47 Critical Care Considerations in the Bariatric Patient

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Abbreviations

ASMBS	American Society for Metabolic and Bariatric Surgery
ICU	Intensive care unit
OSA	Obstructive sleep apnea
SICU	Surgical intensive care unit
VTE	Venous thromboembolism

Chapter Objectives

1. Understand the unique physiologic challenges posed by the bariatric surgery patient in the critical care setting.
2. Understand the effects severe obesity has on pharmacologic dosing in the intensive care unit.
3. Identify specific management strategies for cardiovascular and respiratory support for the critically ill patient after bariatric surgery.

Introduction

According to the National Center for Health Statistics' National Health and Nutrition Examination Survey (NHANES) in 2015–2016, the prevalence of obesity in the United States was 39.8%, affecting approximately 93.3 million adults. The number of obese Americans has significantly increased from 1999 to 2016 [1]. These statistics have a major impact on the complexity of performing elective and emergent surgical procedures across many specialties in the United States as well as the associated postoperative care required.

Worse outcomes have been noted in both the underweight (BMI <18 m/kg^2) and obese critically ill patient [2]. Other studies have associated obesity as an independent risk factor for mortality in the ICU [3]. In addition, morbid obesity is an independent risk factor for the development of organ failure after trauma in the critically ill patient [4]. Given the current obesity epidemic, the number of critically ill obese patients will continue to increase, and a greater understanding of the physiologic challenges associated with obesity in this setting will be needed.

Bariatric patients are medically challenging at baseline. Compared to the general population, patients with severe obesity will present with decreased mobility, higher risk for venous thromboembolism, and chronic medical comorbidities including obstructive sleep apnea and type II diabetes. Physiologic alterations such as impaired cardiac function and decreased pulmonary reserve are more common in patients with obesity. Bariatric surgery also alters their metabolism, inflammatory response, and digestive process making them even more difficult to manage in the critical care setting. Using a systems-based approach, the objective of this chapter is to identify ways to manage comorbid conditions and physiologic alterations that affect the critically ill patient with obesity.

Neurologic

Many patients with obesity have underlying psychological issues such as anxiety and depression, and those with more severe mental illness such as schizophrenia are more vulnerable to significant weight gain secondary to metabolic side effects of antipsychotics. This should be kept in mind when trying to motivate an intubated bariatric patient with

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appropriate cognition. Restarting their home medication regimens as soon as possible and consulting chaplains and a psychologist early in their hospital course when neurologically intact can be helpful in the critical care setting when appropriate.

Other neurological complications can occur after bariatric surgery in patients who have complications that result in poor oral intake. Patients with surgical complications requiring intensive care are certainly at risk for micronutrient deficiencies as are those patients who develop anastomotic ulcers or strictures that severely limit food and vitamin intake. Paresthesias and polyneuropathies can develop due to vitamin B deficiencies [5], and altered mental status and irreversible encephalopathy can result from thiamine deficiency that is undetected or untreated [6]. The risks of these micronutrient complications are greater after malabsorptive procedures but can occur in any bariatric surgery patient who has prolonged periods of inadequate nutrition, nausea, or vomiting.

Pulmonary

Enlarged neck circumferences and increased thoracic and intra-abdominal mass are factors that make managing pulmonary status extremely difficult in this population. Depending on the study, the prevalence of obstructive sleep apnea (OSA) in bariatric patients ranges up to 70% [7]. Complications of OSA include chronic polycythemia and chronic hypercapnia that can lead to pulmonary hypertension, right ventricular hypertrophy, hypertension, and arrhythmias. Untreated OSA also increases the risk for arrhythmias, stroke, sudden death, and intraoperative mortality in addition to reduced airway tone from anesthetics and increased risk of apnea from narcotics. The increased weight on the trachea and lungs increases chest wall resistance and airway resistance, and reduced vital capacity (VC), expiratory reserve volume (ERV), and forced residual capacity (FRC) highly increase work of breathing as well as the risk of desaturation [7].

Positive pressure ventilation, laryngeal mask airways, video-assisted intubation, and positioning in reverse Trendelenburg are all strategies to improve the mechanics of ventilation, preoxygenation, and safe intubation [8]. The use of bolsters or padding under shoulder blades and neck extension are commonly used techniques when intubating patients with obesity as well. In an emergent situation, verification of endotracheal tube placement is highly important. In addition to the gold standard use of capnography and the use of colorimetry and radiography, the use of the tracheal rapid ultrasound exam (TRUE) can also be used [9]. The TRUE consists of placing the linear probe transducer transversely at the trachea overlying the suprasternal notch. On ultrasound, since the trachea should have air within it, the appropriate view will have a hyperechoic tracheal arch with reverberation. If the esophagus (lateral to trachea) has an endotracheal tube with air, then there will appear to be a second trachea. This relatively novel indirect visualization of endotracheal tube placement is fast and has been shown to have a 93% sensitivity and 97% specificity [9].

