Overview of Bariatric Surgery

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To know what is new, one must know what is old. Bariatric surgery has developed along three generic lines: malabsorptive, malabsorptive/restrictive, and purely restrictive. In addition, other metabolic surgical procedures—operations on normal organs to achieve a secondary, metabolic goal—have been used and are being tested. The new bariatric surgeon, in ever increasing numbers, is exemplified by the highly skilled minimally invasive surgeon, trained and experienced in the unique principles of pre-, intra-, and postoperative management of the obese patient. This overview explores seminal approaches in bariatric surgery; discusses new operations available to the bariatric surgeon; summarizes the prevalence data for morbid obesity; highlights the intrinsic medical, social, and economic problems of this disease; and offers predictions regarding the next decade in this field.

MALABSORPTIVE PROCEDURES

Historical beginnings

The jejunoileal bypass was the prototype of malabsorptive procedures and, for that matter, all of bariatric surgery. Originated in 1953 and 1954 by Varco[1] and Kremen, Linner, and Nelson,[2] this procedure dominated bariatric surgery for more than 20 years. Weight loss with the jejunoileal bypass was excellent, but its association with the gas-bloat syndrome, diarrhea, electrolyte imbalance, hepatic fibrosis and failure, nephrolithiasis, cutaneous eruptions, febrile states, and impaired mentation[1] limited its usefulness and allowed the gastric bypass to rise to prominence.

Perhaps dormant, but never extinct, the malabsorptive procedures reemerged in the 1970s in the biliopancreatic diversion and in the 1990s in the duodenal switch. These second-generation malabsorptive procedures share a cardinal trait: no segment of the intestine is left without flow through it. They create an enteric limb carrying food and a biliopancreatic limb carrying bile and pancreatic juice; the limbs join in a common channel in which most of digestion and nutrient absorption must take place. Leaving no stagnant segment of intestine avoids the bacterial overgrowth and toxemia responsible for the majority of complications seen with the jejunoileal bypass.

The biliopancreatic diversion is also known as the Scopinaro procedure because Nicola Scopinaro not only was its creator but also has been its greatest advocate. The initial series of these operations was reported in 1979.[3] Scopinaro has modified the procedure over time. The current operation consists of a partial horizontal gastrectomy with closure of the duodenal stump, gastrojejunostomy with a long Roux limb, and anastomosis of the long biliopancreatic limb to the Roux limb 50 cm from the ileocecal valve, creating an extremely short common channel. In a 2000 publication, Scopinaro and colleagues[4] reported on their 23 years of experience, encompassing 2,316 patients. The initial excess weight loss (IEWL) at 1 year in this series was about 70% (anything above 50% is generally considered laudatory) and was, essentially, maintained for 20 years. The primary complications discussed by Scopinaro and coauthors were diarrhea and flatulence, anemia, stomal ulcers, bone demineralization, and protein malabsorption.

Duodenal switch

The new malabsorptive procedure is the duodenal switch, first introduced by Marceau and coworkers in 1993,[5] and rapidly gaining popularity in the United States and in Canada. Marceau's group deviated from the Scopinaro procedure by: (1) constructing a lesser curvature gastric tube by a vertical two-thirds resection of the stomach, rather than by performing a horizontal gastrectomy; (2) preserving the pylorus; (3) anastomosing the enteric limb to the proximal duodenum; and (4) cross-stapling the distal duodenum without dividing it. Unfortunately, the initial patients rapidly displayed fail-

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Abbreviations and Acronyms
BMI = body mass index
IEWL = initial excess weight loss

ure of the duodenal staple line and weight gain, because the duodenum, unlike the stomach, does not tolerate cross-stapling. Having converted to duodenal division before anastomosing the enteric limb to the proximal duodenum, Marceau and associates[6] recently reviewed 11 years of experience with 467 patients. Their IEWL was 84% at 18 months. They used a common channel of 100 cm. They list as their primary concerns with this procedure flatulence, malodorous stools, and iron and calcium malabsorption.

