inheritance of DM and obesity, increased genetic susceptibility for DM with obesity, a combined inheritance of obesity and DM, and even DM as a cause of obesity.

Improvement in glucose tolerance with weight loss following gastric bypass for morbid obesity has been well documented in our series at East Carolina University, Greenville, NC. In a cohort of 608 morbidly obese patients, 27% had DM type 2 and another 27% had impaired glucose tolerance (IGT), which is a known risk factor for subsequent development of type 2 DM, as well as an independent risk factor for cardiovascular disease. On long-term follow-up after Roux-en-Y gastric bypass, 82.9% of the patients with DM maintained normal levels of plasma glucose, glycosylated hemoglobin, and insulin. During an average follow-up of 7.6 years after Roux-en-Y gastric bypass, 98.7% of the IGT group remained euglycemic, while 1.2% developed type 2 DM. In a previous comparison of the surgical IGT group with a control group of nonoperated on obese patients with IGT, there was a greater than 30-fold decrease in risk of developing type 2 DM in the patients in the surgical IGT group. Analysis of those patients in both the DM and IGT groups who did not remain euglycemic revealed that 37% had inadequate weight loss owing to failure of the surgery. The remaining nonresponders were an average of 7.3 years older and had had their DM diagnosed for 3 years longer than the euglycemic patients. The observation that the probability of reversion to normal glucose metabolism with weight loss decreases with age and duration of DM suggests that there is a deterioration of islet cell function over time.

In a retrospective comparison of an obese cohort with DM who underwent Roux-en-Y gastric bypass with a matched group of obese control subjects with DM who did not undergo surgery for nonmedical reasons, the incidence of death in the control group was 4.5 times that of the surgical patients. Of the control group, 28% died during 6.2 years of follow-up, while only 9% of the surgical group died during a longer 9-year follow-up, including perioperative deaths. The largest reduction was in cardiovascular mortality, representing 54.5% of the control deaths vs only 14.3% of the surgical group deaths.

Hypertension

Many population-based studies have documented the association of obesity with hypertension. The NHANES data showed that the prevalence of hypertension in overweight adults was 2.9 times that of normal-weight adults. This correlation was more pronounced in younger age groups. There is a clear relationship among hypertension, insulin resistance, and hyperinsulinemia. Effects on tubular sodium resorption and on the renin-angiotensin-aldosterone system have been suggested as possible mechanisms. Hyperinsulinemia has further been associated with hyperlipidemias and atherogenesis, termed "syndrome X."

EARLY SURGICAL TREATMENT OF OBESITY

Jejunoileal Bypass

The history of surgery for morbid obesity began in 1954, when Kremen et al published the first case report of an
end-to-end jejunocolostomy performed for weight reduction. Payne then initiated the first clinical program of intestinal bypass for morbid obesity in 1956, initially performing an end-to-side anastomosis of the proximal 15 cm of jejunum to the mid-transverse colon. In 1963 Payne reported initial results in 11 patients revealing dramatic weight loss, although at the expense of significant morbidity with severe diarrhea, electrolyte imbalance, and hepatic failure, leading to 1 death. While Payne originally postulated a second operation to increase bowel length would be required after achieving ideal weight, the jejunoileal shunt was widely condemned and, ultimately, abandoned.

In an attempt to achieve a more physiologically tolerable operation, intestinal bypass with restoration of continuity proximal to the ileocecal valve was proposed. Payne and DeWind performed an end-to-side jejunocolostomy, anastomosing the proximal 36 cm (14 in) of jejunum to the terminal ileum 10 cm (4 in) proximal to the ileocecal valve. The distal divided end of the jejunum was left as a blind end. Their experience with this “14+4” procedure with 58 patients was reported in 1969. As with many of the earlier reports on bariatric procedures, important data, such as mean percentage of excess body weight lost at various intervals after surgery, percentage of follow-up, and lengths of follow-up, were not discussed.

Numerous variations of the jejunoileal bypass (JIB) were subsequently introduced. While preservation of the ileocecal valve did reduce problems with unmanageable diarrhea, there was variable reflux of intestinal contents with the end-to-side anastomosis into the bypassed segment of bowel, leading to unpredictable weight loss. In response to this problem, Scott et al performed an end-to-end jejunoileostomy with drainage of the bypassed intestine into either the sigmoid or transverse colon. In their report of 200 patients in 1977, they compared Payne’s 14+4 operation with 3 variations of the end-to-end procedure that differed in the length of distal ileum (15 vs 20 vs 30 cm [6 vs 8 vs 12 in]) anastomosed to 30 cm (12 in) of proximal jejunum. Weight loss with these procedures cannot be compared directly with later procedures, as results were reported as a change in ratio of lean body mass to weight, or by the undefined terms “satisfactory,” “not ideal,” and “unsatisfactory.” The groups with 30 cm of distal ileum who underwent the Payne operation lost less weight and most began to regain weight after 2 or more postoperative years. The groups with 15 and 20 cm of distal ileum had greater sustained weight loss, with more than 70% losing “to the range of ideal weight.” Persistent diarrhea was a problem with these 2 groups in 20% to 45% of the patients.

