Patient Preparation for Bariatric Surgery

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Foreword

It is my great honor to have been invited to write the Foreword for *Patient Preparation for Bariatric Surgery*. This book, edited by a dear friend and mentor, and one of the forefathers of bariatric surgery, is a comprehensive review of the patient preparation process for bariatric and metabolic surgery. Numerous journal articles and books have been published in this ever-growing surgical specialty, but few have focused specifically on the patient preparation process. For those of us working in this field, we understand and greatly value the importance of ensuring that all three components, patient, surgeon, and the Allied Healthcare team in all Centers of Excellence, are well prepared for this life-changing surgery.

Within the 14 chapters of this book, Dr. Benotti has used his clear vision and understanding of the bariatric patient in conjunction with his vast knowledge, experience, and expertise to discuss a wide array of issues related to patient preparedness. These include chapters spanning topics from primary care referrals and the often-encountered difficulties that these physicians experience when dealing with severe obesity to anesthesia considerations for these challenging operative patients.

Specifically, in the introductory chapter, Dr. Benotti provides the history and evolution of bariatric surgery and public awareness of the disease of obesity and its surgical treatment. Following this, the second chapter discusses the importance of patient referrals from primary care physicians and the need for specific guidelines. Chapter 3 focuses on the importance of educating the patient regarding the perioperative process and realistic expectations from bariatric surgery as well as the importance of active patient participation in the bariatric program, which should be reinforced throughout the patient education process. This chapter also addresses the need for the informed consent.

This aspect of the patient education process is critical for the patient selection process as well as assessing the patient's preparation for surgery. Dr. Benotti stresses the crucial need for patients to make decisions on the basis of relevant information, which is presented clearly and well understood. Failure to understand the risks and benefits of surgery will contribute to unrealistic patient expectations and potential litigation.

Chapter 4 addresses the need for a thorough initial medical evaluation. Assessing functional status and capability for physical activity is emerging as an important component of the patient evaluation and selection process, Dr. Benotti notes. Furthermore, a simple functional assessment with metrics should be part of the initial medical evaluation. Closely related and an equally important component is a psychological and behavioral evaluation, as discussed in Chap. 5. Dr. Benotti has summarized that mental health expertise is crucial for evaluation of candidates suitable for bariatric surgery as well as for postoperative management and compliance. Chapter 6 describes the initial medical evaluation, which should be conducted by a physician who is familiar with obesity-related comorbid conditions contributing to surgical risk.

Chapters 7 and 8 focus on proper nutrition, specifically protein and vitamins, as well as minerals, respectively. Changes in the gastrointestinal anatomy after bariatric surgery result in altered absorptive capability for minerals as well as protein and vitamins. This can result in protein, micronutrient, and mineral deficiencies, which are well-known complications after bariatric surgery. Chapter 9 addresses pregnancy and the association between obesity and increased reproductive risk.

Chapters 10 and 11 relate to therapeutic and diagnostic endoscopy. Endoscopy has emerged as a treatment option for nonoperative management of complications after bariatric surgery. Therapeutic endoscopy is an emerging field related to endoscopic interventions for weight loss.

Chapter 12 addresses risk assessment, a critical component in healthcare today, not just for bariatric surgery but for all aspects of medical care. Large clinical registries and databases have helped to identify patient factors that predict increased surgical risk, which help bariatric surgery programs to identify surgical risks. Chapter 13 discusses how to manage high-risk patients once they are identified. Chapter 14, the concluding chapter, is related to anesthesia challenges for bariatric surgery patients.

I am certain that this comprehensive textbook will become a great resource for bariatric surgeons and physicians as well as all allied health professionals who care for patients with extreme obesity. I personally look forward to adding this to my library.

Weston, FL Raul J. Rosenthal, M.D., F.A.C.S., F.A.S.M.B.S.

Preface

I have had the good fortune to participate in the development of bariatric surgery in the years before 1991, and in the rapid emergence of this intervention as the preferred treatment for extreme obesity. Bariatric surgery, hardly recognized by academic surgical societies as recently as 15 years ago, is now an important service line at most major medical centers, a major focus at academic surgery meetings, and a critical component of the surgical training curriculum in foregut surgery. Bariatric surgery is now widely recognized by medical specialties as a major tool for resolution of obesity-related metabolic derangements, life-threatening disease, and disability related to extreme obesity.

This text is an attempt to review the current literature and best practice recommendations regarding a patient-centered approach to the preparation and selection of candidates for bariatric surgery. It is my hope that this text will contribute to the continuing development, expanded use, and improved implementation of this important and valuable resource.

Southold, NY Peter N. Benotti, M.D.

Acknowledgement

I would like to express my appreciation to all of those teachers who contributed to my education and training in surgery and metabolism. In many challenging situations in the practice of gastrointestinal surgery, this has been for me a precious resource.

This text is dedicated to my bariatric surgery patients, in particular, those who had the courage to undergo this procedure before 1991. Years in this field have provided me with a great respect for patients suffering with extreme obesity who have the courage and determination to undergo bariatric surgery, change their lifestyle, and enjoy the benefits of a healthier life.

In conclusion, I am most grateful for the life-long love and support provided by my family throughout my career in surgery.

Peter N. Benotti, M.D.

Contents

Chapter 1
Introduction

Bariatric surgery has emerged as the optimal and preferred treatment for patients who suffer from health and quality of life afflictions related to extreme obesity. Considered experimental before 1991, bariatric surgery has now been widely embraced by patients and the medical community as the therapeutic potential of these procedures continues to be recognized.

During the last 15 years, this specialty, which was initially unrecognized by academic surgical societies, has emerged as an important service line for major academic and community medical centers. In addition, bariatric surgery has helped reverse the decline of general surgery and emerged as a major source of clinical material for resident training in gastric surgery.

The rapid rise in the popularity of bariatric surgery is multifactorial. The health benefits of these procedures, which provide patients with an opportunity to achieve lasting major weight loss and comorbid disease control, are now stimulating interest in studying the efficacy of these procedures as primary treatment for comorbid conditions like type 2 diabetes in patients with lesser degrees of obesity [1, 2]. Bariatric surgery has been shown to extend life expectancy and to be cost effective for those suffering from extreme obesity [3, 4]. Another important component in the emergence of bariatric surgery has been the improvement in surgical outcomes. In 1991, when bariatric surgery became an accepted treatment for extreme obesity, the best practice mortality was 0.5–1.5 % [5]. The current mortality rates derived from large clinical registries are 0.1–0.2 % [6–8]. These improved outcomes have been achieved despite the development of, and transition to, minimally invasive approaches to bariatric surgery.

Factors contributing to the improvement in surgical outcomes include the formulation of training and credentialing requirements for bariatric surgeons and the establishment of accredited centers of excellence. Current residency training in general surgery provides limited training in advanced laparoscopy, with a minimum of 25 cases required for board eligibility in surgery. During surgical residency training, the exposure of learners to bariatric surgery is also limited because most busy bariatric programs in academic medical centers have dedicated fellows and physician's assistants who routinely participate in the surgical procedures in place of surgical residents. Laparoscopic bariatric surgery procedures are one of the more technically challenging

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Table 1.1 Key elements of fellowship training in bariatric surgery

• Focused experience in minimally invasive bariatric surgical procedures by achieving the case volume equivalent to master the learning curve
• Regular interaction with all members of the multidisciplinary team caring for extreme obesity to gain familiarity with evaluation and management of extreme obesity
• Interaction with dedicated medical subspecialty consultants
• Develop familiarity with the entire scope of bariatric surgery care as a result of involvement in all aspects of the bariatric surgery program

advanced minimally invasive operations with a learning curve ranging from 75 to 100 cases [9, 10]. A case volume sufficient to master the learning curve is currently only available in the 130 current Minimally Invasive and Bariatric Surgery Fellowships [11]. The important learning elements of fellowship training in bariatric surgery are shown in Table 1.1. Despite concerns about patient safety in a training environment, several studies have demonstrated an association between fellowship training in bariatric surgery and improved outcomes [12, 13].

In addition to the formalization of the training curriculum for bariatric surgeons, guidelines for granting privileges in bariatric surgery were developed in 2003 by the American Society for Metabolic and Bariatric Surgery (ASMBS) [14] and updated in 2005. In an effort to improve quality control, to coordinate a more disciplined development, and to establish outcome benchmarks for bariatric surgery, a Centers of Excellence program was launched by the ASMBS in 2003 as a mechanism for the accreditation of bariatric surgery centers. Similarly, the American College of Surgeons (ACS), hoping to extend the quality improvement processes originally developed for trauma and cancer care to bariatric surgery, instituted its own credentialing program for bariatric surgeons and programs.

Both of these programs evolved independently until April 2013, at which time they were combined to form the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP). Institutions, bariatric programs, and bariatric surgeons who meet the requirements apply for and receive provisional approval. This is followed by a site visit where surgical outcomes data, program policies and procedures, program personnel, and facility resources are reviewed in detail. Successful completion of the detailed site visit allows for final approval as a recognized center of excellence. The large clinical bariatric surgery registry, derived from the outcomes data submitted by each center, will provide benchmarks for quality assessment and improvement. The requirements for application for credentialing as a bariatric center of excellence are summarized in Table 1.2.

Increasing awareness of the proven health benefits and improved outcomes in bariatric surgery have resulted in a rapid increase in the number of these procedures performed in the USA since 1991 (Fig. 1.1).

An important contributor to the rapid rise in the popularity of bariatric surgery is the major health problem posed by the increase in the prevalence of obesity during the last several decades. At present, about 1/3 of the US population is obese as defined as a body mass index (BMI) $\geq$30 kg/m^2 and 5 % of the population suffers from extreme obesity defined as a BMI of $\geq$40 kg/m^2 [15, 16]. This epidemic rise in

Table 1.2 The basic requirements for designation as a Center of Excellence in Bariatric Surgery

Criteria for accreditation as a Level I Bariatric Center
Institutional requirements
• Full service-accredited hospital
• Established bariatric surgical program to provide outcome data
• 125 primary weight loss operations during the preceding 12 months
• Director of bariatric surgery
• Bariatric surgery coordinator
Surgeon requirements
• Board certification or board eligibility who meet training requirements
• ≥100 weight loss operations over previous 24 months
• Meet surgeon-credentialing criteria
• Bariatric-specific call schedule with experienced surgeons
Services
• Multispecialty services (pulmonary, cardiology, ICU, infectious disease, nephrology, psychiatry, gastroenterology, thoracic surgery, vascular surgery, imaging and interventional radiology, anesthesiology, endoscopy, minimally invasive surgery)
Facility requirements
• Full service operating rooms with minimally invasive bariatric surgery capabilities
• Post-anesthesia care unit (PACU) personnel equipment for care of morbid obesity and nursing experience in obesity
• Emergency room staffed with emergency room physicians
• Patient accommodations for extreme obesity
Processes
• Mandatory data collection and outcome reporting
• Quality improvement program
• Evidence-based clinical pathways
• Multidisciplinary protocols for patient education, counseling, and informed consent
• Dietary counseling
• Evidence-based protocols for discharge and follow-up

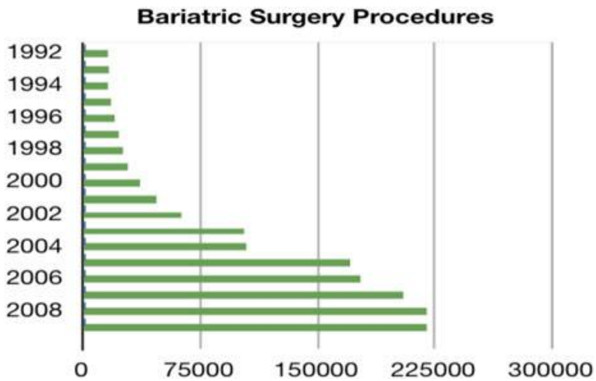

Fig. 1.1 The rapid increase in bariatric procedure volume: 1992–2008

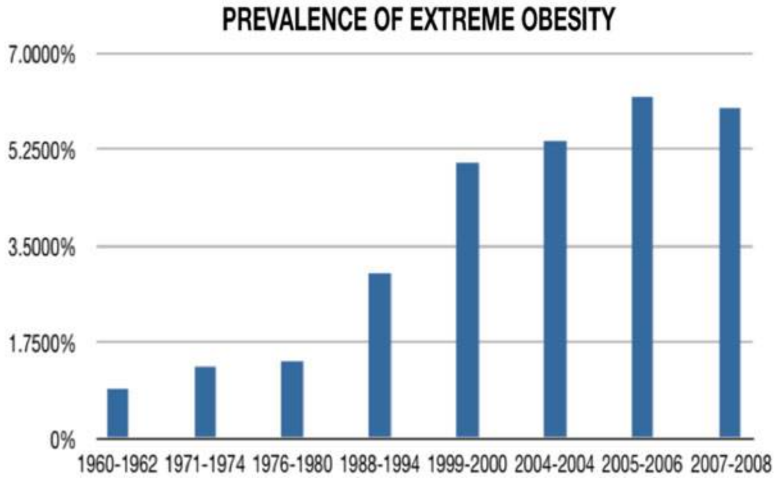

Fig. 1.2 The increase in the prevalence of extreme obesity: 2007–2008

obesity has stimulated national attention to this public health issue, and the American Medical Association has recently recognized obesity as a disease. Of importance to bariatric surgeons is the fact that rates of extreme obesity have increased at a much greater rate during the interval between 1986 and 2000 (Fig. 1.2) [17].

Recent data indicate that the rapid increase in bariatric surgery procedures has slowed during the last several years [18]. This apparent "leveling off" of procedure numbers may be related to the recent economic climate and the reluctance of payers to support a procedure, which costs an estimated $25,000. It may also be related to the media attention given to patients with unfortunate outcomes, which has created a public expectation of zero adverse outcomes [19].

Census data indicates that 5.1 % of the US population suffers from extreme obesity [16], meaning that about 17 million individuals are potential candidates for this treatment. It is expected that 250,000 bariatric procedures will be performed in 2012, which indicates that only 1.5 % of the eligible population will have access to this treatment at present. In the current era of limited patient access to bariatric surgery and economic constraints, adverse postoperative outcomes and longer term patient struggles with complications and weight loss failure continue to detract from the true value of this treatment.

The challenge for the next era of bariatric surgery is to improve outcomes, and control costs, thereby improving the value of this treatment modality. Opportunity for outcome benefits lies not so much in improving the quality of surgical care, as we have accomplished a great deal in this area during the last decade. Today's challenge is to improve the patient and procedure selection process by improved patient-specific risk assessment both for safe surgery and for effective long-term health success. Essential components of the patient-centered preparation for bariatric surgery will be discussed in the following chapters. The goals of patient-centered preoperative preparation process in bariatric surgery are summarized in Table 1.3.

Table 1.3 Goals of patient-centered preparation for bariatric surgery

• To confirm that bariatric surgery is indicated for the patient and that the benefits of lasting weight control outweigh the risks of surgical complications and weight loss failure
• To identify and characterize those comorbid conditions which will adversely affect surgical risk and to intervene before surgery to reduce the risk as well as select the safest procedure when necessary for high-risk patients
• To identify and treat conditions which may diminish the probability of successful long-term weight control and safe nutrition

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Chapter 2
Indications and Patient Referrals for Bariatric Surgery

Indications and Patient Access

The current indications for bariatric surgery are derived from the findings of a National Institute of Health (NIH) Consensus Conference convened in 1991, which established the current criteria for eligibility for bariatric surgery (Table 2.1) [1]. These guidelines, which are primarily based on body mass index (BMI), adequately reflect the medical evidence at the time. However, increasing numbers of bariatric surgeons now feel that more up-to-date revised guidelines for eligibility for surgical treatment are badly needed [2–7].

In the 22 years since the indications for bariatric surgery were established, accumulated knowledge has provided greater insight regarding patient factors which contribute to health risks of untreated morbid obesity to surgical risks, to the risks of long-term complications, and to poor weight loss outcomes. Bariatric surgeons are now in a much better position to make triage decisions regarding surgical candidacy and identify those with the most to gain and perhaps the most to lose with weight loss surgery.

The current BMI-based system for patient eligibility for bariatric surgery does not consider medical need. In the current system, healthy patients with extreme obesity have access to surgery, while disabled patients, for whom bariatric surgery may be the best practice recommended treatment, are frequently denied access to surgery. A number of recent studies point out that the demographics of those who currently undergo bariatric surgery do not reflect the demographics of the US population with extreme obesity in regard to gender, race, obesity disease burden, socioeconomic status, and geographic distribution [2, 3, 6, 7]. A recent study compared a large cohort of patients ($n = 22{,}151{,}116$) eligible for bariatric surgery from the National Health and Nutrition Examination Survey with a cohort ($n = 87{,}749$) who actually underwent bariatric surgery using the 2006 Nationwide Inpatient Sample. This study found significant disparities between the two cohorts in regard to gender, race, insurance coverage, socioeconomic status, and comorbid disease burden [3].

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Table 2.1 Established patient criteria for eligibility for bariatric surgery [1]

National Institute of Health (NIH) criteria for bariatric surgery:

- Motivated patients with body mass index (BMI) ≥40 kg/m^2
- Failure of medical weight loss treatment
- BMI 35–40 kg/m^2 with severe comorbid conditions, which are life threatening or interfere with employment and family function

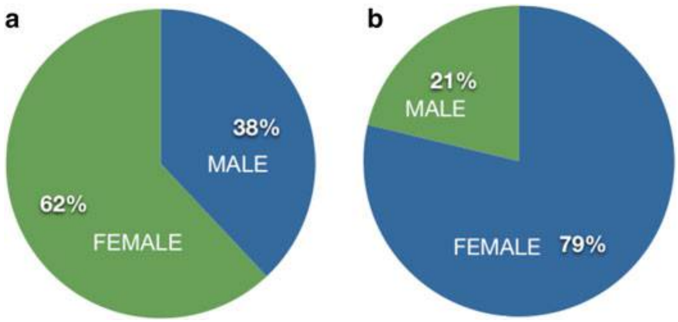

Fig. 2.1 (**a**) Gender distribution among patients eligible for bariatric surgery as determined from census data. Adapted from Martin M, Beekley A, Kjorstad R, et al. Socioeconomic disparities in Eligibility and Access to Bariatric Surgery: a National Population-based Analysis. Surg Obes Relat Dis 2010;6:8–15 [3]. (**b**) Gender distribution among patients who undergo bariatric surgery as determined from a large clinical registry. Adapted from DeMaria E, Pate V, Warthen M, Winegar D. Baseline data from American Society for Metabolic and Bariatric Surgery-designated Bariatric Surgery Centers of Excellence Using the Bariatric Outcomes Longitudinal Database. Surg Obes Relat Dis 2010;6:347–355 [8]

The population characteristics of those eligible for bariatric surgery [3] are compared with the characteristics of bariatric surgery patients from a large clinical registry of 57,918 patients [8] in relation to gender (Fig. 2.1a, b) and race (Fig. 2.2a, b) [3, 8]. The disproportionate access of Caucasians to bariatric surgery at the expense of eligible Afro-Americans is confirmed in other studies of socioeconomic mismatch in bariatric surgery [2, 6].

Additional comparisons of patient characteristics between the bariatric eligible population as determined by national census data and patients actually receiving bariatric surgery reveal additional disparities in regard to insurance status (Fig. 2.3a, b) [3], level of income, and prevalence of metabolic syndrome (Fig. 2.4) [3]. The distribution of bariatric surgery patients by BMI includes a relatively small fraction of the total patients with BMI ≥ 50 kg/m^2, despite the fact that the prevalence of superobesity has increased at a much greater rate in recent years and is accompanied by greater health risks (Fig. 2.5) [2, 8, 9].

These results indicate that the population currently receiving bariatric surgery is predominantly Caucasian, female, young, and privately insured; with high incomes and a relatively low BMI; and is not truly representative of the bariatric eligible

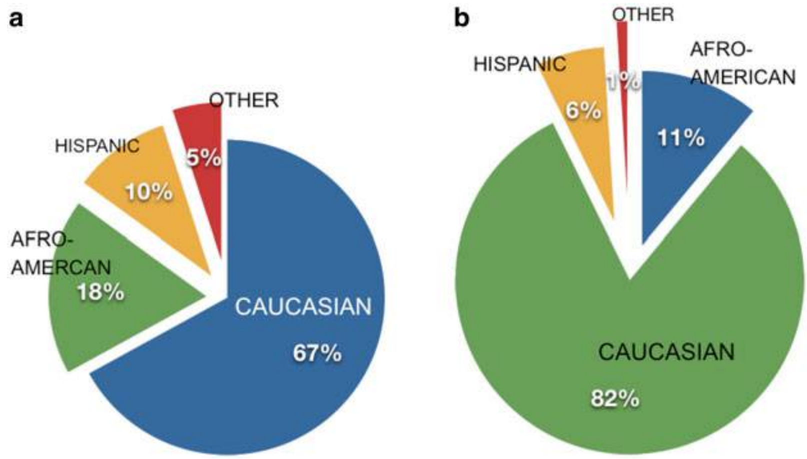

Fig. 2.2 (**a**) Race distribution among those eligible for bariatric surgery as determined from census data. Adapted from Martin M, Beekley A, Kjorstad R, et al. Socioeconomic disparities in Eligibility and access to Bariatric Surgery: a National Population-based Analysis. Surg Obes Relat Dis 2010;6:8–15 [3]. (**b**) Race distribution among those who undergo bariatric surgery as determined from a large clinical registry. Adapted from DeMaria E, Pate V, Warthen M, Winegar D. Baseline Data from American Society for Metabolic and Bariatric Surgery-designated Bariatric Surgery Centers of Excellence Using the Bariatric Outcomes Longitudinal Database. Surg Obes Relat Dis 2010;6:347–355 [8]

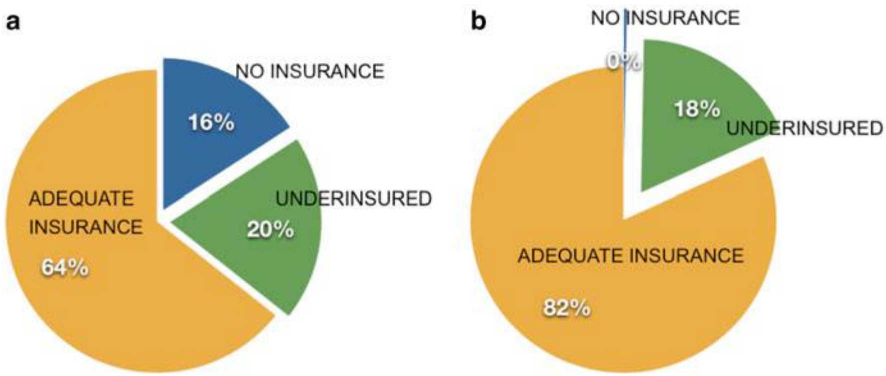

Fig. 2.3 (**a**) Insurance status among patients eligible for bariatric surgery as derived from census data. (**b**) Insurance status among those who undergo bariatric surgery. Adapted from Martin M, Beekley A, Kjorstad R, et al. Socioeconomic disparities in Eligibility and Access to Bariatric surgery: a National Population-based Analysis. Surg Obes Rel at Dis 2010;6:8-15 [3]

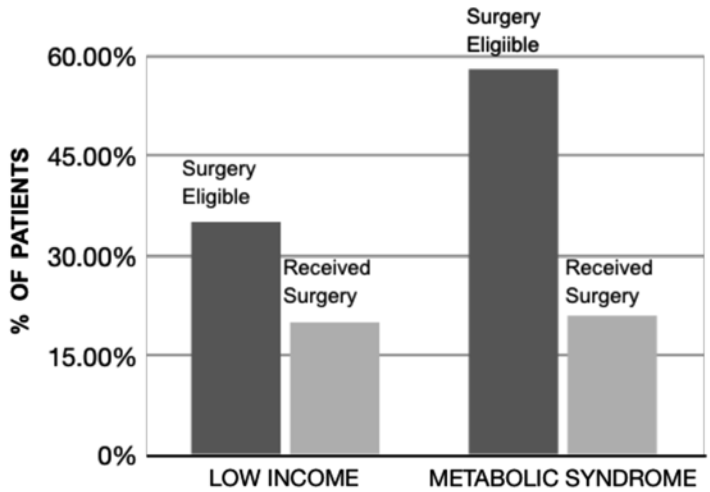

Fig. 2.4 Comparison of income status and prevalence of metabolic syndrome in those eligible for bariatric surgery versus those who actually undergo the surgery. Adapted from Martin M, Beekley A, Kjorstad R, et al. Socioeconomic disparities in Eligibility and Access to Bariatric surgery: a National Population-based Analysis. Surg Obes Rel Dis 2010;6:8–15 [3]

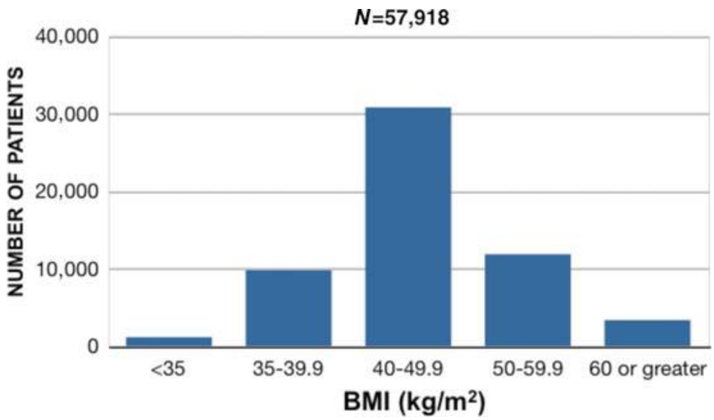

Fig. 2.5 Body mass index (BMI) distribution of those who undergo bariatric surgery as determined by a large clinical registry. Adapted from DeMaria E, Pate V, Warthen M, Winegar D. Baseline Data from American Society for Metabolic and Bariatric Surgery-designated Bariatric Surgery Centers of Excellence Using the Bariatric Outcomes Longitudinal Database. Surg Obes Relat Dis 2010;6:347–355 [8]

population. The current criteria for bariatric surgery eligibility and the limited patient access to surgery exclude large numbers of deserving minority patients who have limited education, limited income, and poor insurance coverage. For many of these excluded patients, bariatric surgery is not merely a treatment option, but the preferred best practice recommendation [4].

The profound limitations and inequalities in patient access to bariatric surgery in the face of increasing numbers of disabled patients with extreme obesity constitute a crisis in public health. Insurance reform policies designed to equalize access to bariatric surgery are clearly needed. Impoverished and poorly insured individuals who suffer from extreme obesity continue to obtain healthcare despite the unavailability of bariatric surgery. In a recent survey of 478 experienced physicians from six medical specialty areas, the respondents indicated that one in five patient visits relate to some condition related to extreme obesity [10]. In addition, additional information indicates that healthcare visits to clinics and emergency rooms as well as hospital admissions will continue for patients with extreme obesity in the absence of improved access to bariatric surgery with obvious cost implications [6].

The cost of healthcare for the vast number of eligible bariatric surgery candidates who are excluded from access to surgery must be reconciled with the expanding body of evidence, which suggests that bariatric surgery is cost effective in the longer term [11–15]. A prospective randomized controlled trial comparing cost and outcomes of bariatric surgery with noninterventional treatment is unethical based on the available literature. Nevertheless, systematic study of risk-adjusted outcomes of bariatric surgery in the poor and uninsured is indicated in order to better answer this question.

The author is reminded of an earlier case series of 1,210 patients who underwent gastric bypass surgery. The average patient age was 42, and 14 % of the patients in the series had no comorbid conditions [16]. For many of the more healthy individuals in this series, the health risks associated with extreme obesity may have been minimal and the urgency of bariatric surgery open for debate. An important aspect of addressing the limited patient access to the only meaningful treatment for those with impaired health and quality of life as a result of extreme obesity is to establish a triage system for referral of bariatric surgery candidates. An obesity-scoring system based on severity of obesity health and quality-of-life impairment should be fundamental in prioritizing referrals for bariatric surgery. An analogy to the MELD scoring system for prioritizing hepatic transplantation in patients with advanced liver disease has been raised in this context [2].

A triage system for individuals with extreme obesity based on health risk and medical need[4] will complement the progress made by bariatric surgeons in surgical risk assessment and will enhance the objectivity of the patient selection process. The time has come to introduce graded levels of indications for bariatric surgery that are based on risk/benefit and medical need.

Patient Referrals and the Role of Primary Care Physicians

The majority of referrals for bariatric surgery are patient directed as potential candidates of bariatric surgery observe the therapeutic power of these procedures as they witness the life change in friends and acquaintances who have achieved meaningful weight loss. In addition, key celebrities who have undergone bariatric surgery have openly shared their experiences via the media and Internet.

Table 2.2 Reasons for failure of primary care physicians to refer eligible patients with extreme obesity for bariatric surgery

• Perceived surgical risks
• Lack of acquaintance with a local bariatric surgeon
• Referral process too complicated and time consuming
• Perceived lack of patient interest in bariatric surgery
• Preference for medical management of extreme obesity
• Excess work involved in the referral

Despite the national attention to the obesity epidemic and the emergence of multiple guidelines for obesity management for physicians, primary care physicians have had a limited role thus far in obesity care. A survey of 478 experienced physicians from six specialties revealed that 20 % of patients seen were extremely obese and that diet and exercise were advised frequently. However, bariatric surgery was the least recommended weight loss treatment even though it is the only established effective treatment for extreme obesity [10]. A survey of 12,385 patients with obesity who underwent a routine health checkup with a physician revealed that only 42 % are advised to lose weight [17]. Additional surveys of primary care physicians indicate that they commonly see and treat patients who have undergone bariatric surgery, but infrequently refer eligible patients for weight loss surgery [18–20]. Reasons for non-referral for bariatric surgery as stated by surveyed physicians are shown in Table 2.2 [10].

Despite the fact that primary care physicians frequently provide care to patients with extreme obesity and to post-bariatric surgery patients, many do not feel confident or competent to manage postoperative patients, and many have little confidence in their ability to evaluate, manage, and counsel patients with extreme obesity [10, 18–20]. This may also be a reason for reluctance to refer eligible patients with extreme obesity for bariatric surgery. Primary care physicians have limited office resources (exam tables, large blood pressure cuffs, large wheelchairs, etc.). They admit to limited ability to perform adequate physical and pelvic exams on patients with extreme obesity as well as limited time and resources for these exams [19].

Frustration and negative attitudes when dealing with extreme obesity are common among primary care physicians, because they perceive that obesity treatment is often without success and that reimbursement for obesity treatment is lacking. Survey data suggests that the level of frustration among primary care physicians when dealing with extreme obesity is inversely related to the extent of their medical knowledge in this area and that there is a real need for improved physician education in the management of severe obesity and better reimbursement for obesity care [10, 18–20]. Hopefully, the recent American Medical Association declaration of obesity as a disease may result in improved medical education and reimbursement for obesity management.

Only a minority of primary care physicians currently feel that extreme obesity is best controlled by surgery and have some familiarity with the different bariatric surgery procedures and their expected outcomes [10, 20]. Another concern for primary care providers is that many do not know a bariatric surgeon, and many are unfamiliar with the indications and results of surgical treatment [10, 20]. A recent survey of academic physicians indicates that only a small fraction of the primary care physicians and endocrinologists surveyed would recommend bariatric surgery for type II diabetic patients with BMI 30–35 kg/m^2. These physicians were similarly reluctant when asked about referral of such patients for randomized clinical trials involving bariatric procedures [21].

These concerns among primary care providers must be addressed if bariatric surgery is to assume an expanded role in the management of extreme obesity as these attitudes contribute to the current limited patient access to bariatric surgery. Bariatric treatment centers must acknowledge the important role of primary care providers in the comprehensive management of obesity and must take steps to actively engage the primary care physician in the processes of care. Improved communication is essential in order to involve and educate the referring physician in the basics of evaluating obesity and its comorbid conditions and in evidence-based treatment strategies. Bariatric treatment centers should either provide or share office resources necessary for complete evaluation of extreme obesity in order to engage community physicians in treatment of obesity.

Bariatric treatment center personnel including surgeons and supporting medical specialists must conduct local, regional, and national continuing medical education (CME) programs to instruct community physicians in the comprehensive management of obesity including comorbidity evaluation, treatment options, pharmacotherapy, physiology of weight loss, and results and complications of surgical treatment [22]. Surveys of primary care providers indicate that they have the perception that bariatric surgery morbidity and mortality rates are much higher than they actually are. Obesity treatment centers should involve bariatric physicians in the preoperative preparation for surgery and in the postoperative management. Interested bariatric physicians should be offered positions in comprehensive obesity treatment centers.

Improved collaboration between community physicians and obesity treatment centers will increase the comfort level of community physicians for obesity care and enhance referrals for surgery. The travel burden for interested patients will be reduced as more of the care can be provided in the community. During the initial development of bariatric surgery, bariatric surgeons and their consultants handled most of the evaluation for extreme obesity including diagnosis and management of comorbid disease conditions. The engagement of community physicians in obesity management will allow for improved recognition and treatment of serious comorbidity and earlier referrals for surgical treatment.

Educational outreach to the primary physicians may help to change the prevailing feeling in the medical community that severely obese individuals are lazy, unintelligent, undisciplined, and unable to make important lifestyle changes [23, 24].

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Chapter 3
Patient Education and Informed Consent

The uniqueness of bariatric surgery makes patient education and informed consent extremely important components of the preparation of candidates for surgery. Bariatric surgical interventions are not curative procedures. They do not eradicate any disease process, but simply create gastrointestinal anatomic changes, which provide patients with assistance in limiting caloric intake and absorption, thus palliating severe obesity and its associated health conditions. All bariatric surgical candidates must understand that they must assume an active participatory role in their obesity treatment in order for bariatric surgery to be successful. This active participation must involve a change in lifestyle and eating behavior as well as compliance with nutritional supplementation and follow-up visits.

Many bariatric surgery candidates and obese individual have unrealistic expectations regarding the weight loss that accompanies bariatric surgery. In one study, candidates for surgery expected to lose an average of 80 % of excess weight and would be disappointed with an average weight loss of 52 % of excess weight [1]. Similar weight loss expectations in excess of usual results were found in another study of patients participating in a variety of weight loss treatments [2]. Patients with extreme obesity who seek bariatric surgery are tired and frustrated with their impaired health and quality of life and look to the bariatric surgery team to solve their health problems and eliminate the need for regular medical care. Many do not accept the fact that they are the most important participants in their own healthcare and that improved health is a function of rational choices. Many have the mindset that their fate is solely related to genetic and environmental factors and that others must resolve their obesity issues.

The importance of active patient participation in the bariatric program should be reinforced throughout the patient education process. The fact that 10–25 % of patients who undergo bariatric surgical procedures will struggle and ultimately fail to achieve long-term weight control is, to a large extent, related to poor patient compliance and inability to make the necessary changes in lifestyle and behavior. In this era of limited access to bariatric surgery, surgical programs must improve their

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Table 3.1 Patient level factors which must be considered in detail during patient selection for bariatric surgery

Factors influencing patient selection for bariatric surgery
• Anticipated patient-specific health risks with untreated extreme obesity
• Patient-specific health problems that may not be improved or might worsen with weight loss
• Patient-specific risks of bariatric surgery and general anesthesia
• Patient-specific conditions that may influence the final health and weight loss outcome in a positive or negative way
• Patient-specific behavioral factors which might interfere with good outcome

ability to identify and select those patients who understand their involvement and are prepared to participate and be accountable in the healthy life change, for which these procedures can open the door.

Bariatric surgery candidates must understand that that the preoperative evaluation process is lengthy and requires regular education and counseling sessions as well as a thorough medical evaluation. The medical evaluation will establish the magnitude of obesity-related health risks and the safety of anesthesia and major surgery. The complete medical evaluation will include a comprehensive history and physical examination followed by additional specialty consultations as determined by the comorbid disease burden. In addition, professional evaluations from mental health experts will take place to provide information regarding the probability of a healthy outcome following the surgery. At the conclusion of this lengthy process, the patient will participate in summary discussions, where each of these important issues and the relevant findings will be presented to each candidate.

The goal of the process is to provide each candidate with detailed information regarding all factors that might argue for or against bariatric surgery (Table 3.1).

At the conclusion of the summary interview, the patient will be given specific recommendations for obesity treatment, which may include surgical treatment, additional preparation prior to surgical treatment, or alternative treatment. The patient-centered health information, which generates the final recommendation and risk–benefit decision, will be shared in detail with the candidate.

The uniqueness of bariatric surgery is related to the partnership between the bariatric surgery team and the patient, which is essential for a successful outcome. The patient education process, the detailed informed consent process, and the establishment of a partnership based on patient participation and accountability are essential components of the new era of patient-centered, quality- and value-based bariatric surgery, which will result in improved outcomes.

The bariatric team members who participate in the patient education and informed consent process must be aware of the critical importance of making an assessment of the level of motivation as this will be an important component of the patient selection process. Patients with extreme obesity seek bariatric surgery for medical, psychological or lifestyle reasons. Several studies have addressed patient motivation for bariatric surgery, and it appears that health issues in relation to comorbid disease or the prevention of comorbid disease are the dominant motivational factors [3, 4]. The results of the largest study are shown in Table 3.2 [3].