Hess and Hess[7] have popularized the duodenal switch in the United States. Their technique is comparable to that of Marceau with a 150 to 200 mL residual stomach and an end-to-end anastomosis of the enteric limb to the postpyloric duodenum (Fig. 1). In their report on 440 patients, over a 10-year time span, they noted an IEWL at 18 months of 80%, using a common channel of 50 to 100 cm. They believe that the total length of the enteric limb (from the cecum to the stomach) should be approximately 40% of the total small bowel length and that the common channel should be somewhere around 10% of the total small bowel length. They made their common channel 50, 75, or 100 cm, as a function of the individual patient's weight, and experimented with several combinations of lengths of the common channel and the enteric limb (Fig. 2). In essence, their IEWL percentage over time was not too different with these various combinations, but the 50-cm common channel combined with a 300-cm enteric limb had nearly a 100% IEWL at 108 months. Their longterm concerns included diarrhea, anemia, calcium malabsorption, and protein malabsorption. These problems can usually be averted by judicious precautionary measures, eg, mild antidiarrhea agents, mineral supplementation, and maintenance of a 65- to 80-gram protein diet.

Today, essentially every bariatric surgical procedure is being performed laparoscopically. Even the complicated duodenal switch, consisting of several operative steps (gastrectomy, enteroenterostomy, duodenal division closure, and duodenoentereostomy) has been done through the laparoscope.[8]

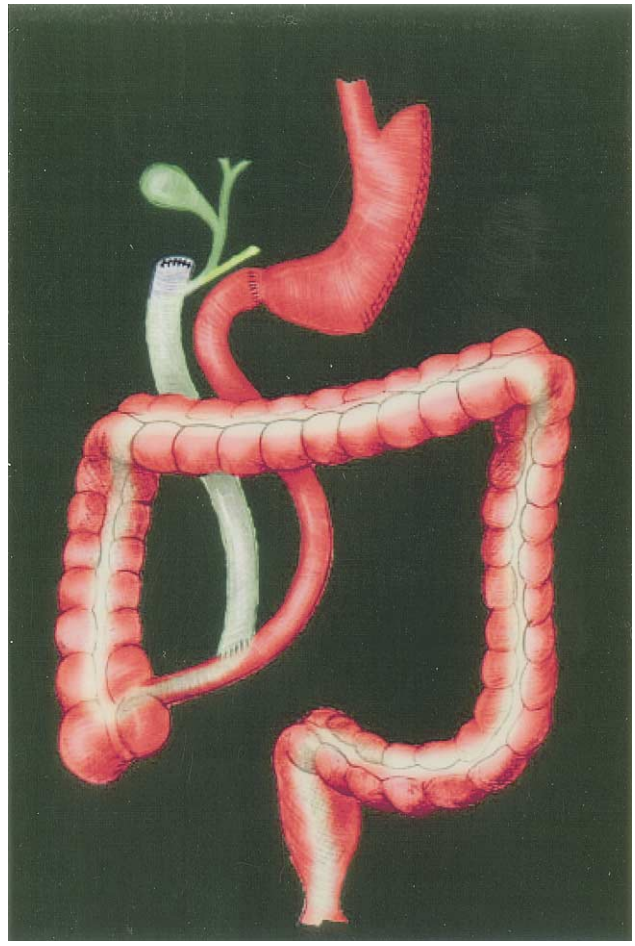

Figure 1. Hess and Hess: duodenal switch with division of the duodenum, 1998.

MALABSORPTIVE/RESTRICTIVE PROCEDURES

Historical beginnings

A separate genus of bariatric procedures that combined intestinal malabsorption with gastric restriction evolved in the 1960s. The gastric restrictive element consists of construction of a small upper gastric pouch (currently, 30 mL or less), with a small outlet orifice (about 1 cm). This pouch empties its swallowed food contents into the small intestine through a Roux limb gastrojejunostomy, the Roux limb having superseded jejunal loop reconstruction. The degree of malabsorption is determined by the extent of the bypass, at a minimum consisting of the distal stomach, the duodenum, and the first segment of the jejunum. The Roux gastric bypass rapidly replaced the jejunoileal bypass because of its marked reduction of complications. Yet, the Roux gastric bypass is not a totally benign procedure; it causes dumping, iron deficiency anemia, and vitamin B_{12} malabsorption. Addi-