If an emergent surgical airway is imminent, keep in mind that you will need "all hands-on deck" in the operating suite, particularly since patients with obesity have limited reserve, and the airway must be secured rapidly. After extending the neck as much as possible, a cricothyroidotomy is performed. The skin incision should be generous for proper visualization, and concerns for cosmesis should be secondary in this emergent situation.

Abnormal baseline mechanics such as reduced total compliance, decreased forced vital capacity, and airway resistance are some of the factors that should be kept in mind when managing a patient with obesity on mechanical ventilation. Ideal body weight (males, 50 kg +2.3∗(weight in kg); females, 45.5 kg + 2.3∗(weight in kg)) should be used to calculate tidal volume, with adjustments made as necessary based upon arterial blood gas results. Those with diagnosed obesity hypoventilation syndrome (OHS) have about a 30% weaker respiratory muscle strength, thought to be due to a thinly stretched diaphragm and/or increased fatty infiltrates into the diaphragm resulting in weakened muscle. This causes a decrease in total lung capacity, forced residual capacity, forced expiratory volume in 1 s (FEV1), and minute ventilation. Note that diffusion capacity remains preserved. These patients should be placed on a higher PEEP initially to overcome basal atelectasis. Lower oxygen levels, atraumatic ventilation strategies, and/or higher blood carbon dioxide levels are all acceptable strategies to manage these patients and can facilitate extubation if the patient has chronic hypoxia or OSA [10]. Reduced lung volumes put obese patients at a higher risk for nosocomial pneumonia and acute respiratory distress syndrome (ARDS). Increased intra-abdominal pressure and diabetic-induced gastroparesis also put these patients at a higher risk for aspiration; thus prevention with elevated HOB and reflux prophylaxis is key.

Prolonged ventilation requirements often lead to the need for a surgical tracheostomy. The overall complication rate of surgical tracheostomy in obese patients is estimated to be 25%, 10% of which are serious and life-threatening [11]. During tracheostomy, the increased amount of submental and anterior cervical adipose tissue makes accurate palpation of the proper landmarks very difficult. If the patient cannot tolerate a trip to the operating room, then a hybrid approach with appropriate cutdown (until landmarks are properly palpable) combined with a percutaneous insertion kit can be performed at bedside. The tracheostomy tube choice is also often overlooked. The anatomical challenge of a thick neck results in higher risk of tube dislodgement, tube collapse, and tube kinking; all of which can be life-threatening. Instead of the standard PVC or Silastic tracheostomy tubes, extra-long silicone tracheostomy tubes are preferred to help prevent such potentially fatal complications.

Cardiovascular

Adipocyte enlargement in patients with severe obesity can alter the biochemistry at the tissue level by reducing blood supply resulting in areas of hypoxia, free radical production, necrosis, and thus overproduction of proinflammatory cytokines creating a constant state of chronic inflammation. This chronic inflammatory state significantly contributes to the metabolic syndrome with additional effects on endothelial dysfunction, reduced arterial compliance, and an atherogenic state [12]. It has been shown that plasma levels of cytokines are proportional to BMI and parallel to serum leptin levels [13].

Obesity results in increased blood volume and cardiac output due to excess tissue. This results in left ventricular hypertrophy (LVH) and hypertension [8]. Metabolic syndrome in the morbidly obese patient not only increases risk for atherosclerosis, hypertension, and dyslipidemia; it also can lead to heart failure and diastolic dysfunction. This greatly impairs the patients' ability to respond to the increased cardiac stress demands of critical illness. Attentiveness to early changes in hemodynamic stability should warrant early baseline transthoracic echocardiogram (TTE) for a baseline, and cardiology consultation should also be sought early. However, TTE is often of poor quality due to body habitus making transesophageal echocardiogram more useful when available. It is also important to remember that when cor pulmonale and pulmonary hypertension are present, central venous pressure monitoring with a central venous catheter may be less reliable.

Difficult vascular access should be anticipated in the critically ill obese patient as obesity results in the loss of anatomic landmarks [14]. The use of ultrasound in the ICU has been shown to aid in the placement of peripheral intravenous lines (PIVs) and helps reduce the number of central venous catheters (CVC) placed in the hemodynamically stable obese patient [15]. When a central line is needed, longer catheters in very large patients may be needed. Catheters as long as 20 cm are available and should be considered when appropriate.

