

obesity in critical illness [created by Paul Young 05/12/07]

general

- Obesity continues to be a health epidemic of the industrialized world, and is associated with substantial morbidity and mortality.
- Obesity has pathophysiologic effects upon all major organ systems. A thorough knowledge of these effects and specific intensive care unit-related issues are necessary for clinicians to anticipate common complications and provide timely and effective treatment for the obese intensive care unit patient.

epidemiology

- Obesity is defined by a body mass index (BMI weight in kilograms divided by height in meters squared) of above 30 kg/m². A BMI > 40 kg/m² is interchangeably classified as severely, extremely or morbidly obese.
- Prevalence estimates of obesity in critical care vary depending on the population studied, ranging from 5.4% in blunt trauma and 17.1% in postoperative cardiac surgical patients to nearly 25% of medical/surgical intensive care unit (ICU) patients.
- Consequently, obesity is frequently encountered in the ICU. Therefore, knowledge of the unique pathophysiology associated with obesity is necessary to deliver effective care

cardiovascular effects of obesity

- Blood volume and cardiac output increase in a linear fashion with increasing levels of obesity. Heart rate is unaffected. This increase in systemic oxygen delivery serves the metabolic demands of excess fat. Splanchnic blood flow is slightly increased and renal blood flow slightly reduced in obesity. Otherwise, cardiac output is similarly distributed to various organs among normal and obese subjects.
- It should be noted that cardiac output, when indexed for body surface area, is not different in obese and nonobese individuals, and obesity should not complicate the interpretation of hemodynamic data.
- Chronically, the supernormal cardiac work required of the obese heart can lead to impaired ventricular performance, the extent of which is influenced by the magnitude and duration of the obesity. In mild to moderately obese subjects, the degree of left ventricular enlargement and wall thickening correlates with the amount of obesity, while the decrement in cardiac performance is related to its duration. Morbidly obese subjects also exhibit higher left ventricular mass, decreased left ventricular systolic function and greater left ventricular diastolic impairment, which is reversed to some degree by weight loss.
- Obese patients have higher resting cardiac filling pressures, which may increase further when the patient is supine exceeding the level necessary for formation of pulmonary edema in bed-bound ICU patients.
- monitoring considerations
 - Since physical exam findings of congestive heart failure may go unappreciated as a result of body habitus in obese patients, invasive measurement of cardiac filling pressures and resultant flows with a pulmonary artery catheter may be helpful in titrating therapy.
 - measurement of noninvasive blood pressure by automated cuffs or by direct auscultation often underestimates arterial blood pressure and exhibits a high number of measurements outside the clinically acceptable range in the critically ill. Thus, direct intraarterial blood pressure monitoring should be strongly considered.

effects of obesity on pulmonary function

- Increased adiposity adversely impacts pulmonary physiology and function. Total respiratory system elasticity is significantly elevated; dominantly by decreased chest wall compliance, but also by decreased lung compliance.
- Total respiratory resistance may also be elevated, especially in the supine position due to early distal airway closure
- Greater elastic and resistive work of breathing in the obese results in disproportionately high oxygen cost of breathing even at rest and may be as high as four times normal.
- Despite working against a less compliant chest wall and a heightened demand for diaphragmatic work, obese individuals are reportedly capable of generating lower maximum inspiratory pressures and have less respiratory muscle endurance compared to the nonobese
- The aforementioned alterations in respiratory mechanics produce abnormalities of pulmonary function with reductions in functional residual capacity, while the total lung capacity and vital capacity are unchanged. In cases of mild obesity the forced expiratory volume in 1 s and forced vital capacity may be normal, but are likely to decline with increasing levels of obesity
- Gas exchange abnormalities, most prominently hypoxemia, correlate with reductions in functional residual capacity. The underlying mechanism appears to be alveolar hypoventilation secondary to airway closure and atelectasis of the basilar airways
- In total, these abnormalities predispose obese patients to respiratory failure in the setting of even mild pulmonary or systemic insults.
- Prudent ventilator strategies include calculating tidal volume based on ideal body weight (IBW) rather than total body weight (TBW) to avoid dangerously high airway pressures and potential barotraumas, prophylactic application of positive end-expiratory pressure up to 10cm H₂O to improve oxygenation, and the use of reverse Trendelenburg position at 45 degrees rather than conventional upright positioning at 90 degrees to facilitate weaning.

nutritional care

- The metabolic response to injury has not been specifically quantitated in obese individuals. The elevated levels of stress hormones, which result in a catabolic state, are, however, thought to be similar between obese and nonobese.
- basic metabolic needs are difficult to estimate. Equations such as the Harris-Benedict equation are commonplace and include weight as a variable. However, whether to use actual body weight (ABW) or IBW remains contentious.
- To date, six studies have examined the use of hypocaloric specialized nutrition support in critically ill obese patients. The number of patients was small with the largest study including only 40 patients. Nutrition delivery was anywhere from 3 to 36 kcal/kg/day IBW or 11-42 kcal/kg/day ABW and provided 0.83-2.2 g/kg/day IBW protein.
- Clinical outcomes have included improved wound healing and fistula closure, lower insulin requirements to maintain glycemic control, decreased ICU stay and number of antibiotic days, and a trend toward more ventilator-free days. Although none of these studies has shown a mortality benefit, no study has shown worse outcomes using a hypocaloric feeding strategy.