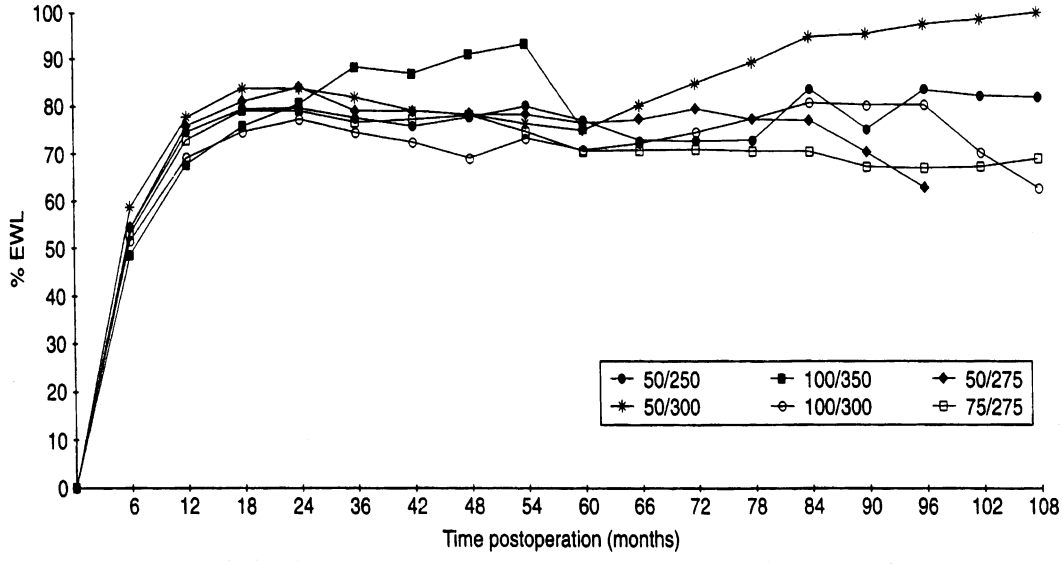

Figure 2. Weight loss with duodenal switch for various combinations of common channel and enteric limb lengths. (From: Hess DW, Hess DS. Biliopancreatic diversion with a duodenal switch. Obes Surg 1998;8:267–282, with permission.) EWL, excess weight loss.

tionally, the surgeon loses the ability to visualize, and when obstructed, to drain the distal stomach and duodenum.

The gastric bypass was developed by Mason and Ito[9] in 1966, utilizing a divided stomach. Alden's successful 1977 series[10] used gastric cross-stapling. Griffen and associates[11] also in 1977, published the first series using the Roux modification. In a 1985 paper from our group,[12] we demonstrated by endoscopic, chemical, and histologic analyses that Roux reconstruction was superior to the loop reconstruction in minimizing bile reflux and mucosal changes secondary to the bile reflux. Over the next few years, several variations of the gastric bypass were introduced, with Linner and Drew[13] returning to the original divided stomach operation to avoid staple-line dehiscence.

Long-limb gastric bypass

In 1987, Torres and Oca[14] reported on revision of failed Roux gastric bypasses by lengthening the Roux limb, enhancing the malabsorptive element of the procedure. This operation was popularized in 1992, by Brolin and colleagues[15] as a primary procedure in the super obese. They defined super obese as 200 pounds or more overweight and defined long-limb as 150 cm (in contrast to their standard limb of 75 cm). Over 7 years, with 45 patients in the series, the IEWL at 24 months was 64% for the long-limb patients, in comparison to 50% with the standard limb. The complications in the long-limb group were no different from those in the standard group. Today, myriad surgeons use the long-limb Roux gastric bypass for super obese patients, but current emphasis is not so much on the length of the Roux limb, but rather on the length of the common channel distal to the Roux limb enteroenterostomy to the biliopancreatic limb.

Laparoscopic gastric bypass

Probably, the major innovation in bariatric surgery is the laparoscopic revolution. In the aftermath of laparoscopic cholecystectomy and laparoscopic Nissen fundoplication, nowhere in this new surgical age of cameras, television screens, foot-long-plus instruments, and abdominal puncture sites has the impact of laparoscopic techniques been more manifest than in bariatric surgery. As already stated, every bariatric surgical procedure is now being performed laparoscopically. The most prevalent laparoscopic bariatric procedure in the United States is the gastric bypass.

