



Morbid obesity and perioperative complications

Andrea Tsai and Roman Schumann

Purpose of review

Approximately 30% of the general surgical population presents with obesity, and the perioperative implications remain concerning. This review provides recent insights regarding morbid obesity and perioperative complications.

Recent findings

Cardiovascular risk including cardiac arrest and myocardial infarction varies by type of surgery and is not always correlated with BMI. Functional status rather than associated comorbidities is an important component for risk assessment of obese patients undergoing noncardiac surgery. Just as for cardiac complications, pulmonary outcomes are influenced by the concurrence of obesity and the metabolic syndrome and/or sleep apnea rather than by BMI alone. New evidence suggests that continuous positive airway pressure treatment before surgery may reduce postoperative complications. Clinical Practice Guidelines for thromboembolic prophylaxis in bariatric patients are available. A comprehensive understanding of the obesity survival paradox has remained elusive. Postoperative surgical infections remain a leading problem related to obesity.

Summary

Further research and evidence are needed for the development of accepted perioperative pathways to address obesity and related comorbidities including sleep disordered breathing and metabolic syndrome as well as evidence-based strategies to reduce surgical infections. Rather than BMI alone, an improved index for obesity risk assessment is needed.

Keywords

obesity, outcomes, perioperative complications

INTRODUCTION

Obesity is a widespread and growing condition with a significant impact on all aspects of healthcare including perioperative care. A 2014 report examining data from 1980 to 2013 found that the prevalence of overweight and obesity worldwide rose by 27.5% for adults and 47.1% for children, with the USA leading in the number of obese individuals, accounting for 13% of the obese population worldwide in 2013 [1]. Obese individuals appear to be at a higher risk for perioperative complications concerning all organ systems. However, as obesity is commonly associated with multiple medical problems, it can be difficult to determine the exact extent to which obesity *per se* contributes to worse outcomes (as opposed to simply being a marker for poor outcomes). Complicating this determination is the nature of the available data and analyses, which are often obtained from large, retrospective databases, such as the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) and others. These databases can have missing or inaccurate data, may be derived from

procedural, diagnosis, billing, or insurance codes, and often require complex statistical modeling for meaningful analyses [2,3]. Being mindful of these limitations, in this article we aim to summarize recent data regarding the postoperative complications of obese patients organized by organ system, as well as inform about updated guidelines for their management and future directions for research and care.

CARDIOVASCULAR COMPLICATIONS

Obesity commonly covaries with metabolic syndrome: a constellation of hypertension, dyslipidemia and dysglycemia. Recently the International

Department of Anesthesiology, Tufts University School of Medicine, Tufts Medical Center, Boston, Massachusetts, USA

Correspondence to Andrea Tsai, MD, Assistant Professor, Department of Anesthesiology, Tufts University School of Medicine, Tufts Medical Center, 800 Washington Street, Box 298, Boston, MA 02111, USA. Tel: +1 617 636 6044; e-mail: atsai@tuftsmedicalcenter.org

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KEY POINTS

- Perioperative complications in obese patients are heterogeneous, but most commonly include infectious, thromboembolic, and surgical complications.
- Obesity is a heterogeneous condition and may be more accurately stratified by presence of comorbidities, metabolic syndrome, and abdominal adiposity rather than by BMI alone.
- Extremes of obesity (BMI > 40 kg/m²) are more consistently associated with morbidity and mortality rather than BMI 25–40 kg/m².

Diabetes Federation, National Heart, Lung, and Blood Institute, American Heart Association, and other major organizations released a statement in an attempt to unify the definition of metabolic syndrome to at least three of the following five criteria: elevated waist circumference (no specific cutoff listed as this metric varies by sex, ethnicity, and region), triglycerides at least 150 mg/dl, high-density lipoprotein less than 40 mg/dl in men or less than 50 mg/dl in women, SBP at least 130 mmHg and/or diastolic at least 85 mmHg, and fasting glucose at least 100 mg/dl [4]. By these criteria, it would seem logical to conclude that obese patients with metabolic syndrome would be at higher risk of postoperative cardiovascular complications; however, the recent literature does not uniformly support this concept [5,6[■]].