Gastrointestinal

A history of bariatric surgery, especially Roux-en-Y gastric bypass, may predispose a patient to ulcer disease and upper gastrointestinal bleed (UGIB) due to ulceration at the gastrojejunostomy (marginal ulcer) [16]. Thus it is important to maintain a patient's home PPI or H2 blocker therapy while in the ICU and in the setting of GI dysfunction, and these medications may have to be converted to IV formulations.

In addition, the intensivist must be cognizant that the post-gastric bypass or duodenal switch anatomy does not allow easy endoscopic access to the biliary tree. Given that obesity is also associated with the development of biliary lithiasis [17], if the patient was to develop choledocholithiasis and sequelae such as cholangitis or gallstone pancreatitis, it is significantly more difficult to decompress the biliary tree since standard ERCP is often not feasible. In patients who have had duodenal switch, there is no endoscopic access to the duodenum, and biliary decompression must be accomplished via the transhepatic route or with direct surgical access to the bile duct. Options in the gastric bypass patient include transhepatic decompression with interventional radiology or laparoscopic-assisted transgastric ERCP.

Obesity is also associated with fatty infiltration of the liver, and nonalcoholic fatty liver disease (NAFLD) is the most common cause of cirrhosis in the United States [18]. More than 90% of obese patients have fatty infiltration of the liver, and one-fourth of these patients will have steatohepatitis or nonalcoholic steatohepatitis (NASH) [19]. One-third of these patients will go on to develop cirrhosis within a decade. Aside from the potential risk of liver decompensation during critical illness, this is relevant with regard to decreased drug clearance, and consultation with the pharmacist is important to ensure appropriate dosing and to avoid hepatotoxic medications.

Nutrition

Nutritional support is critical for wound healing and mitigating catabolism during critical illness and overall recovery in patients with obesity [20]. These patients are also at risk of severe protein-calorie malnutrition, particularly if they had a malabsorptive procedure such as duodenal switch or distal gastric bypass. Their response to relatively lower physiologic stress results in higher glucose levels, higher insulin levels, higher cortisol levels, and lower human growth hormone release than the normal weight population. They also generate more exaggerated levels of norepinephrine and epinephrine in response to lower stress levels [21]. Critically ill patients with obesity undergo accelerated muscle wasting and nitrogen loss through increased proteolysis, accompanied by impaired utilization of fat stores, making nitrogen balance in the critically ill very important. Total calories should be based on ideal body weight (IBW), while base protein requirements should be based on adjusted body weight (ABW= IBW + 0.4∗(weight-IBW)) which helps determine the nutritional replacement needs for hospitalized obese patients. Twenty to 30 kcal/kg/day should be used on obesity-adjusted weight (IBW + (ABW-ABW)∗ 0.025). Overfeeding can result in hyperglycemia and can worsen hypercapnia which can make weaning from mechanical ventilation more difficult. Some studies related to hypocaloric feeds covering appropriate protein requirements report fewer ventilation days, antibiotics, and ICU days [22].

Percutaneous or surgical gastrostomy placement in the gastric remnant of a gastric bypass patient provides an ideal route for enteral feeding access. Surgical jejunostomy will often be required in patients requiring nutritional support following sleeve gastrectomy.

Renal

Obesity is associated with an increased risk of acute renal failure [2, 23] and is an established risk factor for chronic kidney disease (CKD), likely due to the existence of comorbid conditions such as hypertension, diabetes, and atherosclerotic disease as well as due to a chronic supranormal glomerular filtration rate (GFR) due to an increased blood volume and cardiac output as noted above. In addition, obesity is associated with a chronic inflammatory state with increased oxidative stress which may contribute to impaired renal function [8, 24, 25]. Local fat accumulation may cause increased intrarenal pressure with local intrarenal hypertension as well as lipotoxicity. There is marked activation of the renin-angiotensin-aldosterone system (RAAS) beyond expected for degree of hypertension due to enhanced angiotensinogen synthesis in fatty tissue [26]. One large retrospective study of over 16,000 patients after cardiac surgery found that obesity was significantly associated with an increased risk of postoperative renal insufficiency and that the severity of injury was proportional to the degree of obesity [24]. It should also be noted that the commonly used Cockcroft-Gault equation for calculated GFR has been shown to be inaccurate at extremes of BMI and that the Modification of Renal Diseases Study (MDRD) equation is less subject in high obese patients and may have implications in pharmacology in the care of the critically ill obese patient (GFR (mL/min/1.73 m^2) = 175 × $(S_{cr})^{-1.154}$ × $(\text{Age})^{-0.203}$ × (0.742 if female) × (1.212 if African American)) [27].