Laparoscopic bariatric surgeons claim they are performing the standard bariatric procedures laparoscopically. But the inevitable variations in technique dictated by the laparoscopic approach can affect outcomes—affirmatively and negatively. For example, Wittgrove and colleagues,[16] in 1994, originally introduced the anvil of the end-to-end stapler into their upper divided gastric

Table 1. Summary of Data from Nguyen and Associates[21]

Variables	Laparoscopic gastric bypass	Open gastric bypass	p Value
Mortality	0	0	
Operative time (min)	225 ± 40	195 ± 41	<0.01
Leak	1.3%	2.6%	0.61
Wound infection	1.3%	10.5%	0.02
Incisional hernia	0.0%	6.6%	0.02
Anastomotic stricture	11.4%	2.6%	0.06
IEWL at 1 year	68%	62%	NS

IEWL, initial excess weight loss.

pouch endoscopically. Their procedure was modified by de la Torre and Scott,[17] in 1999, by the introduction of the anvil intraabdominally, to allow greater precision in anvil placement, and to avoid esophageal complications. And, Higa and coworkers,[18] also in 1999, in an attempt to avoid the relatively high incidence of laparoscopic gastrojejunostomy leaks, described a technique for hand-sewing this anastomosis.

In a 2000 publication, Wittgrove and Clark[19] reported 6 years of experience in 500 patients. Their IEWL at 1 year was 80%, their mean operative time approached 90 minutes, they had no operative deaths, and their main complications were intraabdominal bleeding (0.8%) and gastrojejunostomy leaks (2.5%). Schauer and associates,[20] also in 2000, reported on two and a half years of experience in 275 patients. Their IEWL at 2 years was 83%, with a mean operative time of 260 minutes, an operative mortality of 0.4%, an intraabdominal bleeding rate of 2.2%, and a gastrojejunostomy leak rate of 4.4%.

In a randomized study of outcomes after laparoscopic and open gastric bypasses, Nguyen and colleagues[21] presented, in 2001, a 155-patient series (79 laparoscopic, 76 open) with 2 years of followup. Their results are summarized in Table 1. In essence, the IEWL at 1 year was fairly similar in the two groups: 68% in the laparoscopic group and 62% in the open group. Mean operative time for the laparoscopic operation (225 ± 40 minutes) exceeded that for the open operation (195 ± 41 minutes). Relative complications were as one would expect with one exception: the late anastomotic stricture rate of 11.4% in the laparoscopic group, as compared with 2.6% in the open group ($p = 0.06$). A flaw in their study design was that the laparoscopic bypasses were performed by one senior surgeon; the open bypasses, by resident surgeons.

PURELY RESTRICTIVE PROCEDURES

Historical beginnings

Purely restrictive operations, as a rule, can be performed more rapidly than gastric bypasses, and they are more physiologic, ie, swallowed food is not rerouted, but only temporarily retained in the upper gastric pouch to induce satiety. Mason not only initiated gastric bypass, but, in association with Printen, performed the first purely restrictive bariatric procedure in 1971.[22] This first gastroplasty consisted of a horizontal gastric division leaving a greater curvature conduit. In 1981, Fabito[23] performed the first stapled vertical banded gastroplasty and reinforced the outlet with seromuscular sutures. Concurrently, Laws and Piatadosi were probably the first to use a silicone elastomer ring as a permanent, nonexpandable constriction for the gastroplasty outlet.[24] In 1980, Mason[25] introduced his last gastroplasty variant—a vertical gastroplasty with a Marlex mesh band wrapped around the outlet channel through a gastric window constructed with the end-to-end stapler. At least half of the vertical banded gastroplasties being performed today use this construction. The remainder use the Eckhout, Willbanks, and Moore[26] modification of Laws' silicone elastomer ring vertical gastroplasty. Fobi[27] combined gastric bypass and a silicone elastomer ring gastroplasty, and later added gastric division with jejunal Roux limb interposition.[28] A complete overview of the historical development of the bariatric surgery procedures will be available.[29]

Laparoscopic vertical banded gastroplasty

In 1994, Hess and Hess[30] and, in 1995, Chua and Mendiola[31] performed the Mason vertical banded gastroplasty laparoscopically. Näslund and coworkers[32] published a 60-patient series, with 3 years of experience, of laparoscopic vertical banded gastroplasties, using the