A multivariable regression analysis of total joint arthroplasties in the Veterans Affairs Surgical Quality Improvement Program (VASQIP) database showed that a BMI at least 40 kg/m² was an independent predictor for cardiac arrest requiring cardiopulmonary resuscitation [odds ratio (OR) 3.94, confidence interval (CI) 1.87–8.3] compared with those with a BMI less than 40 kg/m² [5]. No significant difference was found for myocardial infarction (MI) [5]. An ACS-NSQIP database review of a variety of surgeries (cardiovascular, orthopedic, and oncologic) similarly found little evidence for increased cardiovascular complications in obese patients; the exception was in coronary artery bypass grafting (CABG), where adjusted analyses showed that a BMI at least 40 kg/m² significantly increased the odds of postoperative cardiac arrest and MI (OR = 2.35, CI = 1.01–5.47) [6[■]].

The 2014 guidelines for the perioperative cardiac evaluation of patients undergoing noncardiac surgery has replaced the Revised Cardiac Risk Index with an updated cardiac risk calculator more focused on functional status [7]. Thus, emerging evidence

would seem to indicate that although obese patients may have many of the elements of a high risk Revised Cardiac Risk Index score [coronary artery disease (CAD) or risk factors for CAD, dysglycemia, etc.], this may be less important than functional status in the prediction of acute postoperative cardiac complications [8].

PULMONARY COMPLICATIONS

Obesity is associated with multiple pulmonary comorbidities, including asthma, airway hyper-reactivity, obstructive sleep apnea (OSA), obesity hypoventilation syndrome, pulmonary hypertension, and a restrictive pulmonary physiology [9[■],10–12]. Some estimates describe the prevalence of OSA at almost 70% in bariatric surgery populations [13], and possibly even as high as 90% [9[■]]. Such a high prevalence of sleep disordered breathing (SDB) combined with the perioperative administration of opioids may portend a higher likelihood of postoperative pulmonary complications in this population.

Interestingly, an analysis of ACS-NSQIP data on major abdominal surgeries did not find BMI to be a risk factor for pulmonary complications (as defined by pneumonia, reintubation, and prolonged ventilator support ≥48 h), though prolonged operative time – often a complication of increasing BMI – was [14]. Similarly, BMI does not factor into a 2011 risk calculator for postoperative respiratory failure [15]. In contrast, multivariable regression analysis of VASQIP data on total joint arthroplasties found BMI greater than 40 kg/m² to be an independent predictor for reintubation (OR = 2.56) [5], and a separate ACS-NSQIP analysis found a BMI at least 40 kg/m² to significantly increase the odds of pulmonary complications (same definition as prior) after CABG (OR = 1.81, CI = 1.10–2.98) and valve repair/replacement surgeries (OR = 2.37, CI = 1.50–3.74) [6[■]]. In a more detailed examination of data, an analysis of the Bariatric Outcomes Longitudinal Database found that though postoperative pulmonary complications (pneumonia, atelectasis, pleural effusion, pneumothorax, acute respiratory distress syndrome, and respiratory failure) were generally rare in patients following bariatric surgery (incidence = 0.91%), additional factors such as age, BMI, American Society of Anesthesiologists status, surgical duration, open approach, metabolic syndrome, OSA, asthma, and congestive heart failure each independently were significantly associated with pulmonary complications [16[■]].

Indeed, much interest has been focused on the pulmonary comorbidities associated with obesity and their effects on outcome, especially the role

of OSA. OSA has increasingly come to be recognized as independently associated with cardiopulmonary complications, including emergent intubation, atrial fibrillation, MI, and ICU transfer [11,17,18]. The 2013 Clinical Practice Guidelines for the Perioperative Nutritional, Metabolic, and Nonsurgical Support of the Bariatric Surgery Patient suggest consideration of preoperative screening for OSA in all bariatric surgery patients [19^{***}]. The STOP-BANG questionnaire (loud Snoring, Tiredness, Observed apnea, high blood Pressure, BMI, Age, Neck circumference, and Gender; available at <http://www.stopbang.ca>) is a widely used and validated screening tool for OSA [20]. In a study of patients with BMI at least 30 kg/m², it was found that a STOP-BANG score of three had a 90% sensitivity to predict the presence of OSA (defined as an apnea-hypopnea index ≥ 5) [21]. Recent cohort studies suggest that patients with preoperatively untreated OSA may have an increased risk for cardiopulmonary complications compared with those preoperatively treated with continuous positive airway pressure (CPAP) [18,22]. Similarly, 2014 American Society of Anesthesiologists practice guidelines strongly agree that the preoperative initiation of CPAP should be considered in patients with OSA, and in particular, severe OSA [11]. Recommendations regarding the duration of preoperative CPAP for physical status improvement prior to elective surgery have yet to be determined.

