Clinical Commentary

Clinical Approach to the Critically Ill, Morbidly Obese Patient

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In the absence of a national registry, the prevalence of critically ill, morbidly obese patients in the United States is not known. On the basis of a retrospective study spanning 7 years of intensive care unit (ICU) data (1994–2000), it is estimated that the incidence of morbidly obese patients requiring intensive care treatment approaches 14 cases per 1,000 ICU admissions per year (1). However, this figure is likely to underestimate the true incidence because the database was restricted to nonsurgical patients. The growing interest in gastric bypass underlines the increased public awareness of the medical and economic consequences of this epidemic. The latest numbers released by the American Society for Bariatric Surgery indicate that the rate of bariatric surgeries has risen in the United States alone from 37,000 cases in the year 2000 to 62,400 cases in 2001 and it is expected that the total number of cases may exceed 100,000 by the end of 2003 (2).

Most of the reviews that have provided data on morbidity obese patients have focused on the impact of obesity on individual organ function. Yet, clinical investigations addressing the care of the critically ill, morbidly obese patient are scarce. A recent review published in the AJRCCM detailed the principles and approach to outpatient treatment of obesity (3). The present commentary is aimed at (1) describing the common challenges of treating morbidly obese patients in critical care settings and (2) reviewing the current concepts and suggestions for therapy.

AIRWAY MANAGEMENT

Endotracheal intubation can be a daunting task in critically ill obese patients. In the Australian Incident Monitoring Study, limited neck mobility and mouth opening accounted for most cases of difficult intubation in obese subjects (4). Short sternal distance, receding mandible, and prominent teeth have been advanced as potential causes for difficult intubation (5). Brodsky and colleagues (6) coined the term “problematic” intubation to describe patients in whom the potential for intubation difficulties was present, but in whom actual difficulty with establishing the airway may or may not have occurred. The authors showed that neither absolute obesity nor body mass index was associated with problematic intubation in morbidly obese patients. Only a large neck circumference and a Mallampati score of 3 or more were significantly correlated with a high probability of problematic intubation. Blind nasal intubation has been considered an alternative to orotracheal intubation but the risk of severe epistaxis with potential deterioration in respiratory status has limited its applicability except to the most skilled anesthetist.

When morbidly obese patients assume the supine position while undergoing intubation, the functional residual capacity decreases as a consequence of a reduction in expiratory reserve volume. The reduction in functional residual capacity impairs the capacity of obese patients to tolerate periods of prolonged apneas. Arterial oxyhemoglobin desaturation ensues rapidly and attempts to maintain alveolar oxygen tension by using mask and bag ventilation may be difficult to accomplish. Because of these challenges, induction of anesthesia can be particularly hazardous for those at increased risk of failed intubation. Several authors have recommended awake intubation when the laryngeal structures cannot be visualized or when the actual body weight exceeds 1.75 times the ideal body weight (IBW) (7). Otherwise, rapid sequence anesthetic induction with cricoid pressure to prevent reflux of gastric content into the oropharynx is recommended. End-tidal CO₂ indicators may prove unreliable in monitoring intubation in the presence of widened arterial-to-alveolar ratio (Pco₂). Arterial blood gases are better suited to assess the adequacy of minute ventilation in these cases. A modified acoustic pharyngometer has shown promise in guiding placement of an endotracheal tube (8), but its validity in morbidly obese patients has not been established.

In those patients requiring tracheotomy, standard tracheostomy tubes are typically too short and too curved for proper positioning given the increased distance between the skin and the trachea. Consequently, they are more likely to be dislodged or occluded. Ghoryeb advocated the use of custom-fit tracheostomy tubes in morbidly obese patients (9); however, the feasibility and long-term safety of these tubes have not been established. Others have described a modified tracheotomy technique that includes the removal of cervical fat (10). Early complications (25%) include peristomal infection and local hematoma, while late complications (9%) occur from stenotic tracheocutaneous tract or cervical abscesses.

Percutaneous dilatational tracheostomy is considered a poor choice for morbidly obese patients with large and thick necks, but in one case series of 13 critically ill obese patients, the procedure was associated with a high success rate and a low complication rate (11).