Table 3.2 Results of a survey that included 109 bariatric surgery candidates, regarding the primary reason for considering bariatric surgery

Primary reason for seeking weight loss surgery	$N=109$
Medical health	73 %
Prevention of illness	16 %
Other	4 %
Self esteem	3 %
Improve appearance	3 %
Enhance physical activity	1 %

Adapted from: Munoz D, Lal M, Chen E, Mansour M, Fischer S, Roehrig M, Sanchez-Johnsen L, Dymek-Valentine M, Alverdy J, le Grange D. Why Patients Seek Bariatric Surgery: A Qualitative and Quantitative Analysis of Patient Motivation. Obes Surg 2007;17:1487–1491 [3]

In addition, those involved in the evaluation and education process must be aware that bariatric surgery candidates may extend the truth about health and behavioral conditions. Team members should be prepared to reach out to family members in order to confirm patient related health and behavioral issues. They should look for consistency or ambivalence in the patient's apparent desire to lose weight, and reasons for seeking bariatric surgery [5].

The informed consent aspect of patient education is a critical element in the patient selection and preparation for surgery processes [6, 7]. Patients must make decisions on the basis of relevant information, which is presented clearly and understood. Failure to understand the risks and benefits of surgery will contribute to unrealistic patient expectations and potential litigation.

Candidates for bariatric surgery should understand the rationale for surgical treatment of extreme obesity. They should be made aware of the adverse effects of extreme obesity on health, longevity and quality of life. Recent data demonstrating an all-cause 10-year mortality of 2.1 % in a large cohort of patients eligible for bariatric surgery will stimulate other studies and help establish patient-specific risks of extreme obesity [8]. The potential success of surgical treatment should be compared to the results of conventional weight loss treatments. Specific patient related health risks of obesity such as age, BMI, and comorbid conditions should be discussed in terms of their contribution to increased or decreased health risks.

The current indications for surgery and eligibility criteria for bariatric surgery should be discussed as well as the variations in insurance provider interpretations of medical eligibility for surgery. Candidates should understand the different surgical procedures that are available, the pros and cons of each procedure, as well as the weight loss outcomes and potential complications of each procedure.

The risks of major surgery and general anesthesia should be discussed as well as the probabilities of specific complications including mortality in the experience of the bariatric treatment center. The surgical risks for the individual patient should be discussed in relation to age, BMI, gender, and other patient-level factors which might increase (or decrease) the risks in comparison to the commonly quoted risk probabilities reported by centers of excellence. For example, in an experienced bariatric treatment center, the surgical risks for a 32-year-old woman with a BMI of 45 and only a history of gestational diabetes are much less than those of a 55-year-old male with a BMI of 53, who suffers from systemic hypertension and obstructive sleep apnea. The recently developed risk scores demonstrate that bariatric surgical risk can vary by as much as 20-fold among patients in a given population [9, 10].

In order to clarify potential unrealistic expectations regarding weight loss, candidates for surgery should be made aware of weight loss outcomes from the bariatric center or the literature. Currently, weight loss expectations after surgery are usually presented as averages either from the literature or from the individual program. This does not take into account the large variation in postoperative weight loss outcomes, which always occurs. Each candidate should understand how individual lifestyle, behavior, mental health, and support systems might influence weight loss and health success in a positive or negative way. Patients must understand that the extent of their commitment to lifestyle change and compliance with diet, nutrition, and exercise will have a major influence on weight loss success or failure.

The process of patient education and informed consent for bariatric surgery is lengthy and labor intense. The process is much more than simply obtaining a signature, or disclosure of information. It is based on education and comprehension [6]. Information must be clearly presented in a manner simple enough for patients to understand. Language used in the informed consent process should not include medical jargon or terminology, but should be adjusted to the level of patient vocabulary. It is now apparent that limited literacy is a potential barrier to the informed consent process and may be a factor contributing to the patient access problem in bariatric surgery.

Health literacy as defined by the NIH is the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions [11]. In 2003, it was estimated that 36 % of the US population or 80–90 million individuals have inadequate health literacy skills [11]. Segments of the population where the prevalence of health literacy problems are high include older age groups, those with chronic disease, those with limited education, and racial minority groups. Impaired health literacy is associated with adverse health outcomes and increased use of emergency services.

Although health literacy and its impact on bariatric surgery have not been well studied, it is probably a major factor limiting patient access to bariatric surgery because of the complexity of the informed consent process. Cognitive ability of candidates for bariatric surgery is emerging as an important factor in the patient selection process. A recent study suggests that the level of patient income is associated with greater independent use of educational resources and improved knowledge of the risks of obesity and bariatric surgical procedures [12]. Extremely obese patients currently excluded from bariatric surgery often have the most to gain from this intervention. The challenge for bariatric programs is to develop strategies to address the health literacy problem in order to improve patient comprehension and improve compliance. Candidates with impaired health literacy may be difficult to recognize because of patient embarrassment, and the fact that these individuals are unlikely to ask questions during teaching sessions [6].

Table 3.3 Communication enhancements that have been found to improve patient comprehension of informed consent information

• Written communication
• Audiovisual and multimedia interventions
• Extended discussions and teaching sessions
• Test/feedback techniques

Adapted from: Schenker Y, Fernandez A, Sudore R, Schillinger D. Interventions to Improve Patient Comprehension in Informed Consent for Medical and Surgical Procedures: A Systematic Review. Med Decis Making 2013;31:151–173 [12]

A recent review of 44 studies of informed consent interventions and patient comprehension suggests that enhanced communication interventions will improve comprehension (Table 3.3) [13].

Successful Bariatric Programs have introduced a variety of teaching aids in order to improve and facilitate patient education. A recent randomized trial has shown that a video-based teaching aid is superior to written material in regard to knowledge, decision-making, and outcome expectations. In addition, teaching success has also been reported with Internet-based teaching aids [14, 15]. Bariatric programs should document all patient teaching sessions and the level of patient participation. Failure to attend teaching sessions may reflect a lack of patient focus and motivation and should be considered in the patient selection process [16, 17]. In situations where patient literacy seems to be affecting the informed consent process, an individualized approach involving simplification to a sixth grade vocabulary and repetition has been reported [18].

During the process, each candidate should be assessed in regard to his or her level of comprehension, and the extent of comprehension should be documented [6, 19]. Confirmation of understanding of the elements of informed consent is essential before any interventional procedure for weight loss.

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Chapter 4
Initial Medical Evaluation

The 1991 National Institute of Health Consensus Conference Statement on Gastrointestinal Surgery for Morbid Obesity recommends that a multidisciplinary team with individual expertise in internal Medicine, Surgery, Psychiatry, and Nutrition evaluate prospective candidates for bariatric surgery [1]. Because patients with extreme obesity are frequently victims of discrimination [2], bariatric treatment centers should provide the necessary resources to establish a supportive environment, which addresses the physical limitations of extremely obese patients (Table 4.1).

Candidates for Bariatric Surgery frequently receive suboptimal medical care, and many have obesity related medical or mental health conditions, which are undiagnosed or inadequately treated when come for bariatric surgery evaluation. The multidisciplinary medical team evaluating candidates for surgery must have familiarity with the health risks of obesity and a comfort level with the diagnosis, complete evaluation, and best practice management of obesity and its associated disease burden. In many medical centers, bariatric surgery programs form the cornerstone for the comprehensive multidisciplinary management of obesity.

The bariatric team must have a working relationship with specialists for timely consultations involving Upper Endoscopy, Cardiology, Pulmonary Medicine, Sleep Medicine, Endocrinology, Infectious Disease, Nephrology, as well as Thoracic and Vascular surgery. These aligned specialists must have expertise in diagnosis, comprehensive medical evaluation, prognosis, and best management of obesity related illnesses which contribute to health risks and risks of bariatric surgery. An example of this needed expertise is in the medical evaluation and management of pulmonary hypertension in bariatric surgery candidates. This condition is fairly common in patients with extreme obesity and can have a variety of causes and contributing factors. Commonly, when pulmonary hypertension is found on cardiac ultrasound in bariatric surgery candidates, cardiology or pulmonary consultants often do not make additional recommendations for workup because the condition occurring with obesity is best treated by weight loss, which means bariatric surgery. We now know that pulmonary hypertension is a proven risk factor for adverse outcomes and mortality after bariatric surgery [3, 4]. Given the new knowledge of this condition as a surgical risk factor, it would be helpful to know more about the classification, severity, prognosis,

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Table 4.1 Caregiver facility resources that provide a supportive environment for candidates for bariatric surgery

• Nearby parking, handicap parking
• Oversized wheelchairs, furniture, patient gowns, blood pressure cuffs
• Armless chairs in the patient waiting room
• Accessible examination tables
• Patient scales in a private area

and physiological consequences of this condition in order to make informed recommendations regarding the safety of interventions for obesity treatment. Dedicated specialty consultants must be prepared to assist the bariatric team in the risk assessment and selection of surgical candidates. Specialists should be familiar with the risk factors for bariatric surgery within their specialty and feel comfortable with negative recommendations for surgery when indicated by medical risk.

The initial medical evaluation begins with a detailed weight history, including weights at various stages of life, highest weight, a family history of obesity, and success with weight loss efforts. Previous success with weight loss efforts and weight loss maintenance reflects motivation, ability to make diet and lifestyle choices and to diminish food intake for a long period of time. Often the conversation regarding weight history will provide the interviewer with insight regarding the patient's motivation and/or ambivalence regarding weight loss. The evaluator should enquire about the reasons for considering bariatric surgery, with awareness that candidates may not be fully truthful with their answers. Patients may frequently provide a rational motive for surgery when the real driving force relates to appearance or sex appeal. Candidates should be questioned regarding their perceptions concerning obesity, as patient denial of obesity is common among extremely obese patients and should be viewed as a relative contraindication for surgery.

Additional information to be discussed in the Social history should include information about alcohol consumption and drug use as well as details of patient support systems in the home environment. Patients should be asked about attitudes and opinions of other family members about bariatric surgery and weight loss. Since patient behavior is an important element of the patient selection process, the importance of skillful and sometimes crafty history taking should be emphasized [5].

The medical history should address the potential comorbid medical conditions and their severity. Conditions that might increase surgical risk or result in complications during weight loss should be investigated in detail (Table 4.2).

Prospective surgical candidates must understand that common comorbid conditions like hypertension and diabetes will be improving rapidly during the early postoperative period and will require frequent and timely reductions in medications in order to avoid complications related to overdose. The author's experience suggests that the bariatric medical team best handles these medication reductions, as primary care physicians are usually not familiar with the time course of the physiology of weight loss and often may not provide the necessary patient access. Patients will need to have plans made for essential medical follow-up in the early postoperative period.

Table 4.2 Established risk factors in bariatric surgery (derived from Chap. 12)

• Smoking
• Superobesity (Body mass index ≥50 kg/m^2)
• Male gender
• Hypertension
• Thromboembolism history
• Older age
• Limited functional status
• Sleep apnea
• Hypoalbuminemia
• Coronary artery disease
• Stroke
• Angina
• Bleeding disorder
• Dyspnea at rest
• Chronic corticosteroid use
• Obesity hypoventilation
• Pulmonary hypertension
• Liver disease
• Congestive heart failure

The gastrointestinal system review should include questions about symptoms related to biliary and foregut disease. Significant foregut symptoms and/or biliary tract disease may influence decisions regarding additional gastrointestinal evaluation such as upper endoscopy. In addition, because obesity is a risk factor for cancers of breast (in postmenopausal women), endometrium, and colon [6], this should be discussed in the bariatric surgery evaluation, and those individuals who have not followed the usual best practice screening protocols may need updated screening prior to bariatric surgery.

Some assessment of the candidate's level of physical activity is an important part of the medial history as limited functional status is a surgical risk factor [7–9]. An increase in physical activity is an important component of any successful weight reduction program and is now recognized as an important behavior change for optimum results following bariatric surgery [10] as well as for preservation of lean tissue [11] and possibly bone mass during surgical weight loss. In addition, in two small single institution studies, low aerobic fitness as determined by measured maximal oxygen consumption was found to correlate with an increased risk of bariatric surgical complications [12, 13]. A recent study of candidates for bariatric surgery in the Longitudinal Assessment of Bariatric Surgery Study that involved activity diaries and accelerometers found that BMI is inversely related to the amount and intensity of daily exercise. In addition, the study found that 20 % of candidates are sedentary and that only 20 % are quite active [14].

The Six-Minute Walk Test is an accurate and relatively easy way to measure activity level and will provide metrics for further study. This can easily be integrated into most bariatric programs with minimal cost and will provide a reproducible

Table 4.3 Recommended laboratory testing for candidates in preparation for bariatric surgery [19]

• Fasting glucose
• Lipid studies, cholesterol triglycerides, HDL cholesterol, LDL cholesterol
• Chemistry profile: renal and liver function
• Complete blood count
• Ferritin, vitamin B12 level
• TSH
• 25-hydroxyvitamin D
• Fat-soluble vitamin levels (for a malabsorptive procedure)
• Cushing's screen, when indicated

metric for assessment of functional status. This can be used for presurgery and postsurgery comparisons and is now a predictor of mortality for congestive heart failure and primary pulmonary hypertension. This simple test may provide valuable information in regard to surgical risk in the preoperative period and will allow for documentation of improvement and positive reinforcement to patients as activity improves with weight loss [15]. Other simple tests, which predict outcome, are now being studied and may lend themselves to the bariatric evaluation process [16–18].

The physical exam in the patient with extreme obesity is often of little use because the thickness of the subcutaneous fat limits accuracy. It is virtually impossible to assess neck vein distension, intensity of heart sounds, adventitious heart sounds, character of breath sounds, liver size, and hepatojugular reflux. Important aspects of the physical exam include an accurate blood pressure, heart rate, patient weight, height, and BMI calculation. Resting pulse rates in extreme obesity may be surprisingly high. An awareness of this will assist the surgical team in the later interpretation and differential diagnosis of postoperative tachycardia. A careful cardiopulmonary assessment and search for signs of hyperadrenal cortisolism are also important. Varying degrees of leg edema are common findings among the severely obese. Unfortunately the physical exam will not usually reveal clues as to the etiology.

The comprehensive laboratory assessment will provide important information regarding organ function, the severity of obesity-related metabolic derangement, nutritional status, and endocrine function. Table 4.3 summarizes the basic laboratory information needed [19].

After the completion of the initial medical evaluation and laboratory testing, the bariatric program will use this information to plan the remainder of the preoperative medical evaluation including specialty consultation and additional medical testing.

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Chapter 5
Psychological and Behavioral Evaluation

Patients with the best weight loss and health outcomes after bariatric surgery are those who are successful in making long-term changes in eating behavior and lifestyle. These changes include following a regular nutrition and exercise plan and the acquisition of new cognitive skills, which address the relation between emotional stress and food consumption. Inability to make these behavioral and lifestyle changes is likely to lead to weight loss failure, nutritional complications and major depression after surgery. An increasing awareness and understanding of the critical importance of these lifestyle changes has enhanced the role of the psychological and behavioral evaluation in patient selection and preparation for weight loss surgery.

The National Institute of Health Consensus Development Panel in 1991 recommended that a mental health assessment should be a part of the routine evaluation of candidates for Bariatric Surgery. Despite the fact that this evaluation has been performed in the vast majority of bariatric surgery patients during the past 22 years, we still lack evidence-based guidelines regarding the necessary components of this evaluation, and for the recognition of those individuals whose mental health profile and motivation level predict a good health outcome after surgery. The published literature in this area prior to 2004 is difficult to interpret because of methodological limitations related to inconsistent diagnostic criteria for the diagnosis of mental health conditions, lack of suitable controls, and failure to assess the severity of mental health conditions [1, 2]. The more recent literature is made up of an increasing number of studies where mental health disorders are diagnosed and their severity assessed on the basis of structured clinical interviews.

In addition, mental health personnel are now aware that candidates for weight loss surgery want to appear mentally healthy so that their surgery will not be denied. As a result, those patients who agree to participate in clinical research studies of mental health in bariatric surgery patients are informed that unless the research team identifies issues, which contribute to safety risk, the mental health information would be kept from the surgical team [3]. The tendency of bariatric surgery candidates to withhold mental health information, which may threaten their chances of having surgery, may contribute to error in reporting prevalence rates of mental disorders in surgical candidates.

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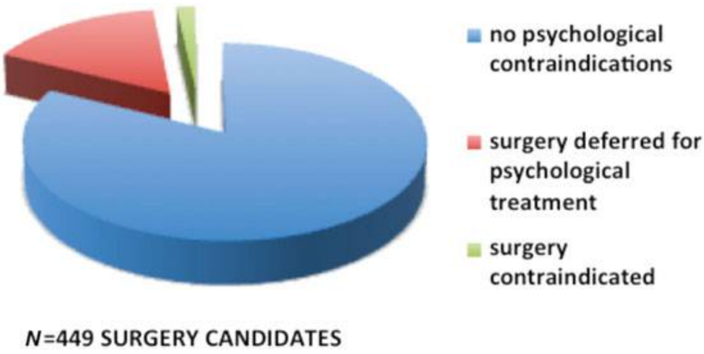

Fig. 5.1 The outcomes of psychological and behavioral evaluations in 449 patients from the Bariatric Surgical Program at the University of South Carolina. Modified from Pawlow L, O'Neil P, White M, Byrne T. Findings and Outcomes of Psychological Evaluations of Gastric Bypass Applicants. Surg Obes Rel Dis 2005;1:523–529 [8]

Candidates for weight loss surgery have a higher prevalence of mental health disorders when compared with other surgical populations, and the extent of mental impairment is related to the degree of obesity [4]. Earlier studies using non-standardized criteria for diagnosis reveal widely divergent prevalence rates, but more recent data are more consistent. Overall, approximately half of bariatric surgery candidates have a lifetime history of a mental health condition [3–7] and about half are taking psychotropic medications [3–7]. The prevalence of current mental health conditions at the time of bariatric surgery evaluation is significantly less and approximates 30 % [3–7].

The most common conditions encountered are Axis I disorders involving mood (major depression or dysthymia), anxiety (generalized anxiety and social phobia), substance abuse, and eating disorders [3–7]. Additional mental health conditions with significant prevalence in bariatric surgery candidates include alcohol abuse [3–5, 7] and personality disorders [7].

Despite the relatively high prevalence of current and lifetime mental health conditions among candidates for bariatric surgery, for most patients, these conditions are either mild, or well controlled because they do not contraindicate bariatric surgery. The findings and results of the psychological evaluations at the University of South Carolina are typical of the findings at most bariatric treatment centers (Fig. 5.1) [8]. In this study, the vast majority of patients had no psychological contraindications for surgery and was considered appropriate for immediate surgery. A small number (15.8 %) were found to be temporarily inappropriate for immediate surgery and surgery was deferred for treatment of a mental health condition, most commonly major depression followed by binge eating disorder. Only 2.9 % were found to be inappropriate for surgery with reasons being active psychosis/thought disorders and inability to provide informed consent [8].

Somewhat similar findings were reported in a small study from the University of Pennsylvania Bariatric Surgery Program where 64 % of patients were immediately cleared for surgery and in only 3 % surgery was found to be contraindicated for mental health reasons [9]. In a survey of Academic and Community bariatric surgery programs, the more common psychosocial reasons for contraindicating surgery were found to be illicit drug abuse, active uncontrolled symptoms of schizophrenia, severe mental retardation (IQ below 50), heavy drinking, and lack of knowledge about surgery [10]. A separate survey of 103 psychologists experienced in evaluations for bariatric surgery revealed that an average of 14.3 ± 12.9 % of candidates are recommended for delay or frank denial of surgery (range: 0–60 %) [11].

Additional generally accepted mental health contraindications to bariatric surgery include recent suicide attempts, recent hospitalizations for mental illness, and borderline personality. At the Mayo Clinic, surgery is delayed until the following criteria are met: no psychiatric hospitalization for 12 months; for substance abuse, ongoing treatment and abstinence for 1 year; for patients with ongoing psychiatric issues, they must be in treatment by a licensed mental health professional who must support the patient's wish for surgery and agree to provide postoperative follow-up care [12].

These studies indicate that a significant number of surgical candidates who have mental health issues are immediately cleared for surgery. Those who are immediately cleared are likely to be patients whose disease manifestations are mild or controlled and those who are involved in ongoing psychiatric care. A recent small study documents improvement in psychosocial status in the first 2 years after gastric bypass surgery with statistically significant improvement in scores for depression and anxiety [13]. A brief review summarizes the overall positive impact of surgical weight loss on mental health, psychosocial functioning, and health-related quality of life [14]. It is also evident that there are significant numbers of patients who do not benefit psychologically from weight loss surgery [15]. There is a clear need for additional high quality research in this area in order to better identify psychological, behavioral, social, and cognitive traits which will better predict surgical outcomes [10].

Another important area where systematic studies are needed concerns the minority of patients whose surgery is delayed for additional treatment of mental health disorders. Typical reasons for delaying surgery include a poorly controlled or untreated Axis I disorder, active binge eating, and substance abuse. There is very limited information available regarding the fate of this group of patients as follow-up rates in the limited number of studies are poor, and systematic longitudinal studies of those patients who complete treatment and then undergo bariatric surgery are lacking. A recent study indicates that mental health issues are common in bariatric surgery candidates who drop out of programs because of failure to complete program requirements [16].

The relatively high prevalence of binge eating disorder in bariatric surgery candidates, and the conflicting results in the limited available literature argue strongly for additional studies in order to better understand the influence of this disorder on surgical outcomes. Short- and medium-term studies indicate that meaningful surgical weight loss can occur in these patients and that the revised foregut anatomy may limit binge eating as well as make it more difficult to assess this disorder after bariatric surgery [2, 17]. Others feel that overeating and loss of control can develop after surgery and adversely affect long-term weight loss [7]. Most recommend that

Table 5.1 Factors that might provide subjective benefit in extreme obesity and should be considered in patient selection for bariatric surgery

Subjective benefits of being obese
• Generates help and pity from others
• Excuse for social and vocational failings
• Avoidance of physical activity
• Protection from fear of unwanted sex

Modified from: Kral J, Patient Selection for Treatment of Obesity. Surg Obes Rel Dis 2005;1:126–132 [24]

patients with active binge eating disorder symptoms should have surgery deferred for counseling and behavioral treatment. If they respond and are cleared for surgery, ongoing adjuvant psychological treatment will be essential during follow-up. Clearly, additional information is needed regarding Binge Eating, and the newly diagnosed Night Eating Syndrome (both conditions common in bariatric surgery candidates), in regard to optimum management in conjunction with bariatric surgery [1].

Another component of the psychological and behavioral evaluation of candidates for bariatric surgery, which is emerging as a possible outcome predictor, is cognitive function ability. Several studies have identified deficits in cognitive function both in obese subjects [18, 19], and in bariatric surgery candidates [20, 21]. The identified deficits in cognitive function involve reduced memory and executive function capabilities. In the current environment, which focuses on high caloric foods, weight loss and weight maintenance require a conscious and sustained effort that is mediated via executive function abilities. Deficits in executive function ability are felt to unfavorably affect compliance with caloric restriction and adherence to a weight loss program. In a cohort of 84 candidates for bariatric surgery, 14–15 % were found to have cognitive deficits identified by testing. In this cohort, baseline cognitive abilities in attention, executive function, and memory correlated with 1-year weight loss achievement after bariatric surgery [21]. In a similar study, the level of cognitive performance at 12 weeks after bariatric surgery predicted the extent of weight loss achievement at 24 months after bariatric surgery [22]. Although, the data relating cognitive capabilities to bariatric surgical outcome is preliminary, this will likely prove to be important in the process of patient selection for surgery and in relation to postoperative counseling since cognitive function does improve with surgical weight loss [23].

Another behavioral area, which needs to be better understood in the context of patient selection for bariatric surgery is an evaluation of the patient's potential subjective benefits of being obese (Table 5.1) [24].

A previous history of sexual abuse is common in bariatric surgery candidates, with the prevalence ranging from 17 to 32 % [25–27]. Longitudinal studies indicate that candidates with a sexual abuse history have satisfactory short-term weight loss after bariatric surgery, with outcomes similar to patients with no history. However, concern is raised by a recent study from the Mayo Clinic, which found a high incidence of psychiatric hospitalizations for these patients after bariatric surgery despite weight loss at 2 years, which was no different from controls [28]. The results of these studies indicates that patients with a history of sexual abuse should be considered for bariatric surgery, and they should be advised regarding the risk of mental illness during weight loss. Clearly these patients will benefit from ongoing mental health evaluation and treatment in the postoperative period.

It is apparent from review of the literature that there are many different approaches and many different types of mental health professionals who perform psychological and behavioral assessments on bariatric surgery candidates. Many programs use psychological assessment instruments such as the Minnesota Multiphasic Personality Inventory, Beck Depression Inventory, Millon Behavioral Diagnostic, Personality Assessment Inventory, and many others [10–12].

Although a mental health evaluation for surgical candidates has been a best-practice recommendation since the beginnings of bariatric surgery, the current psychological and behavioral evaluation requires much more than a search for psychopathology. The emerging trend is to conduct a structured, comprehensive interview that should include skillful questioning addressing all factors thought to be important for the necessary changes in lifestyle and the best surgical outcome. These include social support systems, interpersonal relationships, marital satisfaction, past diet success, evidence of ability to make behavioral changes, and patient comprehension of the risks, benefits, and requirements for success after bariatric surgery. The reader is referred to several examples of current comprehensive psychological and behavior evaluation protocols from prominent bariatric surgery centers of excellence [29, 30].

The evolving experience and research in the area of psychological and behavioral assessment of bariatric surgery candidates indicates that consensus and guidelines in this area are badly needed. This will require networking and education of mental health professionals interested in the mental health of extreme obesity. Such networking will facilitate the sharing of new knowledge and unification of evaluation standards. It is apparent that the role of the mental health professional in patient management for bariatric surgery is changing and that the role of the psychologist should extend beyond mere assessment of surgery candidates. Improved identification of mental health and behavioral conditions that affect outcomes after bariatric surgery invite an expansion of the psychologist's role which should include ongoing interventions and monitoring postoperative success. A psychological classification system for bariatric surgery candidates has been proposed as a communication and management tool [31]. Such a system allows all team members to be aware of mental health issues and risks, and engages patients in discussions regarding mental health conditions and postoperative outcome. The optimal manner of managing surgical candidates with mental health or behavioral issues should involve a thorough preoperative assessment and concurrent management of mental health issues after surgery [7]. The obesity epidemic and the limited access issues for bariatric surgery candidates today provide opportunity for the development of a separate mental health specialty addressing issues in extreme obesity.

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Chapter 6
Comprehensive Medical Evaluation

Extreme obesity is associated with many comorbid medical conditions that contribute to the risks of cardiovascular disability and death. Many patients who are interested in surgical weight loss will present with comorbid conditions that are undiagnosed, improperly evaluated, or inadequately treated. Bariatric Surgeons and their program personnel should have a solid understanding of the obesity disease burden, current recommendations for diagnosis and evaluation, prognosis, and implications regarding surgical risk. This understanding is essential for risk management, patient selection, and communication with consulting medical specialists. In general, the obesity disease burden, the number of comorbid conditions and their severity are influenced by increasing body mass index (BMI), increasing age, and male gender [1]. The duration of extreme obesity is another important factor, which influences the severity of the obesity disease burden.

A recent advisory from the American Heart Association addressing the evaluation and management of severely obese patients undergoing surgery calls attention to a number of clinical findings, which mandate additional testing (Table 6.1) [2]. Younger patients, especially women with BMI ≤45 kg/m^2, who are free of these conditions and have a normal capacity for exercise will generally need little additional preoperative medical evaluation or testing.

Respiratory Assessment

Respiratory conditions, respiratory symptoms, and limited exercise tolerance are commonly encountered in patients with extreme obesity. Even in the absence of demonstrable respiratory abnormalities, sedentary individuals with extreme obesity will have breathlessness with exertion that is related to deconditioning. Similarly, many inactive patients with extreme obesity may have significant impairment of respiratory function in the absence of symptoms.

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Table 6.1 Clinical conditions associated with extreme obesity, which should influence preoperative cardiac assessment and management [2]

• Atherosclerotic cardiovascular disease
• Congestive heart failure
• Systemic hypertension
• Pulmonary hypertension
• Cardiac arrhythmia
• Thromboembolism
• Limited exercise capacity

Table 6.2 Alterations in pulmonary function associated with severe obesity

• Reduced compliance of lungs and chest wall
• Increased respiratory resistance
• Increased work of breathing
• Reduced lung volumes

Because of expanded adipose tissue and lean body mass, extreme obesity is associated with an increased oxygen consumption and carbon dioxide production with an increase in resting minute ventilation [3]. Additional physiologic alterations in pulmonary function associated with obesity are summarized in Table 6.2.

Increases in upper body fat, increased pulmonary blood volume, and closure of dependent airways can increase respiratory "stiffness" (reduce system compliance) to a significant degree [3]. These alterations, which increase the work of breathing, are associated with increasing BMI. The increase in respiratory work may be clinically important after upper abdominal surgery when additional temporary reductions in pulmonary function related to surgery and anesthesia increase the risk of respiratory failure.

Reduction in lung volume is the most frequently found respiratory alteration in severe obesity. Mild reductions in Total Lung Capacity (TLC), Vital Capacity (VC), and 1 min Forced Expiratory Volume (FEV_1) are often seen, but the most profound reduction is in the Expiratory Reserve Volume (ERV), which is exponentially related to BMI (Fig. 6.1) [4]. The reduction in ERV occurs because the obese abdomen displaces the diaphragm into the thorax. ERV can reduce to as low as 20 % of predicted value [4], but the other component of the Functional Residual Capacity (FRC), the Residual Volume (RV), remains unchanged in extreme obesity. Significant reductions in FRC will predispose to small airway closure during normal tidal breathing, which results in ventilation–perfusion mismatch and hypoxia. These physiologic changes are most pronounced in the recumbent position, where maximal diaphragmatic displacement into the thorax occurs. Bariatric surgery patients with reduced FRC are at increased risk for dangerous hypoxia during endotracheal intubation after the pharmacologic induction of apnea, because the reduced FRC limits the safe duration of apnea. The reductions in FRC are correlated with increasing age, increasing BMI, and male gender [5].

An important component of the respiratory evaluation of bariatric surgery candidates is the Arterial Blood Gas (ABG) analysis. This valuable test is often overlooked in the preoperative assessment. Several studies have documented a significant

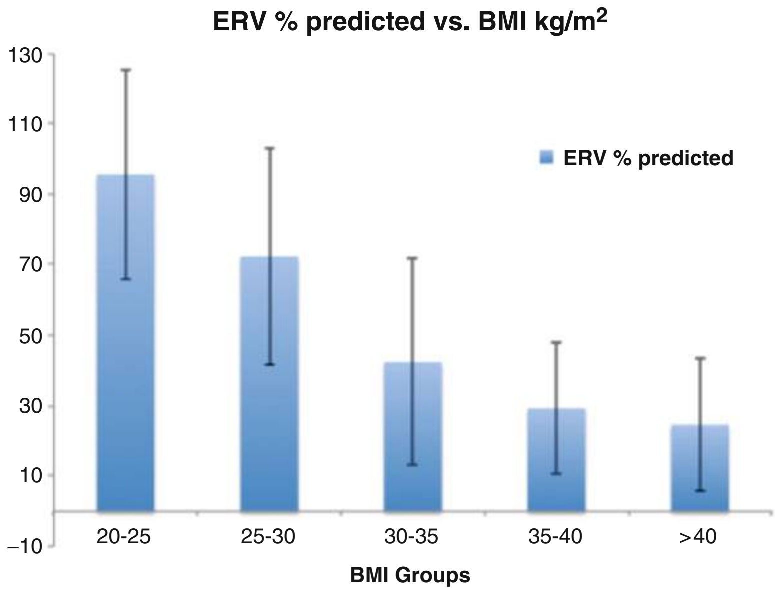

Fig. 6.1 The exponential relationship between increasing BMI (kg/m^2) and the % predicted reduction in Expiratory Reserve Volume (ERV). *BMI* body mass index

prevalence of hypoxia and hypercarbia in these patients [6, 7]. ABG analysis is essential for accurate patient-centered risk analysis as it will enable diagnosis of the Obesity Hypoventilation Syndrome (OHS), a condition associated with a high mortality, and will identify patients at risk for postoperative respiratory failure. In addition, information from ABGs will facilitate the optimal management of anesthetic and perioperative respiratory care [6, 8]. Postoperative hypoxemia is common in bariatric surgery patients and correlates with reduced perioperative tissue oxygenation, which has been recently documented following bariatric surgery [9]. Tissue hypoxia will reduce tissue resistance to infection and interfere with wound healing.

A full pulmonary evaluation including chest film, pulmonary function tests (PFT), and ABG analysis is indicated for those bariatric surgery candidates who have documented pulmonary conditions, those with limited exercise tolerance because of dyspnea, those with a history of heavy smoking, and those with BMI ≥60 kg/m^2.

Obstructive Sleep Apnea

Obstructive Sleep Apnea/Hypopnea Syndrome (OSAHS) is a recently discovered respiratory disorder that is a cause of daytime sleepiness, and disturbed sleep. It can cause mortality and contributes to surgical morbidity. The syndrome is caused by

Table 6.3 Clinical clues to the identification of obstructive sleep apnea

• Polycythemia
• Regular heavy snoring
• Nocturnal gasping, choking
• Witnessed apneas
• Daytime sleepiness

recurrent upper airways obstructions during sleep that cause hypoxia, increased respiratory effort, and frequent arousals. An apnea is a breathing pause lasting ≥10 s and a hypopnea is present during continuous breathing, when ventilation is reduced by at least 50 % for ≥10 s [10]. The Apnea–hypopnea Index (AHI) is the sum of apneas and hypopneas per hour of sleep. A diagnosis is established when the AHI is ≥5/h. During sleep, the negative pressure of inspiration closes the airway as the striated airway-dilating muscles relax. Muscle tone is reduced during sleep and the airway narrows causing snoring, apneas and hypopneas. This results in hypoxia, and then arousal from sleep. The arousal may be accompanied by cardiac acceleration, blood pressure rise, and increased sympathetic activity [10].

Surveys of the general population reveal that OSAHS is present in 9 % of adult women and 24 % of men [11]. This condition is much more common in obesity because subcutaneous fat and periluminal fat contribute to airway narrowing. In addition, reduced respiratory compliance further predisposes to airway closure. The actual prevalence of this syndrome increases as BMI increases [10]. In candidates for bariatric surgery, this condition is extremely common. A recent study from a bariatric center of excellence revealed an overall prevalence of 77 % in prospective candidates with 30.7 % having mild OSA ($5 \leq AHI \leq 15$), 19.3 % having moderate obstructive sleep apnea (OSA) ($15 < AHI \leq 30$), and 27.2 % having severe OSA ($AHI > 30$) [12].

OSAHS is associated with hypertension, sudden cardiac death, heart failure, arrhythmias, and other conditions with cardiovascular risk [11]. In addition, preliminary recent evidence suggests a possible link with insulin resistance and steatohepatitis in severe obesity [13]. The syndrome is associated with perioperative respiratory complications because general anesthetics decrease upper airway dilator muscle activity, anesthetic medications will interfere with the arousal response, and narcotics will suppress respiratory drive [14]. The repetitive chronic airway collapse and hypoxia associated with this condition causes pulmonary arterial vasoconstriction, which will contribute to chronic vascular remodeling and pulmonary hypertension (PH) [15], a recently discovered risk factor in bariatric surgery [16].

Clues to the identification of this condition include the presence of polycythemia, a history of regular snoring, nocturnal gasping, choking, witnessed apneas, or daytime sleepiness (Table 6.3).

Several survey tools are available [17, 18] which may help facilitate the diagnosis. However, because of poor negative predictive values with these tools [12], many routinely refer bariatric surgical candidates for full polysomnography with the recording of multiple respiratory and neurophysiologic signals during sleep.

Candidates for bariatric surgery should have this condition evaluated and diagnosed early by polysomnography in order to allow time for preoperative treatment with Continuous Positive Airway Pressure (CPAP) during sleep. This treatment has been shown to improve sleep symptoms, cognition, mood, blood pressure, and hypoxia as well as reduce pulmonary artery pressures [19]. Unfortunately, the delays associated with managed care, precertification, and approval have interfered with the use of this treatment modality prior to bariatric surgery in patients who might benefit from this treatment.

Obesity Hypoventilation Syndrome (The Pickwickian Syndrome)

The association between daytime somnolence and obesity has been known for many years. The most famous early report of this condition consists of a case report by Burwell describing an obese individual who was hospitalized after falling asleep at a poker game holding a full house of aces and kings [20]. The syndrome is defined as daytime hypercapnea ($PaCO_2 \geq 45$ mmHg) and sleep disordered breathing (most commonly severe sleep apnea) and hypoxia ($PaO_2 < 70$ mmHg) [21]. Other conditions that may be present at diagnosis include cor pulmonale, PH, hypersomnia with no other explanation, and erythrocytosis [22].