For the treatment of renal disease and hypertension in the obese patient, angiotensin-converting enzyme (ACE) inhibitors are ideal as they mitigate the overactivated RAAS. ACE inhibitors have been shown to markedly decrease proteinuria in obesity and decrease progression to renal failure [26]. However, in the acute on chronic renal failure patient, treatment is largely supportive and may include temporary hemodialysis for severe renal insufficiency [27].

Endocrine

Severe obesity is associated with many metabolic and physiologic derangements that must be carefully managed in the ICU setting [28]. Many patients have baseline type 2 diabetes mellitus, and the metabolic stress of critical illness can easily result in additional insulin resistance and hyperglycemia. Due to an unreliable volume of distribution, avoiding subcutaneous insulin in the critical care setting is recommended. Intravenous insulin allows for more reliable dosing, improves glucose oxidation in septic patients, and may reduce catabolism. Maintaining euglycemia not only decreases the incidence of postoperative infection but also improves survival and reduces myocardial infarction [28].

A medical history consisting of chronic joint or back pain, asthma, or rheumatoid arthritis should be obtained as these conditions may be related to exposure to prior steroid use. If so, these patients can develop hypoadrenalism and require investigation with a cosyntropin stimulation test and possible stress-dose steroids. A history of hypothyroidism can also affect critical care management. Thyroid replacement therapy should be reinitiated early in the patient's hospital course.

Infectious Disease

One prospective observational study found that obese patients in the critical care setting were significantly more likely to develop bacteremia and catheter-related bloodstream infections. The authors postulate that this is related to difficult vascular access and reluctance to discontinue intravenous access even if infection is suspected, as new access may be prohibitively difficult to obtain. This series, however, did not find that there was a significant difference in the rate of pneumonia or urinary tract infections (UTI) in the obese versus normal weight patient [29]. Other studies however have found that obesity is a risk factor for ICU admission and mortality in the setting of H1N1 influenza [30], potentially due to a disordered immune response and altered cytokine response [31]. Other studies have demonstrated that increasing BMI is a risk factor for both UTIs and pyelonephritis, with up to five times increased risk compared to nonobese patients [32].

Although obesity may be a risk factor for developing infection, outcomes of sepsis in obese individuals are controversial. The "obesity paradox" is the observed J-shaped curve demonstrating that underweight and severely obese patients have worse outcomes, while overweight and moderately obese patients with BMI between 25 and 40 have lower mortality [33]. As these observations are based on meta-analyses of heterogeneous patient populations, it is difficult to draw conclusions about these complex associations. However, some of the observed outcomes may be due to excess adipose tissue acting as an energy reservoir [34]. Another retrospective analysis found that obese patients had the lowest 28-day mortality, followed by overweight and then normal weight patients. They hypothesize that this may be due to a relatively blunted inflammatory response, as levels of proinflammatory IL-6 were lowest in higher BMI patients. In addition, obese and overweight patients received less body weight-adjusted fluids and vasopressors compared to normal weight patients. The authors conclude that fluid resuscitation and vasopressors doses should be adjusted for ideal body weight, and what appeared like under resuscitation was ironically protective in the obese patient population [35].

Pharmacology

One consideration for drug dosing in bariatric surgery patients includes the drug's volume of distribution (Vd), a function of its lipophilicity. Drugs with a high Vd (i.e., lipophilic) will require higher doses (and loading doses) in patients with increased adipose tissue, while those with low Vd may require little adjustment in drug dosing [36]. Lean body weight (LBW) is most commonly used when calculating weight-based dosing by investigators in drug trials. As it is correlated to creatinine clearance, it may be more accurate than other calculations such as ideal or adjusted body weight. With regard to maintenance dosing, clearance is multifactorial and depends on whether the drug is metabolized by the liver, kidney, or a combination. Rarely, drugs such as cisatracuronium undergo Hoffman degradation. As noted above, obesity is associated with renal and hepatic dysfunction. Thus, the best measure of subsequent drug dosing after initial loading is clinical response. For example, antiarrhythmic medications may require breakthrough dosing; heparin drips should be titrated according to established protocols and coagulation studies; and antibiotics should be dosed on trough and peak serum levels after initial weight-based loading dosing. Another consideration is the altered gastrointestinal anatomy in the bariatric patient when dosing enterally. For example, one study from the Netherlands found that the area under the curve (AUC) for aspirin was significantly higher after gastric bypass, while it was significantly decreased for oral omeprazole after bypass, perhaps accounting for persistent ulcer symptoms in this patient population [37]. These dosing challenges can be minimized by administering parenteral formulations.