PULMONARY MANAGEMENT

The mechanical properties of the total respiratory system, the lung, and the chest wall of morbidly obese patients are characterized by marked derangements compared with subjects of normal weight (12). These alterations in pulmonary function dictate a modified approach to the management of respiratory failure.
lung volumes are reduced and airway resistance is increased, a tidal volume based on patients’ actual body weight is likely to result in high airway pressures, alveolar overdistention, and barotrauma. The current consensus favors that the initial tidal volume be calculated according to ideal body weight and then adjusted according to systemic arterial blood gases. Because of a reduced compliance of the total respiratory system, inflation pressures should be interpreted with caution. The safe upper limit of pressure exposure undoubtedly varies in response to these properties, but limiting transpulmonary pressure to about 35 cm H2O seems a defensible approach adequately supported by the literature. The addition of positive end-expiratory pressure should facilitate alveolar recruitment and prevent atelectasis. Pelosi and coworkers demonstrated that the addition of 10 cm H2O in sedated paralyzed morbidly obese patients reduced elastance of the respiratory system and improved oxygenation compared with nonobese subjects (13).

In a retrospective study, morbid obesity has been associated with prolonged mechanical ventilation, extended weaning periods, and a longer ICU and hospital length of stay (1). Reasons for delayed liberation from mechanical ventilation were attributed to the increased work of breathing and suboptimal lung mechanics. One study suggests that the reverse Trendelenburg position at 45 degrees in obese patients resulted in a larger tidal volume and lower respiratory rate, thus facilitating the weaning process by optimizing lung mechanics (14). The use of bilevel positive airway pressure at a level of 12/4 postextubation (i.e., with inspiratory and expiratory positive airway pressure set at 12 and 4 cm H2O, respectively) has been shown to ameliorate pulmonary function and improve oxygenation after open gastric bypass surgery (15). For those with obesity hypoventilation or hypercapnic respiratory failure, the application of nasal positive-pressure ventilation might reduce the need for intubation and invasive mechanical ventilation. However, no randomized controlled trials have been conducted on the efficacy of this approach in critically ill, morbidly obese patients.

**PERIOPERATIVE MANAGEMENT**

For intensivists who are consulted about surgical patients with morbid obesity, the combination of increased intraabdominal pressure, high volume, and low pH of gastric contents places the morbidly obese patient at a higher risk of aspiration, particularly when gastric motility is reduced from continuous analgesia (16). Positioning the patient in reverse Trendelenburg at 45 degrees may help to alleviate the increased intraabdominal pressure and prevent gastroesophageal reflux. Propylaxis against acid aspiration is recommended even if these patients do not declare any symptoms of heartburn or reflux (17).

Atelectasis can be responsible for fever and hypoxemia postoperatively. The use of incentive spirometry, rigorous physiotherapy, and aggressive pulmonary toileting should be instituted soon after surgery (18). This should be combined with an effective pain control regimen through either an intravenous patient-controlled analgesia system or regional anesthesia. The epidural route is considered the preferred route for opioid administration because it is associated with less nausea and respiratory depression, and with improved pulmonary function (19).

Morbidity from surgery can be in excess of 10% (20). Early complications include wound dehiscence, wound infection, bleeding, pulmonary embolism, and death. Abdominal wound dehiscence is usually ascribed to increased tension on the fascial edges at the time of closure, resulting in decreased perfusion. Compromised vascularity predisposes the wound to bacterial proliferation and necrosis. The collection of hematomas or seromas increases tension on the sutured incisions, causing healing delays and reduced tissue oxygenation (21). Supporting the wound with one or more extra-large elastic binders is useful during transfers, coughing, or other activities that increase pressure on the abdomen or chest. Perioperative antibiotics will decrease the incidence of wound infections in clean contaminated cases compared with similar populations in which antibiotics are not used (22). However, when compared with normal-weight patients, the incidence of wound infection still remains significantly higher (23).

Abdominal compartment syndrome has been implicated in multisystem organ failure in critically ill, morbidly obese patients. Multiple trauma, massive hemorrhage, and protracted surgical operations with extraordinary volume resuscitation are the situations in which this syndrome is most frequently encountered (24). This diagnosis should be considered when urinary bladder pressure, adjusted for sagittal abdominal diameter (25), is elevated in the face of a decrease in oxygen delivery index (DOI=1 < 600 ml of O2 per minute per meter squared), a reduction in static and dynamic compliance, and a drop in urine output (< 0.5 ml/kg per hour) (24). Treatment involves expedient decompression of the abdomen and reduction of the intraabdominal pressure.