This condition is fairly common among candidates for bariatric surgery and may be missed in centers that do not check ABGs. The prevalence among patients with OSA is 20 % [23] and in a small study of 229 bariatric surgery candidates, 16 % had $PaCO_2 \geq 45$ [6]. The prevalence of OHS increases as BMI and AHI increase. The perception that this condition may go unrecognized in bariatric centers is supported by a study of 4,332 patients admitted to an internal medicine service, where 32 % met the diagnostic criteria for obesity hypoventilation. Of these patients, only a small fraction was given the diagnosis and received treatment. Short-term follow up of these patients demonstrated a high mortality in comparison to non-OHS patients with similar extent of obesity [24].

OHS patients are usually discovered in their 50s or 60s. They are usually morbidly obese (BMI ≥40 kg/m^2), and have OSA with an AHI in the severe range [21]. Most have classic symptoms of OSA, which include loud snoring, nocturnal choking, witnessed apneas, excessive daytime somnolence and morning headaches. Physical findings often include increased neck circumference, oropharyngeal crowding, a loud pulmonary second sound (may be impossible to identify in extreme obesity), and lower extremity edema [22, 23, 25]. Although the definitive test for the diagnosis is an ABG performed on room air, additional findings, which suggest OHS include an abnormal oxygen saturation detected on finger oximetry [21, 22] and an elevated bicarbonate level. Chau et al. developed a handy decision tree which demonstrates that OHS is unusual if the serum bicarbonate level is <27 meq/l, and that a bicarbonate level ≥27 meq/l, coupled with an AHI ≥100 has a strong association with OHS [26]. Major physiological differences between patients with OHS and OSA with eucapnia include an increase in respiratory load, an impaired CNS response to hypoxia and hypoventilation, and impaired neurohumoral responses (leptin resistance) [25].

OHS must be considered among candidates for bariatric surgery because it is a proven risk factor for mortality and perioperative adverse events. In addition, OHS is commonly associated with PH and right ventricular dysfunction or failure. PH is now an established risk factor for postoperative adverse events and mortality following bariatric surgery [16]. If the diagnosis of OHS is suspected, pulmonary consultation is indicated to rule out other causes of hypoventilation and to initiate treatment. In addition, cardiac ultrasound is indicated to look for PH and right ventricular dysfunction. If PH is found, more definitive studies are indicated (please refer to the discussion of “Pulmonary Hypertension” on this chapter).

If OHS is present and bariatric surgery is contemplated, treatment of OHS with CPAP or bi-level ventilation is indicated. This treatment will improve gas exchange and pulmonary hemodynamics, which will improve working conditions for the right ventricle. Short-term positive airway pressure for ≤3 weeks will reduce nocturnal hypoxia, improve hypercarbia and improve breathing during sleep. Longer-term therapy will improve lung volumes, improve ventilator response to CO_2, and reduce mortality [26]. CPAP treatment should be supervised by a Pulmonary Medicine specialist who ideally should document the improvement with treatment and share the details of this with the bariatric team. In addition, for severe cases, tracheostomy should be considered before bariatric surgery, as this will improve gas exchange and facilitate perioperative positive pressure ventilation.

Cardiac Assessment

Obesity is a well-known risk factor for atherosclerosis and cardiovascular disease. Comorbid conditions in association with obesity including hypertension, insulin resistance, and hyperlipidemia are commonly referred to as the “metabolic syndrome” and have a strong association with cardiovascular morbidity and death. The long-standing association between obesity and heart failure is related to the presence of the metabolic syndrome with an associated chronic inflammatory state, abnormal endothelial function, and hypercoagulability [27]. The profound favorable changes in cardiovascular health that occur in association with weight loss success after bariatric and metabolic surgery are a major driving force behind the rapid acceptance of bariatric surgery as the treatment of choice for extreme obesity [28].

In conjunction with the introduction and evolution of bariatric surgery, cardiologists have studied the structure and function of the heart in patients with extreme obesity and have discovered consistent patterns of alterations in cardiac structure and function as well as profound hemodynamic changes. The expanded adipose tissue mass and supporting lean body mass in extreme obesity will increase total body oxygen requirements which necessitates compensatory increases in circulatory and respiratory demands. Adipose tissue, which is now known to be highly metabolically active, commands substantial blood flow (7.4 ml blood flow/100 g adipose tissue/min) [29]. This has been translated to a blood flow of 3 l/min for 100 kg of fat [30]. In extreme obesity, blood volume is expanded resulting in increased preload, which supports the increase in cardiac output [30]. Autopsy studies of patients with extreme obesity show evidence of enlarged cardiac chambers and cardiac muscular hypertrophy with the extent related to the degree of obesity [31]. Studies in echocardiography have been performed in large numbers of obese patients, compared with lean controls, and demonstrate the combination of dilatation of cardiac chambers and hypertrophy of ventricular muscle, with incidence related to extent and duration of obesity [32].

Studies in morbidly obese patients with and without congestive heart failure (CHF) indicate that heart failure in obesity is accompanied by increases in cardiac output, right sided filling pressures, pulmonary artery pressures, and pulmonary capillary wedge pressures [30, 32]. In addition, those morbidly obese patients with heart failure had larger chamber size and more ventricular hypertrophy than those without heart failure [32]. The presence of heart failure is correlated via sigma curve with the duration of extreme obesity [32]. In patients with associated OSA or OHV, hypoxic vasoconstriction and vascular remodeling will cause increased pulmonary artery pressures with a gradient between pulmonary capillary wedge pressure and pulmonary artery diastolic pressure [30].

The problem of pulmonary congestion in extreme obesity is frequently complicated by abnormalities in diastolic function that are frequent in extreme obesity. The hypertrophied left ventricle in extreme obesity is stiffer with reduced compliance resulting in impaired left ventricular filling in diastole. As with left ventricular mass, the duration of obesity influences the extent of diastolic dysfunction [30]. Many bariatric centers have evaluated patients with long-standing extreme obesity, who have a past history of CHF treatment, and yet, left ventricular systolic function and ejection fraction are normal. These patients have what is now termed diastolic heart failure [33]. The studies of systolic function in extreme obesity yield conflicting results. A study of 43 morbidly obese patients with heart failure revealed a mean cardiac output 5.62 ± 1.48 l/min with a cardiac index of 2.3 ± 0.55 l/min/m^2 [32]. Noninvasive studies of systolic function demonstrate both preserved and depressed systolic function in association with heart failure in severe obesity [30].

The increased circulatory demands in extreme obesity result in an increase in cardiac output, stroke volume and stroke work. In order to facilitate the increased blood flow requirements, systemic vascular resistance falls. The increased cardiac output leads to chamber dilatation, which increases wall stress. In order to compensate for the increase in wall stress and to preserve systolic function, eccentric ventricular hypertrophy occurs. If ventricular hypertrophy and muscle function can keep pace with the increases in wall stress, systolic function is maintained. If hypertrophy cannot adequately compensate for wall stress, systolic function will decrease. In these patients, the heart failure will involve systolic and diastolic ventricular failure. Autopsy studies have demonstrated areas of cardiac muscle necrosis and fibrosis and areas of myocardial fatty deposition (steatosis) in the hypertrophied left ventricle. There is recent interest in the concept of fatty degeneration of the heart as

Table 6.4 Cardiovascular physiologic alterations which are associated with extreme obesity

- Increased resting heart rate
- Increased resting cardiac output
- Increased resting stroke volume
- Increased ventricular wall thickness
- Decreased maximal exercise O_2 consumption

Table 6.5 Risk factors for perioperative cardiovascular complications in the general population from the Revised Cardiac Risk Index [36]

- Major surgery (abdominal, thoracic, vascular)
- Coronary artery disease (myocardial infarction, chest pain, previous coronary revascularization)
- Congestive heart failure
- Cerebrovascular disease
- Preoperative treatment with insulin
- Preoperative creatinine levels >2 mg/dl

Modified from Lee T, Mercantonio E, Mangione C, Thomas E, Carisi A, Polanczyk C et al. Derivation and Prospective Validation of a Simple Index for Prediction of Cardiac Risk of Major Noncardiac Surgery. Circulation. 1999;100:1043–1049 [36]

a contributor to obese cardiomyopathy [34]. The interested reader is referred to an excellent review of the pathogenesis of the cardiomyopathy of obesity [30]. The changes in cardiovascular structure and function associated with extreme obesity are summarized in Table 6.4.

The cardiomyopathy of obesity is present in 31 % of patients with morbid obesity, especially those with long standing extreme obesity [30]. Clues to the diagnosis include a recent weight gain accompanied or followed by dyspnea with exertion, paroxysmal nocturnal dyspnea, orthopnea, or extremity edema. At this time, if investigated, systolic function is usually normal. Atrial fibrillation or atrial flutter may be present. When cardiomyopathy occurs with OSA or OHV, signs of right heart failure will be present. Physical findings including gallop (S3, S4 heart sounds) rhythm, pulmonary rales, jugular venous distension, hepatojugular reflux, and extremity edema. Many of these physical findings will be missed due to the thickness of subcutaneous fat.

Atherosclerotic cardiovascular disease is also common in extreme obesity, especially in association with metabolic syndrome. Coronary artery disease, if occult or undiagnosed, will increase the risks of bariatric surgery. The prevalence of coronary artery disease in extreme obesity is unknown, but cardiac complications following bariatric surgery occur in 0.7–1.5 % [35]. The Revised Cardiac Risk Index [36] has been useful for the identification risk factors for perioperative cardiovascular complications in the general population (Table 6.5).

These risk factors are derived from studies of large numbers of patients undergoing elective noncardiac surgical procedures. The risk of a cardiovascular complication is a function of the number of risk factors. In the absence of an established cardiovascular risk index for bariatric surgery, these risk factors should be used in decision-making regarding the need for additional cardiac studies or consultation. In general, younger patients who are active and who are without risk factors do not need routine detailed cardiovascular evaluation. Additional testing may be indicated in the presence of multiple risk factors.

The physical exam and the electrocardiogram often underestimate the presence and extent of cardiac dysfunction in obese patients [2]. Exercise testing is the most important component of cardiovascular evaluation in patients with risk factors as it can provoke signs of ischemia in patients with significant occult disease and will sometimes unmask limitations related to obese cardiomyopathy. In order to assess functional status, one must have familiarity with the metabolic equivalents (METs) related to activities of daily living. For a 40-year-old 70 kg male in a resting state, oxygen consumption (VO_2) is 3.5 ml/kg/min or 1 MET [37]. Functional capacity is classified as excellent (greater than 10 METs), good (7–10 METs), moderate (4–6 METs), and poor (less than 4 METs). Patients with poor functional status have increased perioperative risks [37].

In extreme obesity, measurement of exercise capacity is a predictor of complications because cardiorespiratory fitness in extreme obesity is similar to that measured in populations with heart failure and worsens with increasing BMI [38]. The same investigators found that the incidence of composite adverse events in bariatric surgery patients was increased to 16.6 % if peak oxygen consumption was <15.8 ml/kg/min as compared to 2.8 % if peak oxygen consumption was ≥15.8 ml/kg/min [39]. The guidelines for perioperative evaluation also call for a surgical risk categorization (Low risk: <1 % cardiac risk; Intermediate risk: 1–5 % cardiac risk; High risk: >5 % cardiac risk) to assist in decision making regarding the need for additional testing [37]. Bariatric surgery is in the intermediate risk category.

A complete cardiac ultrasound examination can be successfully performed in only 70 % of patients with extreme obesity because of technical limitations or poor echocardiographic windows. In this situation, transesophageal stress echocardiography with Dobutamine should be considered in patients with risk factors [2]. Radionuclide ventriculography can also provide information regarding the function of right and left ventricles. The accuracy of thallium scanning diminishes when BMI exceeds 30 kg/m^2 [40]. The risk/benefit efficacy of beta blockade in the presence of coronary artery disease remains unknown in patients with extreme obesity as the two recent trials do not report BMI [41, 42]. In the absence of needed evidence based guidelines for preoperative cardiovascular evaluation of patients with extreme obesity, the reader is referred to the Guidelines on Perioperative Cardiovascular Evaluation and Care for Non-cardiac Surgery [37].

Pulmonary Hypertension

Extreme obesity is often accompanied by varying degrees of PH. Frequently when this diagnosis is made or suspected in bariatric surgery candidates, consultants often indicate that the best treatment is weight loss, and that additional study is

Table 6.6 Current clinical classification scheme for pulmonary hypertension

Group 1	Primary pulmonary hypertension: idiopathic familial, drug and toxin induced (appetite suppressant drugs), rare medical conditions
Group 2	Secondary to left heart disease: Left atrial or ventricular disease (including systolic and diastolic dysfunction); left sided valvular disease
Group 3	Secondary to pulmonary disease or hypoxia: COPD, sleep disordered breathing, obesity hypoventilation
Group 4	Secondary to chronic thromboembolism
Group 5	Unclear and multifactorial etiologies

Extreme obesity can contribute to Groups 2–4
COPD chronic obstructive pulmonary disease

unnecessary. The recent studies from a large clinical registry, which confirm that PH is a risk factor for composite adverse outcomes [16] and 30-day mortality [43] following bariatric surgery, justify a closer look at this condition in the evaluation of candidates for bariatric surgery. PH is defined as a mean Pulmonary Artery Pressure that exceeds 25 mmHg on right heart catheterization. This condition can occur as a primary disease or as a physiologic consequence of another condition. The current classification scheme for PH is summarized in Table 6.6 [44–47].

As can be seen from Table 6.6, obesity and its comorbid conditions are significant causes of secondary PH. There is limited information regarding the prevalence of PH in extreme obesity. The reported incidence in the Bariatric Outcomes Longitudinal Database, which is the largest clinical registry in bariatric surgery, is 0.4 % [16, 43]. However, this may be an underestimate since a single institution cohort study found that 28 % of otherwise healthy individuals with BMI >30 kg/m^2 had a Pulmonary Artery Systolic Pressure (PAS) >30 mmHg by echocardiography [48]. Among a cohort of 220 consecutive patients with OSA, the prevalence of PH confirmed by invasive direct measurement was 17 % [49]. Within these small studies, BMI was found to correlate with the prevalence of PH. A small VA study of 70 consecutive morbidly obese males (age 50 ± 10 years) with newly diagnosed OSA revealed 41 % with pretibial edema. All patients with pretibial edema underwent right heart catheterization and, of these, 25 % had severe PH [50]. It is quite likely that the prevalence of significant PH in bariatric surgery candidates is underrepresented in present day bariatric surgery registries.

Unfortunately, the clinical symptoms are nonspecific. They include dyspnea and occasional syncope with exertion, palpitations, and leg edema. Clinical signs are unreliable in extreme obesity. They include loud second heart sound (P2), murmur of tricuspid regurgitation, giant v waves, and a pulsatile liver. More advanced cases are accompanied by signs of right ventricular failure. In extreme obesity the pathogenesis of PH depends on the comorbid conditions. OSA (Group 3) is accompanied by repetitive nocturnal hypoxia and increased sympathetic activity, which induces pulmonary artery vasoconstriction. Repeated pulmonary vasoconstriction leads to pulmonary arteriolar remodeling including intimal proliferation, medial hypertrophy, and other changes that increase pulmonary vascular resistance [44]. In obesity

OHS, pulmonary artery vasoconstriction is stimulated by hypoxia, hypercarbia and acidosis followed by arteriolar remodeling. In OHS, PH tends to be more common and more severe than in OSA [51, 52].

PH related to left heart disease (Group 2) is the most common etiology when PH is diagnosed by echocardiography [46]. In extreme obesity, the stiff hypertrophied left ventricle alters diastolic filling, which increases left heart filling pressures. This can occur with preservation of systolic function, but is obviously worsened by reduced systolic dysfunction. These derangements common to the obese cardiomyopathy increase pulmonary venous pressures. Long-standing increases in pulmonary venous pressures lead to increases in pulmonary vascular resistance, which lead to PH.

Another obesity related etiology of secondary PH is chronic thromboembolic disease (Group 4). This condition is present in 4 % of patients from the general population followed for 2 years after surviving a pulmonary embolus [53]. This condition is probably more common in extreme obesity, a proven risk factor for thromboembolism, where other comorbid conditions like OSA are likely to contribute to PH. Incomplete clot resolution or recurrent thromboembolism causes an increase in pulmonary artery pressure, pulmonary vascular resistance, and right ventricular strain. The links between extreme obesity and venous thrombosis are numerous and will be discussed in the next section of this chapter.

Transthoracic echocardiography is currently used as a screening tool for PH. This modality provides a calculated estimate of pulmonary artery systolic pressure. However, this noninvasive test has significant limitations, which relate to technical issues and interobserver variability [44, 45, 50]. In the clinical setting, significant differences occur between noninvasive estimates and invasive measurements of pulmonary artery systolic pressure Echocardiography can provide important information about systolic and diastolic function of the left and right ventricles [54]. In PH, the level of right ventricular function is a major determinant of prognosis and risk [44, 45, 51]. Because of the limitations of echocardiography, established guidelines for diagnosis and management of PH require confirmatory invasive diagnostic testing for the diagnosis of PH and for information regarding the classification, which facilitates treatment and risk assessment [51, 52]. Right heart catheterization provides direct measurement of PA pressures, calculation of vascular resistance, measurement of pulmonary capillary wedge pressure (PCWP) and cardiac index. A PCWP >15 identifies pulmonary hypertension related to left heart disease (Group 2), and a PCWP ≤15 will identify patients with hypoxia (Group 3) or chronic thromboembolism (Group 4) [44–46, 51, 52]. Additional testing necessary for the diagnosis and evaluation of PH are listed in Table 6.7 [44, 45, 51, 52].

If the diagnosis of PH is confirmed and the evaluation complete, the prognosis and possible treatment options should be determined. The prognosis in PH is determined by the information from right heart catheterization (CVP, PA pressures, and Cardiac Index), and a functional assessment, most commonly, the 6-min walk test [55, 56]. A low cardiac index, evidence of right ventricular failure, and poor functional state are ominous prognostic signs in patients with PH [51, 52].

Table 6.7 Essential tests required for the complete medical evaluation of pulmonary hypertension

- Pulmonary function testing
- Overnight oximetry
- V/Q lung scan
- Connective test screen
- HIV
- CBC with platelet count
- Liver function tests
- Antiphospholipid antibodies
- Assessment of exercise capacity
- Confirmatory right heart catheterization
- Left heart catheterization if needed to clarify PCWP
- Coronary angiogram if concern causing dyspnea

PCWP pulmonary capillary wedge pressure

How the above evaluation and assessment schemes relate to candidates for bariatric surgery remains unclear. Since PH is now a proven risk factor for severe complications and death after bariatric surgery, more complete evaluation of candidates with PH and strategies for perioperative monitoring are needed. In addition, this is to some extent a modifiable risk factor. Data from right heart catheterization might provide bariatric teams with hemodynamic information under basal conditions and good oxygenation, which might help direct perioperative fluid and respiratory management.

Venous Thrombosis and Pulmonary Embolism

Obesity is an established risk factor for thromboembolism [57, 58]. The vast majority of Bariatric Surgery Programs are currently using thromboembolism prophylaxis routinely, but thromboembolism remains the leading cause of postoperative fatality in experienced bariatric centers despite a low incidence of 0.3–0.4 % [59–61]. An autopsy study of ten deaths after bariatric surgery found that thromboembolism was present in 80 % and a direct cause of death in 30 % [62]. Bariatric surgery candidates with a history of previous thromboembolism are at higher risk for mortality after bariatric surgery [63, 64].

Multiple factors contribute to the thrombosis risk associated with obesity. These include an increase in plasma levels of plasminogen activator inhibitor-1 (PAI-1), increases in circulating procoagulant microparticles, endothelial dysfunction, increased production of inflammatory cytokines, and increased plasma levels of clotting factors [58].

PAI-1 is an inhibitor of plasminogen activation and increases will inhibit fibrinolysis. PAI-1 is synthesized in adipose tissue and plasma levels are increased in relation to BMI [58]. PAI-1 production is upregulated by the increase in inflammatory cytokines in obesity, and levels increase in relation to the degree of insulin resistance [65]. PAI-1 is felt to be an important mediator of the cardiovascular risks associated with metabolic syndrome [66].

Circulating microparticles are fragments shed from the plasma membrane of cells that are challenged by procoagulant or proinflammatory stimuli. They are phospholipid vesicles containing procoagulant material and are released from platelets, leukocytes, or endothelial cells. Microparticles from activated endothelial cells reflect endothelial dysfunction and are increased in different cardiovascular risk conditions [67].

Microparticles are also released from activated platelets and have thrombogenic properties as well. In a recent study of 58 morbidly obese women, circulating microparticle levels were significantly elevated in comparison to levels in non-obese controls [68].

Inflammatory cytokines produced by adipose tissue cells including tumor necrosis factor-α, and interleukin-1 are felt to contribute to the production of PAI-1 [58]. In addition, a recent small study found that secretory products from adipose tissue of morbidly obese subjects free of cardiovascular risk factors caused activation and alteration of endothelial cells [69]. Extreme obesity is also associated with elevations in plasma levels of many clotting factors. The reader is referred to a recent study of 180 consecutive candidates for bariatric surgery who underwent detailed laboratory testing to determine the prevalence of inherited and acquired thrombophilias [70]. The alarming prevalence of thrombophilias in these patients suggests that similar preoperative studies may help identify candidates for surgery who may benefit from more aggressive or extended thromboembolism prophylaxis.

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Chapter 7
Nutrition I: Protein and Vitamins

Although obesity is a manifestation of overnutrition, recent evidence suggests that nutrient abnormalities and deficiency states are not uncommon in individuals suffering from extreme obesity. Clinicians are familiar with starvation-related malnutrition, but may be less familiar with the recognition of deficiencies in protein or micronutrients which are classified as malnutrition associated with chronic disease [1]. Despite the variety and availability of relatively low cost foods in the western world, micronutrient deficiencies are frequent in the severely obese and probably reflect a poor quality diet with high carbohydrate and fat intake.

Many severely obese patients turn to bariatric surgery as the only treatment that offers them a meaningful chance for a longer and healthier life. The association of micronutrient deficiencies with extreme obesity may influence the severity of comorbid disease, the risks of surgery, and the probability of severe deficiency during the period of rapid weight loss and diminished food intake. Bariatric surgery programs will need to expand the nutritional assessment to include an accurate dietary history and more detailed assessment of micronutrient status. Table 7.1 summarizes several current studies of micronutrient status in candidates for bariatric surgery [2–4]. These results suggest that abnormally low levels of many nutrients are unexpectedly common among candidates for bariatric surgery.

Protein

Strategies for maintenance of adequate protein nutrition for patients in the face of rapid postoperative weight loss and limited food intake remain a challenge for bariatric surgery programs. Lack of attention to protein nutrition in bariatric surgery patients can lead to postoperative complications, interference with comorbidity resolution with weight loss, and impairment of physical function. The human body is made up of two major compartments: body fat (which includes all fat in the body), and fat free mass (which includes bone, water, muscle, and organs).

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Table 7.1 Results of several recent studies addressing nutritional status among candidates for bariatric surgery

Study	Ernst et al. [2] (%), (*n*=232)	Ernst et al. [2], (*n*=89)	Flancbaum [3] (%), (*n*=379)	Schweiger et al. [4] (%), (*n*=114)
Albumin	12		1.1	0
Total protein	–		–	0
Calcium	–		3.2	0.9
Phosphate	8		–	2
Magnesium	4.7		–	–
Ferritin	6.9		8.4	23.9
Hemoglobin	10.1		22	18.4
Zinc	24.6		–	–
Folate	3.4		–	24.3
Vitamin B_{12}	18.1		0	3.6×
25(OH) vitamin D_3	61.2		68.1	–
Parathormone[a]	36.6		–	39
Copper		0	–	–
Selenium		32.6	–	–
Vitamin B_1		0	29	–
Vitamin B_3		5.6	–	–
Vitamin A		0	–	–
Vitamin E		2.2	–	–

Nutrient status reported according to prevalence (%) with abnormally low serum nutrient levels
[a]Value is % with levels above normal

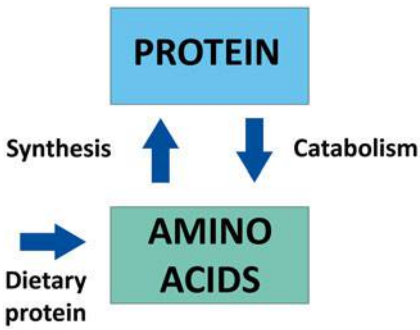

Fig. 7.1 The overall scheme of body protein turnover

Body protein, a major component of the fat free mass, is constantly turning over with ongoing synthesis of new protein and breakdown of senescent protein. Protein turnover is the balance between protein synthesis and protein breakdown (Fig. 7.1).

Body protein turnover is not a fully efficient process and a daily supply of dietary protein is needed for maintenance of muscle and visceral protein balance. The recommended dietary allowance (RDA) for protein is 0.8 g/kg/day. An anabolic state occurs when protein synthesis exceeds protein catabolism. This can occur in an actively exercising individual whose diet is adequate in protein and energy. When the breakdown of protein exceeds synthesis a catabolic state occurs. The period of rapid weight loss during the first 6–9 months after bariatric surgery is a period of major protein catabolism, which is induced by severe caloric restriction and compounded by limited dietary protein intake. This condition of partial starvation can lead to both loss of fat mass and significant loss of lean tissue with health consequences.

A small percentage of candidates for bariatric surgery may have deficiencies of protein, which can be detected, as low levels of albumin and total protein. Due to the major changes in protein economy following bariatric surgery procedures, a detailed protein nutritional assessment and dietary history as well as diet education focusing on the critical importance of an adequate dietary protein intake needed for healthy weight loss is essential for bariatric surgery candidates. Major preoperative protein deficiencies are best corrected during the preoperative period in order to avoid additional surgical morbidity.

Following bariatric surgery, numerous factors contribute to the risks of poor protein nutrition. All of the procedures limit the gastric acid and pepsin hydrolysis of dietary protein. Gastric bypass and the malabsorptive procedures both bypass the duodenum and proximal jejunum, thus altering the normal environment for digestion and absorption of dietary protein. In addition, anorexia, early satiety, and intolerance to red meat all will limit dietary protein intake. Several studies have demonstrated that dietary protein intake in patients in the first year following restrictive, gastric bypass, and malabsorptive procedures falls well below the RDA for protein [5, 6]. In one study of 101 consecutive patients undergoing gastric bypass or sleeve gastrectomy, protein intake from food and supplements was assessed at 4, 8, and 12 months after surgery. A protein intake of <60 g/day was present in 45, 35, and 37 % of the cohort was found at 4, 8, and 12 months after surgery. Poor compliance with protein supplements was also noted [6]. Major protein catabolism in the first 6–9 months after bariatric surgery is confirmed by body composition studies, which demonstrate 18–30 % losses of lean body mass during this period [7, 8]. Protein catabolism has functional consequences, which include hair loss, fatigue, muscle weakness, and possibly visceral losses.

There is now evidence that a protein intake which is ≥60 g/day or ≥1.1 g/kg/day during the first year after bariatric surgery will result in less protein catabolism and preservation of lean tissue [9]. There is also evidence that a dietary protein intake of ≥1 g/kg/day during the first year after gastric bypass surgery will provide healthier weight loss and preservation of lean body mass [10]. Compliance with a postoperative diet that is adequate in protein is feasible and attainable when appropriate follow-up and dietary education are provided [10, 11].

Additional potential advantages of a high protein diet after bariatric surgery include improved weight loss as a result of an increased energy expenditure, better glucose control, lipid lowering, and reduced weight regain [11]. This is an important area for potential study in bariatric surgery because of the real likelihood that adherence to a high protein diet will enhance many of the established benefits of bariatric surgery.

Candidates for bariatric surgery must be made aware of the critical importance of protein nutrition and protein economy in the health outcome and safety of major weight loss. The capacity to understand this and cooperate with recommendations and follow-up expectations should be a factor in patient selection for surgery. Patients must understand that short-term catabolism is usually without consequence in a well-nourished individual, but longer-term catabolism is dangerous. A postoperative diet containing 60–120 g/day of protein is recommended in nutritional guidelines to maintain fat free mass [11–13]. During close follow-up, if protein intake remains <60 g daily, nutritional supplements are indicated. There is some evidence that dietary enhancement with the branched chain amino acids, especially leucine, may influence the conservation of lean tissue during periods of catabolism. A leucine intake of 10 g per day is recommended after bariatric surgery. Protein sources rich in leucine include whey protein (14 %) and Casein (10.1 %) [11, 14]. Bariatric programs need to engage nutritionists with knowledge of the large array of protein modular supplements to closely monitor patient diet and protein intake following bariatric surgery.

Thiamine (Vitamin B1)

Thiamine deficiency is a well-known and feared nutritional complication of bariatric surgery. Absorption of thiamine takes place in the jejunum and ileum via an active carrier-mediated process. Intestinal thiamine is derived from two sources: diet and generation of the vitamin by the intestinal bacterial flora. The level of thiamine in the extracellular fluid regulates its intestinal absorption. Following absorption, thiamine is phosphorylated and becomes a vital cofactor for steps in glycolysis and the oxidative decarboxylation of carbohydrates. It is also a cofactor for pyruvate dehydrogenase, which regulates the entry of pyruvate into the Krebs cycle. Lack of thiamine is occasionally associated with lactic acidosis because thiamine regulates the conversion of lactate to pyruvate. Because of a short half-life and limited stores, a continuous supply of this vitamin is essential for optimal metabolism. The RDA for thiamine is 1.1–1.2 mg/day [15].

Thiamine nutrition is usually assessed by measurement of levels of thiamine in serum and/or red blood cells. The normal serum level of thiamine is 80–150 μg/dl. A normal level does not exclude the diagnosis of deficiency, and the more definitive test is red cell level of thiamine diphosphate. In the clinical situation, if there is suspicion, empiric treatment is cost-effective and preferable to waiting for results from reference laboratories [15].

Clinical manifestations of thiamine deficiency involve the nervous and cardiovascular systems. Wernicke's encephalopathy involves ocular abnormalities, ataxic gait, and mental status changes. Congestive heart failure is also caused by thiamine deficiency. Thiamine deficiency is also common in patients taking furosemide in doses of 80 mg per day as furosemide causes increased thiamine excretion in the urine [15]. Thiamine deficiency as determined by low levels has been reported in 15.5–29 % of candidates for bariatric surgery, especially in African Americans and

Hispanics [3, 16]. Postoperative deficiency has been reported as early as 4 weeks after bariatric surgery and should be suspected in any patient with poor dietary intake after bariatric surgery. It should also be considered in any patient with cerebral dysfunction after bariatric surgery. Deficiency appears to be less common after restrictive procedures.

Candidates for bariatric surgery should be screened for thiamine deficiency and those with low levels should be supplemented with 100 mg thiamine, two to three times daily. This should be continued for 1 month or until levels normalize [17]. Perioperative supplementation in doses of 100 mg, two to three times daily, should be provided parenterally [3, 17]. Postoperative patients with neurologic symptoms suggesting deficiency should receive aggressive parenteral replacement. Dosage and duration of therapy are controversial, but current recommendations are for 100–200 mg per day for 7–14 days [13, 18]. All bariatric surgery patients should receive a daily multivitamin supplement which contains thiamine.

Ascorbic Acid (Vitamin C)

Vitamin C has an important antioxidant function as a neutralizer of reactive oxygen substances. It also has a major role in connective tissue metabolism, proline hydroxylation, and in facilitating the absorption of heme iron. Dietary sources of vitamin C include citrus fruit and green vegetables. The RDA for vitamin C is 90 mg/day for males and 75 mg/day for females [1]. Vitamin C deficiency causes scurvy with symptoms of generalized weakness, fatigue, and bleeding in skin as well as gums. Vitamin C nutrition is usually assessed by blood levels. Normal values are 0.6–2 mg/dl [1]. Information regarding vitamin C deficiency in bariatric surgery candidates is limited. However, a recent study of 266 consecutive elective general surgery patients included 167 candidates for bariatric surgery (BMI ≥35). In the entire cohort, increasing BMI was associated with a lower ascorbic acid level and 36 % of the cohort was either depleted (level <0.3 mg/dl) or deficient (level 0.3–5.9 mg/dl) [19]. Data about vitamin C deficiency after bariatric surgery is also limited. In a 1-year study comparing patients after gastric bypass and duodenal switch, vitamin C levels increased during the first postoperative year with supplementation. A second study documented falling vitamin C levels during the second postoperative year [20]. Scurvy has been reported in a postoperative bariatric surgery patient with vomiting and poor dietary intake [21].

Bariatric surgery candidates should be screened for vitamin C deficiency. Patients with depletion or deficiency should be treated with repletion doses of 200 mg per day in order to minimize surgical risks related to vitamin C. Postoperative supplementation with a multivitamin preparation provides 60–100 mg. This should be sufficient if postoperative food intake is sufficient. Additional indication for supplementation is to enhance iron absorption. Patients should be made aware that vitamin C supplementation will increase oxalate excretion and the risk of kidney stones [22].

Vitamin B_{12} (Cobalamin)

Vitamin B_{12} is a water-soluble vitamin utilized by all cells as a coenzyme for many metabolic reactions. The absorption of this vitamin is complex and involves several areas of the gastrointestinal tract that are involved with bariatric surgery. Cobalamin is ingested bound to dietary proteins. In the gastric lumen, cobalamin is released from its binding to dietary protein and complexes with R-binding protein which is derived from saliva. As part of the gastric response to a meal, parietal cells release Intrinsic factor, which has a binding site for cobalamin that is inactive at low pH. Intrinsic factor accompanies the cobalamin-R-binding protein complex to the duodenum where the cobalamin is released from R-binding protein by pancreatic enzymes. Cobalamin then binds to intrinsic factor at alkaline pH and this complex is bound by enterocytes in the terminal ileum where absorption takes place.

Vitamin B_{12} is involved in the metabolism of every cell as it participates in synthesis and regulation of DNA. In addition, it has a role in fatty acid synthesis and energy production. In conjunction with folate, it is the cause of the megaloblastic anemia seen with deficiency of either vitamin. Vitamin B_{12} is also involved in the central nervous system development, myelination, and function. Humans are capable of storing vitamin B_{12} in the liver with stores between 2 and 5 mg. The daily requirement is 2.4 μg, and the liver stores allow for a long interval between the onset of deficient intake and the development of deficiency symptoms. The initial test to assess the status of vitamin B_{12} nutrition is measurement of the serum B_{12} level. Normal values are 200–900 ng/ml. Levels <170 ng/ml even in the absence of symptoms suggest deficiency, and deficiency symptoms are common with levels <100 ng/ml. Both false positives and negatives are common. Confirmation of deficiency may require measurement of serum levels of methylmalonic acid or total homocysteine as these levels are markedly elevated in the setting of B_{12} deficiency and levels will fall promptly with replacement which allows for monitoring of replacement [23].

In the studies of candidates for bariatric surgery, the prevalence of vitamin B_{12} levels below threshold is 0–18 % (Table 7.1) [2–4, 24]. Given the complex absorption of this vitamin and the anatomic alterations created in bariatric surgery, it is not surprising that postoperative deficiencies are quite common. The reported incidence of postoperative vitamin B_{12} deficiency is 26–70 % [12], but most of the studies document only falling serum levels and not proven symptomatic deficiency [24, 25]. Contributors to deficiency include limited postoperative intake of animal proteins, limited gastric acid cleavage of B_{12} from dietary protein, and diminished production of intrinsic factor [26]. Manifestations of B_{12} deficiency include macrocytic anemia, leukopenia, glossitis, thrombocytopenia, paresthesia, and irreversible neuropathies [23].

Candidates for bariatric surgery should be screened for vitamin B_{12} nutrition deficiency. Routine postoperative supplementation with a multivitamin preparation, which contains 6–25 μg B12 per tablet, is not sufficient to prevent falling levels and deficiency. A crystalline B_{12} supplement providing ≥350 micrograms B_{12} daily has been shown to increase serum levels in patients with low levels [27]. Treatment of deficiency requires higher doses. In parenteral dosing, about 10 % of the injected dose is retained [23]. Parenteral replacement consists of several 1,000 μg doses during the first week, then weekly until improvement occurs. Subsequent dosing is 1,000 μg monthly [23]. In patients with pernicious anemia, high doses of oral therapy (2,000 μg daily) have been shown to be as effective as parenteral treatment [23]. This has not been studied in deficient bariatric surgery patients. Bariatric surgery patients should have vitamin B_{12} nutrition assessed each year after surgery.

Folic Acid (Vitamin B_9)

Folic acid is a water-soluble vitamin, which has multiple important functions. It is necessary for purine and pyrimidine synthesis and is involved in amino acid metabolism. In addition, it is a coenzyme for the transfer of single carbon units. It is readily absorbed from the upper small intestine, although its absorption may be reduced in the presence of vitamin B_{12} deficiency. The daily requirement for this vitamin is 100 μg per day. Humans have the capacity to store about 5 mg of this vitamin, which provides an adequate supply for 2–3 months. Requirements for folic acid are increased in pregnancy. Deficiency is usually related to a deficient diet or diminished absorption and concurrent vitamin B_{12} deficiency. Clinical findings associated with deficiency include a megaloblastic anemia which is similar to that observed with vitamin B_{12} deficiency.

