THE ANESTHETIC MANAGEMENT OF OBESE PATIENTS PRESENTING FOR NEUROSURGICAL PROCEDURES: A NARRATIVE REVIEW

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Abstract

Obesity is an increasingly prevalent comorbidity in the United States and throughout the world. As a consequence, an increasing number of obese patients present to the operating room for surgery with unique perioperative considerations. Anesthesiologists must be able to take safe, effective care of these patients. This narrative review discusses the anesthetic implications of obesity and offers methods for providers to care for obese patients undergoing neurosurgical procedures in the perioperative period. The review examines the preoperative, intraoperative, and postoperative issues that anesthesiologists encounter, as well as unique challenges that are addressed during the care of obese patients.

Key Words: Obesity, Neurosurgery, Anesthesia, Review

Introduction

Obesity is a growing health concern that presents unique challenges for health care systems worldwide. It has become increasingly prevalent, particularly in the United States, where it is now the second most common preventable cause of death behind smoking[1]. In 2016, 36.2% of adults in the U.S. met criteria for obesity as compared to 11.9% in 1975; globally, the prevalence of obesity in adults is estimated to be 13% in 2016, about three times the level in 1975[2]. Anesthesiologists are encountering patients with this disease more and more frequently, and must be prepared to manage the often complex perioperative care of these patients. Virtually every organ system is negatively impacted by increasing adiposity[1]. Neurosurgical anesthesia commands special attention to several

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considerations, including neurosurgical critical care, patient positioning, and teamwork with surgeons, nurses, neurophysiologists, and intensivists. In this narrative review, we discuss the anesthetic implications of obesity during neurosurgical procedures.

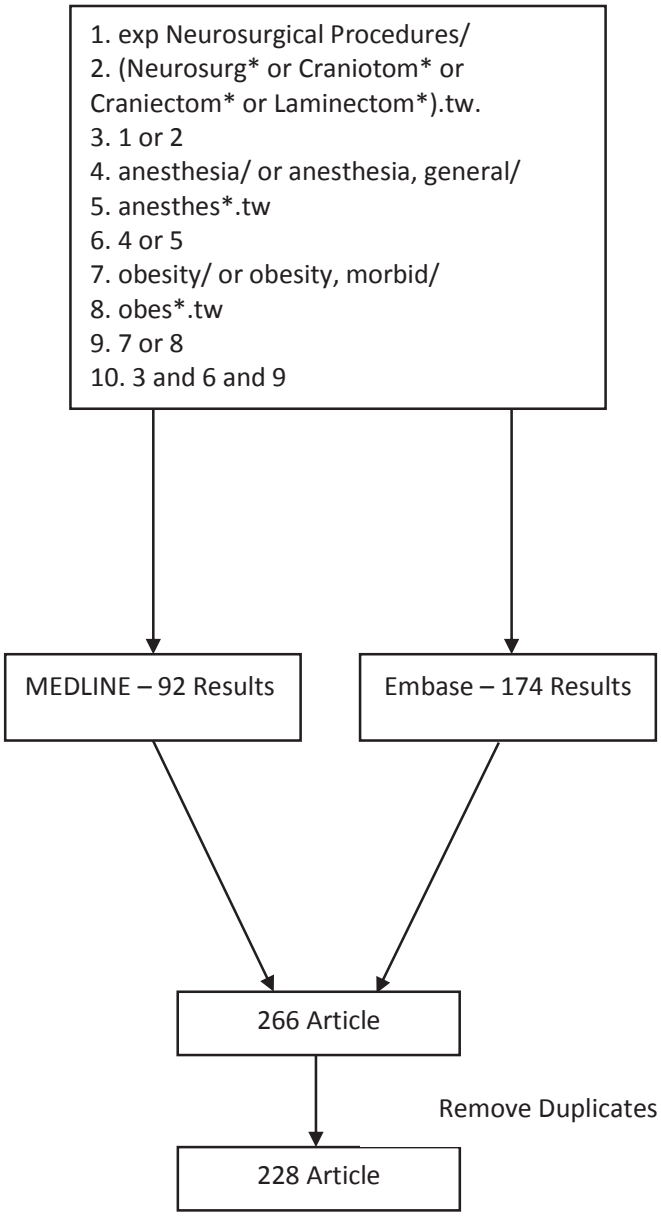
Materials and Methods

A comprehensive search strategy was developed by the authors with the collaboration of a professional librarian. The Medline and EMBASE databases were searched in March 2017 for articles that included variations of keywords including "anesthesia", "obesity", and "neurosurgery". The search was re-run in June 2018 for additional articles. We sought articles that addressed neurosurgical procedures and anesthetic techniques. Figure 1 exhibits the comprehensive search strategy that was utilized.