Peritonitis from anastomotic or staple line leak is a serious and life-threatening complication of bariatric surgery. Diagnosis is often difficult and clinical signs may be subtle. Persistent fever, tachypnea and tachycardia, worsening abdominal pain, back pain, pelvic pain, or unrelenting hiccups should be aggressively investigated and exploratory laparotomy should be strongly considered even if radiologic studies are inconclusive (26). Acute gastric distention is another potential complication of laparoscopic or open gastric bypass surgery. Edema or obstruction at the enteroenterostomy is usually the culprit and early recognition is critical to avoid staple line disruption or leak at the gastrojejunostomy anastomosis.

**VASCULAR ACCESS**

Central venous access can be technically challenging in critically ill, morbidly obese patients. Obesity can obscure anatomic landmarks, increase the depth of insertion necessary to gain venipuncture, and potentially interfere with the angle of insertion. Yet, there has been no well designed comparative study to address the rate of complications from central venous catheters in this particular group. In a retrospective study of 117 critically ill, morbidly obese patients, there was no significant difference in the mechanical complication rate between morbidly obese patients and nonobese patients (1). The use of a small-bore locator needle and the application of Doppler ultrasound techniques have been shown to increase the probability of successful catheter placement, reduce complications, and decrease the need for multiple insertion attempts (27). Peripherally inserted central catheters are a potential alternative to centrally placed catheters if performed early during hospitalization (28). Single- or double-lumen catheters accomplish most infusion needs and provide adequate means of blood sampling. Although the risk of thoracic complications is somewhat reduced, aseptic techniques should be strictly maintained during insertion to avoid line infection.

**PROPHYLAXIS OF DEEP VEIN THROMBOSIS**

The precise incidence of venous thromboembolism in critically ill, morbidly obese patients is unknown. Because of its clinically silent nature, primary prevention is the key to reduce morbidity and mortality. Unfortunately, limited data exist concerning effective prophylactic regimens in the morbidly obese. These patients are typically excluded from trials because of altered pharmacokinetics (29) and the equivocal results of diagnostic tests used to confirm or exclude thromboembolic diseases. The
generally accepted modality includes low-dose unfractionated heparin (5,000 units administered subcutaneously every 8 hours) with or without sequential compression devices. The suggested doses of low molecular weight heparins for prevention of clinically significant thromboembolic events in morbidly obese patients have been extrapolated from pharmacokinetic studies. However, clinical efficacy has not been tested except in limited trials of patients undergoing bariatric surgery. In a nonrandomized prospective study of 481 patients (mean body mass index, greater than 50 kg/m²), enoxaparin administered at 40 mg every 12 hours was superior to a lower dosage of 30 mg every 12 hours in preventing postoperative deep venous thrombosis (30). No difference in bleeding events was reported between the two doses. Nadroparin at a dosage of 5,700 IU once daily has been shown in a randomized trial to be as efficacious as a higher dosage of 9,500 IU once daily in preventing deep vein thrombosis in patients if started preoperatively and continued until discharge (31). Nadroparin is available in Europe only and has not received Food and Drug Administration approval in the United States.

For those with limited cardiopulmonary reserve, including those with evidence of pulmonary hypertension, the placement of a prophylactic inferior vena cava filter before bariatric surgery has been advocated by some authors when contraindications for anticoagulation are present (32). However, there is no evidence of the clinical efficacy or the long-term benefits of this approach in critically ill, morbidly obese patients beyond that indication.

**PHARMACOLOGIC CONSIDERATIONS**

The obese body is characterized by a higher proportion of adipose tissue and lower proportions of tissue water and lean body mass. These alterations account for differing patterns of drug absorption and distribution that can lead to subtherapeutic or toxic drug responses. In addition, the patient’s underlying comorbidities influence substantially the pharmacokinetic properties of therapeutic modalities, making monitoring of serum concentrations more reliable than empirical drug dosing based on previously published nomograms.