Studies of candidates for bariatric surgery indicate that the prevalence of low folate levels is 3.4–24 % [2, 4, 28, 29]. Utilizing measurements of red blood cell folate levels in 232 candidates for bariatric surgery, levels consistent with deficiency were noted in 5.7 % of the cohort [30]. This same study found that serum folate levels fell in the first year after gastric bypass surgery. The frequency of clinical signs of folate deficiency in this cohort was not recorded. Clinical folate deficiency is unusual in bariatric surgery, because folate can be absorbed all along the gastrointestinal tract, and a multivitamin preparation contains 400 μg per dose, which usually is sufficient to correct low levels [30]. Definitive recommendations are difficult because of insufficient data regarding exact prevalence as determined by red cell folate levels in post-gastric bypass patients. Compliance with a multivitamin supplement should be stressed and additional studies are needed. Folic acid supplementation is indicated for all women of childbearing age because of the risk of neural-tube defects with folic acid deficiency [13].

Vitamin D

Interest in vitamin D is extremely high because of its involvement in many important biological mechanisms and the high prevalence of depletion among extremely obese individuals (Table 7.1). The majority of daily vitamin D is synthesized in the skin from 7-dehydrocholesterol after exposure to ultraviolet B rays in sunlight.

Table 7.2 Status of vitamin D nutrition as determined by serum level of 25(OH)D in serum [31]

Condition	Serum 25(OH)D Level (ng/ml)
Healthy range	30–60
Depleted	20–29
Deficient	10–19
Repletion goal	≥30

Some dietary vitamin D is available as ergocalciferol (D_2) from mushrooms and as cholecalciferol (D_3) from shellfish, cod liver oil, and milk fortification. Activation steps are necessary for the hormonally active form. Hydroxylation in the liver produces 25-hydroxyvitamin D (25(OH)D) from both D3 and D2. The circulating level of 25(OH)D is an accurate clinical indicator of vitamin D status. A second hydroxylation step in the kidney activates 25(OH)D to calcitriol (1,25(OH)D). Calcitriol has a short half-life and measurement is not helpful clinically in assessment of vitamin D status [31].

The vitamin has a critical role in the maintenance of calcium and phosphorus homeostasis and bone health. It enhances the intestinal absorption of calcium, and regulates calcium and phosphorus in the body while supporting bone mineralization, remodeling, and maintenance. In addition, the vitamin is involved in immunomodulation, pancreatic β cell stimulation, and cancer protection [32]. Deficiency of this vitamin results in diminished intestinal calcium absorption, which results in reduced levels of calcium. The fall in calcium levels stimulates the secretion of parathyroid hormone (PTH) resulting in increased synthesis of 1,25(OH)D, bone resorption, calcium conservation, and decreased calcium excretion. Such a compensatory increase in PTH usually indicates negative calcium balance, vitamin D deficiency, or both. In the setting of vitamin D deficiency, the metabolic feedback regulation is aimed at preserving calcium homeostasis at the expense of bone mass. Symptomatic deficiency states are associated with osteomalacia, diminished bone density and fractures. Additional indirect consequences of deficiency include muscle weakness and falls [32].

The RDA of vitamin D is 600–2,000 international units (IU) per day. Regular sensible exposure to sunlight is also recommended. Assessment of vitamin D nutrition is performed by measurement of the level of 25(OH)D in the serum (Table 7.2) [31].

During recent years, there has been a trend toward falling serum levels of 25(OH)D, especially among non-Hispanic blacks, according to the Third National Health and Nutrition Examination Survey (NHANES III). A high prevalence of the population studied had 25(OH)D levels below the healthy range [33]. Studies in candidates for bariatric surgery demonstrate deficient levels of 25(OH)D in 36–61 % with a smaller percentage having levels consistent with severe deficiency (Table 7.1) [2, 4, 34–36]. These studies also demonstrate a significant prevalence of hyperparathyroidism among candidates for bariatric surgery. There appears to be an inverse relationship between levels of 25(OH)D and PTH levels, with both worsening as BMI increases. Despite the known fact that severe deficiency of vitamin D causes secondary hyperparathyroidism, this inverse relationship does not appear to be causative at all levels of 25(OH)D, but a direct consequence of obesity and its extent [36].

Table 7.3 Laboratory findings in association with severe vitamin D deficiency

25 (OH)D	<10 ng/ml
Calcium	Normal or decreased
Phosphorus	Normal or decreased
Alkaline phosphate	Increased
Parathormone	Increased

Dietary vitamin D is absorbed in the distal jejunum and ileum. Calcium is actively absorbed in the duodenum and proximal jejunum, a process enhanced by vitamin D in an acid environment. There is also limited passive absorption of calcium in the remaining small intestine. The significant prevalence of vitamin D abnormalities in extreme obesity, together with the likelihood that bariatric surgical anatomic changes may worsen the situation, creates a challenge for bariatric programs to develop effective strategies to monitor and maintain calcium and vitamin D nutrition. All of the bariatric surgical procedures have been shown to cause adverse effects on calcium and vitamin D nutrition; however, the impact appears to be less with the purely restrictive procedures where gastrointestinal continuity is maintained. The prevalence rates for vitamin D deficiency after gastric bypass and malabsorptive procedures are not well established because of variable patient compliance with supplementation and variable dosing of supplements [31].

Candidates for bariatric surgery should have assessment of vitamin D and calcium nutrition well in advance of surgery in order to diagnose and treat deficiency states. Laboratory evidence of severe vitamin D deficiency is outlined in Table 7.3.

Supplementation should include calcium and vitamin D. Because some studies suggest that levels respond better to supplementation with D_3 because of its longer half-life, this may be superior to supplementation with D_2 [32]. Calcium should be supplemented in doses of 1,500–2,400 mg per day. The citrate salt is preferred for long-term supplementation because it can be absorbed in the absence of gastric acid. Calcium supplementation should be provided in divided doses of 500 mg throughout the day in order to maximize absorption. Calcium should not be supplemented at the same time as iron for best absorption and minimizing side effects.

The endpoint for vitamin D supplementation is a 25(OH)D level of ≥30 ng/ml. Lower doses of calcium and vitamin D can usually be used after restrictive procedures. Gastric bypass and malabsorptive procedures mandate high-dose vitamin D supplementation. Randomized trials indicate that higher dose supplementation is more effective [37, 38]. Examples of high-dose supplementation regimens after gastric bypass are calcium at 1,500–2,000 mg per day and vitamin D at 2,000 IU daily, or calcium at 1,200–2,000 mg daily and vitamin D 50,000 IU 2 or three times weekly.

Additional longer-term data is needed in order to make more definitive recommendations regarding supplementation after bariatric procedures. It is apparent that this is a nutrition issue of extreme importance in bariatric surgery and cannot be neglected. Each program must address this in patient education and nutritional follow-up. Despite the risks, it appears that bone health can be maintained even after malabsorptive procedures with close follow-up, regular lab monitoring, and aggressive supplementation [39]. For additional current information, the reader is referred to current reviews [31, 32, 40].

Vitamin A

Vitamin A refers to a collection of fat-soluble hydrocarbons which include retinol, retinal, retinoic acid, and several provitamin A carotenoids including beta-carotene. Vitamin A is important for vision as the retinal form is bound to protein to form rhodopsin in rods and iodopsin in cones. Rhodopsin is needed for night and low light vision. Vitamin A also supports the function of conjunctival membranes and the cornea. Other important functions include involvement in cell growth, genetic transcription, and maintenance of immune function. Vitamin A is found in foods from animal sources including dairy products, fish, meat, and liver. The vitamin is absorbed in soluble micelles in the duodenum. Most of the vitamin A in the body is stored in the liver. The RDA for vitamin A is 900 retinol activity equivalents (3,000 IU) daily [1]. Requirements are increased in pregnancy and lactation.

Vitamin A nutrition is assessed by measurement of retinol levels in plasma. The normal range is 32–78 μg/dl [1]. A diminished retinol level indicates deficiency. The most common symptoms of vitamin A deficiency are xerophthalmia (conjunctival dryness) and difficulty with night vision. Deficiency of vitamin A is unusual in the United States, but is becoming more well known after bariatric surgery. Factors contributing to deficiency after bariatric surgery include oxidative stress, malabsorption of lipids, and poor lipid and dietary vitamin A intake [26]. There is limited information regarding the prevalence of low vitamin A levels among candidates for bariatric surgery. A recent retrospective analysis of 100 patients found that low levels of vitamin A were present in 11 % [28]. Another study of 114 patients with extreme obesity found that the prevalence of subthreshold levels of vitamin A was 14 % and that of beta-carotene was 37.5 % [41]. Several studies of postoperative patients have shown that vitamin A and carotenoid levels fall significantly during the first postoperative year [41–43]. After gastric bypass procedures, vitamin A levels fall and deficiency rates of 8–11 % are observed at 1 and 2 years after surgery [41, 42]. The impact of vitamin A supplementation after gastric bypass is not clear as daily supplementation did not prevent falling vitamin levels in one study [41].

The prevalence of subthreshold levels of vitamin A is significantly higher following more malabsorptive bariatric procedures. Several studies document low levels of vitamin A in 50–68 % at 2–4 years after biliopancreatic diversion despite supplementation [44, 45]. Despite the high prevalence of subthreshold vitamin levels in bariatric surgery, clinically symptomatic deficiency states are rare after bariatric surgery and are limited at present to case reports [46–48]. Although reduced levels of vitamin A have been documented in candidates for bariatric surgery and in postoperative patients following gastric bypass and malabsorptive procedures, it is apparent that there is much to be learned about vitamin A nutrition in bariatric surgery. Additional studies are indicated to provide information on the dose and impact of supplementation aimed at preserving levels before best practice recommendations can be established.

Vitamin E

Vitamin E refers to a collection of fat-soluble compounds, which include tocopherols and tocotrienols. Alpha tocopherol is the compound with the most biological activity. Alpha tocopherol levels are controlled by the liver, which takes up the various nutrient forms of vitamin E absorbed in the small intestine, and re-secretes the vitamin as α tocopherol. The primary function of vitamin E is as an antioxidant. The vitamin protects cells from damage from reactive oxygen species that are generated by the oxidation of fats. Additional functions include involvement in immune function and preservation of healthy endothelial function. The RDA of vitamin E is 15 mg/day. Dietary deficiencies of vitamin E do not exist. Clinical deficiency is unusual and only occurs in the setting of severe malabsorption (chronic gastrointestinal disease and extensive intestinal resection).

Information about vitamin E nutrition in bariatric surgery is very limited. One study of a small number of candidates for surgery documented low vitamin E levels in 2.2 % [2]. In another study, candidates for bariatric surgery had lower levels of lipid corrected vitamin E levels compared with nonobese controls [49]. Levels are normal in other studies of candidates for bariatric surgery. Clinical deficiency following bariatric surgery has not been described, but several studies do demonstrate that vitamin E levels fall after gastric bypass and malabsorptive bariatric procedures [43–45]. These and other studies [50, 51] suggest that protection against oxidative stress may fall after bariatric surgery with declining levels of vitamin E. The clinical significance of this observation is unknown, but it appears that this decline in vitamin E after bariatric surgery occurs despite some degree of supplementation. Best practice recommendations for management of vitamin E nutrition are needed.

Vitamin K

There are two natural forms of vitamin K: K1 (phylloquinone) from vegetable and animal sources and K2 (menaquinone), which is synthesized by bacterial flora and found in liver tissue. Vitamin K is required for the posttranslational carboxylation of glutamic acid in the synthesis of coagulation factors II, VII, IX, and X as well as Protein C, Protein S, and osteocalcin. The vitamin is found in green leafy vegetables and the recommended daily requirement is 100 μg per day. Absorption is from the ileum and jejunum. Vitamin K turnover is rapid and the body pool of this vitamin is limited. Symptoms of vitamin K deficiency relate to hemorrhage mainly in newborns and in adults with extensive gastrointestinal disease or biliary obstruction. Broad-spectrum antibiotics can precipitate deficiency by eliminating small intestinal bacteria that synthesize menaquinone. Vitamin K deficiency is treated by oral administration of 2.5–25 mg/day or by parenteral administration of 5–15 mg vitamin K [52].

There is little available information regarding vitamin K nutrition in bariatric surgery. Vitamin K levels can be measured, but the clinical diagnosis of deficiency is usually made on the basis of an elevated prothrombin time or reduced levels of clotting factors. A recent survey of 115 female candidates for bariatric surgery assessed vitamin K nutrition with serum levels and found no cases of deficiency [53]. There are no reports of vitamin K deficiency after gastric bypass surgery suggesting that deficiency is rare. However, a recent case report of a fetal death from cerebral hemorrhage in a woman with vomiting and gastric band slippage during pregnancy suggests that close monitoring of women of childbearing age after bariatric surgery may disclose limited critical micronutrient reserves [54]. Two studies have found in a small number of patients that vitamin K levels are low in 50–60 % of patients in late follow-up after malabsorptive procedures [44, 45], with one study showing an increase in vitamin K levels with duration of follow-up [44]. No clinical deficiencies were reported in these studies.

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Chapter 8
Nutrition II: Minerals

Iron

The importance of iron nutrition is fairly well known to bariatric centers because iron deficiency is one of the more common nutritional complications of bariatric surgery. Iron is a critical element in cellular function. It has a major role in oxygen transport as an oxygen carrier in the hemoglobin molecule. Heme iron is also bound to muscle myoglobin. Iron is involved as a component of the cytochrome enzyme system in mitochondrial electron transport. Iron is available in diet in two forms, molecular and heme iron. Meat is a major source of heme iron in the diet and 2/3 of the body iron store of 4–5 g in well-nourished adults is derived from heme iron.

Molecular iron enters the stomach in the oxidized (Fe^{3+}) form. Gastric acidity and ascorbic acid facilitate the solubilization of elemental iron. Absorption of iron takes place in duodenal and proximal jejunal mucosal cells. These absorptive cells then release iron to the circulation bound to transferrin. Heme iron is also absorbed in the duodenum where pancreatic enzymes free the heme moiety from dietary hemoglobin and myoglobin. The recommended daily allowance for iron is 8–18 mg per day. Iron stores are mainly in liver, spleen, and bone marrow. There is no excretory pathway for iron, with daily loss coming only from loss of epithelial cells from skin, urinary epithelium, gastrointestinal mucosa, and loss of blood.

Factors that contribute to iron deficiency include an increase in iron demand (pregnancy and growth), increased loss of iron (bleeding, menses), and diminished dietary intake (dietary deficiency or malabsorption). The stages in the development of iron deficiency and the diagnostic tests are summarized in Table 8.1. In the initial phase of progression to deficiency, there is a period of negative iron balance where the daily demands for iron and/or losses of iron exceed the iron available in diet. During this period, iron stores make up the deficit and iron homeostasis is maintained until stores are depleted. During this period, the only hint of developing problems with iron is a falling ferritin level. Under most conditions, the serum ferritin level correlates with iron stores and when the level falls to ≤15, iron stores are depleted and the deficiency state begins. When stores are depleted, the serum iron

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Table 8.1 Laboratory values at various stages in the development of iron deficiency

Laboratory assessment of iron nutrition				
Iron status	Normal	Depletion, no deficiency	Deficiency, early anemia	Severe deficiency
Marrow iron stores	Normal	Reduced	Absent	Absent
Plasma ferritin, level (mcg/l)	60–140	<25	<15	<10
Hemoglobin level (g/dl)	Normal	Normal	9–12	6–7
Transferrin IBC (mcg/l)	300–360	330–360	390	410
Transferrin saturation (mcg/dl)	20–50	30	<15	<15
Mean corpuscular volume	80–100	80–100	<80	<65

Adapted and modified from: Hoffman R, Benz EJ, Silberstein LE, Heslop HE, Weitz JI, Anastasi J. Hematology: Basic Principles and Practice, 6th edn. Chapter 34:437–449. Copyright © 2013, Elsevier Inc. [41]

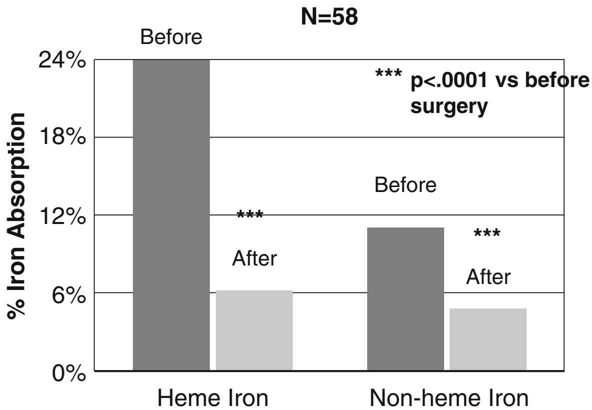

Fig. 8.1 Iron absorption measured after a test meal containing labeled heme and inorganic iron. The test meal was given before and 12 months after gastric bypass and sleeve gastrectomy. Adapted from Ruz M, Carrasco F, Rojas P, Codosceo J, Inostroza J, Basi-fer K, et al. Heme- and Nonheme-iron Absorption and iron Status 12 Months After Sleeve Gastrectomy and Roux-en-Y Gastric Bypass in Morbidly Obese Women. Am J Clin Nut 2012;96:810–817 [6]

level will begin to fall reflecting deficiency. Hemoglobin synthesis is preserved while iron levels remain in the normal range. Once the transferrin saturation falls to 20 %, hemoglobin synthesis becomes impaired and anemia develops.

The prevalence for iron deficiency among candidates for bariatric surgery on the basis of abnormal blood levels is 1–15 %, with a large majority in females [1–5]. Recent evidence suggests that negative iron balance is an inevitable consequence of bariatric surgical procedures and that the progression to iron deficiency is a major risk, but responsive to good surveillance and supplementation. Studies using test meals of labeled inorganic and heme iron show that absorption of both is significantly impaired 12 months following gastric bypass and sleeve gastrectomy in comparison to before surgery (Fig. 8.1) [6]. Mechanisms for the diminished absorption relate to

Table 8.2 The commonly used oral iron supplements and the amount of elemental iron available

Preparation	Elemental iron (mg)
Ferrous gluconate (325 mg)	39
Ferrous sulfate (325 mg)	65
Ferrous fumarate (325 mg)	107

loss of gastric acidity, bypass of the duodenum, and delay in the contact of the food bolus with pancreatic and biliary secretions [7]. In addition to major limitations in absorption, diet reviews indicate that daily intake of iron in the diet of postoperative bariatric surgery patients is well below the recommended dietary allowance [8].

This evidence suggests that depletion of iron stores and deficiency is inevitable after bariatric surgery without judicious follow-up and supplementation. Iron depletion and deficiency anemia are common after all types of bariatric surgery. The prevalence was summarized in a recent review of retrospective reports, which indicated a wide-ranging prevalence. After purely restrictive procedures, rates of 0 % at 1 year to 32 % at 4 years are reported. Following gastric bypass, rates of 13–52 % are reported with higher rates occurring with longer follow-up. After malabsorptive procedures, rates of 20–45 % are reported [9]. Variation in reported rates is a reflection of differing care plans for iron supplementation and variations in patient compliance with supplementation. One report of a 0 % incidence of iron deficiency in a cohort of 589 patients followed over 3 years following biliopancreatic diversion with duodenal switch indicates that good follow-up and supplementation can potentially control this condition. In addition, this report raises questions about the nutritional significance of partial preservation of the duodenum in the duodenal switch procedure [10].

The evidence to date indicates that iron nutrition can be managed in bariatric surgery patients with careful follow-up, supplementation, and surveillance for iron depletion. Several studies of inorganic iron tolerance with blood levels following an oral dose of elemental iron indicate that absorption takes place following bariatric surgery [11, 12]. In the majority of postoperative patients, iron nutrition can be managed with oral iron therapy. Multiple oral preparations are available from simple iron salts to more complex preparations designed for sustained release. For treatment of deficiency, up to 300 mg of elemental iron may be given daily, usually in divided doses of 50–65 mg of elemental iron through the day (Table 8.2).

In patients with limited gastric retention capacity, iron solutions are a consideration. In the normal individual, such therapeutic doses of iron should allow for absorption of up to 50 mg per day. The rate of response in the post-bariatric surgery patient is a function of how much absorption takes place and will require close monitoring of dose and response. The goal of treatment is not only to resolve anemia, rather to partially restore at least some part of the iron stores. Continued treatment after resolution of anemia and monitoring serum ferritin should accomplish this. There is some evidence that the response to oral iron may be augmented by the simultaneous administration with ascorbic acid to enhance absorption [12]. Because of the limited human capability for iron excretion, injudicious treatment or even supplementation can lead to iron overload.

Unfortunately, patient compliance with oral iron treatment or supplementation may be a challenge for the bariatric center because of the common occurrence of unpleasant gastrointestinal symptoms (nausea, vomiting, abdominal pain, and constipation) in association with iron therapy. This mandates close communication with patients, possible changes in iron preparation, and regular checks on patient compliance. Failure of oral therapy is an indication for referral for parenteral iron replacement, which is an increasingly common occurrence after bariatric surgery, especially for women of childbearing age [13]. It is evident that skilled nutritional care, patient teaching, and careful follow-up are essential in the preservation of quality of life in regard to iron nutrition.

Zinc

Zinc is the second most common trace element in the body. Total body zinc amounts average 1.5–2.5 g, slightly less than total body iron. The majority of total body zinc (60 %) is in low turnover pools in muscle and bone. Zinc is essential for normal cellular metabolic activity as it is a component of 250 important proteins including Angiotensin Converting Enzyme, Alkaline Phosphatase, Carbonic Anhydrase, and DNA Polymerase. Its importance lies in stabilization of protein and DNA structure, protection from free radical damage, growth and development, and wound healing. It also has a role in cell division and apoptosis. The major site for gastrointestinal absorption is the duodenum and proximal jejunum, with absorption regulated by zinc nutritional status. Pancreatic enzymes are necessary for the release of dietary zinc. Dietary sources of zinc include meat, chicken, nuts, lentils, and fortified cereals. Zinc is excreted primarily via the gastrointestinal tract with 10 % urinary excretion. When zinc becomes deficient, gastrointestinal and urinary excretion will decline. The obligatory gastrointestinal losses associated with malabsorptive procedures may interfere with the process of reducing gastrointestinal zinc losses in the setting of deficiency [14]. The recommended dietary allowance for zinc is 8 mg/day for females and 11 mg/day for males.

Zinc deficiency is common worldwide and is characterized by impotence, hypogonadism, oligospermia, alopecia, impaired taste, immune dysfunction, impaired wound healing, and various skin lesions. Currently, body zinc status is most commonly assessed by measurement of plasma levels. Plasma levels do not correlate with tissue levels and may not be the best test to assess zinc status. Measurement of red blood cell zinc levels may prove to be superior, but is not commonly performed at present. In plasma, zinc is bound to albumin, and thus any condition such as protein malnutrition or an inflammatory state, which reduces blood levels of transport proteins, will reduce the blood zinc level [14, 15].

Among candidates for bariatric surgery, blood levels of zinc are below threshold in 8–30 % of patients [1, 14, 16, 17]. Among these studies, the lowest incidence of

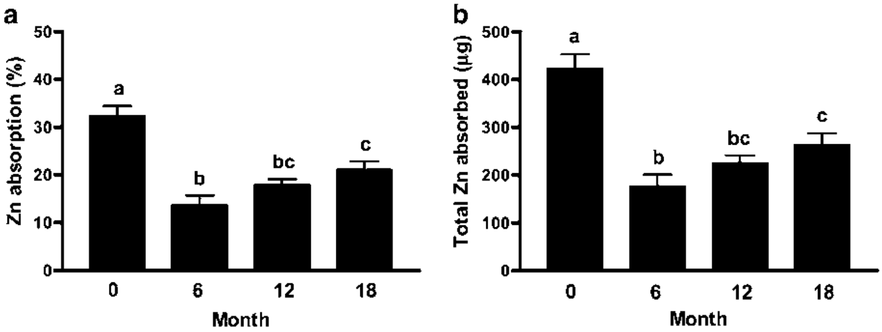

Fig. 8.2 Mean zinc absorption from a standard test meal given before, and 6, 12, and 18 months after Roux-en-Y Gastric Bypass. Reproduced with permission from Ruz M, Carrasco F, Rojas P, cococeo J, Inostroza J, Basi[fer K, et al. Zinc Absorption and Zinc Status are Reduced after Roux-en-Y Gastric Bypass: A Randomized Study using two Supplements. Am J Clin Nut 2011; 94:1004–1011 [19] Copyright © 2014 by the American Society for Nutrition

low zinc levels was 8.1 % in a cohort with no abnormalities of albumin or circulating protein [14]. The effects of bariatric surgery on zinc nutrition have not been well studied to date, but the impact of bypassing the duodenum and displacement of the contact of pancreatic enzymes with food and other factors related to bariatric surgery appears to induce a period of negative zinc balance after gastric bypass and malabsorptive procedures. Despite a limited intake of zinc in the first 2 months after gastric bypass, plasma and red blood cell zinc levels are maintained, but urinary excretion declined [18]. A more recent study of 67 women before and then at 6, 12, and 18 months after gastric bypass surgery assessed zinc nutriture with multiple analytical tests and zinc absorption using dual isotopes of zinc at each interval showed that zinc nutritional status slowly deteriorated at each time interval and that zinc absorption was significantly reduced at 6 months with a modest but significant recovery by 18 months (Fig. 8.2) [19].

Another study, utilizing zinc tolerance tests before and after gastric bypass surgery, has also demonstrated a major reduction in zinc absorption following gastric bypass [11]. It appears as though abnormalities of zinc nutrition are even more pronounced after malabsorptive procedures with high prevalences of abnormally low zinc levels 4–5 years after surgery [17, 20]. Despite the high prevalence of low zinc levels in late follow-up after malabsorptive procedures, no clinical evidence of zinc deficiency has been reported.

The evidence to date suggests that zinc nutrition should be assessed and closely followed in bariatric surgery patients. It is apparent that routine postsurgery supplementation with multivitamin and mineral supplements may not be sufficient to maintain adequate zinc nutrition, at least after gastric bypass and malabsorptive procedures. Additional long-term data regarding zinc status and the impact of supplementation regimens are needed.

Copper

Copper is an essential trace element and an integral part of many body enzyme systems. It has a role in iron metabolism, melanin synthesis, energy production, central nervous system function and maintenance, neurotransmitter synthesis, connective tissue formation, and scavenging for free radicals. Dietary sources of copper include shellfish, liver, legumes, bran, and organ meats. The recommended dietary allowance for copper is 0.9 mg/day for males and females and 1 mg/day in pregnancy. The average normal copper intake is 1–1.1 mg per day. Absorption of copper takes place in the stomach and duodenum [21]. The nutritional status of copper is assessed by measurement of plasma levels of copper and ceruloplasmin, a protein which binds and transports copper as well as facilitates the mobilization of iron stores in the liver [21]. Normal values for copper levels are 75–145 mg/dl. When copper levels fall below 65 μg/dl and ceruloplasmin levels fall below 20 mg/day, the diagnosis of copper deficiency is established [21].

Deficiency of copper is very unusual in the normal population, but is now well recognized as a possible complication of bariatric surgery. Clinical features of copper deficiency after bariatric surgery include hematological abnormalities (anemia with or without leukopenia, neutropenia, or thrombocytopenia) and various neurological problems, which include gait unsteadiness, fatigue, muscle weakness, extremity numbness, and paresthesias. Frequently, these symptoms are confused with iron or B_{12} deficiency and the diagnosis is considered only if patients do not respond to treatment and lab studies show low copper nutrition [22]. Copper deficiency should be part of the differential diagnosis in the evaluation of anemia after bariatric surgery. Treatment of copper deficiency with oral or parenteral copper will resolve anemia, but the potential for resolution of neuropathic signs and symptoms is variable. These observations confirm the need for better copper surveillance in bariatric surgery patients. There are a number of published case reports of copper deficiency occurring very late after gastric bypass or malabsorptive procedures [23–25]. An additional case report of a patient who developed copper deficiency after a long interval following a Whipple procedure supports the importance of the duodenum in copper absorption [26]. A recent case report of a patient who developed symptomatic copper deficiency within 2 years after gastric bypass has generated interest in more systematic study of copper nutrition in bariatric surgery [27].

Copper nutritional status has not been extensively studied in candidates for bariatric surgery. Several small cohorts have been studied with no patients having subthreshold levels [1, 22]. In another reported series of 115 female patients prior to biliopancreatic diversion, 68 % had subthreshold copper levels [28]. The final study of candidates compared copper levels in 78 patients, 1.3 ± 0.9 years after gastric bypass surgery, with 77 controls with extreme obesity (BMI >40 kg/m^2), and demonstrated that postoperative gastric bypass patients had lower levels of copper and 15.4 % of the post-gastric bypass patients had levels consistent with copper deficiency compared with a zero prevalence among candidates for surgery (Fig. 8.3) [29].

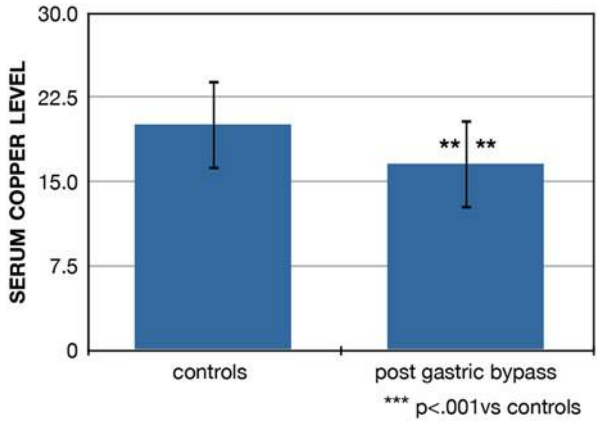

Fig. 8.3 Serum Copper levels (μmol/l) compared in 77 control patients with extreme obesity (BMI >40 kg/m^2) and in 78 postsurgery patients averaging 1.3 ± .9 years after gastric bypass surgery. Adapted from Ernst B, Thurnheer M, Schultes B. Copper Deficiency after Gastric Bypass Surgery. Obesity 2009; 17:1980–1981 [29]

The validity of copper and ceruloplasmin levels in the assessment of copper nutritional status has been questioned because of the potential for cytokine-induced elevation of ceruloplasmin may mask copper deficiency states [15]. Several studies have demonstrated that the malabsorptive procedures result in a higher prevalence of copper deficiency when compared to gastric bypass [22, 30]. In the more systematic longitudinal studies after gastric bypass and malabsorptive procedures, no clinically symptomatic patients with copper deficiency were encountered despite the high prevalence of laboratory evidence of deficiency. This is probably related to prompt supplementation as soon as deficient levels are identified.

Most of the reported cases of copper deficiency occur late after bariatric surgery, although patients may have been symptomatic for long periods as the diagnosis was not made. The recent scattered reports of earlier onset deficiency after gastric bypass argue for copper status assessment for candidates for surgery, appropriate nutritional counseling, and regular surveillance for copper abnormalities after surgery. It is also apparent that routine multivitamin and mineral supplements containing small amounts of copper cannot be relied on to prevent deficiency [31]. Copper deficiency should be in the differential diagnosis of any postoperative patient with hematological and/or neurological complaints.

Selenium

Selenium is a trace element, which is essential in small amounts, but potentially toxic at high levels. It is a necessary component of a number of proteins called Selenoproteins. Important selenoproteins include the glutathione peroxidases, which protect cells from oxidative injury from reactive oxygen species and thyroid hormone deiodinases, necessary for synthesis of thyroid hormone. The major functions of selenium involve antioxidant activity and support for vitamin E activity.

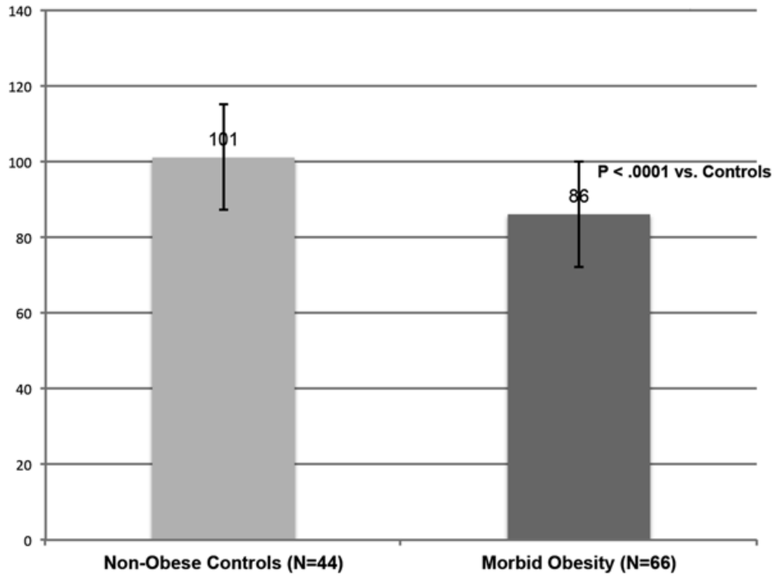

Fig. 8.4 Selenium Levels are compared in candidates for bariatric surgery ($n=66$) and nonobese female controls ($n=44$; BMI ≤ 30 kg/m^2) [33]

Food sources for selenium include organ meats, seafood, muscle meat, US grains, and Brazil nuts. The recommended dietary allowance for adults is 55 mg per day. Deficiency of selenium is rare and can occur in chronically ill patients who are receiving total parenteral nutrition. Symptoms and signs of deficiency include muscle weakness, fatigue, and congestive heart failure from cardiomyopathy [32].

Only recently is there any data about selenium status in bariatric surgery patients. The first report is a case report of a patient with life-threatening cardiomyopathy related to selenium deficiency who recovered with supplementation [32]. In this case, deficiency was diagnosed on the basis of extremely low blood levels of selenium and glutathione peroxidase. In a survey of morbidly obese subjects, selenium levels were found to be significantly lower than in nonobese controls (Fig. 8.4) [33].

A small study of patients undergoing gastric bypass ($n=9$) revealed no preoperative patients with low selenium levels, a significant fall in levels at 3 months after surgery, and a return toward normal at 1 year after surgery [34]. The limited evidence to date suggests that disturbance of selenium nutrition is a concern after bariatric surgery, and that additional studies are needed.

Summary

> At the moment surgery produces far larger changes in the *way* obese people die, than on the *day* that they die.
>
> From Leslie Klevay, Obesity Surgery 2010;20:672–673 [15].

The above statement reflects the perception of a scholar of internal medicine and nutrition who is commenting in a letter to the editor on micronutrient deficiency states in bariatric surgery. These comments should serve as a challenge to bariatric surgery programs to expand the nutritional assessment of candidates for bariatric surgery, and to provide improved patient- and procedure-centered nutrition education and surveillance programs during postoperative follow-up. The combination of a nutritionally poor high-energy diet before surgery, limited dietary intake after surgery, avoidance of healthy foods, and surgically created malabsorption sets the stage for major micronutrient deficiencies contributing to poor health and impaired quality of life after surgery.

Improved nutritional assessment with correction of micronutrient deficiencies before surgery will reduce the risk of disabling nutritional deficiency syndromes in the early postoperative period. Evidence indicates that individuals who undergo malabsorptive procedures are at greater risk for micronutrient deficiency, and thus, postoperative nutritional surveillance and supplementation protocols should be tailored to the patient and the procedure.

The majority of studies regarding micronutrient status in bariatric surgery are retrospective and difficult to interpret because of differences in patient populations, surgical procedures, assessment techniques, nutritional management, and patient compliance. The limited data from prospective studies suggest (even though the numbers are small) that micronutrient status may be better maintained with more focused postoperative supervision by nutrition specialists [35, 36]. More of these studies are needed.

Better perioperative nutritional management will enhance patient safety and promote improved health and quality of life outcomes. As bariatric and metabolic surgery aspires to expand its role, the challenge to improve nutritional care is issued. For best practice nutrition recommendations, the reader is referred to several excellent reviews [37–40].

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Chapter 9
Pregnancy

For many years, obstetricians have urged obese women to lose weight prior to becoming pregnant because of the increased risk of reproductive complications in the setting of obesity (Table 9.1) [1, 2].

Because of lack of success with conventional weight loss programs, many women of childbearing age are currently seeking bariatric surgery as a means of achieving major weight loss and safer pregnancies. At present, nearly 80 % of bariatric surgery patients are females, with a large majority in the reproductive age group. The increasing popularity of bariatric surgery among obese women introduces additional responsibility for bariatric surgery programs to provide information and guidance in the area of fertility, pregnancy, contraception, nutrition, and mental preparedness for pregnancy after bariatric surgery. Although the risks of many reproductive complications of obesity like gestational weight gain and hypertensive disorders of pregnancy are reduced by surgical weight loss [1, 3], bariatric surgery does introduce other important risks, which will be discussed in this chapter.

Obesity is a well-known cause of infertility because of hyperandrogenism and polycystic ovarian syndrome resulting in irregular menses, anovulatory cycles, and amenorrhea. Weight loss is recommended for obese women who desire pregnancy in order to correct ovarian dysfunction and restore fertility. Candidates for bariatric surgery must be advised that menstrual cycles are likely to improve promptly during weight loss with normalization of fertility [4]. This fertility rebound during weight loss may result in surprise and unwanted pregnancies, which may introduce additional stressors during a difficult period for patients after bariatric surgery. In order to avoid these difficulties during the period of rapid weight loss, female candidates for bariatric surgery should consider the use of contraception for 1 year after bariatric surgery [5].