Figure 1: Comparative Search Strategy

The search revealed 228 unique articles after removal of duplicate articles. Twenty-five articles which were non-English were excluded. The articles were reviewed for inclusion into this review. Supplementary articles that were identified were added only if they included relevant information. Known relevant publications and textbooks were added in addition to this literature search. Article acquisition was performed by multiple authors. The final review consisted of 55 articles/sources. Figure 2 is a flowchart that demonstrates the authors acquisition of articles.

Figure 1
Comparative Search Strategy



Preoperative Considerations

Obesity is defined as an abnormal amount of adipose tissue in relationship to lean muscle mass, typically ≥20% over ideal body weight[3]. While it is a disease with both environmental and genetic components, it is ultimately best described as a disease where energy intake exceeds energy spent[4]. Body mass index (BMI), which is calculated by the formula (BMI = wt/height^2 in kg/m^2), is a frequently encountered measurement to help evaluate body fat, which is a ratio of the patient's weight to his or her height[3,5]. High BMI is typically categorized into four distinct groups: overweight is BMI 25.0 to 29.9 kg/m^2, obese is BMI 30 to 40 kg/m^2, morbid obesity is BMI >40 kg/m^2, and super morbid obesity is >50 kg/m^2 [6]. The prevalence of certain comorbid diseases increases with elevated BMI, such as cardiovascular disease, hypertension, diabetes, and certain cancers[5,7]. Currently over one third of the United States population meets criteria for obesity[3].

Surgical risk increases with high BMI, although there remains opportunity to learn whether this applies to all surgery or just specific subtypes. For example, obesity has not been shown to worsen post-

operative outcomes in most cranial neurosurgical patients, but there has been increased morbidity and/or mortality in spine surgical patients[8] and temporal lobe epilepsy patients of BMI >40[9]. Furthermore, obesity has been shown to be associated with adverse events in craniotomy for aneurysm clipping[10]. This is likely related to the association between perioperative hyperglycemia and worse neurologic outcomes in subarachnoid hemorrhage patients. Type 2 diabetes is more common in obese patients which makes avoiding perioperative hyperglycemia more challenging in these patients[11]. Regardless, there is certainly increased risk of anesthetic related complications including hypoxemia, difficult intubation, hypercapnia, obstructive sleep apnea, and aspiration[7]. Intravenous access can be challenging in obese patients, along with difficulty in obtaining non-invasive blood pressure cuff readings. Post-operatively they are at increased risk of thromboembolic events and surgical site infections[7,12,13]. Some have even suggested that patients at very high risk for deep vein thrombosis should have a prophylactic filter placed in the inferior vena cava, though this is not standard practice in our experience[3]. In addition, there has been some data to suggest a higher rate of reoperation in morbidly obese craniotomy patients[14].

The pharmacokinetics of some medications are altered in the obese patient, specifically for certain opioids and benzodiazepines[15]. For most drugs, dosing should be based on lean body weight, but this is not true for all anesthetics as seen in table 1. Ideal body weight does not account for the difference in lean body weight for severely obese patients, and therefore lean body weight is better for initial dosing due to its correlation with drug clearance and cardiac output[3]. Lean body weight is calculated as (1.1 × TBW-0.0128 × BMI × TBW) for males; for females it is calculated as (1.07 × TBW-0.0148 × BMI × TBW)[16]. Remifentanil is unique in that the recommended dosing is based on ideal body weight in obese patients, due to alterations in the pharmacokinetic profile of the drug[17]. Commonly used drugs during neurosurgery, such as mannitol, also have altered pharmacokinetic characteristics; utilizing mannitol based on actual body weight can lead to greater than expected plasma concentrations and ultimately increased serum osmolality[18].

Table 1

Recommended Dosing of Medications for Standard Anesthetics

Lean Body Weight	Total Body Weight
Non-depolarizing Neuromuscular Blockers Rocuronium, Vecuronium	Depolarizing Neuromuscular Blockers: Succinylcholine
Narcotics: Fentanyl, Remifentanil	Midazolam
Propofol for maintenance infusions	Propofol for induction dosing
	Cisatracurium

The pulmonary status of obese patients is of particular concern to the anesthesiologist. Intubation can be more challenging in obese patients due to difficulty in positioning, increased neck circumference, excessive oral soft tissue, and occasionally limited jaw mobility[19]. Obese patients exhibit decreased lung compliance, a decreased functional residual capacity, and an increased closing volume, all of which can lead to rapid oxygen saturation[20]. While obesity is commonly referenced as a risk factor for postoperative pulmonary complications[6], this has not been shown to be true in all studies; obstructive sleep apnea (OSA) may be a more reliable risk factor[21]. However, given that obese patients are more predisposed to OSA, providers must maintain vigilance when monitoring the respiratory status of obese patients. Some institutions have recommended utilizing preoperative positive airway pressure systems to optimize patients, and prepare patients for postoperative use as well[22]. Patients who utilized continuous positive airway pressure devices at home at levels higher than 10 cm H_2O are at risk for difficult ventilation; patients who have an apnea-hypopnea index score (a measure of the severity of sleep apnea) of greater than 30 are at risk of rapid desaturation during the induction of anesthesia[1]. Furthermore, practitioners should be aware of contraindications to positive airway pressure systems after neurosurgical procedures, such as transsphenoidal hypophysectomy. Anesthesiologists should also be aware that obese patients can have indistinct neck landmarks and short neck length, possibly leading to more difficulty with placement of a surgical airway[23].