In addition to screening for OSA and treatment with CPAP, research is ongoing regarding the optimal intraoperative ventilation strategy for obese patients. This population has a unique pulmonary physiology, with decreased lung volumes, increased pleural pressures, and increased upper and lower airway resistance [12,23,24]. Evidence in patients (of any BMI) undergoing major abdominal surgery suggests that intraoperative ventilation with low tidal volumes (6–8 ml/kg predicted body weight) as well as positive end-expiratory pressure (PEEP) and recruitment maneuvers impart outcome benefits (a composite of pneumonia, respiratory failure, sepsis, and death) [25], but observational studies suggest that obese patients are at higher risk of being ventilated with large, potentially injurious tidal volumes [10,26]. The high versus low positive end-expiratory pressure during general anaesthesia for open abdominal surgery (PROVHILO) trial examined high (12 cm H₂O) vs. low (≤ 2 cm H₂O) PEEP in patients undergoing open abdominal surgery irrespective of the presence of obesity and found no difference in outcomes (a composite of postoperative pulmonary complications including hypoxia, pneumonia, acute respiratory distress syndrome, atelectasis, and more) [25]; however, the

applicability of the PROVHILO trial observation to an obese population, with a predisposition for atelectasis, is unclear [10,23]. The protective ventilation with higher versus lower PEEP during general anesthesia for surgery in obese patients (PROBESE) trial seeks to answer the question of PEEP in obese patients by comparing intraoperative ventilation with PEEP at least 12 and recruitment maneuvers to PEEP of four without recruitment maneuvers in patients with a BMI at least 35 kg/m²; enrollment is ongoing [27]. With regards to recruitment maneuvers, a trial of 50 patients with BMI at least 35 kg/m² undergoing laparoscopic gastric bypass surgery found no outcome differences with the addition of two recruitment maneuvers to a standard intraoperative ventilation strategy of tidal volumes of 6 ml/kg ideal body weight and 10 of PEEP [28]. Pending further data, an intraoperative ventilation strategy using low tidal volumes (≤ 8 ml/kg predicted body weight) and higher PEEP (8–15 cm H₂O) in combination with recruitment maneuvers is recommended by some reviewers [10].

THROMBOEMBOLIC COMPLICATIONS

Obesity is recognized as an independent risk factor for perioperative venous thromboembolism (VTE) [29–34]. Recent ACS-NSQIP database analysis finds that a BMI at least 40 kg/m² significantly increased the odds of VTE after CABG, total hip arthroplasty, colectomy, prostatectomy, and pancreatectomy [6^{***}]. Clinical Practice Guidelines for the Prevention of VTE in nonorthopedic surgical patients state that most bariatric surgery patients are at high risk for VTE [35], and this risk increases with higher BMI (particularly ≥ 40 kg/m²), prolonged operative time, older age, male sex, and history of OSA, obesity hypoventilation syndrome, or VTE [30,35,36]. The 2013 Clinical Practice Guidelines for bariatric surgery patients recommend VTE prophylaxis for all bariatric patients (sequential compression devices as well as chemoprophylaxis), with continued chemoprophylaxis after hospital discharge for high-risk patients [19^{***}]. Guidelines suggest that dosing of enoxaparin, dalteparin, or tinzaparin should be based upon total body weight up to a weight of 144, 190, and 165 kg, respectively [37]. Additionally, guidelines do not recommend using an inferior vena cava filter for VTE prophylaxis a priori [19^{***},35].

RENAL COMPLICATIONS AND RHABDOMYOLYSIS

An adjusted analysis of ACS-NSQIP data showed that a BMI at least 40 kg/m² was a risk factor for acute renal failure and progressive renal insufficiency after

CABG, cardiac valve repair or replacement, gastrectomy, colectomy, cystectomy, and prostatectomy [6¹¹]. The increased risk of acute renal failure was also found in a VASQIP database analysis of patients with BMI greater than 40 kg/m² undergoing total joint arthroplasties [5].