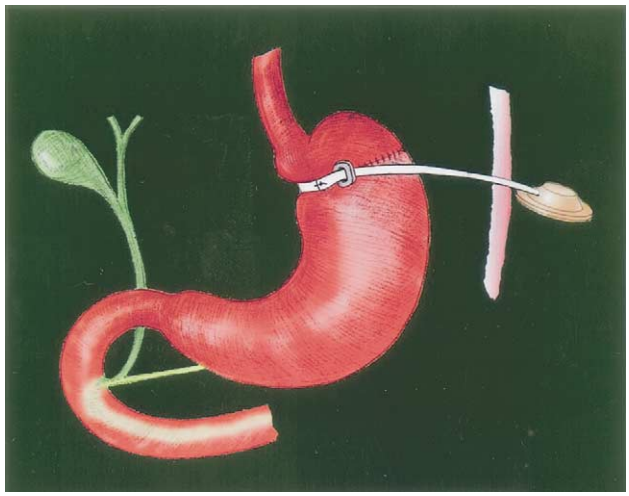

Figure 3. Kuzmak: Silicone elastomere ring adjustable gastric band, 1986.

Mason technique. Their operative time averaged 126 minutes, with no operative deaths. They reported a decrease in the initial body mass index (BMI, as kg/m^2) of 11.7% (they do not give weight loss in IEWL units). Their conversion rate to an open procedure was extremely high: 25%.

Gastric banding

Of all the purely restrictive gastric procedures, gastric banding, or simply placing a gastric band around the upper stomach, is the least invasive, because a small pouch and a small stoma are created in one step. The stomach is not cut or crushed by staples, no anastomoses are made, and the natural, physiologic passage of food is not altered.

Wilkinson and Peloso (1978),[33] Kolle (1982),[34] and Molina and Oria (1983)[35] can be credited with initiating gastric banding. Kusmak (1986)[36] introduced the inflatable silicone elastomer band connected to a subcutaneous port, which can be used for the percutaneous introduction or removal of fluid to adjust the caliber of the contricting gastric band (Fig. 3). Catona and colleagues[37] (1993) adapted the procedure to a laparoscopic approach, and Forsell and associates[38] (1993) were the first to place an adjustable gastric band laparoscopically.

Rarely has an operation been greeted with as much approbation and condemnation as has gastric banding. Rarely has as much literature been generated about an operation—numerous articles on how I do it, others on how I do it better, how I have fewer problems, how problems are inevitable, how this is the best and worst of all bariatric procedures. In Europe, where the majority of these operations have been done, the debate has taken on almost nationalistic proportions. In Sweden, where the Swedish Adjustable Gastric Band (Obtech Medical AG, Baar, Switzerland) is the most-used gastric band prosthetic, there is cautious approval and some disenchantment. In Italy, there is, as a rule, rave acceptance of the Lap-Band (Bioenterics Corporation; Carpinteria, CA), the other commonly available band prosthetic. In the United States, there has only been limited use of the Lap-Band in a FDA-sanctioned clinical trial.

Three landmark papers provide an overview of available knowledge and opinion in this field: From Australia, a country that supports gastric banding, O'Brien and associates[39] reported on 4 years of experience with 277 patients receiving the Lap-Band. The IEWL at 1 year was 51% and, unlike most series in the bariatric surgery literature, the weight loss progressed over time to an IEWL of 68.2% at 4 years. The operative mortality was 0%, with a 1.8% conversion rate. Their main complication was gastric prolapse leading to an increased pouch capacity, followed by gastric obstruction (9%).

In 2001, the 25-author Italian Collaborative Study Group[40] reported on 5 years of experience with the Lap-Band in 1,265 patients. Their weight loss at 2 years, reported as a percentage reduction in the BMI, was 30.8%. Their operative mortality was 0.55%, with a 1.7% conversion rate. They cited as their major complications pouch dilation (5.2%), band erosion (1.9%), and port or tube problems (4.2%).

A much-quoted negative report was that of DeMaria and others,[41] who published independently of the other six centers in the United States Lap-Band trial. With 37 patients and 4 years of followup, they reported a 37 ± 2.3% decrease in the IEWL at 2 years (equivalent to a 16.9% decrease in the BMI); African-American women had the poorest results. The operative mortality was 0%, with a conversion rate of 2.7%. They were distressed with their complications: band leakage in 5.4% (n = 2), infection in 5.4% (n = 2), band slippage in 8.1% (n = 3), and, primarily, esophageal dilation in 71% (18 of 25 patients measured). But of these 18 patients, only 2 (8%) had the band removed for symptoms of reflux. In all fairness, there were too few patients in this series, with no allowance for a learning curve, and too many surgeons (n = 3), none of whom had any previous laparoscopic bariatric surgery experience. The report of all seven centers, or of the other six centers, in this study has

yet to be published. The IEWL results from the other six centers might not differ markedly from those of DeMaria, and colleagues. In any event, the role of gastric banding with respect to the spectrum of morbidly obese patients will require further assessment. On June 5, 2001, the FDA approved the Lap-Band for limited distribution.