With increasing experience and length of follow-up, a growing variety of complications related to JIB were reported. Of 230 patients who underwent the 14+4 end-to-side procedure, DeWind and Payne reported that 29 (49%) of the men and 88 (51%) of the women required rehospitalization for management of complications related to the operation. Percentage of initial weight lost in 2 years was from 32% to 74%. Overall, mortality was 8%, including 10 deaths due to liver failure. There were significant problems with hypoalbuminemia, hypokalemia, hypocalcemia, hyperbilirubinemia, migratory polyarthritis, calcium oxalate urinary calculi, and elevated liver enzymes levels. Diarrhea and flatulence were common. The excluded intestinal segment was associated with various problems, including intussusception, bypass enteritis, and colonic pseudo-obstruction. Hocking et al reported that the risk of progressive liver disease existed indefinitely and that ongoing careful follow-up was necessary. Griffen et al finally stated, “. . . a 50% morbidity rate and roughly a 10% mortality following jejunoileal bypass are sufficient reasons to abandon it as an appropriate operation for the morbidly obese.”

**Modern Malabsorptive Procedures**

Descendant operations of the JIB persist in the form of the biliopancreatic diversion, first reported in 1979, and the duodenal switch. These modern operations differ from the JIB variants in that no intestinal limb is excluded from flow of some type, thus, eliminating the blind loop syndromes or bacterial overgrowth that were likely contributing causes of the liver problems, arthralgias, bypass enteritis, and colonic pseudo-obstruction seen with JIB. The biliopancreatic diversion, as described by Scopinaro in MacDonald et al, is constructed with a 200- to 300-mL proximal gastric pouch, a distal gastrectomy to reduce incidence of marginal ulcer, and a nonrestrictive gastroileostomy performed 250 cm proximal to the ileocecal valve. The biliopancreatic limb is anastomosed to the intestinal limb 50 cm proximal to the ileocecal valve. Fat absorption, therefore, is restricted to the short 50-cm common channel, while protein and starch are absorbed throughout the 250-cm intestinal limb. Scopinaro and colleagues reported 73% to 78% loss of excess body weight from 2 to 14 years after surgery, with a protein malnutrition rate of only 2.7%. Close follow-up and patient compliance are necessary to minimize this complication.

Duodenal switch is a variant of the biliopancreatic diversion with original modifications by Marceau et al in 1993 and Hess and Hess in 1998. The primary differences of the switch include a greater curve gastrectomy and preservation of the pylorus, with anastomosis of the enteric limb to the first portion of the duodenum just distal to the pylorus. As with the biliopancreatic diversion, the biliopancreatic secretions are diverted to the distal common channel. Reported benefits include reduced marginal ulceration, reduced protein malnutrition, and reduced hepatic dysfunction.

**Gastric Restrictive Procedures**

Mason and Ito first described the gastric bypass in 1967, beginning the era of gastric restrictive procedures. Griffen et al noted similar weight loss to that seen with JIB with fewer late complications. Because of technical difficulties associated with gastric bypass and concern about the excluded distal stomach, many varieties of gastroplasties were introduced during the 1970s by Gomez, Pace et al, and LaFave and Alden. The basic design of these procedures was a stapled partitioning of the proximal stomach to create a small pouch that communicated with the distal stomach through a restrictive channel. These procedures were widely performed because of their technical simplicity and lack of metabolic complications. Over time, however, excessive failure rates were noted, at least par-

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tially due to pouch and outlet dilation. Conversely, excessive restriction often led to reflux problems and the mal-adaptive eating behavior of liquids and soft foods, resulting in weight gain. Comparative studies by Pories et al. and Naslund et al confirmed the superior results of gastric bypass over those of the gastroplasties.

**SUMMARY**

The prevalence of obesity is increasing in the United States and globally in children, adolescents, and adults, in both sexes, and in most races and ethnic groups. While there are differential rates of overweight and obesity among groups, the wide distribution of the increased prevalence implicates environmental changes as the major contributing factors, particularly changes in diet and activity that promote increased caloric intake and decreased energy output. Health consequences of the increased prevalence of obesity include corresponding increases in the numerous comorbidities associated with obesity, most importantly type 2 DM, hypertension, and cardiovascular disease.

As medical approaches to weight loss have been generally inadequate and unsuccessful, surgery has emerged as the primary treatment for morbid obesity. Early surgical procedures, the JGBs, involved bypass of variable lengths of small intestine to create malabsorption. Owing to an unacceptable incidence of complications with JIB procedures, including malnutrition, cirrhosis, liver failure, calcium oxalate renal calculi, and other problems associated with bacterial overgrowth in the bypassed bowel, restrictive operations were developed to limit intake rather than cause malabsorption. Evolution of gastric bypass and development of other modifications of purely restrictive procedures (eg, vertical banded gastroplasty and adjustable gastric banding) has continued to date. Despite accumulated knowledge from experience, no general agreement as to the optimal procedure has been reached, if one, indeed, does exist for any given morbidly obese patient. Analysis of results of surgical alternatives has always been hindered by a lack of comprehensive data collection, poor long-term patient follow-up, and lack of standardization of the technical aspects of the procedures and of reporting of results. With the increasing prevalence of morbid obesity and concomitant increase in procedures and number of surgeons performing them, these deficiencies will likely assume increasing importance.

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