**Sedatives and Analgesics**

There are no established guidelines for the optimal drug of choice for sedation in the critically ill, morbidly obese patients. Midazolam, lorazepam, and propofol are currently the three sedatives most commonly administered in the ICU. Propofol is a hypnotic agent with a rapid onset and offset. Its volume of distribution is the largest among any other sedatives, and represents the amount of drug that becomes redistributed to poorly perfused sites (33). There is some evidence that prolonged use may be associated with slower recovery (34), but it is unclear whether extreme obesity contributes to the observed effect. Serum triglyceride levels should be monitored intermittently when propofol is infused for prolonged periods, particularly in those with elevated baseline levels. Because propofol is emulsified in a soybean base, it may increase CO₂ production (35). For those with hypercarbia, adjustment to minute ventilation may be required. Loading dose is based on ideal body weight with maintenance infusion titrated to the desired end point (36).

Midazolam has the shortest half-life among the benzodiazepines, but its sedative effect might be prolonged in the morbidly obese because of its accumulation in adipose tissue (37). When combined with propofol or fentanyl, its clearance might decrease as a result of competitive inhibition of CYP3A4 (cytochrome P-450, subfamily IIIA [naphthidine oxidase], polypeptide 4) (38, 39). The combination of haloperidol and midazolam can decrease the dose required to produce sedation and minimize the risk of respiratory depression. Nonetheless, daily discontinuation with retitration to a target Ramsey Scale end point (40) is advocated to reduce the duration of mechanical ventilation and ICU length of stay (41). A new sedation instrument, the Adaptation to the Intensive Care Environment, was developed to assess patient adaptation to the intensive unit care environment; however, its validity in critically ill, morbidly obese patients has not been proven yet (42).

Significantly less expensive than the other synthetic opioids, fentanyl is the preferred analgesic agent for critically ill, morbidly obese patients with hemodynamic instability or morphine allergy (43). It does show, however, evidence of cumulative effect after prolonged infusion and can potentially induce chest wall rigidity, which may delay extubation of morbidly obese patients with marginal respiratory reserve (44).

**Neuromuscular Blockade**

Atracurium and vecuronium both have a limited volume of distribution, but whereas vecuronium dosing is based on IBW, the hyposensitivity to atracurium observed in obese individuals necessitates calculation of the dose on the basis of total body weight (45). There are no studies demonstrating a reduction in neuromuscular complications when intermittent dosing techniques are used instead of continuous infusions. Periodic monitoring with the train of four should be conducted routinely to adjust the rate of infusion. The increased adiposity around the wrist may require, however, higher milliamperes to produce the desired result.

**Anticoagulants**

Morbid obesity had little to no effect on weight-based heparin dosing protocols using total body weight in systemic anticoagulation (46). Data evaluating the safety and efficacy of weight-based dosing of low molecular weight heparins for the treatment of venous thromboembolism in this group of patients are limited. Pharmacokinetic studies suggest that body mass does not appear to have a significant effect on the response to low molecular weight heparins in obese patients with normal renal function (47–49). Nonetheless, monitoring of anti-Factor Xa activity should be considered. Although the timing of blood sampling in relation to dose and the optimal range of values has yet to be clearly defined, a peak anti-Factor Xa level drawn 4 hours after a dose is given is considered most useful (50). For twice daily administration, a target anti-Factor Xa level of 0.6 to 1.0 IU/ml has been recommended. The range at 4 hours for those treated with a once daily dose is less certain, but a level of 1.0 to 2.0 IU/ml is suggested (51).

For severe sepsis, the PROWESS (Protein C Worldwide Evaluation in Severe Sepsis) trial has excluded patients weighing above 135 kg (52). A pharmacokinetic–pharmacodynamic analysis found that larger patients have increased mean plasma clearance of drotrecogin than do normal patients, with recommended dosing strategies being based on actual body weight (53). However, there have been no safety data to support such a recommendation at the present.