Although there is controversy about how long to postpone pregnancy after bariatric surgery, most agree that the period of rapid weight loss is an inopportune time for a pregnancy and may increase the risk of nutritional complications for the fetus. Bariatric surgery patients need to understand that pregnancy is a period of increased nutritional requirements for many of the micronutrients discussed in the previous chapters, and that the period of rapid weight loss is usually a period of negative

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Table 9.1 Potential maternal reproductive complications which are associated with obesity

• Early miscarriage
• Preterm labor
• Intrauterine fetal death
• Gestational diabetes mellitus
• Gestational hypertension
• Preeclampsia
• Fetal macrosomnia
• Cesarean delivery
• Anesthetic complications
• Infectious morbidity
• Thromboembolism

Table 9.2 Factors that contribute to maternal nutritional deficiency in mothers who have previously undergone bariatric surgery

• Reduced dietary intake
• Food aversions
• Nausea and vomiting from pregnancy
• Increased micronutrient requirements for pregnancy
• Surgical malabsorption

body balance for many of these important micronutrients because of reduced food intake and altered absorption. Although there are scattered reports of successful and uncomplicated pregnancies during the first year after bariatric surgery [6, 7], most agree that the recommended interval should be 1 year, which encompasses the period of rapid weight loss for most patients [8, 9].

Recommendations for maternal weight gain during pregnancy have been established by the Institute of Medicine. For normal weight individuals (BMI 18.5–24.9 kg/m^2), recommended weight gain with pregnancy is 11.5–16 kg, and for overweight individuals (BMI 25–29.9 kg/m^2), it is 7–11.5 kg [10]. Adequate weight gain during pregnancy is felt to be essential for a healthy intrauterine environment and for promotion of normal fetal growth. There are many controlled and retrospective cohort studies which show that gestational weight gain is less in patients after bariatric surgery [11–15], and that weight gain is greater when pregnancy occurs ≥18 months after bariatric surgery [16]. Gastric band patients may have an advantage, because frequent band adjustments during pregnancy may allow optimization of dietary intake during pregnancy [14]. The studies comparing maternal weight gain after bariatric surgery with either community or obese controls have not demonstrated clinically relevant neonatal complications associated with less maternal weight gain. The clinical significance of maternal weight gain in the patient with extreme obesity who is losing weight after bariatric surgery remains to be proven because of the potentially offsetting favorable effects of patient education, judicious nutritional supplementation, and focused high-risk obstetrical care [17].

Nutritional deficiencies are a major cause for concern for women who become pregnant after bariatric surgery, because mild nutritional deficiencies are common, especially during rapid weight loss. Factors that contribute to nutritional deficiencies during pregnancy following bariatric surgery are summarized in Table 9.2.

Table 9.3 Summary of information from case reports demonstrating maternal nutritional deficiencies related to bariatric surgery and associated adverse neonatal outcomes

• Growth retardation [18–20]
• Electrolyte, acid-based disorders [21]
• Cerebral hemorrhages (vitamin K deficiency) [21, 22]
• Microphthalmia, retinal damage, hypotonia (vitamin A deficiency) [19, 20]
• Anemia (vitamin B12 and iron deficiency) [7, 23, 24]
• Failure to thrive (vitamin B12 deficient breast milk) [25]
• Neural tube defects (folic acid deficiency) [26]

Nutritional abnormalities can potentially affect the intrauterine environment, which influences fetal development and possibly future health. The influence of nutrition on these processes is poorly understood. The concern for micronutrient deficiencies stems from the growing number of case reports demonstrating significant maternal nutritional deficiencies during pregnancy and associated adverse neonatal outcomes (Table 9.3) [1, 2, 18–26].

Unfortunately, few prospective studies address this issue, and the prevalence of adverse neonatal outcomes related to maternal nutritional deficiency is unknown. The retrospective cohort studies that involve small patient numbers suggest that the prevalence is small and may be related to poor nutritional follow-up and/or poor patient compliance. The few more systematic studies suggest that close nutritional follow-up and aggressive supplementation can improve nutrition and lessen the risk of adverse outcome [22, 23], but more prospective longitudinal nutritional studies of pregnant post-bariatric surgery patients are needed.

Another cause for concern in the management of pregnancy in patients following bariatric surgery is the potential for the development of maternal gastrointestinal complications related to the bariatric procedure during pregnancy. The sudden onset of acute gastrointestinal symptoms (abdominal pain, nausea, and vomiting) is always a concern for the patient after bariatric surgery. The development of acute gastrointestinal disease in a pregnant patient should be considered a surgical emergency and mandates the involvement of the bariatric surgeon in the management. Failure to promptly treat or inappropriate conservative treatment invites additional risk both to the mother and fetus.

Mechanical complications of gastric band placement including slippage and gastric prolapse may occur with increased frequency during pregnancy, perhaps related to increased nausea and vomiting during early pregnancy, increased abdominal pressure, and repositioning of abdominal viscera [27, 28]. Prompt treatment is essential in this situation because of the nutritional requirements during pregnancy and the nutritional risks related to treating a pregnant patient with nothing by mouth for any length of time. Urgent removal of the band may be necessary, and can be performed allowing the pregnancy to proceed uneventfully [13, 28]. An increase in mechanical band complications during pregnancy has not been reported in other case series [13, 29]. These conflicting results may be explained by the different techniques for band placement and the frequent use of prophylactic band deflation and adjustments during pregnancy [14].

Table 9.4 Best practice recommendations for management of pregnancy in a bariatric surgery patient [35]

• Consider as high-risk pregnancy
• Close collaboration between obstetrician, nutritionist, and bariatric surgeon
• Assess baseline nutritional status and advise patient
• Close surveillance for nutritional deficiency after sleeve gastrectomy, gastric bypass, and malabsorptive procedures
• Follow nutritional recommendations for immediate post-bariatric surgery diet (60 g protein/day and supplements)
• Daily multivitamin and mineral supplement with increased supplementation after sleeve, gastric bypass, and malabsorptive procedures
• Patients with limited oral intake need specialty care and enhanced nutritional support or supplementation
• Periods of limited oral intake related to acute gastrointestinal conditions require nutritional support, possibly parenteral nutrition
• Abdominal pain should be considered as a medical emergency and an indication for consultation with a bariatric surgeon

There are also a number of case reports of intestinal obstruction, volvulus, and intussusception occurring in pregnant patients who have undergone gastric bypass previously. A recent review cited 11 such case reports [2], and others have been reported [30–33]. A number of these cases resulted in maternal and fetal deaths because of misdiagnosis and inappropriate conservative treatment. In addition, the optimal diagnostic imaging approach may not have been used initially because of fear of harm to the fetus [34]. Acute abdominal pain in a pregnant patient who has previously undergone bariatric surgery is a surgical emergency. Urgent consultation with a bariatric surgeon is essential. Prompt diagnosis and intervention if necessary are critical in the preservation of maternal and fetal health.

Best practice evidence-based recommendations for the management of bariatric surgery patients who become pregnant are summarized in Table 9.4 [35].

The reader is referred to several current and comprehensive reviews for more information [1, 2, 17, 35]. An informed and motivated patient who is well managed after bariatric surgery will experience healthy, nutritionally sound weight loss and, when pregnancy occurs, will create an intrauterine environment which will likely promote favorable health, body composition, and metabolism for the child, adolescent, and future adult [36].

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Chapter 10
Diagnostic Endoscopy: Perioperative

Gastrointestinal surgeons have embraced upper gastrointestinal endoscopy as a diagnostic and therapeutic tool, and its use by surgeons in the evolution of bariatric surgery has been a major factor in promoting the establishment of these procedures in the scope of general surgery clinical practice and training. Since the development of bariatric surgery, flexible upper endoscopy has been an important tool for patient management, both before and after bariatric surgery. During recent years, endoscopic interventions for both weight loss and treatment of metabolic disease have been introduced and are being incorporated into treatment protocols by bariatric surgery centers. The purpose of this chapter is to review the current practice guidelines and evidence concerning the use of flexible endoscopy in bariatric surgery.

Preoperative Endoscopy

Endoscopy is commonly utilized in the preoperative evaluation of candidates for bariatric surgery. Many patients who suffer from extreme obesity have symptomatic disease of the foregut as a comorbid condition, and in the presence of foregut symptoms such as dyspepsia and gastroesophageal reflux, the indications are established. If the contemplated bariatric surgical procedure is a gastric bypass or biliopancreatic diversion with duodenal switch, the distal stomach and duodenum will be inaccessible by conventional endoscopy, thereby raising concern about missing important pathology. The purpose of preoperative endoscopy is to detect and treat lesions that potentially can affect the type of surgery performed, cause postoperative complications, or contribute to symptoms later after surgery [1]. There are a number of published series of upper endoscopy in candidates for bariatric surgery which demonstrate a variety of foregut conditions like large hiatal hernias, acute ulcers of the stomach or duodenum, esophagitis, and Barrett's Esophagus often in patients without symptoms of foregut disease [2–6]. Not infrequently, lesions discovered at endoscopy result in a change of surgical approach or a delay in surgery for appropriate treatment or additional studies (Table 10.1) [2–7].

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Table 10.1 Lesions discovered at endoscopy prior to bariatric surgery and their potential impact on surgical decision-making

Lesions	Frequency (%)	Impact
Gastric or duodenal ulcer [3–6]	0–23	Delay surgery for healing; repeat endoscopy
Large hiatal hernia [3–5]	<10	Avoid band placement; consider crural repair
Severe gastritis or esophagitis [3, 19]	3	Delay surgery for medical treatment
Barrett's esophagus [4, 6, 12, 19]	0.2–3.1	Postoperative surveillance
Gastric cancer [7]	1 case report	Gastric resection
Intestinal metaplasia [18, 19]	<1	Gastric resection or survey remnant stomach
Carcinoid tumors [3, 22]	<1	Surveillance of gastric remnant or resection
Gastric polyps [5]	<1	Surveillance of gastric remnant or resection
Gastric MALT lymphoma [24]	1 case report	Medical treatment and/or resection
Helicobacter pylori	30–40	Medical irradiation

MALT mucosa-associated lymphoid tissue

European guidelines for bariatric surgery recommend preoperative endoscopy for all patients prior to surgery, even those without symptoms [8].

The important benign, premalignant, and malignant conditions encountered in bariatric surgery have been recently reviewed [2]. Barrett's Esophagus is more common in obesity [9, 10], and has been reported as an endoscopic finding with a frequency approximating 1–3.7 % in bariatric surgery candidates [3, 11, 12]. Preliminary results suggest that this lesion will regress or disappear after gastric bypass [13]. The implications of knowledge of this condition before bariatric surgery on the informed consent process, the choice of surgical procedure, and on post-op surveillance are obvious.

There is also an association of adenocarcinoma (as opposed to squamous carcinoma) of the esophagus with obesity [14]. Although this lesion has not as yet been reported in candidates for bariatric surgery, there are a number of case reports of this lesion developing as early as several months after bariatric surgery raising the question of whether or not the lesion was present before the surgery [15, 16]. There is no known association between gastric cancer and obesity, but gastric cancer has been identified in at least one candidate for bariatric surgery [7].

Gastrointestinal Stromal Tumors (GIST) can be incidentally encountered during bariatric procedures [17]. These lesions are nearly always asymptomatic and are unlikely to be discovered at preoperative endoscopy. They are usually found in the gastric fundus and cardia and may be missed unless the surgeon inspects the stomach during laparoscopy. When encountered, a frozen section should confirm the diagnosis and the lesion should be resected with clear margins (R0 resection).

Another lesion of concern to the bariatric surgeon is intestinal metaplasia, which occurs in evolution after atrophic gastritis and can slowly progress to gastric adenocarcinoma. This lesion has been found on preoperative endoscopy in several series of bariatric surgery candidates [18, 19], many of whom were asymptomatic [19], and has been found on histological examination of 427 consecutive resected gastric remnants after gastric bypass in 0.7 % of patients [20]. In the presence of extensive intestinal metaplasia of the incomplete type in the distal stomach, resection at the time of gastric bypass may be indicated [21].

Additional lesions that are important to bariatric surgeons include carcinoid tumors, gastric polyps, and gastric lymphoma. Carcinoid tumors are neuroendocrine tumors that occur rarely (4 %) in the stomach [2]. These lesions have been found occasionally in the stomach [22] and duodenum [3] on endoscopic evaluation of bariatric surgery candidates. When multiple gastric carcinoids are encountered, gastric resection should be a consideration in conjunction with the bariatric procedure [22]. Gastric polyps are also occasionally found on preoperative endoscopy [5]. Of these, adenomatous polyps are considered premalignant, although hyperplastic and hamartomatous polyps are rarely associated with gastric cancer. When these are encountered, consideration regarding gastric resection at the time of bariatric surgery or surveillance of the gastric remnant is necessary [23]. There is one case report of a gastric lymphoma identified on preoperative endoscopy in a bariatric surgery candidate [24].

Helicobacter pylori (*H. pylori*) infection is present in 30–40 % of candidates for bariatric surgery, and studies suggest that preoperative testing may be advantageous. Treatment to eradicate *H. Pylori* prior to bariatric surgery was found in one study to reduce the incidence of postoperative marginal ulcers when compared with historical controls [4]. In another study, a positive test for *H. Pylori* was associated with a higher likelihood of positive endoscopic findings [19]. Preoperative testing for *H. Pylori*, and eradication if found positive, is recommended for bariatric surgery candidates [1].

Available information regarding risk and outcomes of endoscopy in extreme obesity is limited. Emerging evidence suggests that increasing BMI is a risk factor for hypoxemia during endoscopy [25]. In one small series of preoperative endoscopies in candidates for bariatric surgery, critical events occurred as severe hypoxemia ($SaO_2 < 60$ %) occurred in 2.9 % and were associated with sleep apnea syndrome. Emergency bronchoscopic intratracheal insufflation with oxygen was required in each case [6]. Endoscopy in the severely obese carries significant risk, and better studies are needed to define risk factors. Clearly sleep apnea and super obesity may be indications for anesthesia support for endoscopy [26].

Despite the fact that foregut lesions may be found on surveillance endoscopy in asymptomatic bariatric surgery candidates, routine preoperative use of endoscopy remains somewhat controversial. In asymptomatic patients, the likelihood of finding a lesion which will change the surgical approach is low, and, similar to screening mammography, may result in additional negative testing which adds to the cost and does not alter the management. Additional prospective studies are needed to assess the outcome benefits of routine preoperative endoscopy in bariatric surgery.

Postoperative Endoscopy

Endoscopy has a major role in the postoperative managements of patients undergoing bariatric surgical procedures. As more bariatric surgeons are trained in the era of minimally invasive surgery, they are performing endoscopy on their own patients. The bariatric surgeon is in the best position to understand the postoperative foregut

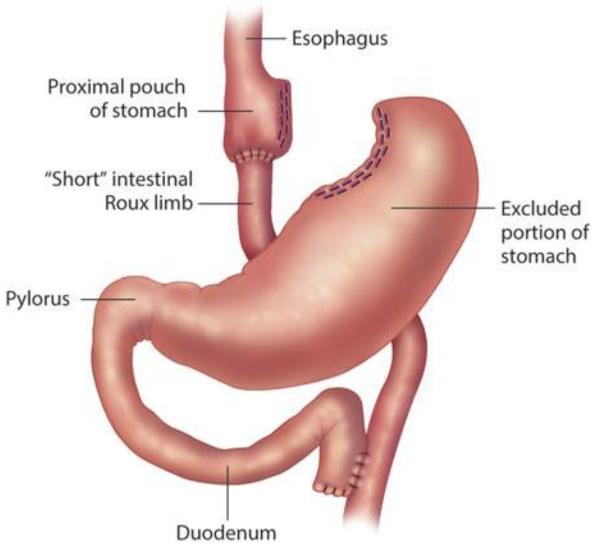

Fig. 10.1 Roux-en-Y Gastric Bypass

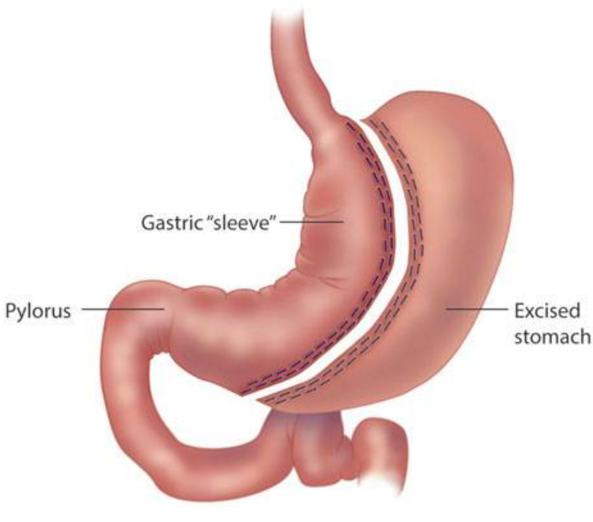

Fig. 10.2 Sleeve gastrectomy

anatomy, and thus may have an advantage in the interpretation of the endoscopic findings. If non-surgeons perform postoperative endoscopy, they must be familiar with the anatomy of bariatric procedures, and should review operative notes and procedure diagrams (Figs. 10.1, 10.2, and 10.3). Foregut symptoms such as nausea, vomiting, and abdominal pain are symptoms that are common after bariatric surgery (Table 10.2).

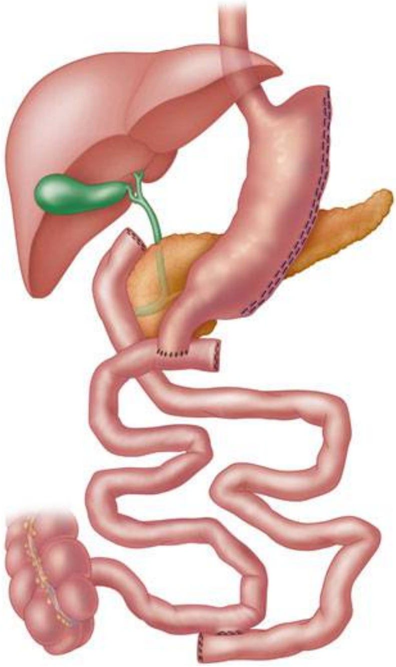

Fig. 10.3 Biliopancreatic diversion with duodenal switch

Table 10.2 Clinical signs and symptoms that frequently lead to foregut endoscopy in postoperative bariatric surgery patients

• Nausea
• Vomiting
• Dysphagia
• Pain
• Reflux
• Severe diarrhea
• Anemia, bleeding
• Weight loss failure

Nausea, vomiting, and reflux symptoms commonly occur during the postoperative progression of diet, especially with the initiation of solid food. This often results in calls to the bariatric program from concerned patients. The most common cause of these symptoms in the early postoperative period is maladaptive eating behavior as patients struggle to adjust dietary habits to their new foregut anatomy by eating too much at one time, eating too fast, or eating with inadequate chewing. These complaints should mandate dietary counseling in conjunction with adjustment of diet to liquids followed by slow re-progression of diet. Symptoms that persist or progress despite dietary instruction and adjustment or symptoms occurring with foods that were previously well tolerated should be evaluated by endoscopy to look for organic causes [1, 27].

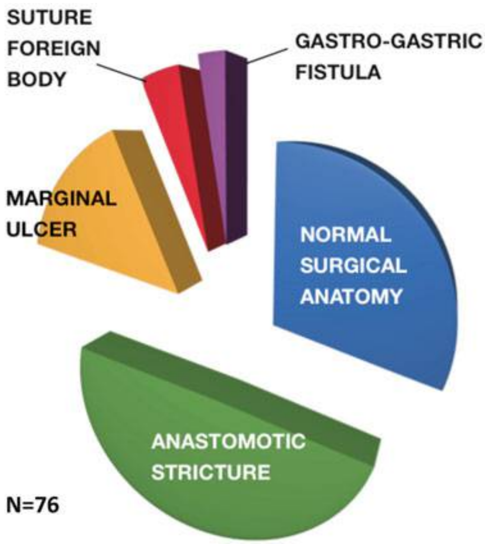

Fig. 10.4 The endoscopic findings in a series of 76 patients who underwent diagnostic endoscopy because of foregut symptoms after Roux-en-Y gastric bypass surgery. Modified from Lee J, Van Dam J, Morton J, Curet M, Banerjee S. Endoscopy is Accurate, Safe, and Effective in the Assessment and Management of Complications Following Gastric Bypass Surgery. Am J Gastroenterol. 2009; 104:575–582 [29]

Table 10.3 Foregut complications after bariatric surgery

- Marginal ulcer
- Leak/fistula
- Anastomotic stricture
- Band erosion
- Biliary tract disease

Several longitudinal cohort studies report that 7–11 % of bariatric surgery patients undergo postoperative endoscopy [28, 29]. A report of 1,079 gastric bypass patients from a major bariatric center over a 7-year period identified 76 patients (7 %) who were referred for endoscopy because of foregut symptoms. The endoscopic findings from this study are shown in Fig. 10.4 [29]. In this study, a normal endoscopy was found in 31.6 %, an observation confirmed in another study cohort revealing normal exams in 28 % of symptomatic postoperative patients [30]. A normal endoscopy in a symptomatic patient suggests that noncompliant eating behavior is the likely cause of symptoms, and that additional counseling and possible psychological consultation are needed. Often close questioning will identify sources of stress or tension in the home environment that cause the symptoms. Marginal ulcers are a common cause of foregut symptoms and are well-known surgical complications after bariatric surgery (Table 10.3).

The overall incidence of marginal ulcer is reported as 0.6–16 % in recent reviews [27, 31]. Several longitudinal studies have observed a decreasing incidence with time after bariatric surgery with the greatest incidence early in the postoperative period [30, 31]. The exact cause of marginal ulcer is not clear but proven risk factors include diabetes, tobacco use, nonsteroidal anti-inflammatory agent use, inhaled

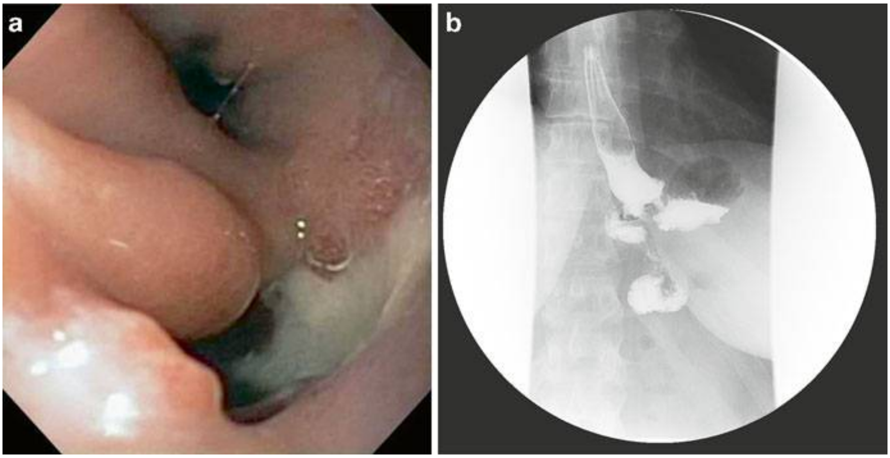

Fig. 10.5 (**a**) Endoscopic view of the gastric pouch and a gastrogastric fistula complicating a Roux-en Y-gastric bypass procedure (graciously provided by Jon Gabrielsen MD, Department of Surgery, Geisinger Medical Center, Danville Pa). (**b**) Upper GI view of a gastrogastric fistula after a Roux-en-Y gastric bypass procedure. Courtesy of Jon Gabrielsen MD, Department of Surgery, Geisinger Medical Center, Danville PA

steroid use, and large gastric pouch size [31]. Additional contributing factors include mucosal ischemia, *H. Pylori* infection, foreign body, and gastrogastric fistula. The gastrojejunal anastomosis after roux-en-Y-gastric bypass is sensitive to gastric acid in the absence of duodenal bicarbonate buffering, and both increased pouch size and gastrogastric fistula will increase the potential for acid injury. If a marginal ulcer is found at endoscopy, the pouch must be carefully examined for gastrogastric fistula. If not found at endoscopy, an upper GI contrast study with dilute barium is indicated (Fig. 10.5a, b).

Treatment of marginal ulcer includes proton pump inhibitors and sucralfate as well as smoking cessation. Ulcers that are refractory to medical treatment should be treated surgically. Factors that predispose to failure of medical treatment include gastrogastric fistula and tobacco exposure. A report of a refractory ulcer patient with a positive urinary nicotine level who denied tobacco exposure suggests that this scenario should be considered before surgical management takes place [30].

Stomal stenosis or anastomotic stricture is another fairly common complication of bariatric surgery, most often following the gastric bypass procedure. In the gastric bypass procedure, the surgeon must create a watertight and tension-free anastomosis with satisfactory blood supply. The anastomosis must be small enough to cause food restriction, but substantial enough to allow normal hydration and nutrition. The normal anastomosis diameter is usually about 12 mm. A stricture is defined as an anastomosis <10 mm in diameter [1]. This complication was reported with an incidence of 11–16 % [32–34] early in the evolution of laparoscopic gastric bypass, but more recent studies report an incidence of 4.4–8 % [35–38]. Factors contributing to stricture formation include mucosal ischemia, anastomotic tension, marginal ulcer with cicatrix formation, and factors related to anastomotic technique. Evidence suggests that the incidence is higher when the 21 mm circular stapler is used for the gastrojejunal anastomosis [38], but some have reported good results with this technique [36]. The lowest reported incidence (0.7 %) has been reported in a series with hand-sewn gastrojejunal anastomoses, using absorbable monofilament suture material [35].

This condition presents with vomiting and dysphagia initially with solids, but later involving liquids. Epigastric and retrosternal pain may also be present. Prompt diagnosis and treatment is essential in order to minimize the associated risk of problems with hydration or nutrition. The diagnosis can be made by contrast radiography, but endoscopy is preferred for more precise diagnosis, recognition of marginal ulcer, and treatment [1]. Endoscopic dilatation is the treatment of choice using balloon dilators or wire-guided boogie dilators. Gradual dilation over several endoscopy sessions is the most common approach in order to minimize the risk of perforation. Endoscopic dilatation in 1–4 sessions is successful in resolving the problem for most patients [1, 27, 36, 39, 40]. Patients who recur or fail to respond to multiple dilatations will require surgical revision [39]. Once the diagnosis of anastomotic stricture is made, concurrent nutritional care with alternate feeding strategies such as liquid nutrition or enteral nutrition via remnant gastrostomy may be needed.

In gastric bypass patients who have a retro colic Roux-en-Y limb, scar formation at the mesocolon opening may obstruct the Roux limb 10–15 cm from the gastrojejunal anastomosis [41]. The clinical presentation is similar to the presentation with gastrojejunal anastomotic stricture. Endoscopy will demonstrate a normal gastrojejunal anastomosis, a small segment of dilated jejunum, then the stricture. Treatment for this condition is surgical revision and not endoscopic dilatation [42]. The diagnosis of this complication is another example of the potential benefit of the bariatric surgeon performing his own postoperative endoscopy.

Gastrointestinal leaks and fistulas are life-threatening complications of bariatric surgery. The incidence from selected series from the last decade reported in a recent review ranges from 0.8 to 7 % [43]. More recent reports from large clinical registries from centers of excellence include leak rates of 0.42 [44] and 0.6 % [45]. The traditional management of leaks complicating bariatric surgery has been urgent surgery because of the common progression of systemic toxicity, multiorgan failure, hemodynamic instability, and death, which accompany leaks. As minimally invasive bariatric surgical procedures developed, the routine use of closed suction drains and early postoperative upper GI contrast studies has become common, and patients with postoperative leaks have been identified in a setting of stable vital signs and only mild foregut or respiratory symptoms [46]. Many of these patients have contained leaks defined by extra luminal contrast, which drains back into the GI tract, collects in small spaces, or immediately traverses the surgical drain [43]. Such patients may not need emergency surgery as a life-saving intervention, and may respond to nonoperative treatment, which includes nothing by mouth, intravenous antibiotics, drainage of all collections, and nutritional support.

Nonoperative management of leaks avoids the morbidity of emergency reoperation, but is a slow process necessitating a lengthy hospitalization. As nonoperative management of contained leaks became more widely practiced with success,

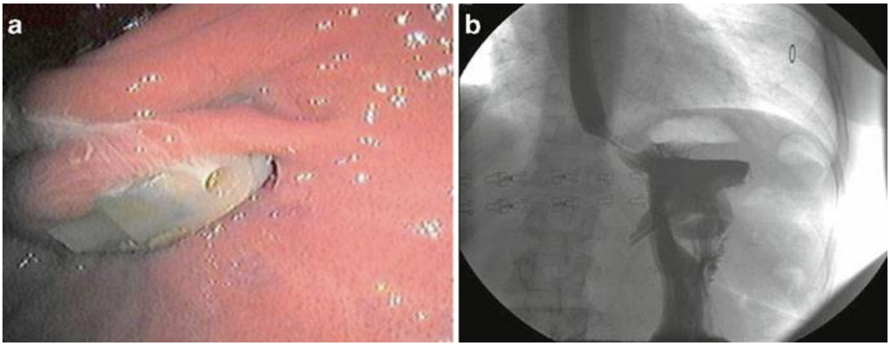

Fig. 10.6 (**a**) Endoscopic view of a gastric band eroding into the gastric lumen (Courtesy of Raul Rosenthal MD, Chairman, Department of General Surgery, Cleveland Clinic, Weston, Florida). (**b**) Upper GI series views of an eroded gastric band (Courtesy of Raul Rosenthal MD, Chairman, Department of General Surgery, Cleveland Clinic, Weston, Florida)

endoscopic treatments involving the use of stent placement [47] and injection of fibrin sealants [48] have been introduced in an effort to accelerate healing with non-operative treatment. Both endoscopic techniques can potentially seal the leak and allow for resumption of oral feedings and reduced peritoneal spillage. Although these techniques remain unproven as yet by randomized prospective trials, their efficacy in selected patients is established [49–52], and the use of nonoperative management of leaks, especially from the gastrojejunal anastomosis in gastric bypass and from the greater curve staple line in sleeve gastrectomy, is increasing [43, 51, 53]. Leaks from the gastric remnant and from more distal small intestinal anastomoses are more commonly associated with fulminant peritonitis, and emergency surgery remains the preferred treatment [42, 51, 53].

Additional endoscopic procedures recorded in case reports or small case series include endoscopic full-thickness gastric suturing to close small gastrogastric fistulae [54], as well as endoscopic vacuum-assisted sponge closure [55], and use of a fistula plug [56], or combinations of interventions in the treatment of leaks or fistulas. There is a need for prospective studies to establish efficacy and specific indications for these techniques, but it is apparent that new endoscopic treatment paradigms for management of leaks are emerging. As bariatric surgeons become more familiar and comfortable with nonoperative management of leaks and fistulas, they should be aware of the emerging body of knowledge involving the significance of the Gut Microbiota in the pathogenesis and management of sepsis complicating gastrointestinal surgery [57]. Since adult hypoalbuminemic malnutrition is common among bariatric patients treated for leaks with nonoperative therapy [50], and a risk factor for bad outcomes in gastrointestinal surgery [58], enteral nutritional support via gastrostomy, jejunostomy, or endoscopically placed nasojejunal feeding tube should be utilized as supportive treatment.

Gastric band erosion into the gastric lumen is another complication of bariatric surgery where endoscopy has a major role (Fig. 10.6a, b). Several recent studies

Table 10.4 A comparison of the prevalence of gallbladder pathology in candidates for bariatric surgery with a control group of organ donors [69]

	Bariatric surgery patients	Organ donor controls	*p*
Number	478	481	
Age	42 ± 9	52 ± 10	
BMI	52 ± 10	27 ± 7	<.05
Females	88 %	47 %	<.0001
Previous cholecystectomy	3.1 %	7 %	<.0001
Normal gall bladder pathology	21 %	72 %	<.0001
Cholelithiasis	25 %	5 %	<.0001
Cholecystitis	50 %	17 %	<.0001
Cholesterolosis	38 %	6 %	<.0001

Adapted from Dittrick G, Thompson J, Campos J, Bremers D, Sudan D. Gallbladder Pathology in Morbid Obesity. Obes Surg 2005;15:238–242 [69]
BMI body mass index

report an incidence of <5 % with some variation in case series incidence up to 9 % from earlier reports [59–62]. Erosions can occur in the absence of symptoms, or cause loss of satiety, port site infection, and abdominal pain [60]. The diagnosis is made at endoscopy, and the treatment is removal with a subsequent revision bariatric surgery procedure. Removal is most commonly performed as a laparoscopic surgical procedure with band removal and gastric repair [59, 60, 63]. Techniques for endoscopic removal of eroded bands have been developed and carried out successfully in several small studies [61, 64]. Each approach to band removal has its own advantages and complications [65]. Both procedures require general anesthesia, and the endoscopic approach requires advanced endoscopic skills. The most cost-effective approach should be determined by prospective randomized trials.

Endoscopy is commonly utilized in the management of biliary tract disease in conjunction with bariatric surgery. Morbid obesity and rapid weight loss are well-known independent risk factors for gallbladder and biliary tract disease [66–68]. The high prevalence of biliary disease in bariatric surgery candidates is illustrated in Table 10.4, which compares gallbladder pathology in morbid obesity patients who undergo concurrent cholecystectomy with organ donor controls [69].

In another study of cholecystectomy specimens from bariatric surgery patients with a negative preoperative gallbladder ultrasound, only 29 % had normal gallbladder histology [70]. Because of the association between extreme obesity and gallbladder disease, gallbladder ultrasound is routinely performed as part of the preoperative medical evaluation of bariatric surgery candidates. Generally, about 20–27 % of bariatric surgery candidates have had previous cholecystectomy, and another 10–15 % have cholelithiasis discovered on preoperative ultrasound. Of those with gallstones, only a small fraction is symptomatic [71, 72].

The incidence of gallstone formation during weight loss following bariatric surgery is also quite high. Several stone prevention trials in small numbers of patients have demonstrated that stone formation rates in the first year after bariatric surgery can be as high as 30–70 % [71, 73]. In these studies, most of the stones found by sequential postoperative ultrasound examinations are asymptomatic, but 7–20 % of the bariatric surgery patients with gallstones required cholecystectomy during the first postoperative year. At 3 years after laparoscopic gastric bypass, another prospective study documented a cholecystectomy rate of 28 % [74]. A cholecystectomy rate of 19 % at 3 years after laparoscopic gastric bypass was reported in another recent study [75]. Others have not observed such a high incidence of stone formation and need for cholecystectomy after bariatric surgery [72, 76], and controversy exists regarding gallbladder management in conjunction with bariatric surgery. Cholecystectomy at the time of gastric bypass has been shown to be safe, and does not complicate port placement. It does, however, add significant time to the operative procedure and adds to the length of hospitalization [77].

Most bariatric surgeons in the current era of minimally invasive surgery do not advocate prophylactic cholecystectomy at the time of bariatric surgery, but most advocate selective cholecystectomy in bariatric surgery candidates with symptomatic stones. Continued controversy exists regarding the management of bariatric surgery candidates with asymptomatic gallstones. Several randomized controlled trials have confirmed that a 500–600 mg daily dose of ursodiol for 6 months after bariatric surgery is effective prophylaxis for gallstone formation [78, 79]. Despite this evidence, this is not routinely used because of cost to patients and poor compliance. Systematic prospective longitudinal randomized trials are needed in order to clarify gallbladder management in bariatric surgery.

The incidence of choledocholithiasis following bariatric surgery is unknown, but some series do report a small incidence of gallstone pancreatitis [76]. Use of Endoscopic Retrograde Cholangiopancreatography (ERCP) is uncomplicated after gastric band placement and sleeve gastrectomy, but becomes a technical challenge after gastric bypass and biliopancreatic diversion [80]. After these procedures, ERCP is long, requires a high level of advanced endoscopy expertise, and is successful only 67 % of the time [80, 81]. The majority of bariatric surgeons prefer transgastric ERCP via the gastric remnant because it requires standard endoscopic skills and is more reliable [82–85]. Transgastric access to the gastric remnant following gastric bypass can be performed by interventional radiology utilizing CT guidance or by endoscopic ultrasound-guided insufflation of the gastric remnant for percutaneous access [86, 87]. These procedures have the disadvantage of requiring sequential dilatations of the gastrostomy tube tract, which will delay the intervention and resolution of symptoms. When dictated by urgent symptoms, transgastric ERCP can be performed using laparoscopic access to the excluded stomach [82]. Percutaneous transhepatic access to the biliary tree and choledocoscopic examination of the biliary tree have also been utilized [88].

These various techniques for endoscopic access to the gastric remnant and biliopancreatic limb following gastric bypass as well as the transgastric techniques mentioned above may also be needed for endoscopic evaluation of the foregut in post-bariatric surgery patients [80, 89–91]. Indications in addition to biliary tract disease include suspicious lesions discovered on preoperative endoscopy, gastrostomy feeding access for supplemental nutrition, anemia, and gastrointestinal bleeding.