Virtually every organ system is affected by obesity. There is an increase in metabolic demand that is met by an increase in preload, afterload, and

cardiac output (approximately (0.1 L/min/kg of excess adipose tissue) that is achieved mainly by increases in stroke volume[19]. There is an overall increased risk of cardiac ischemic events and dysrhythmias in obese patients secondary to coronary artery disease and the fatty infiltration of the conduction system[19]. Obese patients are at increased risk of renal insufficiency, gastroesophageal reflux and hiatal hernias, hepatic insufficiency due to fatty infiltration of the liver, and positioning injuries due to adipose tissue compression of peripheral nerves[19].

Obesity can cause certain conditions to be more prevalent, which can lead to neurosurgical referral such as in the case of nerve compression[24]. Benign intracranial hypertension, which is mainly a disease of women of reproductive age, is postulated to be more common in obese patients. A potential mechanism is that increases in intra-abdominal pressure lead to an impedance in venous return from the brain, causing an increase in intracranial venous pressure and an increase in intracranial pressure[25]. Diseases, such as diabetes or acromegaly, can be secondary to brain tumors which have clinical implications for anesthesiologists[26].

Intraoperative Considerations

There are common difficulties that anesthesia providers are likely aware of in managing obese patients. These include difficulty with airway management, obtaining intravenous access, and obtaining blood pressure readings. There are challenges not normally seen in standard BMI patients, such as central lines that are not long enough, resulting in a non-intravascular position[27]. There can be difficulty in identifying infiltrated intravenous lines as more fluid can be deposited into an obese patient's extremities without proper identification[23]. There are considerations that practitioners should be aware of that are exclusive to neurosurgical procedures.

Positioning during prone spine surgery is of considerable importance and its difficulty in obese patients is well described in the literature. Excessive abdominal pressure from extra body fat can increase venous pressure, causing a potential reduction in spinal cord perfusion[28]. Furthermore, chest rolls can restrict the abdomen even more which can intensify this issue. This can potentially be avoided by allowing the abdomen to hang freely of compression, which can be accomplished with a Wilson frame, although challenges with ventilation can still be noted[29]. Furthermore, obese patients in the prone position have been shown to have higher intraoperative blood loss during lumbar spine surgery[29]. Surgeons may encounter challenges with identifying the correct anatomic level and obtaining surgical instruments of an appropriate length, as well as obtaining fluoroscopic equipment of appropriate length[4,23]. There is also evidence to suggest that obese patients are at increased risk of post-operative vision loss during spine surgery[30]. Positioning of obese patients for prone cases can be challenging, as some equipment is not suitable for the weight requirements of obese patients[23]. Pressure points should be checked carefully, although cushion gel pads or weight bearing rolls may experience excess weight, leading to skin breakdown[1]. One unique consideration is the possibility of injuries to staff; in fact, it has been described in the literature that in extremely challenging cases that patients can be intubated awake and then position themselves prone[20,31]. Providers should be extra cautious when securing endotracheal tubes in obese patients going into the prone position as dislodgement can be catastrophic[23]. Providers should consider having emergency equipment such as a fiberoptic bronchoscope or laryngeal mask airways to emergently secure the airway in the event of dislodgement.

Obesity itself can be secondary to certain diseases that may present in patients for neurosurgery. Cushing's syndrome is an illness caused by the endogenous production of corticosteroids by the adrenal glands, or by exogenous administration of corticosteroids. Such steroids frequently lead to obesity, resulting in patients presenting for trans-sphenoidal pituitary surgery at increased body mass index (BMI)[26]. This syndrome is notable for poor wound healing, hypertension, diabetes, and infertility, as well as obstructive sleep apnea[32]. Providers should be more inclined to obtain arterial access for invasive blood pressure and serum blood glucose monitoring.

Awake craniotomy can be extremely challenging in obese patients and should not be undertaken lightly. Obstruction and hypoventilation can lead to

hypoxia and hypercarbia; however, these problems are exceptionally important in craniotomy as they can increase intracranial pressure and exacerbate difficulties obtaining adequate surgical exposure. A laryngeal mask airway technique has been described successfully for obese patients[33], as well as the intraoperative use of a continuous positive airway pressure machine[34]. However, one must still be aware of the increased risk of aspiration, hypoxia, and hypercarbia in this patient population. We recommend prophylactic antiemetic use during these cases. Advanced airway equipment such as a fiberoptic bronchoscope should be considered for airway emergencies during these cases. In extreme cases, surgical airway could be discussed with the patient during the preoperative evaluation.