**Antimicrobial Agents**

With the exception of aminoglycosides, the net effect of pharmacokinetic consequences of obesity on clinical outcome has not been studied rigorously with regard to antimicrobials. Clinical studies suggest using a dosing weight for aminoglycosides, quinolones, and β-lactams obtained by the following formula: Dosing weight = [correction factor × (actual body weight – ideal body weight)] + ideal body weight; where the correction factors are 0.45, 0.4, and 0.3, respectively (54). Suggested dosing adjustments for antimicrobials are provided in the online supplement.
Morbid obesity decreases the quality of portable chest X-ray and obscures the distinction between pneumonic infiltrates and pulmonary edema. Excessive mediastinal adipose tissue projects an abnormal mediastinum on plain chest radiograph, mimicking thoracic aortic aneurysm. A computed tomography scan would offer improved visualization of the pulmonary parenchyma and the surrounding vasculature barring weight restriction of the scanner table.

Ultrasound imaging of the lower extremities is usually limited by the surrounding edema (55). Magnetic resonance venography should be considered instead for intrapelvic and proximal thrombi (56) if clinically indicated.

For those patients requiring diagnostic imaging, intrahospital transfer of the morbidly obese patient is best accomplished on the patient’s own hospital bed. Prior knowledge of the weight limits for each scanner should be investigated before expending the energy and assuming the risk of transporting the patient out of the ICU.

**NUTRITIONAL REQUIREMENTS**

Although morbidly obese patients have excess body fat stores, they are prone to develop protein malnutrition during metabolic stress (57). The elevated basal insulin level in obesity suppresses lipid mobilization from body stores, causing an accelerated breakdown of protein to fuel gluconeogenesis (58). The result is a rapid decrease in lean body mass and an increase in ureagenesis and urinary nitrogen losses.

Estimates of energy expenditure in the critically ill have been derived traditionally from the Harris–Benedict equation, but several studies have shown its inaccuracies when it comes to whether ideal or actual body weight should be used (59). In morbidly obese patients, indirect calorimetry is considered the method of choice to determine energy expenditure if the inspired oxygen is less than 60%. System leaks, the effect of water vapor pressure, and errors in calibration can all contribute, however, to erroneous values. If indirect calorimetry is not available, the current recommendation calls for nutritional support of 20 to 30 kcal/kg per day on the basis of obesity-adjusted weight (IBW + [ABW – IBW] × 0.25, where IBW is ideal body weight and ABW is adjusted body weight) (60) and 1.5–2.0 g/kg of IBW per day. Most of the calories should be given as carbohydrates and fat to prevent fatty acid deficiency. Dickerson and colleagues argued that a hypocaloric enteral feeding could achieve comparable nitrogen balance compared with eucaloric enteral feeding without adverse clinical outcomes (61). In a retrospective study of 40 critically ill obese surgical patients, the hypocaloric feeding group had significantly shorter ICU stays, fewer days of antibiotic therapy, and a trend toward a decrease in days of mechanical ventilation.

Serum thyroid-stimulating hormone should be determined routinely in those patients admitted with hypercapnic respiratory failure. Not uncommonly, hyperglycemia develops rapidly as a result of both gluconeogenesis and glycolysis. Aggressive treatment with intravenous insulin improves control of blood sugar (62) and may limit organ damage in critically ill surgical patients (63). Tight sugar control has been advocated to improve ICU outcome, but a universal guideline for treatment of hyperglycemia in medically ill obese patients is lacking at the present time.

**NURSING CARE**

With decreased vascularity in adipose tissue, the critically ill obese patient is at high risk for pressure ulcers. The inability of the morbidly obese to reposition themselves is a precursor to pressure-related injuries. The implementation of bariatric beds with low air-loss surfaces or air-fluidized bed with pressure relief features may help to alleviate the problem for those who are expected to stay in beds for more than a few days (64). For patients with deep infected ulcers, surgical debridement is necessary to promote wound healing. Tissue samples should be sent for quantitative culture because the presence of more than 10⁷ organisms has been associated with impaired healing (65). A commercially available form of platelet-derived growth factor has been shown in randomized trial to increase the rate of healing and to reduce significantly the ulcer volume compared with placebo (66).

The moist environment in skin folds encourages microbial growth, which commonly leads to fungal infections in the obese. Placement of a soft folded cloth between the surfaces of skin folds reduces friction and absorbs moisture. Nonmedicated powders, such as cornstarch, absorb moisture but tend to clump when applied heavily. For this reason, they should be used sparingly. Antifungal powders or creams can be used for actual infection, but are not recommended for routine prophylaxis (67).

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