In addition to renal complications, obese patients undergoing bariatric surgery are at higher risk of rhabdomyolysis because of positioning injuries, with an incidence as high as 30.4% according to some sources [19¹¹]. The risk of rhabdomyolysis increases with BMI greater than 55–60 kg/m², and guidelines suggest consideration of postoperative screening with creatine kinase levels in higher risk groups [19¹¹].

SURGICAL COMPLICATIONS

An increased risk for surgical complications in patients with obesity has been reported in several studies. These complications include longer operative times [38–40], possibly increased blood loss [38,40], increased rates of reintervention [5,34,36], and increased rates of infection [5,6¹¹,32–34,36,40]. Analysis of various general surgery patients has shown a significant direct correlation between increasing BMI and increased intraoperative blood loss [38,40]. The clinical significance of this finding, however, is unclear; analysis of ACS-NSQIP data on various cardiovascular, orthopedic, and oncologic surgical patients found either no relation of BMI to blood transfusion, or a decreased odds of blood transfusion comparing BMI at least 40 kg/m² to normal BMI patients [6¹¹].

Analyses of procedure duration in general surgery patients have shown excess weight to be a risk factor for longer operative times, with each degree of BMI increase over normal directly correlating with increased procedure duration [38–40]. Increased operative times, in turn, are significant predictors for both medical and surgical complications [16¹¹,36,39]. BMI at least 50 kg/m² increases the odds for reoperation after bariatric surgery [36] and total shoulder arthroplasty [34]. In VASQIP data on total joint arthroplasty, a BMI greater than 40 was an independent risk factor for reoperation [5].

Infectious complications are a particular concern in patients with obesity; analysis of ACS-NSQIP data on 16 major cardiovascular, orthopedic, and oncologic surgeries found that a BMI at least 40 kg/m² significantly increased the odds for wound complications in all surgeries analyzed except for pneumonectomy [6¹¹]. Analysis of ACS-NSQIP data on bariatric patients showed that postdischarge complications were most commonly infectious in nature (wound infection comprising 49% of those

with postdischarge complications, urinary tract infection 17%, and organ space surgical site infection 11%) and significantly correlated with BMI at least 50 kg/m², prolonged operative times and steroid use [36]. Analysis of a population of general surgery patients showed a wound infection incidence of 4.8% for those with a normal BMI (18.5–25 kg/m²), 11.0% for BMI 25–30 kg/m² and 10.9% for BMI greater than 30 kg/m² [40]. An increase in infectious complications has also been documented for orthopedic procedures in patients with obesity. A VASQIP analysis shows BMI greater than 40 kg/m² as independently predicting superficial infection in total joint arthroplasty (OR 2.11, CI 1.39–3.21) [5]. Various analyses of the PearlDiver database, a national insurance database, show a significant increase in odds of infection for patients with a BMI greater than 30 kg/m² (compared with <30 kg/m²) when undergoing open reduction and internal fixation of distal humerus fractures or total elbow arthroplasty [33], total ankle arthroplasty or ankle arthrodesis [32], and an increase in odds of infection for patients with BMI greater than 50 kg/m² (compared with <50 kg/m²) undergoing total shoulder arthroplasty [34]. These findings indicate that careful attention to strategies directed at minimizing infectious complications should be adopted, including the use of minimally invasive approaches when possible, weight-adjusted antibiotic dosing, and layered closure of incisions [6¹¹,19¹¹,36].

MORTALITY

Despite evidence of increased medical and surgical complications in the obese surgical population, the effect of obesity on mortality is unclear. Though some surgical literature suggest that any increase in BMI over normal is associated with decreased survival [5,41], other surgical literature suggest an obesity paradox, where limited increases in BMI (in the 25–40 kg/m² range) may provide a survival benefit compared with normal weight patients [6¹¹,42–44]. Analysis of ACS-NSQIP data on cardiovascular, orthopedic, and oncologic surgeries indicate that patients with BMI at least 25 kg/m² did not have an increased odds of 30-day mortality, and in fact those with BMI 25–40 kg/m² experienced significantly lower odds of 30-day mortality following abdominal aortic aneurysm repair, total hip arthroplasty, gastrectomy, and colectomy [6¹¹]. Similarly, multivariate analysis of 78 762 Canadian CABG and combined CABG and aortic valve replacement patients found a survival advantage for patients with a BMI 25–29.9 kg/m² and no difference for patients with a BMI 30–34.9 kg/m²