OTHER PROCEDURES

Historical beginnings

Among historical metabolic surgical procedures there was stereotaxic stimulation and electrocoagulation of sites in the lateral hypothalamus by Quaade and colleagues in 1974.[42] Using current technology, this approach may warrant revisitation.

Robotics

In 1999 Cadiere and colleagues[43] reported the first laparoscopic band placement performed robotically.

Pacing

Gastric pacing[44] and vagal pacing[45] have been tested in animals and in preliminary human trials. The rationale or chemophysiologic hypothesis for these approaches is that inducing gastric paresis, efferent vagal central nervous system stimulation, or both, will induce satiety. It is too early to pass judgment on these relatively simple, quickly performed electrical stimulation procedures.

PREVALENCE OF MORBID OBESITY

Obesity and morbid obesity have reached epidemic proportions in the United States and in many parts of the western world. According to a summation of the National Health Examination Survey (NHES I: 1960-1962) and the National Health and Nutrition Examination Survey (NHANES I: 1971-1974; NHANES II: 1976-1980; NHANES III: 1988-1994), the prevalence of obesity (BMI $\geq$ 30) geometrically increased to 22.5% in 1994, from 12.8% in 1962, in the 20- to 74-year age-adjusted population.[46] This translates to one of approximately every four individuals aged 20 to 74 years. Accelerating trends for Class II morbid obesity (35.0 $\leq$ BMI $\leq$ 39.9), Class III morbid obesity (BMI $\geq$ 40), and Classes II and III combined are depicted in Figure 4. The 1988-1994 figure for individuals, age 20 to 74 years, with a BMI $\geq$ 35 was 8.1% or about 1 of 12 in this population cohort. Based on the Flegel and associates report,[46] the Monteforte and Torkelson analysis,[47] and

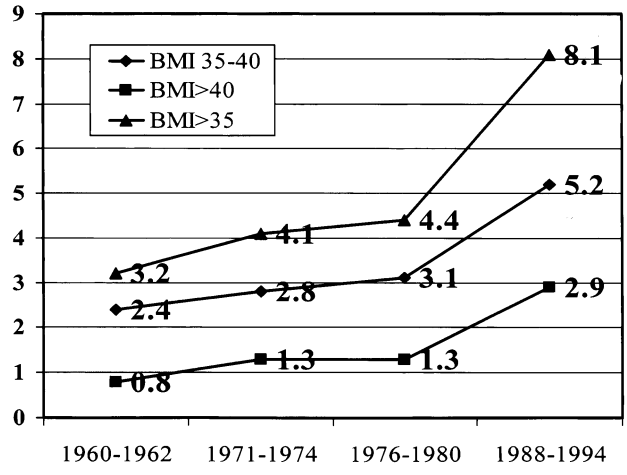

Figure 4. Prevalence of obesity: National Health Examination Survey (NHES) and National Health and Nutrition Examination Surveys (NHANES) reports 1960-1994, age adjusted (20 to 74 years); based on Flegal and associates.[46] BMI, body mass index.

the 2000 US census[48] an estimated 10 million people in the United States have a BMI between 35 and 40, and an additional 5 to 6 million have a BMI $\geq$ 40. A recent random telephone survey confirms the NHANES data and estimates that the prevalence of obesity (BMI $\geq$ 30) in the United States is now 19.8% of individuals over age 18 (1 of 5).[49]

COMORBIDITIES OF MORBIDITY OBESITY

Comorbidities of morbid obesity affect essentially every organ system: cardiovascular (eg, hypertension, coronary heart disease); respiratory (eg, asthma, sleep apnea); metabolic (eg, diabetes, dyslipidemia); musculoskeletal (eg, osteoarthritic hips, etc); gastrointestinal (eg, cholelithiasis, cirrhosis of the liver); endocrine and reproductive (eg, cancer of the uterus, cancer of the breast); dermatologic (eg, intertriginous dermatitis); neurologic (eg, pseudotumor cerebri); and psychological (eg, depression).[50,51] In our society, obesity and morbid obesity pose social, marital, and sexual problems because obese people are ridiculed, shunned, and, somehow, considered incapable and intellectually inferior.[52] Obesity is also an economic problem associated with denial of employment, restriction of career advancement and higher educational opportunities, and uninsurability or requisite high insurance premiums.[53] Truly, morbid obesity is a life-enveloping and life-denying affliction. It can be stated with assurance that morbid obesity is second only to cigarette smoking as the underlying cause of death in the United States.