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Chapter 11
Therapeutic Endoscopy

Endoscopic Procedures for Weight Loss

Endoscopic interventions to promote weight loss began 25 years ago with the introduction of the initial intragastric balloon. Although the field remains in its infancy, the technology is now rapidly expanding, perhaps driven by the huge impact of bariatric surgery on health afflictions related to obesity. This technology has the potential to provide low-risk intervention options which can be used for preoperative weight loss in high risk candidates for bariatric surgery, ambulatory repetitive treatments to address problems with weight maintenance following bariatric surgery, and low-risk primary procedures for obesity treatment. The increased interest in endoscopic interventions is driven by the major unsolved issues in bariatric surgery today, which include the proper management of the postoperative patient who struggles with weight maintenance and weight regain as well as patient access to bariatric surgery [1–4].

Many of these endoluminal technologies remain investigational at present and outcomes must be carefully scrutinized in regard to safety, efficacy, and durability of results. Additional challenges to implementation include the need for advanced endoscopic skills and equipment with implications regarding cost, training, learning curve, and patient risk. A recent survey of bariatric surgeons concerning expectations for endoluminal therapy suggests that more modest weight loss outcomes are acceptable as these procedures are low risk in comparison to surgical revision [3]. For these new interventions, clearly defined benchmarks for efficacy in balance with risks are needed for thorough evaluation of each technology [3, 4].

P.N. Benotti, *Patient Preparation for Bariatric Surgery*,
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Endoscopic Procedures to Restore Pouch and Stoma Size After Bariatric Surgery

Weight maintenance and weight regain are major concerns after foregut bariatric surgery procedures. This is often a progressive problem in later follow-up and is frequently associated with some recurrence of the obesity disease burden [5, 6]. Bariatric surgeons have observed that the early and prolonged satiety, which occurs after the gastric bypass and restrictive procedures, does diminish somewhat in association with enlargement of pouch and stoma. This loss of prolonged satiety causes earlier return of hunger, which may be accentuated by reactive hypoglycemia. The frequent result is increased frequency of small meals and weight regain. Foregut workup in many of these patients does reveal some enlargement of gastric pouch and gastrojejunal stoma.

The exact cause of weight regain after gastric bypass and other procedures is unknown and is probably multifactorial. Several studies have demonstrated that preservation of a small gastric pouch and stoma is associated with better 1–2 year weight loss, and that pouch and stoma enlargement correlates negatively with 1–2 year weight loss [7, 8]. Other studies examining pouch and stoma size after gastric bypass demonstrate an association between weight regain and pouch and stoma size [9, 10]. These are all retrospective observational studies, which do not confirm causality, but they have led bariatric surgeons to offer surgical revision in order to restore the early and prolonged satiety in order to better manage weight regain and maintenance. A major need in bariatric surgery is prospective trials aimed at identifying patient and anatomical factors which influence weight loss and weight maintenance.

Endoscopic Sclerotherapy

Endoscopic sclerotherapy of the enlarged gastrojejunostomy stoma (Fig. 11.1a) is a procedure designed to reintroduce early satiety by the endoscopic injection of a sclerosing solution (sodium morrhuate) circumferentially into the tissue around the anastomosis and reduce stoma size (Fig. 11.1b, c) [11]. This procedure was first reported in 2003 [12], and has been reported in a number of small case series with the injection of 6–13 ml of sclerosing solution per patient [13–15]. The procedure does appear to reintroduce early satiety, and results in improvement in weight trends in the majority, especially after multiple treatments [13–15]. Reported weight loss is modest, and only short-term results with up to 1-year follow-up in small numbers of patients have been reported. The poor track record of gastric restriction procedures for obesity would suggest that this technique, when used repeatedly, may have a role in weight maintenance after gastric bypass, but should be combined with other aggressive efforts to change lifestyle and behavior. The evidence to date suggests that this procedure is unlikely to be the definitive solution for gastric bypass weight maintenance struggles.

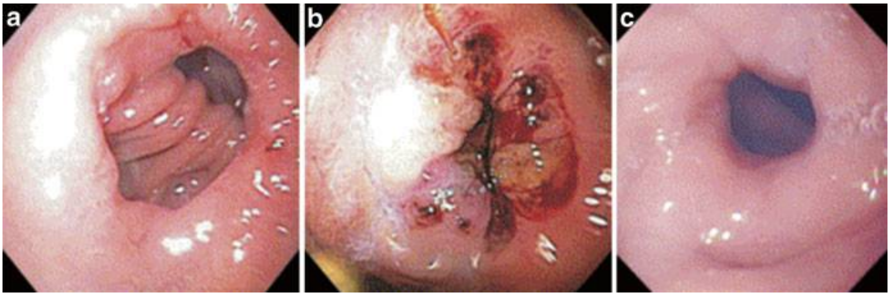

Fig. 11.1 (**a**) A dilated gastrojejunostomy stoma in a patient gaining weight after gastric bypass. (**b**) The gastrojejunostomy stoma of the patient in *panel* (**a**) after injection with sodium morrhuate (**c**) The gasrojejunostomy stoma of the patient in *panels* (**a**) and (**b**) after several injections with sodium morrhuate (Reprinted with permission from Catalano M, Rudic G, Anderson A, Chua T. Weight Gain After Bariatric Surgery as a Result of a Large Gastric Stoma: Endotherapy with Sodium Morrhuate May Prevent the Need for Surgical Revision. Gastrointest Endosc. 2007;66:240–245. © 2007 Elsevier) [11]

Reported complications are minimal in most series. The largest series reports a 2.4 % incidence of bleeding, and there is a case report of life threatening hematemesis occurring in a patient who underwent endoscopic sclerotherapy 11 days after a cardiac catheterization with placement of a drug-eluting stent in the left anterior descending coronary artery with institution of daily aspirin and anti-platelet treatment [16]. This procedure is fairly simple, can be repeated on an ambulatory basis, and does not require specialized equipment or training. Longer-term prospective randomized trials are needed to further define the role of this technology.

Bard Endocinch Suturing System

This technology (C.R. Bard, Inc., Murray Hill, NJ) has been used for gastric plication in the treatment of gastroesophageal reflux and for gastrojejunal stoma reduction after gastric bypass. Under endoscopic visualization, suction is used to draw tissue into a hollow capsule at the end of an endoscope. A hollow needle is then used to pass a suture through the tissue held in the capsule. The process is repeated in a second tissue bite, and the suture is tied using a knot-pusher [2]. After pilot studies demonstrated feasibility and safety, the technology was utilized in a randomized, double-blind, Sham-controlled trial of 77 patients with weight loss problems after gastric bypass. The results of this trial are published in abstract form. General anesthesia was used and treated patients underwent anastomotic mucosal ablation and plication of the anastomosis with interrupted stitches. Sequential follow-up was provided for 6 months. Reduction of stoma diameter to <10 mm was achieved in 89 %. Weight loss was modest at 6 months (4.7 % in test patients vs. 1.9 % in controls, $p = .041$). Weight stabilization or weight loss occurred in 96 % vs.

78 % in controls ($p < .001$). Adverse events were minor including nausea, vomiting and throat pain [17]. This technology has also been used in a small study to treat refractory dumping after gastric bypass with promising results [18]. No peer-reviewed reports of weight loss trials or additional weight loss studies using this technology are found, and currently, the device is not available.

Stomaphyx

This technology can provide a full-thickness gastric plication, and serosa-to-serosa tissue folds for either antireflux or gastric plication for obesity. The device uses a helical retractor to draw the full-thickness gastric wall into the device and the plication is established by the placement of polypropylene H fasteners. Multiple H fasteners can be placed to achieve gastric volume reduction (Fig. 11.2). In the initial pilot study, 39 patients with late weight regain after gastric bypass underwent endoscopic pouch reduction. Multiple fasteners (12 to 41) were placed, with an average of 17 per patient. Procedure duration averaged 35 min. Adverse events were minor with 87 % experiencing sore throat and 77 % self-limited epigastric pain. Weight loss was modest (10–19 % excess weight loss), with only limited numbers evaluated at 6 and 12 months after the procedure [19].

This transoral plication technology was also studied in 64 patients after gastric bypass with inadequate weight loss, gastroesophageal reflux or dumping. An average of 23 fasteners were placed per patient with procedure time averaging 55 min. Adverse events were minor with only two patients requiring observation in hospital, one for transient bleeding and one for nausea. Common adverse events were sore throat and transient epigastric pain. Symptoms were improved in 80 %, and weight loss was modest with only short-term follow-up [20]. This technology has also been used for pouch reduction following vertical banded gastroplasty with only short-term results reported, an average hospital stay of 1.5 days, and only minor adverse events. No long-term weight loss data is provided [21].

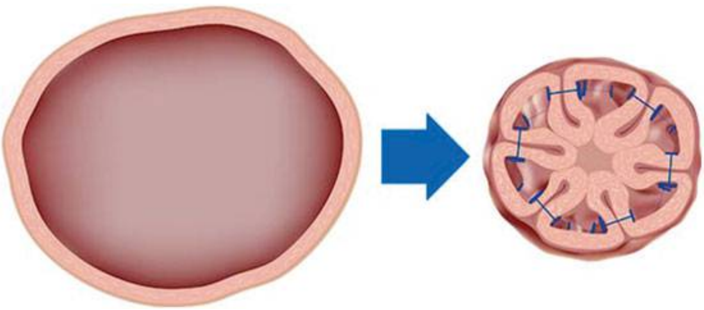

Fig. 11.2 A diagram showing gastric plication and volume reduction after endoscopic placement of multiple H fasteners (with permission from Endogastric Solutions, ©2014 EndoGastric Solutions, Inc.)

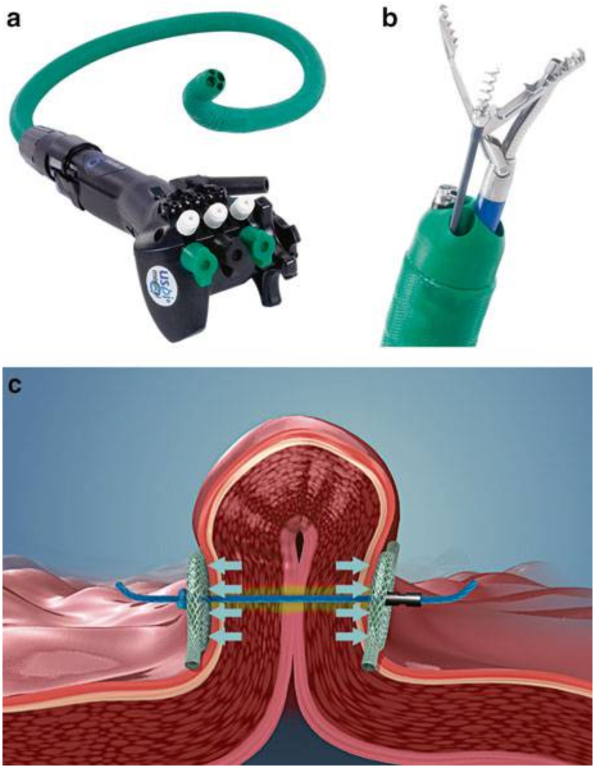

Fig. 11.3 (**a**, **b**) The incisionless operating system provides multiple endoscopic channels, which allow for tissue grasping, tissue approximation and full thickness suture placement. (**c**) Illustration of a full thickness, serosa to serosa plication using the incisionless Operating System tissue anchors (with permission from USGI Medical, © 2014 USGI Medical, San Clemente, CA)

More recent studies have raised some concern because two studies suggest that weight loss is maximal in the first 6 months with subsequent weight regain [22, 23]. One of the studies reporting follow-up endoscopy in 12 patients, at an average of 18 months post procedure demonstrates no sustained reduction in pouch or stoma size from the original sizes [22]. In addition, a major life-threatening complication of this procedure, performed by an inexperienced endoscopist, has recently been reported [24]. Currently, this technology is no longer available, but similar technology is in use for transoral fundoplication.

Incisionless Operating Platform

The Incisionless Operating Platform (USGI, San Clemente, CA) combines endoscopy and laparoscopic technologies in a multilumen system with channels for endoscopy and three operating channels for tissue grasping, tissue approximation, and full thickness suture placement (Fig. 11.3a, b). In place of sutures, the system deploys unique tissue anchors that can be drawn together and cinched under direct vision with tactile feedback. The anchors are designed to distribute the tissue tension over a large area, which may be advantageous for tissue healing (Fig. 11.3c).

This technology has been studied in a series of revision procedures following gastric bypass (Restorative Obesity Surgery Endoscopic; ROSE). A pilot study of five patients demonstrated feasibility, safety and short-term weight loss [25]. This trial was continued and expanded to include 20 patients with weight gain and dilated stomas after gastric bypass surgery. Successful tissue plications were accomplished in 17 of the 20 patients with an average of five plications per patient. Procedure time averaged 1 h and 43 min and general anesthesia was utilized. Complications were minor and weight loss averaged 5.8 kg at 1 month and 8.8 kg at 3 months. Technical difficulties occurred in small and narrow gastric pouches [26].

This technology was also studied in a multicenter trial involving 9 institutions and 116 patients with prior gastric bypass. Successful plications were placed in 112 of 116 patients, with an average operative time of 87 min to place 5.9 tissue anchors per patient. Procedures were performed in the operating room (88 %) or the Endoscopy unit (12 %). Most (85 %) were discharged the same day, and complications were minor and self-limited (three asymptomatic superficial distal esophageal tears, pharyngitis, nausea, vomiting, and epigastric pain). Follow-up endoscopy was performed at 3 months ($n=83$), and at 1 year ($n=13$). Durability of anchors and tissue plication was noted in 94 % at 3 months and in all patients at 1 year. Mean 6-month weight loss was 6.5 kg. The authors noted that technical modifications improved the procedure capabilities [27]. A later review of this same cohort with additional follow-up demonstrated the continued presence of tissue anchors at the 1-year endoscopy exam in 61 of 66 patients studied. The overall 1-year follow-up was 65 % and weight loss was 5.9 ± 1.1 kg. These investigators found in a multiple regression analysis that a smaller stoma was associated with better weight loss [28].

This interesting technology is also being studied in trials of primary endoluminal interventions for weight loss, which will be discussed in a subsequent section of this chapter.

OTSC-Clip

The OTSC-clip (Ovesco Endoscopy, Los Gatos, CA) has been used for treatment of upper gastrointestinal bleeding and closure of the stomach in natural orifice transluminal endoscopic surgery. In addition, it has been recently shown to have promise in gastrointestinal leak repair [29]. The clip is made of nitinol (Fig. 11.4a), and applies constant pressure to the tissue between its closed jaws. The clip is mounted on an applicator cap, which attaches to the tip of an endoscope (Fig. 11.4b). The edges of the tissue to be approximated are grasped with forceps and pulled into the applicator cap. The clip is then applied to the tissues in the cap (Fig. 11.4c). This has been studied in 94 patients with loss of satiety or increased meal frequency after banded gastric bypass. The average stoma diameter was 35 mm. General anesthesia was used and procedure time averaged 35 min. Stoma size was reduced by 80 %. There were no major complications. Five patients with post-procedure dysphagia required endoscopy and two needed dilatations. Modest weight loss was reported with follow-up to 1 year [30]. No other trials of this technology for weight regain after bariatric surgery are found at this time.

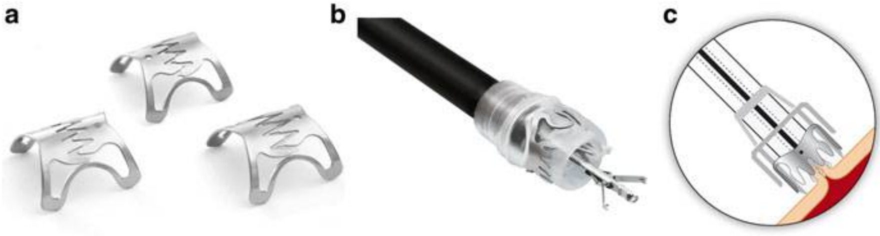

Fig. 11.4 (**a**) The OTSC-clip used to approximate gastric tissue. (**b**) The OTSC-clip mounted on an applicator which is attached to an endoscope. (**c**) Diagram illustrating the endoscopic application of the OTSC-clip to the gastric wall (with permission from Ovesco Endoscopy USA Inc © 2014 Overco Endoscopy USA Inc.)

Overstitch Endoscopic Suturing System

The OverStitch Endosocopic Suturing System (Apollo Endosurgery, Inc., Austin, TX) is a suture applicator in a cap mounted at the end of a double-channel endoscope (Fig. 11.5a). The anchor, which is passed through the primary channel functions like a curved needle has the capability of placing interrupted, or continuous sutures under direct vision (Fig. 11.5b). The suture is secured using a cinch device.

As yet, there are no published peer-reviewed clinical trials using this technology. The technology has been used in a successful endoscopic closure of a chronic gastro-cutaneous fistula after percutaneous endoscopic gastrostomy [31]. A series of nine patients with gastrojejunal stomal dilatation after gastric bypass underwent stomal reduction with the OverStitch technology and was presented in abstract form only. All stomas were successfully reduced from and average of 26.2 mm to <10 mm in an average time of 36 min, with a median of three interrupted sutures (Fig. 11.5c). Weight loss at 1 month was 6.9 % of total weight. Several complications were reported. All were minor except one patient who required balloon dilation after 4 days [32]. Several other small series demonstrating feasibility and safety have been recently presented at national forums. This technology is promising and appears to provide good full-thickness tissue approximation. It may also be an important technology for the treatment of leaks, fistulas, and other bariatric complications [2].

Endoscopic Intervention as a Primary Treatment of Obesity

Gastric Balloon

The gastric balloon is the most widely studied endoscopic intervention for weight loss. Beside its space occupying effect in the stomach, there is another physiologic rationale for this intervention. Gastric distension is a stimulus for cholecystokinin secretion from the duodenum. In addition to its other better-known effects, cholecystokinin delays gastric emptying and causes pyloric constriction. Gastric distension does appear to influence satiety and results in decreased food intake [33].

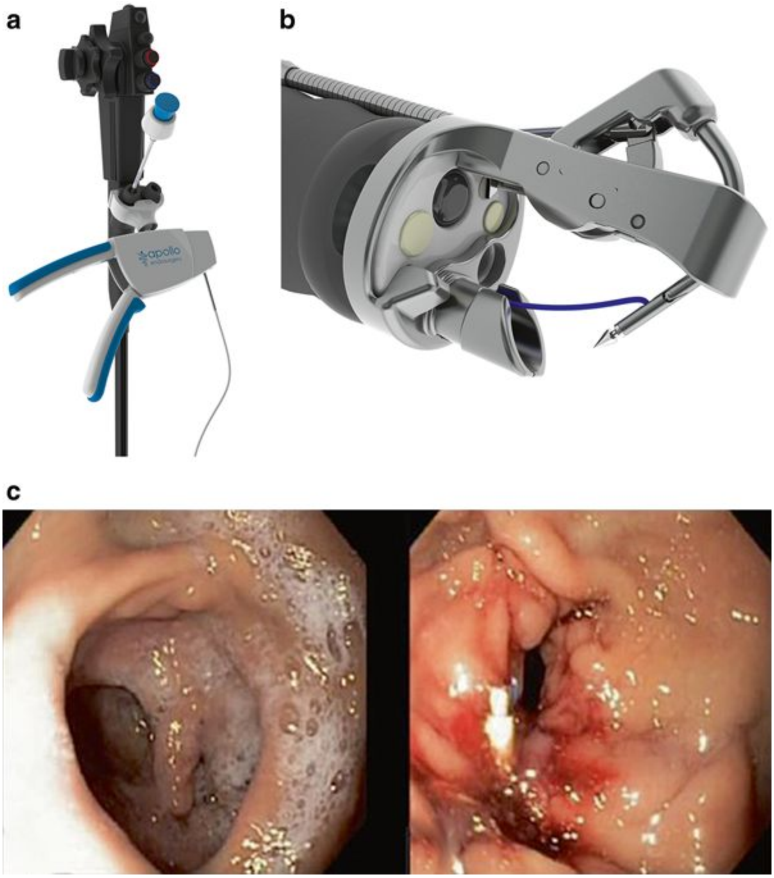

Fig. 11.5 (**a**) The suture applicator mounted on a double channel endoscope. (**b**) The suture applicator at the tip of the endoscope. (**c**) An endoscopic view of a dilated post-gastric-bypass gastrojejunostomy stoma after stomal reduction with interrupted endoscopic sutures (with permission from Apollo Endosurgery, Inc., Austin TX © 2014 Apollo Endosurgery Inc.)

The original gastric balloon was introduced in 1985. This balloon was insufflated with 220 ml of air, which is now considered too little volume. Modest weight loss was observed, but complications including gastric erosions, gastric ulcers, small intestinal obstruction and esophageal injuries during placement resulted in its removal from the market. After a panel of experts was convened for design recommendations and an extended period of research, the BioEnterics intragastric balloon (BIB, Allergan Inc., Irvine, CA) was introduced. This balloon is spherical, made of non-irritating silicone elastomer, and holds 400–700 ml of saline (Fig. 11.6). The adjustable volume allows for variation based on stomach size and response. The BIB has been well studied abroad, but is currently unavailable for use in the USA.

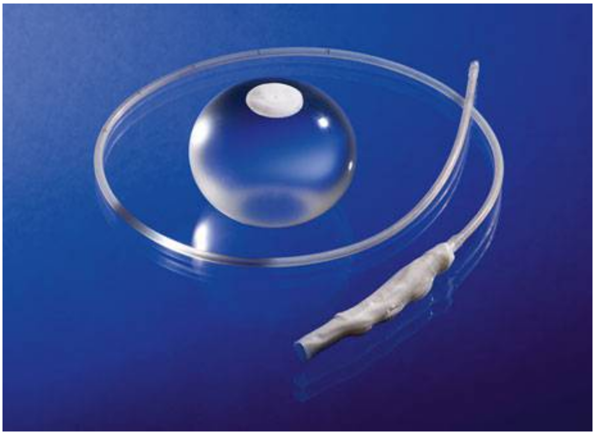

Fig. 11.6 The BioEnterics Intragastric balloon (Image courtesy of Allergan Inc., Irvine, CA, © Allergan Inc, used with permission)

This BIB was studied in 2,515 candidates for bariatric surgery in Italy between 2000 and 2004. These patients underwent insertion of the BIB balloon inflated with 500–700 ml of saline colored with methylene blue. Balloons were left in place for 6 months. In two patients (0.08 %), insertion was complicated by gastric dilatation treated conservatively. Early balloon removal (24 h-1 month) was required in 30 patients (1.2 %) because of psychological intolerance ($n=11$) and gastric obstruction ($n=19$). Other major complications included five gastric perforations, two of which were fatal. Four of the five patients with gastric perforation had had previous gastric surgery. Additional significant complications included esophagitis (1.3 %) and gastric ulcer (0.2 %), which were managed medically. Weight loss at 6 months was reported as 33.9 ± 19 % of excess weight [34].

In a more recent large European study [35], 714 morbidly obese individuals who were possible bariatric surgery candidates had the BIB balloon placed for a variety of indications over a 2-year period. Exclusion criteria included previous gastric surgery. The patients received liquids for the first 5 days, followed by a 1,000 kcal diet. They were followed weekly in a bariatric surgery program. BIB placement was uncomplicated and usually performed as an ambulatory setting. Most balloons were inflated to 600 ml. Despite this, gastric and small intestinal obstruction was not observed. Early balloon removal (24 h to 6 weeks) was needed for 31 patients (4.3 %), for psychological intolerance in 25, and for gastroparesis without obstruction in 6. Other complications were managed medically and were controlled after a short duration of symptoms (Table 11.1).

A second balloon was placed in 112 patients. Weight loss at 6 months was 41.6 ± 21.8 % of excess body weight and significant resolution or improvement in comorbid disease was observed [35].

In a 6-month trial, 32 patients were randomized into two groups for a prospective crossover study where patients received the BIB band or sham procedure for 3 months, and then treatments were crossed over. The complications were minimal and 3-month weight loss was significantly greater ($p < .001$) in BIB patients (Fig. 11.7) [36].

Table 11.1 Complications following Bioenteric Intragastric Balloon (BIB) placement in 714 patients with extreme obesity

Complication	*N* (%)	Management
Psychological intolerance	25 (3.5)	Removal
Gastroparesis	6 (0.8)	Removal
Vomiting	140 (19.6)	Medical
Epigastric pain	137(19.1)	Medical
Gastroduodenitis	22 (3.1)	Medical
Esophagitis	7 (0.9)	Medical

Adapted from Lopez-Nava G, Rubio M, Prados S, Pastor G, Cruz M, Companioni E et al. BioEnterics® Intragastric Balloon (BIB®). Single Ambulatory Center Spanish Experience with 714 Consecutive Patients Treated with One or Two Consecutive Balloons. Obes Surg 2011; 21:5–9 [35]

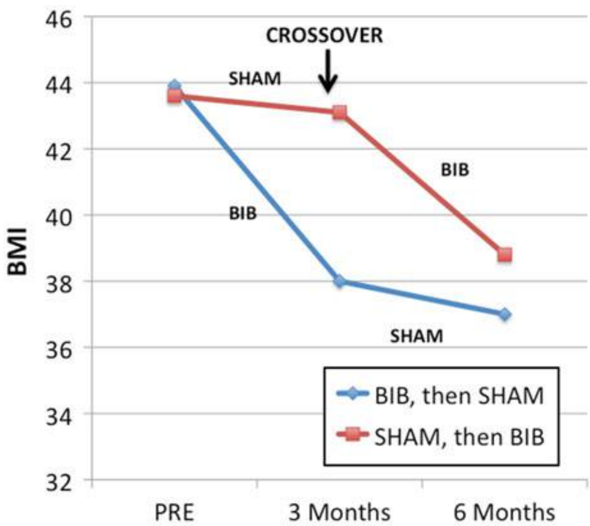

Fig. 11.7 The weight loss results of a double-blind randomized prospective crossover study comparing BioEnterics intragastric balloon (BIB) placement with a sham procedure (BMI is kg/m²). *BMI* body mass index. Modified from Genco A, Cipriano M, Bacci V, Cuzzolaro M, Materia A, Raparelli L et al. BioEnterics Intragastric Balloon (BIB): a Short-Term, Double-Blind, Randomised, Controlled, Crossover Study on Weight Reduction in Morbidly Obese Patients. Int J. Obes. 2006; 30:129–133 [36]

Additional favorable data are derived from a meta-analysis, which assessed safety and efficacy of the BIB in review of 15 studies and 3,608 patients [37]. Early balloon removal was necessary in 4.2 %, and severe complications were present but infrequent. They included 26 gastrointestinal obstructions, as well as the four gastric perforations and the two mortalities observed in the above-mentioned Italian study [34]. No additional mortalities were noted. Weight loss was 32 % of excess weight [37].

The BIB has been studied in a non-randomized trial in 60 consecutive super-super obese bariatric surgery candidates (BMI 66.5 ± 3.4 kg/m²). In 24 patients, the BIB balloon was placed for preoperative weight loss before laparoscopic gastric bypass, and the remaining patients ($n = 37$) underwent laparoscopic gastric bypass. Balloons were in place for 155 ± 62 days and resulted in a BMI loss of 5.5 ± 1.3 kg/m². Operative time was reduced by nearly 60 min ($p < .01$) in the balloon-treated group, and favorable improvement or resolution in comorbid conditions was noted.

Fig. 11.8 The ReShape Duo ingragastric balloon (Image provided courtesy of ReShape Medical, San Clemente, CA, © Reshape Medical, used with permission)

Significant adverse postoperative events were less frequent ($p < .05$) in the balloon-treated patients. No balloon-related complications were reported [38]. Similar encouraging results are also observed in one additional study where the gastric balloon was used as a tool for preoperative weight loss before bariatric surgery [39, 40].

The favorable results with the BIB have stimulated additional research and product development and newer balloon modifications are now being studied in clinical trials. A recent multicenter prospective randomized trial comparing diet and exercise with diet, exercise, and a ReShape Duo intragastric balloon (ReShape Medical, San Clemente, CA), in 30 patients with BMI of 30–40 kg/m^2 has recently been reported, demonstrating safety and short-term weight loss (Fig. 11.8) [41].

Gastric balloon technology has been studied extensively outside of the USA and appears to facilitate significant short-term weight loss and favorable health improvements in patients with extreme obesity. The risk profile has improved with improved technology and more rigid exclusion criteria, which should include prior gastric surgery and fundoplication. We often overlook the fact that patients with extreme degrees of obesity (BMI > 60) usually have major health risks. When these risks are balanced against the current risks of the gastric balloon, use of the balloon may be supported [33]. If this technology continues to demonstrate acceptable complication rates, is will be an important addition to the treatments available for multidisciplinary obesity management. It will have an important role as a bridge to safer bariatric surgery in high-risk patients, and also may have a role in the preoperative evaluation as a test of compliance or response to gastric restriction.

Duodenal–Jejunal Bypass Sleeve

The duodenal–jejunal bypass sleeve or liner (Endobarrier Gastrointestinal Liner, GI Dynamics, Lexington, MA) is an endoscopically inserted and removal device which is anchored in the duodenum and functions as an intestinal liner which prevents ingested nutrients from contact with the mucosa of the proximal small intestine, and prevents the contact of bile and pancreatic juice with ingested nutrients until beyond the distal end of the liner. This system is designed to simulate the physiology duodenal bypass, which occurs with the gastric bypass operation. Initial studies in an animal model indicated that this system resulted in weight loss and improvement in parameters of glucose homeostasis [42]. In a small trial in 12 patients, the endoluminal barrier was successfully inserted, left in place for up to 12 weeks, and successfully removed. No major adverse events were noted and significant weight loss was observed [43].

The endoluminal duodenal–jejunal bypass sleeve has also been studied in a randomized controlled trial in comparison with very low calorie diet for preoperative weight loss in bariatric surgery. In a 12-week study, 25 patients underwent sleeve placement and 14 were randomized to the diet only arm. Average initial BMI in the patient group was 42 ± 5.1 kg/m^2. The 12-week study was completed by 20 of the 24 test, and 4 of 14 control patients. Weight loss at 12 weeks was 22 % of excess weight, which was statistically significant ($p = .02$) in comparison to controls. Adverse events were minor and were related to procedural and product development [44].

Preoperative weight loss before bariatric surgery was studied in a multicenter randomized trial in 41 patients with morbid obesity comparing the endoluminal barrier ($n = 30$) with diet alone ($n = 11$). The endoluminal liner was successfully placed in 26 patients, and left in place for 12 weeks in 24 patients and for 24 weeks in 3 patients. Weight loss at 12 weeks in the test patients was 19 % of excess weight and in controls, 6.9 % ($p < .002$). Major improvements in diabetic test patients were observed during the trial, and 88 % of the test patients lost >10 % of excess weight. No major adverse events were reported, with the most common being post-implant nausea and abdominal pain as well as post-explant local site inflammation [45].

A longer-term study demonstrating significant weight loss and physiologic improvement associated with the use of the EndoBarrier has recently been reported. In this single-center study, 42 morbidly obese patients were followed longitudinally for 52 weeks after implantation of the endoluminal sleeve. Implantation was unsuccessful in three patients because of unfavorable duodenal anatomy, which complicated positioning of the device. Of the 39 implanted patients, 24 completed 52 weeks of follow-up. Weight loss averaged 22.1 ± 2.1 kg or 47 ± 4.4 % of excess weight. Other variables that improved included statistically significant reductions in waist circumference, systolic blood pressure, diastolic blood pressure, lipid levels, and fasting glucose levels. No major adverse events were reported, but 15 of the 39 implanted patients were explanted before week 52 because of device migration or abdominal pain related to device obstructions. Patient overeating was identified as a contributor to device obstructions related abdominal pain. The median duration of implantation in the 15 with early explantation was 24 weeks [46].

In addition to the peer-reviewed clinical trials summarized, additional trials also demonstrate safety, significant weight loss, and health improvement in patients with extreme obesity [47–49]. A recent report of three patients suggests that the device can be implanted and removed safely using only conscious sedation [50].

This device, which has been favorably represented in regional presentations and the peer-reviewed literature thus far appears to be a low-risk intervention, which is capable of supporting significant weight loss and improvement in comorbid medical conditions. If favorable reports continue, it should be considered as a tool for preoperative weight loss in selected high risk bariatric surgery candidates and a possible short-term test intervention for bariatric surgery candidates who are either undecided about surgery, or those whose motivation and/or compliance potential are in question.

Incisionlless Operating Platform

This technology (Fig. 11.3a, b), which has been discussed above as a restorative endoscopic intervention after gastric bypass [25–28], has also been studied as a Primary Obesity Surgery Endoluminal (POSE) procedure. In this procedure, 8–9 gastric plications are placed in the gastric fundus and 3–4 plications are placed in the distal stomach. These plications are felt to provide restriction of food intake by limiting the potential for fundic meal accommodation. In addition, the antral plications are felt to slow antral motility [51]. The POSE procedure has recently been studied in 45 patients with BMI 36 ± 3.8 kg/m^2. The procedure was associated with two minor adverse events that resolved promptly. Short-term significant weight loss was also observed [51].

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Chapter 12
Risk Assessment in Bariatric Surgery

After the completion of the evaluation of bariatric surgery candidates, when all of the results of patient interviews, specialty consultations, and diagnostic studies are available, the important decisions necessary for patient selection and treatment planning must take place. The detailed findings and recommendations from the surgeon and the bariatric team are shared with the patient at the Summary Interview referred to in Chap. 4. To review some of the issues raised in Chap. 4, informed consent is not simply the patient signature on the consent form, it occurs during the entire process of dialogue between the patient, the surgeon, and the bariatric surgery team members. This dialogue, the components of which take place throughout the evaluation process, should assure that the patient understands the reasons for the treatment recommendations, its risks and benefits, and the available alternate courses of action. All questions must be answered and the patient should agree that the treatment should take place. The underlying principle of informed consent is a shared decision-making partnership between the patient and the surgeon resulting in patient-centered decisions [1].

An essential component of the patient selection and informed consent process involves a careful comparison of risk versus benefit of bariatric surgery. The ability to identify and perhaps quantitate with metrics those patient factors that influence surgical risk, and those that influence weight loss and health success will improve patient and procedure selection as well as surgical outcomes and the overall value of bariatric surgery. Additional benefits of measurement of these factors will allow for a more individualized and patient-centered informed consent process with the presentation of adequate information, and the implementation of strategies to reduce risk when indicated.

Bariatric surgeons have made great progress during the last 5 years in the identification of patient factors that increase surgical risk. The recent studies contributing to risk measurement are summarized in Table 12.1. These studies analyze the data from bariatric surgery databases ranging from single or multicenter center experience, from administrative databases, and from clinical registries [2–13]. In each study, the rate of adverse events or mortality is determined as the primary endpoint. Multiple patient factors are then analyzed by univariate analysis to determine their association with the major endpoint. Those variables that are statistically significant

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Table 12.1 A summary of the studies that have identified patient-related factors associated with increased surgical risks for mortality or adverse events

Study (ref)	Livingston [2]	Demaria [3]	Livingston [4]	Morino [5]	LABS consortium [6]	Turner [7]	Finks [8]	Gupta [9]	Ramanan [10]	Nguyen [11]	Maciejewski [12]	Benotti [13]
Database	Clinical	Clinical	Admin	Clinical	Clinical	Clinical ACS NSQIP	Clinical	ACS NSQIP	Clinical, ACS NSQIP	Admin	Clinical	Clinical
Time period (years)	1998–2004	1995–2004	2001–2002	1996–2006	2005–2007	2005–2008	2006–2010	2007–2008	2006–2008	2002–2009	2002–2009	2007–2011
Outcomes assessed	Mortality Adverse events	Mortality	Mortality	Mortality	Mortality Adverse events	Mortality Adverse events	Mortality Adverse events	Mortality Adverse events	Mortality Adverse events	Mortality	Mortality Adverse events	Mortality
# patients	575	2,075	25,428	13,431	4,776	32,426	25,469	11,023	21,891	105,287	105,287	157,559
30-day mortality (%)	1.4	1.5	0.28	0.25	0.3	0.14	0.1	0.19	0.14	0.17	0.17	0.1
90-day mortality (%)	2.4											
Adverse events (%)	19.7 (overall complications)		9		4.1	3.82	4.9	4.2	5.5		1.48	
Risk factors (odds ratio)	Smoking (1.68) Superobesity (1.96)	BMI ≥ 50 (3.6) Male gender (2.8) Hypertension (2.8) Thromboembolic risk (2.6) Age ≥45 (1.6)	Anemia (3.6) Diabetes (3.6) Male gender (1.8) Chronic lung disease (1.6) Age (1.1) Hypertension	Procedure type Pulmonary embolism	Functional status (2.24) Thromboembolic history (2.24) Sleep apnea (1.37) BMI	Low serum albumin BMI Age Dependent functional status	Procedure type (9.68) Thromboembolic history (1.9) Coronary artery disease (1.51) Age >50 (1.3) Pulmonary disease (1.35) Male gender (1.26) Smoking history (1.20)	History MI/ angina (3.65) Angina one month Dependent functional Functional status (3.48) Stroke (2.89) Bleeding disorder (2.23) Hypertension (1.34) Type of surgery BMI	Age BMI Dyspnea at rest History of hypertension History of percutaneous coronary intervention Peripheral vascular disease with reconstruction of amputation Chronic corticosteroid use	Medicare (3.87) Male gender (3.18) Age over 60 (1.92) Case type	Age > 65 (2.44) Obesity hypoventilation (2.12) Pulmonary hypertension (1.94) BMI > 60	BMI 40–49 (1.65) BMI 50–59 (2.48) BMI 60–69 (5.31) BMI 70+ (7.53) Age 30–39 (O.96) Age 40–49 (1.51) Age 50–59 (2.84) Age 60–60 (4.74) Age ≥70 (7.20); Male gender (2.14) Pulmonary hypertension (4.94) Congestive heart failure (2.65) Liver disease (2.26)

The conditions and associated odds ratios are shown
LABS longitudinal assessment of bariatric surgery, *BMI* body mass index, *ACS NSQIP* American College of Surgeons National Surgical Quality Improvement Program

according to a predetermined threshold are then individually considered for inclusion in a multiple logistic regression model designed to identify independent predictors of the major endpoint. The variables are selected using a manual forward stepwise approach after consideration of supporting literature, the statistical strength of the univariate association, correlation with other variables already in the model, and the frequency of occurrence. The patient-level risk factors identified in each study are listed together with odds ratios, which measure the strength of the association (Table 12.1).