compared with normal weight patients. Increased mortality was only observed in those with BMI greater than 34.9 kg/m² and underweight patients (BMI < 20 kg/m²) [42]. Analysis of 10 427 elective, noncardiac surgery patients in the Netherlands also showed improved long-term mortality in patients with BMI at least 25 kg/m², though this was noted to be because of a strongly reduced risk of cancer-related death [43].

These counterintuitive and seemingly contradictory findings highlight the potential importance of confounders in the use of 'big data' in the analysis of obesity and mortality. Variables with a negative impact on survival, such as positive smoking status, increased age, recent weight loss, and increasing disease severity, are often correlated with a decreased BMI [5,41–43,45], yet are not always accounted for in the analysis of large datasets [43]. Strategies to avoid these confounders are to account for them in multivariate analysis where possible, perform more detailed BMI stratification [45], and limit the analysis of survival data to long-term survival to avoid reverse causation (where decreased BMI itself is not the cause of poor outcomes, but rather is just a marker of the disease severity that results in decreased survival) [42–44]. Similarly, it has not been comprehensively determined if the obesity paradox exists with both 'unhealthy' and 'healthy' obesity, that is, obesity with and without associated comorbidities and metabolic syndrome. In light of these limitations, it is difficult to conclusively determine the association between BMI and perioperative mortality. Compared with normal weight patients, at this time the literature suggests a survival benefit in the lower BMI obesity range and worse long-term mortality at the higher BMI ranges (>40 kg/m²) [41,42,44].

FUTURE DIRECTIONS

As alluded to previously, many confounders may affect BMI and outcomes studies, making BMI – though convenient – an imperfect tool for outcome predictions in patients with obesity [45]. Other potentially more meaningful indices of health and abnormality related to obesity merit further investigation, including adipose tissue distribution (abdominal adiposity) and presence or absence of metabolic syndrome, and SDB. Abdominal adiposity is associated with greater health risks but is imperfectly accounted for by using BMI [43,45]. Therefore, some authors suggest using waist circumference in research as a more meaningful marker of obesity health risk, or alternative measures of abdominal adiposity such as waist-to-hip ratio, waist-to-height

ratio, or computed tomographic measurement of intra-abdominal fat [41,44,45].

Metabolic profiles of obese patients are also variable and independently influence outcomes [46]. As a proinflammatory state, obesity is often, but not always associated with the metabolic syndrome previously described [9^{***}]. The role of obesity, the obesity-induced baseline inflammatory state, and the presence or absence of metabolic syndrome on postoperative physiological and cognitive outcomes remains an important target for the research community.

Finally, although much progress has been made in the area of obesity and SDB, practical questions remain, including universal perioperative care pathways for OSA patients and which target interventions stratified by disease severity are necessary. Additionally, it is unclear whether interventions aimed at weight loss preoperatively would improve outcomes, although preliminary investigation suggests safe and positive results [47].

CONCLUSION

Obesity and the perioperative management of obese patients is a significant problem with potentially widespread implications for postoperative complications that are imperfectly understood. A confounder to ongoing research efforts is the fact that obesity is a heterogeneous condition and the inter-individual variability of adipose tissue distribution, metabolic syndrome, and other associated comorbidities carry different degrees of risk requiring different levels of attention, not always reflected by BMI alone. For these reasons, existing studies, often of large databases, may yield conflicting conclusions. With these considerations in mind, it appears that extremes of obesity (BMI > 40 kg/m²) are more clearly associated with mortality and morbidity, particularly those that are thromboembolic, infectious, and surgical in nature. Increased cardiovascular risk may be present in those undergoing cardiac surgery with BMI at least 40 kg/m² [6^{***}]. From the pulmonary standpoint, presence of OSA imparts greater risk [16[°]], and guidelines suggest OSA screening in the bariatric population [19^{***}].

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Conflicts of interest

There are no conflicts of interest.

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- of outstanding interest

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