Hematology

It is well known that patients with obesity have a higher than average risk for venous thromboembolism (VTE) due to their weight, postoperative coagulopathy, prior hormone therapy, chronic underlying inflammatory process of obesity, venous stasis disease, and decreased mobility. There is still no level 1 evidence to guide specific recommendations for VTE prophylaxis in terms of dosing, duration, or drug of choice for bariatric surgery patients, so current recommendations are based mostly on level 3 data and large body of clinical experience that was compiled in the American Society for Metabolic and Bariatric Surgery's position statement on this topic [38].

The incidence of symptomatic deep venous thrombosis (DVT) and pulmonary embolism (PE) (or a combination of the two) ranges from zero to 2.2% in this patient population [39]. Up to 80% of VTE's occur after hospital discharge [40] and, in a study of autopsy findings in patients who died after gastric bypass surgery, 80% had pulmonary emboli present. The clinical suspicion for PE was present in only 20% of patients' premortem suggesting that there is a high rate of subclinical PE events in the critically ill bariatric surgery patient [41].

Current recommendations for bariatric surgery include mechanical prophylaxis and early ambulation for all patients. Low-molecular-weight heparin (LMWH) or unfractionated heparin (UFH) is used by the majority of bariatric surgeons to provide additional chemoprophylaxis in the hospital. The indications for post-hospital extended chemoprophylaxis are not well defined. Many surgeons will provide 2–4 weeks of LMWH to high-risk patients (prior VTE, hypercoagulable state, immobile patients), but a clear evidence-based algorithm for this practice does not yet exist. Online calculators are available to assess an individual's risk of VTE and help guide the need for extended prophylaxis. In a study by Aminian et al. based on data from the American College of Surgeon's NSQIP database, a calculator was developed to guide extended prophylaxis use. Among 45 examined variables, the final risk assessment model contained ten categorical variables including congestive heart failure, paraplegia, reoperation, dyspnea at rest, non-gastric band surgery, age >/=60 years, male sex, BMI >/=50 kg/m, postoperative hospital stay >/=3 days, and operative time >/=3 h as major risk factors to post-discharge VTE events. When utilizing this calculator, patients who have no other obvious indications for extended prophylaxis (prior VTE, hypercoagulable state, severe immobility) with a score of 0–0.4% receive no post-discharge LMWH, those with a score of 0.4–1.0% receive 2 weeks of extended LMWH, and those with a predicted risk over 1.0% receive 1 month of LMWH after hospital discharge [40].

Routine prophylactic IVC filter placement should not be practiced. While certain very high-risk patients, including those in the ICU with bleeding complications, may benefit from IVC filter placement, routine use of IVC filters has resulted in higher morbidity, specifically filter-related adverse events [42].

Conclusions

Obesity is an epidemic in the United States and a major public health problem globally, and there are specific challenges in the management of the obese critically ill patient. Evidence currently suggests that the disparate outcomes between obese and normal weight patients in the critical care setting are not due to weight alone but are due to complex alterations in physiology and organ dysfunction, hormone regulation, and interactions between cytokines. Evidence is lacking as to whether obesity is protective in critical illness, and further studies are required to refine the best management practices in the care of these patients. Taking a systematic approach to the management of bariatric surgery patients in the ICU will ensure that the organ systems adversely affected by obesity will be appropriately managed. Ultimately, careful attention to detail and an understanding of the physiologic derangements related to obesity will result in better patient care and outcomes.

Question Section

1. A drug's volume of distribution (Vd) is a function of
   A. It's potency
   B. How lipophilic the medication is
   C. How much solution it should be mixed with before infusing
   D. How many vials are used monthly in the unit
2. Obesity is associated with all of the following EXCEPT:
   A. Decreased total lung capacity
   B. Decreased forced residual capacity
   C. Decreased forced expiratory volume in 1 s (FEV1)
   D. Increased minute ventilation
3. Factors associated with increased risk of chronic kidney disease in patients with obesity include:
   A. Hypertension
   B. Diabetes
   C. Atherosclerotic disease
   D. Chronic supranormal glomerular filtration rate (GFR) due to an increased blood volume
   E. All of the above
4. The benefits outweigh the risks for routine IVC filter placement for any bariatric surgery patient admitted to the intensive care unit.
   A. True
   B. False

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