These studies provide information that allows bariatric programs to develop metrics for determination of the specific risk for individual patients, either in the form of a risk score to identify risk classes (i.e., low, medium, or high), [3, 7, 8, 12, 13] or by using calculators to estimate the probability of an adverse event [9, 10]. Many of the risk assessment tools developed thus far have proven efficacy as they have been validated in independent patient populations [3, 8–10, 12, 14, 15].

Risk Factors in Bariatric Surgery

Older age and male gender have been well studied and are established risk factors [3, 4, 7, 8, 10–13, 16, 17]. One study found a dose–response relationship between increasing age and 30-day gastric bypass mortality risk [13]. Similarly, superobesity is also a proven risk factor [2, 3, 6, 7, 9, 10, 12, 13, 16]. The same study found increasing odds ratios for 30-day gastric bypass mortality with each 10 body mass index (BMI) unit increase above 39 [13]. Age, male gender, and superobesity may simply be markers for sicker individuals as several studies have demonstrated a high correlation between the prevalence and number of comorbid conditions and increasing age, BMI, as well as male gender [18–21].

Although it makes intuitive sense that the extent and severity of comorbid conditions should influence surgical risk, this has been more difficult to show. Possible explanations for this difficulty are that there are no uniform standards for establishing the diagnosis and severity of the comorbid conditions that accompany extreme obesity. In addition, the different databases used for risk analysis have varying methodologies to assess the extent of the obesity disease burden. The extent and severity of most comorbid conditions are influenced by age, male gender, and BMI, which influence their statistical significance in multiple logistic regression models. Finally, in some situations, patient self-reporting is employed to document comorbid conditions.

The first study confirming the association between major comorbid disease and surgical mortality was published in 2005 and demonstrated that patients with at least one major comorbid condition have a mortality rate 12 times that of patients with no comorbid diseases [21]. Comorbid conditions which have been identified as risk factors include hypertension [3, 4, 9, 22], thromboembolism [3, 5–7], diabetes [4], pulmonary disease [4, 8], sleep apnea [6], low serum albumin [7], coronary artery disease [8], history of myocardial infarction or angina [9], stroke [9], bleeding disorder [9], dyspnea at rest [10], previous percutaneous coronary intervention [10], peripheral vascular disease with reconstruction [10], obesity hypoventilation [3, 12], pulmonary hypertension [12, 13], congestive heart failure [13], and liver disease [13]. Additional risk factors include smoking [2, 8], chronic corticosteroid use [10], and functional limitation [6, 7, 9]. Since dependent functional status is a proven risk factor and also an indicator of prognosis for several comorbid conditions, bariatric programs should routinely perform a standardized functional assessment such as the 6-min walk test as a part of the evaluation of bariatric candidates.

Risk Scoring in Bariatric Surgery

The original scoring system for bariatric risk is the Obesity Surgery-Mortality Risk Score (OS-MRS), which was introduced [3] and validated in 2007 [14]. This scoring system is derived from a single-center experience with 2,075 consecutive patients who underwent open and laparoscopic gastric bypass procedures between 1995 and 2004 with 31 fatalities (1.5 %). Patient factors found to correlate with mortality include BMI ≥50, male gender, hypertension, and pulmonary embolus risk which includes a previous venous thromboembolic event, previous IVC filter placement, right heart failure, pulmonary hypertension, and/or the presence of venous stasis disease [3]. Despite odds ratios, which ranged from 1.6 to 3.6, the authors elected for simplicity to allow one point in the risk score for each condition. Different risk cohorts were identified on the basis of 0–1, 2–3, and 4–5 conditions present. The authors have demonstrated that outcomes are improved when this scoring system is incorporated in the preoperative preparation of bariatric surgery candidates (DeMaria, personal communication). This scoring system is currently in use in many bariatric surgery programs and has been validated by additional centers [15].

A similar methodology was utilized in a more current study of 30-day gastric bypass mortality derived from a robust clinical registry wherein 81,751 gastric bypass patients from 2007 to 2011 were included. There were 123 fatalities (0.15 %) [13]. The study found that 10-year increments of age beginning at age 40 were associated with increasing mortality risk, and that 10 unit increases of BMI units above 40 kg/m^2 were also independent risk factors. Comorbid conditions associated with mortality risk included pulmonary hypertension, congestive heart failure, and clinical evidence of liver disease. A Roux-en-Y gastric bypass (RYGB) risk score was then developed which accounted for the individual contribution of each of the independent variables using the magnitude of the odds ratio (odds ratios between 2 and 3.99 were given a score of 1 point; odds ratios between 4 and 5.99 were given 2 points; odds ratio >6 were given a score of 3 points). When the RYGB score is compared with the OS-MRS score, both were highly predictive of mortality risk, but the RYGB score demonstrated superior discriminatory power and a higher C-statistic (0.761) [13]. Despite the potential advantage of this risk score, validation is needed.

Other investigators have used similar statistical methodology to identify risk factors and to develop risk calculators for morbidity [9] and mortality [10] after bariatric surgery. This provides an exact model-based estimate of the probability for postoperative morbidity and mortality for an individual patient. These calculators for morbidity and mortality are available for use at http://www.surgicalriskcalculator.com/bariatric-surgery-risk-calculator [9].

Surgical Mortality

During the last decade, risk-adjusted surgical mortality rates for a number of major surgical procedures such as major cancer resections of esophagus, pancreas, and bladder as well as abdominal aortic aneurysm repair, carotid endarterectomy, coronary artery bypass graft and aortic valve replacement have declined [23]. There are multiple reasons for this improvement including regionalization of some high-risk procedures in high volume centers, the introduction of endovascular procedures for high-risk abdominal aortic aneurysm repair, the transparency of outcome reporting in cardiac surgery, regional quality improvement initiatives, improved technology, advances in critical care, and the introduction of patient safety initiatives [23].

A similar decline in bariatric surgical mortality rates during the last decade is shown in Fig. 12.1, which summarizes recent outcome studies [2–13, 24, 25]. Mortality rates for the different bariatric surgical procedures also differ (Table 12.2),

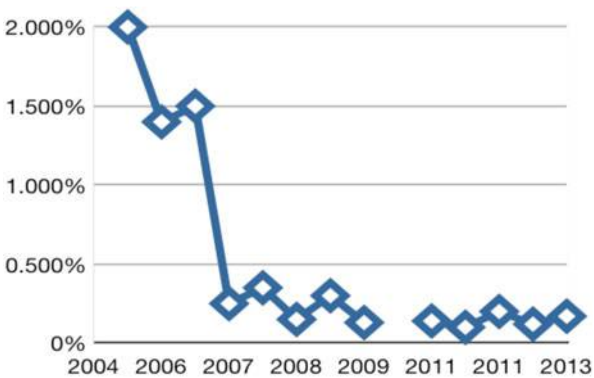

Fig. 12.1 Improvement in mortality related to bariatric surgery during the last decade (2004–2013)

Table 12.2 Bariatric surgery 30-day procedure-specific mortality rates from the Bariatric surgery longitudinal database (BOLD) [13]

Procedure	N	Mortality (%)
Roux-en-Y gastric bypass	81,751	0.15
Gastric banding	63,669	0.02
Sleeve gastrectomy	7,323	0.13
BPD with duodenal switch	1,660	0.36

Adapted from: Benotti P, Wood C, Winegar D, Petrick A, Still C, Argyropoulos G et al. Risk Factors Associated With Mortality After Roux-en-Y Gastric Bypass Surgery. Ann Surg 2014;259:123–130 [13]
BPD biliary pancreatic division

and many have included bariatric procedure type as a variable in risk adjustment models, which allows surgeons to quantitate the exact impact of a procedure change in the risk/benefit decision making and informed consent process [5, 8, 9].

Current Limitations of Risk Assessment Studies

The proliferation of risk assessment studies in recent years has reinforced the need for rigorous data collection if this information is to be used to establish evidence-based benchmarks and improve patient safety. The administrative data sources have provided important information, but lack BMI and other bariatric surgery specific data elements. Coding issues introduce error, and information about extent and severity of comorbid diseases is limited. Data is limited to the original hospitalization, and the significant numbers of mortalities and adverse events that occur after early discharge following bariatric surgery are not captured [26].

Clinical data sources like NSQIP, which are not specific for bariatric surgery, have yielded valuable information, but weight loss specific data points concerning specific comorbid conditions and postoperative complications such as anastomotic leak may not be captured [26]. Single-center clinical databases are numerous, but lack standardized methodologies for documenting extent and acuity of the obesity disease burden and assessing adverse events.

There is a need for Weight Loss Specific Multi-institution databases with standardized schemes for patient evaluation and for recording comorbid conditions [27]. In addition, there is significant variation in the reported rates of adverse events thus far. Most of the studies report rates of serious complications at 3.8–5.5 % (Table 12.1). Variations from these results raise questions of reporting accuracy [28]. A standardized system for documenting adverse events as major and minor is lacking at present.

Summary and Conclusions

The advantages of a universally accepted standardized system for risk assessment and adjustment in bariatric surgery are numerous and exciting:

- Risk adjustment will allow experienced Bariatric Centers to offer interventions to high-risk patients without fear of sanctions.
- Risk adjustment will facilitate studies addressing the cost effectiveness of bariatric surgery. In particular, better identification of high-risk patients will facilitate clinical trials to confirm the unproven statement that high-risk patients have the most to gain from bariatric surgery. This may not be true for all high-risk patients.
- The ability to identify high-risk patients early in the evaluation process allows for identification and optimization of medical conditions prior to surgery. A recent clinical study suggests that risk scoring at the program level may improve outcomes [29].

- Risk assessment will enhance the patient-centered informed consent process by expanding the reasonable information available to make an informed medical decision.
- Standardized risk adjustment will allow for the establishment of bariatric surgery benchmarks to facilitate credentialing of programs and quality improvement initiatives.
- The use of similar statistical methodology can be applied to medical, behavioral, and social factors to better identify predictors of long-term health success of bariatric surgery.

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Chapter 13
Management of the High-Risk Bariatric Surgery Candidate

Bariatric surgery programs now have the capability to identify specific risk factors for each patient, and recent advances in obesity management have identified new treatments and interventions that should allow for a variety of patient-centered risk management options. The preoperative evaluation process in bariatric surgery is lengthy enough to allow for early identification of the high-risk candidates and appropriate allocation of resources in order to optimally manage risk factors during the preoperative process. Extreme obesity is now accepted as a chronic disease without a definitive cure. Bariatric surgery should not be viewed as an isolated treatment attempting to eradicate the disease, but as an important component of a continuum of treatments and interventions designed to provide durable control of this crippling condition. Candidates for bariatric surgery must be made aware that their participation and accountability in the treatment of this condition must be an important part of this continuum.

Multidisciplinary obesity management involving expertise in internal medicine, medical specialties, surgery, psychiatry, and nutrition is now the recommended standard of care, established by the NIH Consensus conference in 1991. This should be the standard of care for bariatric surgery programs as it is recently reaffirmed as a best practice recommendation [1] and a quality indicator [2] for bariatric surgery. Unfortunately, recent survey evidence indicates that these multidisciplinary resources may not be available to patients at many programs offering bariatric surgery [3].

If bariatric centers introduce patient-centered risk management, added resources to include expertise in intensive lifestyle intervention, exercise training, physical rehabilitation, dietary intervention and monitoring, as well as smoking cessation consultation should be available for bariatric surgery candidates. This chapter defines opportunities for improved risk management, which should allow for better patient selection and improved outcomes.

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Assessment and Management of Comorbid Diseases

The list of comorbid conditions that contribute to surgical risk is large and offers multiple opportunities for preoperative treatment and optimization. Bariatric surgery programs should acquire familiarity with current medical guidelines for optimal management of comorbid conditions as appropriate diagnosis and management will improve outcomes. It is no longer sufficient to rely fully on outside busy specialists to assess and manage the investigation of comorbid conditions. Specialists who are accountable to the bariatric program should collaborate closely with the bariatric team throughout the preoperative process.

Each comorbid condition that has been identified as a risk factor is listed in Table 13.1, together with management strategies to be considered in order to reduce risk.

Cardiopulmonary conditions which add to risk including obese cardiomyopathy, ischemic heart disease, congestive heart failure, obesity hypoventilation, pulmonary hypertension, obstructive sleep apnea, and chronic obstructive lung disease are extremely important as they offer many opportunities for treatment and optimization before intervention [4–10]. Many of these conditions may be undiagnosed or inadequately investigated prior to the evaluation for bariatric surgery. Proper management requires that the bariatric program team members have familiarity with the diagnosis and management of these conditions. Close and ongoing collaboration with specialists will be necessary to optimize many comorbid conditions.

Functional assessment is an important part of the assessment of severity and prognosis of many conditions and also can be used as an index of response to treatment. A simple test for functional assessment, which can easily be incorporated into the bariatric surgery evaluation process, is the 6-min walk test [11]. Optimization of the more serious cardiopulmonary conditions like obesity hypoventilation, congestive heart failure, and pulmonary hypertension will likely delay surgery or mandate decisions regarding lower risk interventions. All of the cardiopulmonary conditions will improve with preoperative weight loss (to be discussed later in this chapter).

Thromboembolism is a modifiable risk factor for mortality and adverse events. All patients with extreme obesity are at increased risk for venous thromboembolism [12], and thromboembolism is a leading cause of postoperative fatality after bariatric surgery. The multiple factors that contribute to the increased thromboembolism risk in obesity are discussed in Chap. 7. With current frequent use of thromboembolism prophylaxis, overall thromboembolism rates are <0.5 %, but are higher in cohorts with added risk factors which include male gender, prior venous thromboembolism, superobesity, older age, functional impairment, use of hormone therapy, obesity hypoventilation syndrome, pulmonary hypertension, venous stasis disease, and longer operative time [12]. Bariatric surgery candidates with additional risk factors may benefit from more detailed hematologic assessment as thrombophilia is more common in extreme obesity [13]. Recommendations for prophylaxis for bariatric surgery patients are outlined in Table 13.1 [14]. The reader is also referred to the current American Society for Metabolic and Bariatric Surgery (ASMBS) position statement on thromboembolism prophylaxis for current best practice recommendations [12].

Table 13.1 A summary of patient factors and comorbid conditions, which affect surgical risk and strategies to reduce risk

Comorbid conditions	Management strategies for risk reduction
Recent angina	Cardiology evaluation; percutaneous intervention vs. medical treatment; evaluate systolic and diastolic function by echo [4]
Recent percutaneous coronary intervention	Cardiology evaluation; treat on the basis of clinical status and consider stress text; echo to assess systolic and diastolic function [4]
Poorly controlled hypertension	Optimize medical treatment; functional assessment; consider preoperative weight loss
Congestive heart failure	Cardiology evaluation; diuresis; assess systolic and diastolic function by echo; functional assessment; preoperative weight loss [4, 5]
Obese cardiomyopathy	Functional assessment; cardiology evaluation; assess systolic and diastolic function by echo [5, 11]
Cor pulmonale	Cardiology evaluation; diuresis; assess LV function; pulmonary function; pulmonary function tests; arterial blood gas; optimize pulmonary status; functional assessment; polysomnography; noninvasive ventilation if indicated; preoperative weight loss [5, 11]
Pulmonary hypertension	Cardiology and pulmonary function evaluation to determine etiology; assess systolic and diastolic function; assess right ventricular function; pulmonary function studies, arterial blood gas; polysomnography; noninvasive ventilation, if indicated; thromboembolism evaluation; manage underlying etiologies; functional assessment; preoperative weight loss; consider right-heart catheterization [8, 9, 11]
Obesity hypoventilation	Arterial blood gas; pulmonary evaluation; polysomnography; noninvasive ventilation functional assessment; cardiology evaluation; assess left and right ventricular systolic and diastolic function; evaluate for pulmonary hypertension; consider preoperative weight loss [6, 7, 11]
Chronic obstructive lung disease (inhalers), asthma	Pulmonary function studies; pulmonary evaluation; preoperative optimization (inhalers, bronchodilators)
Obstructive sleep apnea	Pulmonary evaluation; pulmonary function studies; polysomnography; noninvasive ventilation, if indicated; functional assessment; consider arterial blood gas; consider cardiac echo to assess systolic and diastolic function and right ventricular function [10, 11]
Thromboembolism risk	All are at moderate–high risk; high risk: older age, high BMI, immobility, prior thromboembolism, hypercoagulable state, obesity hypoventilation syndrome, pulmonary hypertension, venous stasis disease, hormone therapy, expected long operation, open surgery, male gender; combine mechanical compression with chemoprophylaxis (preferably low-molecular-weight heparin); consider additional work-up for hypercoagulable state in high-risk patients [12–16]
Diabetes	Control preoperative hyperglycemia; endocrinology evaluation and optimize medical management; consider preoperative weight loss [17–21]
Hypoalbuminemia	Evaluate protein nutrition status and correct deficiency before surgery; evaluate for chronic liver disease [25–30]
Functional impairment	Integrate functional assessment as part of preparation for bariatric surgery; establish prehabilitation programs for impaired candidates and combine with preoperative weight loss [31–44]

A small subset of bariatric surgery candidates with cardiopulmonary diseases or histories of thromboembolism require therapeutic anticoagulation. These patients are at significant risk for perioperative bleeding complications and will require special attention during the preparation for surgery. Specific challenges include the indications for bridging anticoagulation, the timing of transition from prophylaxis to therapeutic anticoagulation after bariatric surgery in the context of a short hospital stay, and the transition to oral anticoagulation. Traditionally, bariatric surgery programs have delegated this management issue to the physician prescribing the anticoagulation. An example of problems with this approach occurs in the gastric bypass patients who require chronic warfarin and must be restarted on warfarin after successful surgery. Gastric bypass patients usually require a lower dose of warfarin in the first 30 days after surgery, and the lack of awareness of this has resulted in a high incidence of readmissions for bleeding related to overdosing with warfarin [15]. The cause of this is unknown, but may involve a negative vitamin K balance during the initial weeks after gastric bypass. The bariatric surgery team should manage these patients with the transition to warfarin closely monitored with weekly or bi-weekly coagulation studies. The reader is referred to current practice guidelines regarding anticoagulation management during invasive procedures [16].

Diabetes has historically been associated with a perioperative infection risk. More recently, hyperglycemia in the perioperative period has been associated with immune dysfunction [17] and is a proven risk factor for perioperative infections in general and vascular surgery [18]. A recent study has demonstrated an association between perioperative hyperglycemia and adverse outcomes in a veteran population undergoing colectomy for cancer [19]. Many bariatric surgery candidates with type II diabetes have poor glucose control, and perioperative hyperglycemia is common with bariatric surgery. Perioperative management strategies focusing on tighter glucose control utilizing insulin infusion have been shown to improve outcomes [20] and are now considered an emerging perioperative quality indicator. Although the impact of hyperglycemia on bariatric surgical morbidity has not been formally studied, most agree that tighter glucose control is an opportunity for risk reduction [21]. The reader is also referred to the discussion of perioperative glycemic control in Chap. 14.

Hypoalbuminemia has recently been identified as a risk factor in bariatric surgery [22], and other studies have identified hypoalbuminemia as an important prognostic indicator in major surgery [23, 24]. Hypoalbuminemia is common among patients with acute and chronic medical conditions. It can be caused by many conditions including the nephrotic syndrome, hepatic cirrhosis, heart failure, and malnutrition. In addition, it is often caused by an acute or a chronic inflammatory response. This condition may be present in 1–12 % of bariatric surgery candidates (Chap. 6, Table 6.1) [25, 26]. If hypoalbuminemia is identified in bariatric surgery candidates, the etiology must be determined. If related to protein malnutrition, this should be corrected prior to surgery [27]. An evaluation for cirrhosis [28], another significant bariatric surgery risk factor [29, 30], is also indicated.

Extreme Obesity and Functional Impairment

Impaired functional status has been identified recently in several studies as a risk factor for adverse outcomes following bariatric surgery (Chap. 12, Table 12.1). Functional impairment and reduced levels of physical activity are common among candidates for bariatric surgery. Accelerometer data and patient diaries from the Longitudinal Assessment of Bariatric Surgery Study (LABS) indicate that more than half of the candidates for bariatric surgery have very limited levels of physical activity (Fig. 13.1) and that the extent of physical activity is inversely related to BMI [31]. The same investigators later demonstrated that walking limitations are very common in candidates for bariatric surgery. Of 2,458 candidates asked to perform a long corridor walk test, 28 % were ineligible because of limiting comorbidity or they declined to participate, and only 65 % were able to complete the walk test [32]. Most of the focus on physical activity in bariatric surgery thus far has been during the postoperative period where the improvements are well documented [33, 34]. However, the identification of functional impairment as a surgical risk factor as well as the observations that preoperative attention to physical activity leads to an increase in preoperative physical activity [35], to increased physical activity readiness [35], and to an increase in postoperative physical activity [36] are shifting the focus to the preoperative preparation phase.

The health benefits of physical activity include improved flexibility, strength, and balance; improved bone health; improved cardiovascular health; improved diabetic control; improved psychological well-being; improved cognitive function; enhanced sleep quality; and improved longevity [31, 37]. Most bariatric surgery candidates are unable to take advantage of these health benefits. The recent evidence of increased surgical risk associated with functional impairment and the finding that poor aerobic fitness among bariatric surgery candidates is associated with in increased risk of adverse events [38] have stimulated interest in the enhancement

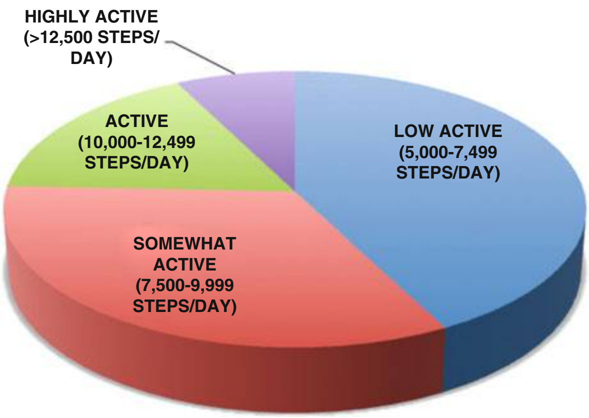

Fig. 13.1 A survey of physical activity levels of candidates for bariatric surgery ($n=756$). Adapted from King W, Belle S, Eid G, Dakin G, Inabnet W, Mitchell J et al. Physical Activity Levels of Patients Undergoing Bariatric Surgery in the Longitudinal Assessment of Bariatric Surgery. Surg Obes Relat Dis. 2008;4:721–728 [31]

of physical activity in the preoperative period before bariatric surgery. Although there is little evidence thus far supporting an outcome advantage with increased preoperative physical activity, there is evidence that intensive physical activity programs together with diet can improve comorbid conditions and induce significant weight loss in severely obese patients [39].

The term "prehabilitation" is the process of enhancing functional capacity in order to allow an individual to better withstand a physiologically stressful event such as surgery. Studies in prehabilitation have thus far come from Canada perhaps because of the longer waiting period for elective surgery. The lengthy preoperative preparation process, which is the rule for bariatric surgery, will easily accommodate prehabilitation strategies. Studies in prehabilitation are available in other surgical specialties and have documented some important physiologic improvements prior to surgery. In a study of 112 patients prior to major colorectal surgery, structured exercise regimens were tested for a mean of 52 days before surgery. A significant fraction of the patients tested demonstrated improvements in maximal oxygen consumption and performance in the 6-min walk test as a result of the prehabilitation program [40]. In this study, 33 % improved physical function, 38 % did not change significantly, and 29 % deteriorated (mostly because of lack of adherence to the regimen). Patients who deteriorated were at greater risk for a life-threatening complication. Those who improved had a more rapid functional recovery after surgery [41]. A simple walking and breathing program seemed to be successful with good patient participation in this study.

In a small study of operable lung cancer patients prior to thoracotomy, a structured exercise regimen was prescribed with the goal to increase physical fitness. The exercise program was individually tailored to each patient's fitness level and supervised by specialists. Outcome assessments included the 6-min walk test and measurement of maximum oxygen consumption (VO_{2peak}). The investigators demonstrated that a short-term preoperative exercise program did improve aerobic fitness and walking capacity (Fig. 13.2a, b). No information regarding the impact on surgical outcome is provided [42].

These pilot studies in prehabilitation indicate that improvement in physical function is possible in preoperative patients. Similar feasibility studies are needed in bariatric surgery candidates, especially those with functional impairment. Functional impairment among candidates for bariatric surgery has multiple causes including cardiopulmonary comorbid disease, musculoskeletal degenerative disease, and mental health conditions such as severe depression. In these patients, prehabilitation can be enhanced by concomitant weight loss programs, which will favorably affect nearly all comorbid conditions. In older adults, the combination of exercise and weight loss has a greater positive effect on physical function than either intervention alone [43].

The implementation of prehabilitation programs will be a challenge for bariatric programs because of the physical impairments common to extreme obesity and the reluctance of bariatric surgery candidates to participate because of fear of embarrassment and failure. Additional expertise in exercise therapy will be necessary to provide counseling and assessment of each patient's physical capacity in order to individualize physical activity programs [44]. Such individualized effort will have the advantage of enhancing patient confidence in the program, which should

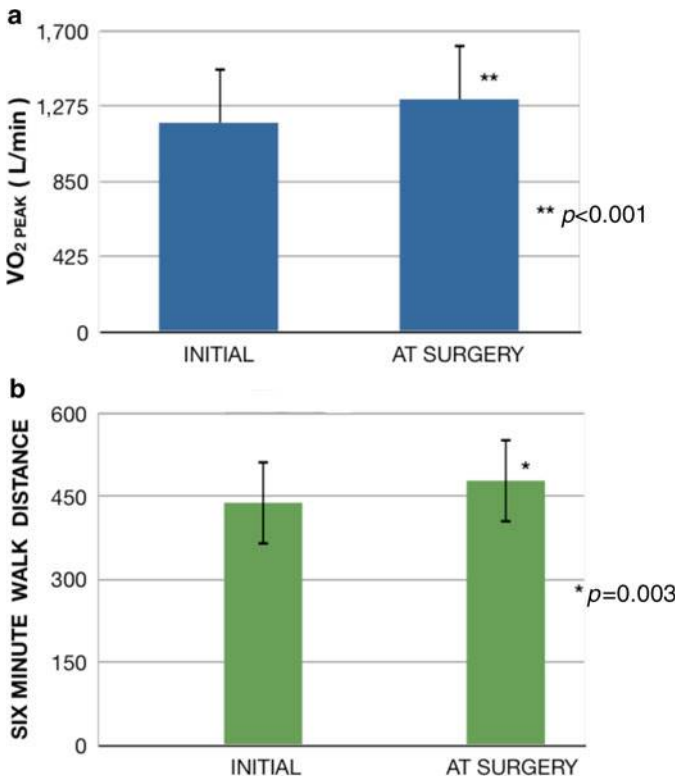

Fig. 13.2 The physiological benefit of a supervised exercise program on aerobic fitness. (**a**) Peak oxygen consumption before and after presurgical exercise and (**b**) 6-min walk test performance before and after presurgical exercise. Adapted from Jones L, Peddle C, Eves N, Haykowsky M, Courneya K, Mackey J et al. Effects of Presurgical Exercise Training on Cardiorespiratory Fitness Among Patient Undergoing Thoracic Surgery for Malignant Lung Lesions. Cancer 2007;110:590–598 [42]

enhance patient accountability and compliance. Progress can be monitored by sequential functional assessments such as the 6-min or long corridor walk tests. The establishment of milestones and documentation of attainment will provide additional motivation and sense of involvement for patients. Hopefully, the official designation of obesity as a disease will allow for expanded resources available for multidisciplinary obesity centers and development of prehabilitation programs for impaired patients.

Smoking and Bariatric Surgery

Tobacco smoking is a well-known cause of preventable deaths worldwide and also known to surgeons as a risk factor for surgical morbidity. Several studies have confirmed that smoking is a risk factor for adverse events after bariatric surgery (Chap. 12,

Table 13.2 The physiological impact of smoking on the components of wound healing [51]

Wound healing component	Effect of smoking
Wound inflammation and hemostasis	Enhancement of wound thrombosis formation; attenuation of inflammatory cell infiltration into wound; decreased neutrophil and monocyte phagocytosis; increased neutrophil release of proteolytic enzymes, collageno-lysis
Wound proliferation and remodeling	Inhibition of fibroblast migration and proliferation; reduced collagen production; impaired neovascularization
Wound contraction	Enhanced wound contraction
Wound and tissue perfusion	Reduced blood flow and aerobic metabolism
Oxidative stress	Enhanced release of reactive oxygen species; increased consumption of vitamin C which limits the availability for collagen synthesis

Table 12.1) [45–47]. In a survival analysis of 18,972 postoperative bariatric surgery patients studied between 1986 and 2001 (mean postoperative follow-up of 8.3 years), there were 654 mortalities (3.45 %). The risk for death of smokers in this cohort was twice that of nonsmokers (hazard ratio 2.05; 95 % confidence interval 1.67, 2.52; $p < .0001$) [48]. Another VA study of bariatric surgery using the NSQIP methodology found that the extent of smoking correlated with the odds ratios of failure to wean from mechanical ventilation within 48 h of the procedure [45]. Smoking also influences adverse events after bariatric surgery as a contributor to the risk of thromboembolism [49, 50] and marginal ulcer [51].

Mechanisms for the physiological impact of smoking on surgical complications include alterations in respiratory epithelium with impaired mucociliary clearance, an increase in closing volume predisposing to atelectasis, and a decline in expiratory airflow rates. Bariatric surgery candidates frequently have significant abnormalities in pulmonary function related to the extent of obesity, and this may heighten the clinical impact of smoking on pulmonary reserve. The majority of the morbidity related to smoking after surgery, however, involves wound complications including wound infection, flap necrosis, and wound dehiscence. Many of the important components of wound healing are adversely affected by smoking. The effects of smoking on each phase of wound healing are summarized in Table 13.2 [52].

Cessation of smoking does reverse the adverse effects of smoking on wound perfusion and on inflammatory cell function. The effects on the proliferative phase remain impaired [52].

Although this has not as yet been studied in bariatric surgery, there is substantial evidence that smoking cessation can be achieved in preparation for surgery and can reduce surgical morbidity. A systematic review of 11 randomized controlled trials in 1,194 patients found that preoperative smoking cessation programs involving regular (weekly) individual counseling and nicotine replacement therapy carried out over 1–2 months prior to surgery do result in both short- and longer term smoking cessation. The review found that those smoking cessation programs that were of lesser intensity were not significant in their impact on smoking cessation. In addition, a meta-analysis of the pooled results found that interventions for smoking cessation are able to significantly reduce surgical morbidity (pooled risk ratio 0.45; 95 % confidence interval 0.41–0.78; $p < 0.001$) [53]. The optimum duration of smoking cessation prior to surgery is 8 weeks or more [54], and there is some evidence that cessation for less than 4 weeks prior to surgery may be of no benefit and actually increase the risk of pulmonary complications [55]. The positive impact of smoking cessation and improved surgical outcomes is substantiated by a randomized controlled study involving three surgical centers, wherein 120 patients were randomized to an intensive smoking cessation program and to a control group prior to elective knee and hip replacement surgery. A blinded evaluator assessed surgical complications in the trial. Overall complications in the intervention group occurred in 18 % in comparison to 52 % in the control group ($p = 0.0003$) [56].

Until now, bariatric surgery programs have taken a limited approach to smoking cessation, probably because of unfamiliarity with current treatment options, time constraints, and concerns about lack of success. The proven risks of smoking in bariatric surgery mandate that programs give more attention to smoking cessation in preparation for surgery because this is now a best practice recommendation and will soon be an important quality indicator [1, 57, 58]. If the prevalence of smoking among candidates for bariatric surgery is similar to the prevalence of smoking in the general population, then 20 % of candidates may benefit from an intensive preoperative program for smoking cessation. For excellent suggestions regarding establishment of such a program for bariatric surgery candidates, the reader is referred to an excellent current review [59].

Programs should develop a policy and procedure outlining the evaluation and management of smoking for surgery candidates. The policy should summarize the risks of smoking, protocols for smoking assessment, resources available for intensive counseling, nicotine replacement therapy, appetite suppression, and other approaches for smoking cessation. The program policy for smoking should be made available to bariatric surgery candidates before they enroll in the preoperative program and should be a part of the informed consent process. Bariatric program personnel should familiarize themselves with current recommendations and available treatment options for smoking cessation [60, 61]. Clinical trials to assess the impact of smoking cessation prior to bariatric surgery are needed, both to confirm that cessation is achievable and to document an outcome benefit. The establishment of high-quality clinical registries should facilitate such studies.

Preoperative Weight Loss

Many bariatric surgeons have recommended preoperative weight loss for selected patients with superobesity in order to reduce visceral fat and liver size and thus facilitate safe completion of laparoscopic foregut procedures. Perhaps stimulated by the current focus on quality care, patient safety, patient selection, and improved outcomes, preoperative weight loss has been the focus of a number of recent studies. The potential advantages of weight loss before bariatric surgery are summarized in Table 13.3.

Table 13.3 Factors related to preoperative weight loss, which can favorably influence surgical outcomes

• Reduction in liver size
• Reduction in visceral fat
• Improved functional status
• Better control of comorbid conditions
• Improved assessment of patient compliance
• Improved assessment of patient motivation
• Reduced bariatric surgery complications

There is substantial evidence that modest weight loss approximating 5–10 % of body weight has substantial health benefits. These include reductions in blood pressure, improvement in glycemic control in diabetes, improvement in insulin resistance, improvement in liver function, and an increase in HDL cholesterol [39, 62, 63]. In a Veterans Administration study of 30 high-risk bariatric surgery candidates (BMI 56 ± 1 kg/m^2) who lost 12.1 % of body weight over 9 weeks before bariatric surgery, 31 % had improvement or resolution of at least half of the average 3.3 comorbid conditions per patient [64]. In a short-term weight loss study of 106 asymptomatic obese (BMI >30 kg/m^2) subjects with cardiovascular disease risk factors but no known cardiovascular disease, subjects lost an average of 4.5 % of body weight in response to lifestyle intervention. Cardiovascular testing documented improvement in exercise performance (peak oxygen consumption), diastolic cardiac function, and endothelial function [65].

Many bariatric surgeons have questioned the ability of patients with extreme obesity to lose weight prior to surgery. They argue that patients are referred for surgery because they have been unsuccessful with conventional weight loss treatments. Recent evidence suggests that patients with extreme obesity can respond favorably to a diet and lifestyle intervention program prior to surgery. Many programs utilize low-calorie diets in the weeks leading up to bariatric surgery and have reported modest weight loss, improved comorbidity control, and favorable outcomes [64, 66]. Some bariatric surgery centers have established program policies for preoperative weight loss as a strong recommendation for all candidates for surgery. Reports from these centers suggest that the majority of bariatric surgery candidates can accomplish significant preoperative weight loss. The weight loss accomplishment of patients in two such centers is shown in Fig. 13.3a, b [67, 68]. These studies suggest that the large majority of patients prior to bariatric surgery can achieve meaningful weight loss.