vascular access

- Central venous access can be quite challenging in obese patients as normal anatomical landmarks traditionally used to guide placement are often obscured.
- In adults, use of two-dimensional ultrasound guidance for cannulation of the internal jugular and femoral veins unequivocally decreases the risk of failed catheter placement, improves first-pass success, and facilitates faster placement compared with the landmark method

venous thromboembolism prophylaxis

- Obesity is an independent risk factor for development of venous thromboembolism (VTE). It is reported to be the most common cause of postoperative mortality after bariatric surgery, accounting for as many as 50% of all deaths.
- In a study of bariatric surgical patients, those administered enoxaparin 40mg every 12 h had a lower incidence of postoperative deep venous thrombosis compared with those receiving 30mg twice daily. Bleeding events were no different between groups.
- enoxaparin dosed 1.5mg/kg once or 1 mg/kg twice daily in obese patients did not result in supratherapeutic anti-Xa activity, thus supporting the safety of the higher dosing regimens.
- Two other low-molecular-weight heparins, i.e. nadroparin and tinzaparin, have also been studied. Fixed doses of nadroparin given once daily at a dose of 5700 IU appear safe and offer the same benefits as higher dosing regimens. In contrast, weight-based dosing of tinzaparin yields a predictable response regardless of body weight and can be dosed on TBW without a maximal absolute dose.
- Given the paucity of evidence for specific dosing regimens for subcutaneously administered unfractionated heparin in obese patients, it would seem appropriate to use low-molecular-weight heparin in these patients for VTE prophylaxis. Enoxaparin 40mg administered twice daily is the most extensively studied and is preferred. Nadroparin 5700 IU daily or weight-based administration of tinzaparin are reasonable alternatives

pharmacologic considerations

- (i) propofol
 - Propofol is frequently administered continuously for the sedation of mechanically ventilated patients in the ICU. In comparison with healthy nonobese controls, there were no signs of drug accumulation. Larger doses may be required in obese patients
- (ii) fentanyl
 - Fentanyl is a lipophilic synthetic opiate primarily used for analgesia. Clearance is not linearly correlated with TBW above 70 kg. Use of a corrected dosing weight has been proposed and subsequently validated. This dosing weight is the body mass into which the drug distributes and has been coined 'pharmokinetic mass'. Rough approximations of pharmacokinetic mass for patients weighing 70, 100, 120, 140, 160, 180 and 200 kg are 65, 83, 93, 99, 104, 107 and 109 kg, respectively. The actual dose in micrograms per hour equals 1.22 multiplied by the pharmacokinetic mass.
- (iii) benzodiazepines
 - The three most commonly used benzodiazepines in critical care are lorazepam, midazolam and diazepam. All are extremely lipophilic and highly protein bound. For single doses, all three drugs should be dosed on TBW.
 - All three drugs are metabolized in the liver and their effects potentiated by hypoalbuminemia. Hepatic metabolism of diazepam and midazolam produce the active metabolites, desmethyldiazepam and hydroxymidazolam, respectively. As desmethyldiazepam may persist for up to 100 h, use of diazepam cannot be recommended for repetitive dosing in the ICU outside of patients exhibiting symptoms of alcohol withdrawal.
- (iv) neuromuscular blockers
 - are polar and hydrophilic.
 - Vecuronium, rocuronium and cisatracurium should be dosed using IBW.
 - Atracurium is unique amongst neuromuscular blockers because there is a clinically observed hyposensitivity to the drug among obese patients that necessitates dosing based upon TBW to ensure adequate effect.
- (v) antimicrobials
 - With respect to antimicrobials, there is a paucity of data regarding specific dosing for obese patients.
 - In the setting of normal renal function, volume of distribution and drug clearance of vancomycin correlate with TBW, and should be initially dosed based upon this weight.
 - The volume of distribution of ciprofloxacin is expanded in obese patients but not linearly. Thus, the recommended dose is based on IBW plus a correction factor of 45% of excess body weight (TBW - IBW)
 - For aminoglycosides, initial dosing should be based on a calculated creatinine clearance
 - Lastly, despite their exclusion from the Recombinant Human Activated Protein C Worldwide Evaluation in Severe Sepsis Study Group trial utilizing drotrecogin a for the treatment of patients with severe sepsis, follow-up studies of morbidly obese patients have documented similar pharmacokinetics of the drug when dosed upon TBW

impact of obesity on patient outcomes

- Among general medical/surgical ICU patients, the morbidly obese are reported to suffer higher mortality, greater duration of mechanical ventilation and length of stay when compared to the nonobese.
- Obesity is also reported to be an independent predictor of poor outcomes in the ICU
 - In a surgical ICU, investigators reported that morbid obesity conferred elevated odds of death after 4 days of ICU stay and among blunt trauma patients, obese patients suffered more frequent complications (multiple system organ failure, acute respiratory distress syndrome, myocardial infarction and renal failure), including the need for more vasopressors, additional days of ventilator support and more often failed extubation.
 - In cardiac patients, outcomes appear to be unaffected by obesity. After coronary artery bypass graft surgery, early outcomes (death, postoperative myocardial infarction, infectious, respiratory, renal or neurological complications) were no different between the obese and nonobese. Ventilator days and length of stay, both ICU and in-hospital, were also similar, and results from a retrospective study of a large angioplasty registry showed only the most obese patients had higher risk of mortality and subsequent cardiac events.
- Overall, the impact of obesity on mortality seems to be modest and greatest with morbid obesity.