Postoperative Considerations

In the obese patient population, a common concern of anesthesiology and surgical providers is postoperative airway management. Since obesity is a risk factor for difficult intubation and ventilation, providers should be particularly vigilant about the patient meeting extubation criteria upon emergence. Tracheal extubation should be undertaken when the patient is fully awake and demonstrates adequate return of respiratory function, which may occur in the intensive care unit[22]. There should be full reversal of all neuromuscular blockade, and appropriate return of neurological function. Obesity has been associated with delayed extubation and tracheostomy in multilevel cervical spine patients[35,36]. In patients undergoing craniotomy, it has been suggested that if volatile agent is utilized as part of a balanced anesthetic technique that desflurane may be preferable in obese patients, as it allows quicker cognitive recovery and reversal to normal pH and normocapnia[37]. There is mixed evidence regarding the effect of obesity on the risk of post-operative pulmonary complications[38,39]. Techniques that can be utilized to maximize the probability of success for extubation include raising the head of the bed to optimize respiratory mechanics, nasal or oral airways to lower the risk of obstruction, and positive pressure ventilation if needed. For patients that are being transported to the intensive care unit, we recommend full monitoring of patients regardless of whether the patient has been extubated. The use of a portable pulse oximeter should be considered during the transport of all obese patients.

Postoperative pain control can be a challenging problem in the obese patient. Regional anesthetics are frequently employed in other types of surgery, and are occasionally used in neurosurgical procedures; however, block failure and complications have been noted to be higher in obese patients[40-43]. While neuraxial anesthetics are not frequently used in neurosurgical cases, it is important to note that there is difficulty in neuraxial anesthetics with increasing BMI[44]. One technique that has been employed for obese patients is the addition of dexmedetomidine. Studies have demonstrated that some patients require less narcotics in the recovery room after supplementation of general anesthesia with dexmedetomidine, which is advantageous to minimize the risk of respiratory depression in obese patients[45].

Unique Complications

Obese patients are at increased risk of a variety of complications that are rarely seen in normal BMI patients. Obesity has been linked to an increase in the risk of awareness under general anesthesia[46]. It also has been identified as a risk factor for increased risk of symptomatic spinal epidural hematoma after spinal surgery[47]. Obese patients have been associated with increases in resource utilization due to longer surgical times and hospital length of stays, ultimately increasing costs for spinal surgery[48]. Obesity has been shown to increase the risk of specific surgical complications as well, such as cerebrospinal fluid fistula and distal shunt catheter migration[4].

An increased BMI has been associated with a prolonged length of stay in the hospital as well as an increased risk of readmission following lumbar laminectomy for spinal stenosis[49], as well as craniotomy for tumor patients[50]. These patients may require more frequent reoperations given the higher rate of surgical site infections[51]. Surgical site infection rates have been noted to be higher in cervical spine surgery in obese patients as well[52]. This can likely be attributed to longer surgical times, larger and more extensive surgical exposure, and secondary comorbidities such

as diabetes. This substantiates data that suggests that obese patients encounter healthcare costs that are 42% greater per year on average than patients that are not obese[3].

There have been documented cases of ischemic optic neuropathy in obese patients going back many years, raising questions of whether or not obesity is a direct risk factor for development of this complication[53]. As a result, some authors have recommended the avoidance of certain equipment in obese patients, such as the Relton-Hall frame[54].

Obese patients are exposed to unique hematological risks. All surgery exposes patients to the risk of deep venous thrombosis and pulmonary embolism, and neurosurgical patients are no exception. Obese patients are at increased risk of developing venous thromboembolic phenomena[55]. Specifically during spinal surgery, venous epidural bleeding can be increased due to increases in intraabdominal pressure and intrathoracic pressure, specifically in the prone position[23]. It has been hypothesized that it may be more challenging to achieve complete hemostasis in these patients, leading to increased risk of spinal epidural hematoma after spinal surgery[47].

Conclusions

The prevalence of obesity in the neurosurgical patient population is increasing both in the United States and internationally. It is clear that the risk of complications is higher in obese patients undergoing neurosurgical procedures[4]. Providers must be cognizant that obesity affects essentially every organ system, and that as patients' weight increases so do their risks from surgery and anesthesia. To take safe and effective care of obese patients, providers must proactively address the unique risks that obesity presents. More studies evaluating possible interventions during neurosurgical anesthesia could potentially lead to safer care of these patients in the future. Ultimately, vigilance and consideration of the pathophysiology of this disease process will lead to the successful treatment of obese patients during the perioperative period.

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