Two recent short-term medical weight loss trials confirm that diet together with a physical exercise program is superior to diet alone [39, 43]. The incorporation of a diet and exercise program for deserving candidates in a bariatric surgery program has the potential of improving both patient health and functional status, which can favorably affect surgical outcomes. Safe and successful management of medical weight loss and physical exercise by multidisciplinary obesity management programs is labor intense and requires expanded resources, because high-risk patients losing weight will experience rapid improvement in comorbid diseases like hypertension and diabetes. This will necessitate close medical follow-up to make

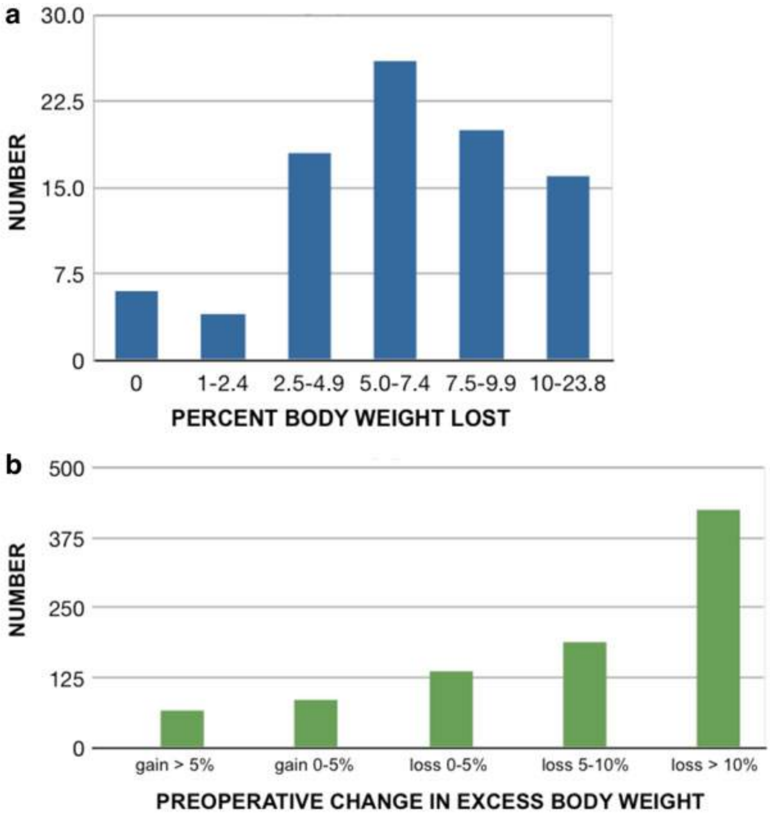

Fig. 13.3 Preoperative weight loss accomplishments from two bariatric programs. (**a**) Stanford ($n=90$). Adapted from Alvarado R, Alami R, Hsu G, Safadi B, Sanchez B, Morton J et al. The Impact of Preoperative Weight Loss in Patients Undergoing Laparoscopic Roux-en-Y Gastric Bypass. Obes Surg. 2005;15:1282–1286. [67]. (**b**) Geisinger ($n=884$) where preoperative weight loss is strongly recommended as well as monitored. Adapted from Still C, Benotti P, Wood G, Gerhard G, Petrick A, Reed M et al. Outcomes of Preoperative Weight Loss in High-Risk Patients Undergoing Gastric Bypass Surgery. Arch Surg. 2007;142:994–998 [68]

appropriate down adjustments in medicines and dosages as these conditions change favorably. The ability to provide these comprehensive services in one center will be a convenience for patients and will increase patient adherence.

Evidence of an outcome benefit from preoperative weight loss in bariatric surgery is beginning to accumulate. A number of imaging studies have documented that weight loss before surgery decreases liver size, liver fat, visceral fat, and subcutaneous fat [64, 69, 70]. The benefit of this is shown in studies demonstrating shorter operating times [67, 71] and surgeon perception of greater ease of the procedure [66] in association with preoperative weight loss. An interesting retrospective study from a single program experience reviews the outcomes when preoperative weight loss of 10 lbs is mandated for selected high-risk candidates who are felt to have a high ratio of visceral to subcutaneous fat. In a 4-year retrospective study involving 353 total gastric bypass patients, 74 (21 %) were required to lose 10 lbs before surgery and the remainder ($n = 279$) did not lose weight. The preoperative weight loss patients ($n = 74$) were heavier (BMI 54.2 ± 6.7 vs. 47 ± 5.7, $p = .001$), had more males (30 % vs. 13 %, $p = .001$), and had more patients with hypertension (60 % vs. 40 %, $p = .005$) and sleep apnea (35 % vs. 24 %, $p = .054$). By current standards, this is a high-risk cohort. Operative time was longer in the weight loss cohort, but complications were less frequent ($p = .035$) [72].

A randomized trial involving an initial 100 patients but with only 61 patients completing the study did not demonstrate any reduction in operative complications [71]. However, the later results of this small study did demonstrate that those who lost at least 5 % of body weight before surgery had greater than 1-year weight loss [73]. A large retrospective review from a major bariatric center studied 884 subjects undergoing open or laparoscopic gastric bypass over a 5-year period. Preoperative weight loss of at least 10 % of excess body weight was achieved by 48 % (Fig. 13.3b). This study found that preoperative weight loss was predictive of a shorter length of stay and a greater weight loss result at 1 year [68]. In order to determine the explanation for the shorter observed length of stay associated with preoperative weight loss, the same authors reviewed the hospital records of each of the 881 patients who underwent open or laparoscopic gastric bypass. They found that preoperative weight loss was statistically associated with a reduction in operative complications [74].

In a recent multicenter randomized trial, 298 morbidly obese patients were randomized either to a 2-week very-low-calorie diet (VLCD) or to a regular diet control group prior to laparoscopic gastric bypass surgery. The groups were comparable in regard to established risk factors. The group randomized to the VLCD ($n = 145$) lost 4.9 ± 3.6 kg and the control group ($n = 149$) lost 0.4 ± 3.2 kg ($p < .001$). Operative times were not different between the two groups, but surgeon perception of difficulty was higher in the control group and complication rates were lower in the VLCD group ($p = .04$) [66].

Although not as yet available in the USA, endoscopic interventions have been studied in the context of weight loss before bariatric surgery. The weight loss results with the gastric balloon and the duodeno-jejunal bypass sleeve are reviewed in Chap. 12. These interventions have demonstrated significant short-term weight loss and physiologic improvement in comorbid conditions. When these interventions were studied prior to bariatric surgery, health benefits and surgical outcome improvements have been demonstrated [75–78].

Summary and Conclusions

Less than a decade ago, the implementation of staged interventions was advocated as optimal treatment for high-risk patients with extreme obesity. The establishment of patient registries allows for the identification of treatable patient-level factors that influence surgical risk. Once the patient behavioral evaluation process in bariatric surgery is more standardized, similar statistical methodology can be used to identify behavioral and lifestyle factors which correlate with optimal weight loss and health improvement after bariatric surgery. The extended time period for patient evaluation, instruction, and work-up prior to bariatric surgery is ideal for the implementation of new programs to optimize identified patient risk factors. This will mandate expanded multidisciplinary services incorporated in a patient-friendly bariatric surgery program with patient-centered multidisciplinary management.

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Chapter 14
Anesthesia Considerations in Bariatric Surgery

An important focus in the patient-centered preparation for bariatric surgery should involve close collaboration between anesthesiologists and bariatric surgeons in the evaluation of individual patients with possible anesthesia or airway risks and in the establishment of perioperative policies and procedures for management of specific high-risk conditions. Current best practice recommendations for anesthesia management in bariatric surgery are derived from evidence-based reviews of current literature and recommendations from experienced consultants [1, 2]. Many of the current guidelines for anesthetic management of patients with extreme obesity in other surgical specialty areas are derived from experience with bariatric surgery patients. Although there are currently no requirements for credentialing anesthesiologists in the management of bariatric surgery patients, current guidelines recommend that anesthesia departments identify an experienced skilled anesthesiologist to function as liaison and advisor between the anesthesia department and the bariatric surgery program. This designated anesthesiologist should be a regular participant in bariatric surgery morbidity and mortality reviews as well as quality improvement endeavors. An important aspect of this collaboration between bariatric programs and anesthesiologists should be to establish protocols for consultation and early preoperative evaluation of patients who may present special challenges for anesthesia.

Extreme Obesity and Lung Function

In patients with extreme obesity, abnormalities of lung function are common, especially in the awake supine position. The administration of general anesthesia worsens these derangements frequently resulting in hypoxia and hypercarbia. Extreme obesity is associated with reductions in functional residual capacity (FRC),

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Table 14.1 A summary of pulmonary function and gas exchange findings in patients with superobesity

	Weight/height 0.9–1	Weight/height >1
Number	25	18
Mean weight (lbs), range	349 (308–397)	414 (347–500)
VC (% predicted)	74.7 ± 4.6	72.7 ± 6.5
FEV_1 (% predicted)	71.4 ± 4.5	68.7 ± 5.9
ERV (% predicted)	23.8 ± 2.9	25.5 ± 6.5
FRC (% predicted)	62.7 ± 3.4	70.9 ± 7.0
MVV (% predicted)	67.9 ± 5.5	59.5 ± 5.7
TLC (% predicted)	83.2 ± 4.1	81.8 ± 4.2
P_aCO_2 (mm Hg)	46.7 ± 2.5	47.9 ± 2.5
P_aO_2 (mm Hg)	69.1 ± 3.5	65.5 ± 2.8

VC vital capacity, *FEV_1* forced expiratory volume at 1 s, *ERV* expiratory reserve volume, *FRC* functional residual capacity, *MVV* maximum ventilatory volume, *TLC* total lung capacity, *P_aCO_2* partial pressure of carbon dioxide in arterial blood, *P_aO_2* partial pressure of oxygen in arterial blood
Modified from Biring et al. Physiologic Changes of Morbid Obesity. Am J Med Sci 1999; 318:293–297 [4]

expiratory reserve volume (ERV), and total lung capacity (TLC) caused by encroachment of abdominal contents on the diaphragm, reduced respiratory system compliance, and limited respiratory muscle capacity. As a consequence of reduced lung volumes, FRC may fall below closing volume causing airway closure, ventilation/perfusion mismatch, and hypoxemia during normal tidal breathing [3, 4].

General anesthesia compounds these abnormalities because it causes an additional fall in FRC which adds to the ventilation/perfusion mismatch and gas exchange abnormalities. The preoperative reductions in lung volume combined with the additional reduction caused by general anesthesia can result in major right-to-left shunting and hypoxemia [3]. Clinically significant reductions in lung volume are more prevalent in superobesity. Pulmonary function and gas exchange were studied in superobese subjects who were divided into two groups according to weight-to-height ratios [4]. The significant abnormalities in spirometry and gas exchange found in this study are summarized in Table 14.1 [4]. This study focusing only on superobese subjects highlights the clinically significant abnormalities of lung function and gas exchange, which may be hidden in larger surveys of pulmonary function in bariatric surgery candidates.

Additional lung function abnormalities in extreme obesity with possible clinical significance include reduced lung and chest wall compliance and increased work of breathing, which, together with the impingement of the abdominal content on the diaphragms, result in rapid shallow breathing which is most marked in the supine position [3]. These abnormalities must be recognized in decisions regarding extubation after anesthesia or during weaning from mechanical ventilation in the intensive care unit. The reader is referred to Chapter 7 for additional information about pulmonary physiology in extreme obesity.

Anesthesia Preoperative Evaluation of Candidates for Bariatric Surgery

Obstructive sleep apnea (OSA) is an established surgical risk factor and also poses challenges for anesthesiologists. The condition is extremely common among candidates for bariatric surgery [5] such that evaluation for this condition is a necessary part of the comprehensive medical evaluation conducted by the bariatric program. The potential anesthesia risks of OSA are summarized in Table 14.2 [6].

A retrospective study compared 36 patients with sleep apnea and 77 matched controls and found that difficult intubation occurred in 22 % of patients with sleep apnea and 3 % of controls ($p = .003$) [7]. In a retrospective case-controlled study 101 joint replacement (knee and hip) patients with sleep apnea (only 33 using continuous positive airway pressure (CPAP) at home prior to surgery) were compared with 101 joint replacement matched controls. Adverse outcomes occurred at higher rates ($p = .001$), and hospital length of stay was prolonged ($p < .007$) in the patients with sleep apnea [8].

An evaluation for sleep apnea with review of results of any previous work-up should be carried out by the bariatric program, as well as close questioning in regard to any history of problems with airway or intubation is an important part of the anesthesia evaluation. Since the apnea–hypopnea index (AHI) appears to correlate with the extent of reduction in pulmonary function, those patients with more severe sleep apnea should be stabilized on CPAP prior to surgery in conjunction with advanced consultation with the anesthesia department. CPAP for 12 weeks has been shown to improve hypoxia, reduce systemic blood pressure, and reduce pulmonary artery pressures [9]. In another detailed study, 43 obese subjects (BMI 31.6 ± 5.4 kg/m^2) with severe sleep apnea but no known pulmonary or cardiac disease underwent detailed cardiovascular studies before and after 6 months of CPAP treatment via nasal mask. Abnormalities of cardiac structure and function were identified and were associated with increasing AHI. Significant improvement in cardiac structure and function occurred with CPAP treatment (Table 14.3) [10].

Because of the proven physiological benefits of CPAP treatment for OSA, there is agreement among experts that CPAP treatment should be instituted before bariatric surgery in patients with extreme obesity and moderate-to-severe OSA [1, 2, 6]. However, there is limited evidence that preoperative treatment with CPAP may reduce the risks related to sleep apnea [11]. In addition, there is no information about the duration of preoperative CPAP needed to improve outcomes. This is an important area of needed study in bariatric surgery, because many candidates are found to have moderate or severe sleep apnea on preoperative evaluation and are denied preoperative treatment because of managed care denials or delays.

Table 14.2 Anesthesia risks associated with obstructive sleep apnea [6]

• Significant risk of difficult intubation
• High risk of recovery room complications
• Sensitivity to opioids and sedative medications
• Rare risk of sudden cardiorespiratory arrest

Table 14.3 Improvement in parameters of cardiac structure and function in 43 obese patients with severe sleep apnea and no history of cardiac or pulmonary disease after 6 months of CPAP treatment

	Baseline	After 6 months of CPAP	*p*
Heart rate (beats/min)	73 ± 1	67 ± 10	0.02
Stroke volume (ml)	64 ± 10	71 ± 11	.0037
Systolic blood pressure (mmHg)	159 ± 27	138 ± 28	<0.03
Diastolic blood pressure (mmHg)	92 ± 18	80 ± 20	<0.03
Interventricular septum thickness (cm)	1.32 ± .23	0.99 ± .21	0.001

CPAP continuous positive airway pressure

Modified from Shivalkar B, Van De Heyning C, Kerremans M, Rinkevich D, Verbraecken J, De Backer W et al. Obstructive Sleep Apnea Syndrome- More Insights on Structural and Functional Cardiac Alterations and the Effects of Treatment with Continuous Positive Airway Pressure. J Am Coll Cardiol. 2006; 47:1433–1439 [10]

Anesthesia Induction and Airway Management

In anesthesia, the difficult airway refers to clinical situations where a conventionally trained anesthesiologist has difficulty in maintaining oxygenation with mask ventilation of the upper airway, difficulty with intubation of the trachea, or both [12, 13]. Because significant problems with the difficult airway are more common in extreme obesity [7, 14], strategies to increase the non-hypoxic apnea duration during induction and intubation are critical for patient safety. Because of the reduced lung volumes that are common in extreme obesity, the non-hypoxic duration is often limited, especially in the supine position. Current recommendations are to use the head-up position, either the "ramped" [15] or the reverse Trendelenburg position [16] for laryngoscopy and tracheal intubation. In a randomized controlled trial of preoxygenation position, 42 patients undergoing gastric band placement were randomized to two groups. Both cohorts received preoxygenation for 3 min with 100 % oxygen. The control group patients were preoxygenated in the supine position and the test group in the 25° head-up position. The preintubation oxygen tension was higher, and the desaturation safety period was longer in the head-up cohort (Fig. 14.1a, b) [16].

The use of the sitting position for preoxygenation with eight deep breaths over 60 s and an oxygen flow of 10 L/min has also been shown to significantly prolong the safe tolerance to apnea (Fig. 14.2) [17]. Another technique for prolongation of the non-hypoxic apnea period is the use of positive end-expiratory pressure (PEEP) during preoxygenation. In a randomized trial, the use of CPAP at 10 cm with 100 % oxygen for 5 min followed by pressure-controlled mechanical ventilation with PEEP for another 5 min before tracheal intubation was compared with a control group who received 100 % atmospheric oxygen and similar preintubation mechanical ventilation. The use of PEEP increased both the non-hypoxic apnea duration and the PaO_2 prior to apnea (Fig. 14.3a, b) [18]. In a case report involving a critically ill patient with morbid obesity and obesity hypoventilation who needed emergency cholecystectomy, noninvasive bi-level positive airway pressure was used for preoxygenation with dramatic improvement in serial arterial blood gases [19].

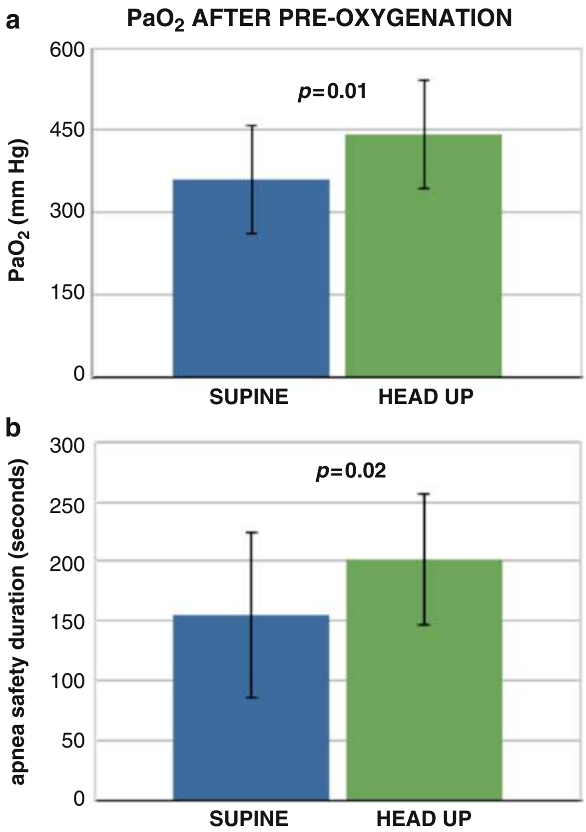

Fig. 14.1 (**a**, **b**) The results of a randomized trial comparing preoxygenation positions prior to endotracheal intubation in gastric band patients. The effect of position on PaO_2 and on apnea safety duration after preoxygenation is demonstrated. Adapted from Dixon B, Dixon J, Carden J, Burn A, Schachter L, Playfair J et al. Preoxygenation is More Effective in the 25° Head-up Position Than the Supine Position in Severely Obese Patients; A Randomized Controlled Study. Anesthesiology 2005; 102:1110–1115 [16]

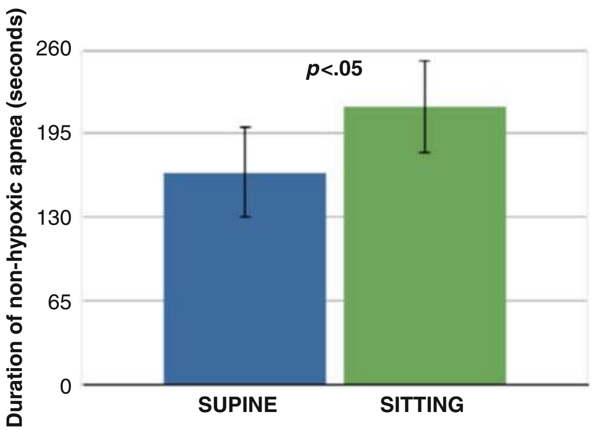

Fig. 14.2 The beneficial effect of the sitting position for preoxygenation on the duration of non-hypoxic apnea in obese patients prior to endotracheal intubation. Adapted from Altermatt F, Munoz H, Delfino H, Cortinez L. Pre-oxygenation in the Obese Patient: Effects of Position on Tolerance to Apnea. Brit J Anesth. 2005; 95:706–709 [17]

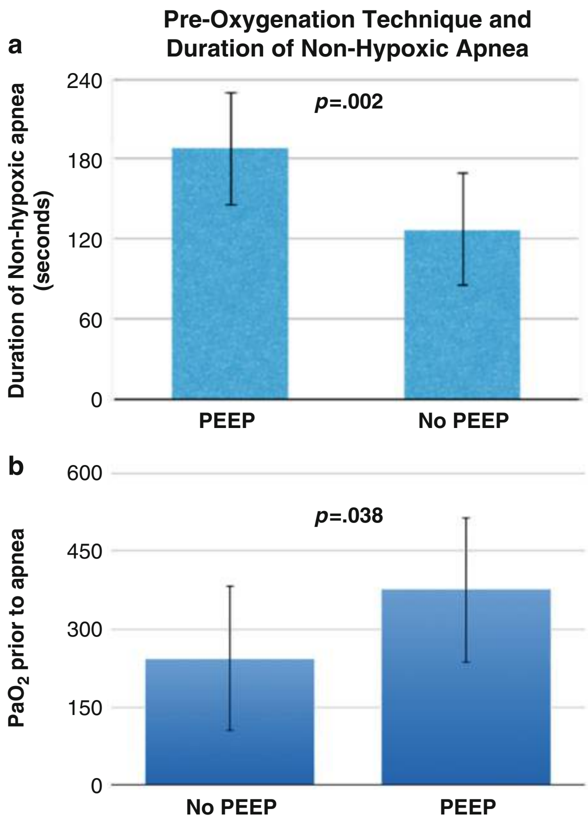

Fig. 14.3 (**a**, **b**): The beneficial effect of the use of PEEP during preoxygenation on non-hypoxic apnea duration and PaO_2 prior to apnea. Modified from Gander S, Frascarolo P, Suter M, Spahn D, Magnusson L. Positive End-Expiratory Pressure During Induction of General Anesthesia Increases Duration of Nonhypoxic Apnea in Morbidly Obese Patients. Anesth Analg. 2005; 100:580–584 [18]

The use of PEEP during induction of anesthesia has been studied in nonobese adults and has been shown to reduce atelectasis [20]. Similarly, PEEP which is optimized using electric impedance tomography has been used in laparoscopic gastric bypass patients ($N=15$), with maintenance of normal FRC and improved oxygenation. In this small study of patients with BMI 49 ± 8 kg/m^2, the optimal level of PEEP was 15 ± 1 cm H_2O, and volume loading was utilized to maintain cardiac index [21]. The use of alveolar recruitment strategies using increases in end-expiratory pressure with volume loading when necessary merits further study in bariatric surgery, especially among the superobese where the reductions in lung volumes tend to be clinically significant. Increased use of alveolar recruitment may impact favorably on perioperative tissue hypoxia, which is common in obesity [22].

Another challenge for anesthesiologists when managing patients with extreme obesity is difficulty with mask ventilation defined as the inability of an unassisted anesthesiologist to maintain the measured oxygen saturation by pulse oximetry >92 % or to prevent or reverse inadequate ventilation during positive pressure mask ventilation under general anesthesia [13, 23]. In a prospective study of 1,502 patients, difficult mask ventilation was encountered in 5 %. Univariate and subsequent multivariate analysis of patient risk factors revealed five risk factors: age >55 years, body mass index >26 kg/m^2, lack of teeth, presence of a beard, and history of snoring [23]. The combination of morbid obesity with another risk factor invites a significant risk and merits advanced preparation by the anesthesiologist [12].

Management of Hypoxemia and Hypoventilation

The prompt recognition and treatment of hypoxemia and hypoventilation complicating bariatric surgery remain a major challenge for anesthesiologists and bariatric surgeons. The overall incidence of respiratory failure complicating noncardiac surgery was found in a Veterans Affairs National Surgical Quality Improvement Program (NSQIP) prospective cohort study of 81,729 to be 3.4 % [24]. Another prospective study of 1,332 patients from the general population who underwent elective abdominal surgery identified 17 % of patients with $PaO_2/FiO_2 < 300$ spontaneously breathing 30 % oxygen 1 h after extubation [25]. The exact incidence of clinically significant hypoxia or hypoventilation after bariatric surgery has not been well studied. A small study designed to identify the incidence of hypoventilation after bariatric surgery involved sequential blood gas sampling and continuous pulse oximetry in 16 postoperative bariatric surgery patients. The study demonstrated a high incidence of worrisome hypoxemia that was not clinically detected (Table 14.4) [26] and one case of life-threatening hypercarbia, which was not detected by clinical providers [27].

Hypoxia that complicates general anesthesia is caused either by regional hypoventilation resulting in ventilation/perfusion mismatch and hypoxemia or by global hypoventilation. The use of opiates suppresses arousal and can complicate either condition. The current post-anesthesia care practice of routinely administering high flows of supplemental oxygen to postoperative patients in order to prevent

Table 14.4 Postoperatiove hypoxemia after bariatric surgery: the results of a small study demonstrating a high incidence of significant hypoxemia in the first 24 hours after bariatric surgery

- $N = 15$
- Body mass index (BMI): 48.2 ± 2 kg/m^2
- Age: 44 ± 4 years

Continuous pulse oximetry monitoring:

- Every patient had more than one episode of SpO_2 <90 % for more than 30 s in the first 24 h after surgery
- Average nadir SpO_2: 75 ± 8 %
- Average longest desaturation <90 %: 21 ± 15 min
- *All episodes undetected clinically*

Adapted from Gallagher S, Haines K, Osterlund L, Mullen M, Downs J. Postoperative Hypoxia: Common, Undetected, and Unsuspected After Bariatric Surgery. J Surg. Res. 2010; 159:622–626 [26]

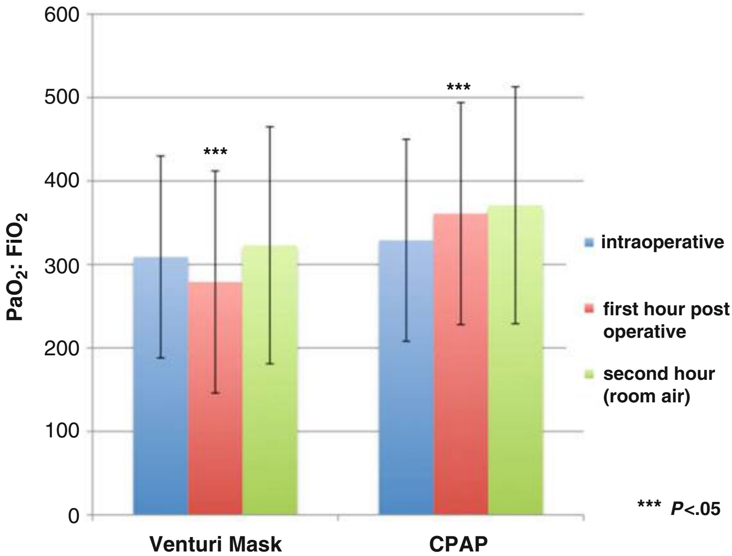

Fig. 14.4 A comparison of the effects of CPAP vs. Venturi mask on parameters of oxygenation during the initial hours after bariatric surgery. *CPAP* continuous positive airway pressure. Modified from Gallagher S, Haines K, Osterlund L, Murr M, Downs J. Life-Threatening Postoperative Hypoventilation after Bariatric Surgery. Surg Obes Rel Dis. 2010; 6:102–104 [27]

desaturation impairs the ability to detect hypoventilation with pulse oximetry [28]. Anesthesia and PACU nurses must be aware of the advantages and limitations of pulse oximetry as a monitoring tool in the detection of potentially serious hypoxemia and hypoventilation. More arterial blood gas analysis is needed in the post-anesthesia setting, especially when desaturation is noted on pulse oximetry and routine arousal maneuvers are unsuccessful.

In nonobese patients without sleep apnea who have significant hypoxemia after elective abdominal surgery, the prompt use of noninvasive positive pressure ventilation will improve gas exchange and reduce the need for reintubation [25]. Limited evidence thus far suggests that CPAP will have similar effects when used to treat hypoxemia after bariatric surgery.

In a randomized trial comparing CPAP (7.5 cm H_2O) with oxygen therapy via Venturi mask in postoperative bariatric surgery patients, improved oxygenation was demonstrated with CPAP (Fig. 14.4) [29]. In this trial, a modest improvement in oxygenation is demonstrated with CPAP at 7.5 cm H_2O. Little is known regarding optimal post op levels of airway pressure increase in extreme obesity, especially in superobesity. Evidence from intraoperative use of alveolar recruitment maneuvers suggests that optimal PEEP levels may be higher than 7.5 cm H_2O [21]. There has been concern among bariatric surgeons that the use of CPAP may increase gastric pouch pressure and predispose to foregut leaks following gastric bypass. Several studies have shown that the use of CPAP does not increase the risk of postoperative leaks [30–32].

Intraoperative Fluid Management

Evidence-based guidelines for intraoperative fluid management during bariatric surgery are needed, as there have been few prospective and controlled studies in this area. The evolution to laparoscopic bariatric procedures has compounded the issue because the physiology of pneumoperitoneum may limit the accuracy of urine volume as an accurate guide for fluid replacement [33]. Physiologic alterations associated with pneumoperitoneum which may contribute to reduced urine output are summarized in Table 14.5 [34].

A liberal approach to fluid replacement during surgery has been shown to reduce postoperative nausea and vomiting [35] and may protect against rhabdomyolysis [36]. However, the exact relationship between fluid administration and development of rhabdomyolysis is not clear as a prospective randomized trial in 100 patients did not find a relationship between intraoperative fluid replacement and the fairly common finding of a postoperative creatine phosphokinase level >1,000 IU/ml which defines biochemical rhabdomyolysis [37].

Potential adverse consequences of liberal fluid replacement protocols include expanded extracellular fluid, interstitial pulmonary edema, and gastrointestinal edema. In a randomized prospective assessor-blinded trial of two perioperative fluid regimens in 172 colorectal surgery patients, a restricted fluid regimen designed to maintain perioperative body weight resulted in better outcomes in comparison with a more liberal fluid regimen. The improved outcomes associated with a restricted fluid regimen included reductions in overall complications ($P=0.003$), tissue healing complications ($p=0.040$), and cardiopulmonary complications ($p=0.007$) [38]. The authors speculate that tissue edema may interfere with oxygen diffusion into cells and cause reductions in tissue oxygen tension and contribute to wound healing complications. Similar prospective controlled studies are needed in bariatric surgery where anastomotic and staple line healing may be related to tissue oxygen tension, which can now be measured [22]. In addition, there is a need for additional simple intraoperative measures which can be used to guide intraoperative fluid replacement [39, 40].

Perioperative Pain Management

The efficacy of multimodality pain control measures is now well accepted as an opiate-sparing approach in bariatric surgery [41, 42]. This is particularly important in patients with moderate or severe obstructive sleep apnea where opiate sensitivity may contribute to airway instability, hypoxemia, and life-threatening hypercarbia.

Table 14.5 Physiological effects of pneumoperitoneum that may contribute to reduced urine output [34]

- Direct pressure on renal vasculature causing reduced renal blood flow
- Intraoperative release of antidiuretic hormone, rennin, and aldosterone

The α_2 agonist clonidine has recently been studied in a randomized, placebo-controlled trial in 30 patients with obstructive sleep apnea undergoing otolaryngological procedures. Clonidine was used as anesthesia premedication and compared with placebo. The patients who received clonidine demonstrated improvement in perioperative blood pressure and other hemodynamic variables as well as decreased requirements for propofol and narcotics [43]. This drug, which is known to reduce opiate consumption and intensity of pain [44], seems ideal to be studied in bariatric surgery patients with obstructive sleep apnea where perioperative hypertension is also common.

Prophylactic Antibiotics

Another important quality indicator in bariatric surgery involves the appropriate use of prophylactic antibiotics for the prevention of surgical site infection. Optimal dosing of antibiotic will provide adequate tissue levels at the time of bacterial contamination, which usually involves the entire procedure. A pharmacokinetic study of cefazolin prophylaxis using a 2 g dose preoperatively with a second dose at 3 h revealed that serum therapeutic concentrations were well maintained, but tissue concentrations were commonly subtherapeutic, especially in superobese patients [45]. This suggests that alternative dosing strategies should be considered and tested.

Perioperative Glycemic Control

There is considerable evidence that perioperative hyperglycemia is a modifiable risk factor for adverse outcomes following surgery. The association between hyperglycemia and postoperative complications has been demonstrated most extensively in cardiac surgery [46, 47] and in critical care [48, 49] but has also been extended to general and bariatric surgery [50, 51]. Furthermore, a number of studies have demonstrated that aggressive management of perioperative hyperglycemia with insulin will reduce mortality and perioperative infections [47–50, 52, 53]. The mechanisms for potential harm from hyperglycemia have been studied in vitro and in animal models, and the experimental physiologic alterations associated with hyperglycemia are summarized in Table 14.6 [54, 55].

A recently published large study from the Surgical Care and Outcomes Assessment Program in the State of Washington studied 11,633 patients undergoing elective colorectal and bariatric surgical procedures at 47 hospitals between 2008 and 2010. The unadjusted rates of in-hospital mortality, reoperations, and composite infections were significantly increased in those with hyperglycemia (>180 mg/dl) (Fig. 14.5). In addition, hospital length of stay was prolonged in those with hyperglycemia ($p < .001$). In the bariatric surgery cohort alone, hyperglycemia was associated with increases in hospital mortality (0.22 % vs. 0.09 %, $p < .001$), reoperations (3.1 % vs. 1.6 %, $p < .001$), and composite infections (2.9 % vs. 1 %, $p < .001$) [50].

Table 14.6 Experimental physiologic alterations associated with hyperglycemia from in vitro and animal studies [54]

Immunosuppression	Interference with normal function of neutrophils and monocytes
	Reduced T cell numbers and subsets (CD-4, CD-8)
	Normoglycemia reverses the immune dysfunction
Cardiovascular	Impaired ischemic preconditioning (increased infarct size)
	Increased systolic and diastolic blood pressure
	Hemostatic changes favoring thrombosis (reduced fibrinolytic activity, increased platelet activation)
	Endothelial cell dysfunction
Inflammation	Increases in IL-6 and TNF-α
Oxidative stress	Enhanced formation of reactive oxygen species

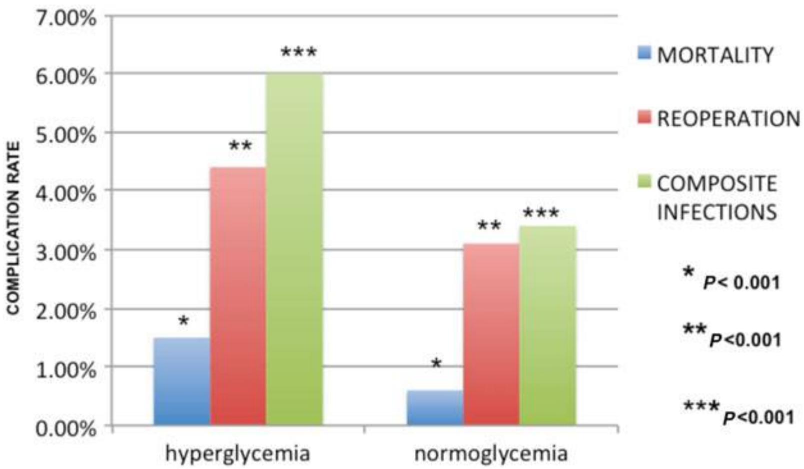

Fig. 14.5 Glycemic control: Colorectal and bariatric surgery outcome ($n = 11{,}633$). Unadjusted rate adverse events and mortality stratified by hyperglycemia (perioperative glucose >180 at any point on the day of surgery, postoperative day 1, or postoperative day 2) vs. normoglycemia. Modified from Kwon S, Thompson R, Dellinger P, Yanez D, Farrohki E, Flum D. Importance of Perioperative Glycemic Control in General Surgery. A Report from the Surgical Care and Outcomes Assessment Program. Ann Surg. 2013;257:8–14 [50]

Despite the increasing evidence demonstrating harm from perioperative hyperglycemia, many institutions still overlook this problem [50] or rely on sliding scale management with subcutaneous insulin, a treatment strategy, which provides inadequate glycemic control and should be abandoned [56–58]. A recent prospective randomized trial of perioperative glycemic control in general surgery patients compared to a basal-bolus insulin regimen with sliding scale regular insulin found that the basal-bolus regimen improved glycemic control and reduced hospital complications [53].

The high prevalence of type II diabetes and prediabetes among candidates for bariatric surgery as well as the significant insulin resistance associated with extreme obesity all contribute to a high risk of hyperglycemia associated with the stress of bariatric surgery. Current best practice recommendation is for improved perioperative glucose control in bariatric surgery [1, 59], but formal guidelines are lacking. A retrospective review of 350 bariatric surgical patients with type II diabetes compared perioperative glycemic management with continuous insulin infusion (CII) with hourly glucose monitoring vs. every 6-h glucose monitoring and subcutaneous insulin treatment. The study found that CII was safe with no reported significant hypoglycemic episodes and a mean hourly insulin requirement of 5.8 U/h during the 24 h beginning in the holding unit before surgery. The efficacy of glycemic control was not reported [60]. Preliminary reports from other bariatric centers reflect the development of protocols for tighter perioperative glucose control [61–63]. Insulin infusion is now the standard of care for the intensive care unit [63], but the optimal management for hospital wards is still debated because of concerns about the cost and resources needed for frequent glucose monitoring and dose adjustment required for safety of CII and prevention of hypoglycemia. Readers are referred to recent excellent reviews for recommendations regarding optimal glycemic management [54, 64, 65].

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