BARIATRIC SURGERY PREDICTIONS, 2001-2011

Surgical practice

The American Society for Bariatric Surgery estimated that approximately 40,000 bariatric surgery procedures were performed in 2000. Given the previous prevalence data and the steep incline in the slope of the incidence plot for obesity and morbid obesity, even a doubling or tripling of bariatric procedures and bariatric surgeons will barely dent the therapeutic need and demand. Because there is no immediate indication on the horizon of the availability of a highly effective and safe pharmaceutical to induce satiety or, in other ways, combat obesity, bariatric surgery is likely to become one of the mainstays of general surgery. Every major hospital will be performing bariatric surgery. Every day one or more bariatric procedures will be on operating room schedules.

Over this decade, bariatric surgery will shift from primarily open surgery to laparoscopic surgery. The ancillary procedures now performed for some bariatric patients by the open technique (eg, closure of esophageal hiatus, cholecystectomy, ventral hernia repair) can and will be done through the laparoscope. Revisional laparoscopic surgery after primary laparoscopic surgery is also feasible because there are fewer adhesions after primary laparoscopic surgery. There will, however, always be some cases of dense abdominal adhesions for which neither primary nor revisional laparoscopic surgery is possible and laparotomy will be necessary. Because lysis of adhesions complicates and often greatly increases the degree of difficulty of an abdominal operation, bariatric surgeons, or at least certain bariatric surgeons, will need to retain their capacity to perform highly demanding open bariatric procedures.

Academic training

Supply gravitates to meet demand. In certain academic centers bariatric surgery has become an integral part of general surgery residency training programs, and of minimally invasive surgery training programs as well. In this decade, the distinction between general surgery training programs and minimally invasive surgery training programs will become blurred and, eventually, disappear. Already, no resident surgeon needs to spend extra time in a minimally invasive program to learn how to perform a laparoscopic cholecystectomy. Similarly, residents will soon be learning laparoscopic bariatric surgery during their 5 years of clinical general surgery training. Indeed, bariatric surgery, with and without laparoscopic procedures, can well save general surgery training programs from becoming the equivalent of preparatory or preliminary programs for the real world of surgical practice.

The basic principles and techniques of gastric and intestinal surgery are being taught in bariatric surgery. Surgery for the morbidly obese has become, for today's surgical residents, what ulcer surgery, cancer surgery, and inflammatory bowel disease surgery was for earlier generations of trainees. Rather than resisting exposure to bariatric surgery, as residents have done in the past, today's surgical residents vie for operating room time in bariatric procedures.

Research in bariatric surgery is a natural for the advocates of the new discipline of outcomes research. Bariatric patients tend to live a long time after their procedures, allowing for longterm followup. They have numerous comorbidities to track and to record for improvement and cure; they have complications to follow; and they have a precise measurement (change in weight) of success or failure for compilation and statistical assessment.

Basic clinical research is extremely well-suited to bariatric surgery. Potential research projects in this population abound. Certain diseases, such as type 2 diabetes, can be uniquely studied, in a relatively short time frame, in morbidly obese individuals undergoing bariatric surgery. The marked weight loss seen within 3 months after bariatric surgery causes type 2 diabetes to disappear, affording researchers a splendid chance to study the pathophysiology of peripheral insulin-resistant diabetes.

Algorithm

Though many in the field of bariatric surgery are striving to find the perfect procedure—one that is totally effective, safe, and lasting—it is doubtful that a single such operation will be found and will become the standard of care in the field. Many bariatric surgeons currently perform only a single bariatric procedure, even though a spectrum of well-tested bariatric procedures is available. Bariatric specialists should certainly be able to perform more than one operation.

An algorithm can be extremely helpful in selecting the most appropriate operation for a given patient. Such an algorithm needs to take into consideration weight, age, gender, comorbidities, race, nationality, body habitus, outcomes expectations, operative safety, side effects, and

longterm complications. An operative algorithm is what is needed and what will be new in bariatric surgery 2001–2011.

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