Review Article

Neurosurgery in morbidly obese patients

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Abstract

Obesity has significant impact on various organ systems of the body and thus needs a well-planned anaesthetic management. Obese patients with multiple co morbidities are expected to have more complications than normal individuals. Obesity may influence the risk of aneurysm formation and rupture and/or the outcome of patients who have aneurysmal SAH. Most of the neurosurgeries require different patient positions for adequate exposure of surgical site. Moreover morbidly obese patient means a huge and heavy patient who will require bigger operating table and other accessories and their implications. Confusion regarding the risks and benefits of mechanical and pharmacological prophylaxis in neurosurgical patients for DVT with risks of major and minor haemorrhage still persists. The anesthetic concerns in an obese patient undergoing neurosurgery have not been studied so far. This review aims in discussing obesity in neurosurgical patients.

Key words: Anaesthetic management, complications, morbid obesity, neurosurgery

INTRODUCTION

Obesity is a global health hazard. It is a pandemic of the twenty-first century. As of 2012, more than one-third (34.9% or 78.6 million) adults and 16.9% youth are obese in the US.[1] In the world, at present there are 1.6 billion overweight individuals and 400 million obese people. An increased prevalence of meningiomas has been reported in obese individuals.[2] Obesity can be the cardinal feature in patients with craniopharyngioma and pituitary adenomas. Therefore, an increased number of morbidly obese individuals are likely to be encountered by the anaesthesiologist for elective as well as emergency neurosurgical procedures. There is not enough literature regarding anaesthetic challenges for such procedures in obese patients. This review aims at discussing the concerns for a morbidly obese patient presenting for neurosurgery.

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PRE-OPERATIVE CONCERNS

Comorbidities

Obesity has a significant impact on various organ systems of the body as shown in Table 1. Patients with body mass index (BMI) of >30, with a waist circumference of >102 cm in male and >88 cm in women, have very high chance for developing type 2 diabetes, hypertension, and cardiovascular disease.[3] Obesity is an independent risk factor for cardiovascular morbidity in the form of coronary heart disease, right and left ventricular failure, sudden death, and obesity cardiomyopathy.[4] Obesity leads on to generalised accumulation of adipose tissue, especially around the soft palate, tongue, and hypopharyngeal region causing narrowing of airway and makes these patients

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Table 1: Organ system effects of obesity

Organ System	Manifestation
Cardiovascular	Hypertension Coronary artery disease Peripheral vascular disease Ischemic and haemorrhagic stroke Myocardial infarction Venous thromboembolism Peripheral venous insufficiency
Respiratory	OSA Obesity hypoventilation syndrome
Metabolic	Type 2 diabetes and impaired glucose tolerance Hyperlipidaemia
Musculoskeletal	Back pain Lumbar disc disease Osteoarthritis of weight-bearing joints
Gastrointestinal	Cholelithiasis Gastroesophageal reflux Non-alcoholic fatty liver
Endocrine	Polycystic ovary syndrome Male hypogonadism
Malignancies	Endometrium Breast Ovary Pancreas Prostate Hepatic Colorectal
Dermatological	Intertriginous dermatitis
Neurological	Pseudotumor cerebri Carpal tunnel syndrome Dementia
Psychological	Depression Eating disorders

OSA=Obstructive sleep apnoea

more prone to develop obstructive sleep apnoea (OSA) syndrome.[5] Most of the morbidly obese patients are hypothyroid, a prevalence of 19.5% has been reported.[6] Obesity hypoventilation syndrome has been seen in approximately 50% of the obese patients with BMI >50 kg/m^2.[7]

Prediction of difficult airway

Increased neck circumference and presence of OSA are found to be strongly associated with difficult airway management in morbidly obese patients[8,9] A ratio of neck circumference to thyromental distance of ≥5 has a sensitivity of 88.2% and negative predictive value of 97.8% in the identification of difficult airway in obese patients.[10] Acromegalic patients have potential difficult airway. Seidman *et al.* studied the anaesthetic records of acromegalic patients who underwent transsphenoidal pituitary surgery, 12 of the 28 patients had difficult intubation and 3 patients required fibreoptic intubation.[11] In obese patients with Arnold–chiari malformation and other craniovertebral anomalies, extreme degrees of neck movements should be avoided to decrease brain stem compression.[12]

INTRAOPERATIVE CONCERNS

Monitoring

Electrocardiography and non-invasive blood pressure might not be that reliable in obese patients. Gain of the electrocardiogram (ECG) is to be set accordingly, and ECG leads should be properly secured. The anaesthesiologist should have a low threshold for establishing invasive monitoring. Precordial Doppler, transoesophageal echocardiogram and end tidal nitrogen monitors are commonly instituted in neurosurgeries with high risk of venous air embolism, but their specific usefulness and technical difficulties in this subset of morbidly obese patients are yet to be studied. Bispectral index targets are the same in morbidly obese patients as compared to their non-obese counterparts.[13]

Vascular access

Thick subcutaneous layer of fat makes intravenous access as well as central venous cannulation difficult in these patients due to the difficult identification of landmarks. Ultrasound-guided cannulation, long needles and catheters with length at least 20 cm have also been recommended in these patients.[14]

Positioning for laryngoscopy

Collins *et al.* studied the direct laryngoscopic views of morbidly obese patients positioned between sniffing and ramped position, they observed that the ramped position significantly improved the laryngeal view.[15] Ramping or forced extension of C-spines should not be attempted in fracture of cervical spines. Ramping is achieved either by a set of folded blankets, towels or commercially available head elevation pillows[16] under the head and shoulders, while 'table ramp' technique can be achieved by raising the head end of the operating table by 25° at the trunk and lower extremity hinge so as to align the external auditory meatus and sternal notch at the same level.

Drug dosage

Obese patients have an increased blood volume and relatively increased cardiac output and increased blood flow to vital organs. In addition, they have an increased lean body mass and adipose tissue. Dosing of lipophilic agents is based on total body weight (TBW), while less lipophilic or hydrophilic agents are based on ideal body weight (IBW). However, there are several exceptions to this generalisation as obesity is associated with changes in protein binding and clearance of drugs. IBW is calculated by formulae shown in Table 2.

Most of the anaesthetic drugs are based on either the TBW or IBW as shown in Table 3.

Amongst the inhalation agents, desflurane has been associated with early cognitive recovery and better acid-base profile in patients undergoing craniotomy for supratentorial mass lesions compared to sevoflurane.[22]

Positioning for surgery

Most of the neurosurgeries require very few patient positions for adequate exposure of surgical site. These positions and their implications are shown in Table 4.

Moreover, morbidly obese patients require bigger operating tables and other accessories, the list of few with their maximum weight bearing capacity are shown in Table 5.

Positioning such patients necessitates more staff and extra caution to avoid injury to the patient as well as the theatre personnel. The anatomic landmarks might be obscured by the large amount of adipose tissue, so vigilance during protecting the pressure points is critical. Awake intubation followed by awake prone positioning onto the Jackson table has been described in a morbidly obese patient before anaesthesia induction for emergency lumbar discectomy.[29]

Rhabdomyolysis

There are numerous cases of rhabdomyolysis occurring in morbidly obese patients reported in literature.[30-33] Hence, vigilance during positioning is critical during prolonged neurosurgical procedures.

Deep vein thrombosis prophylaxis

Obesity is a prothrombotic state, a number of mechanisms are proposed including enhanced platelet activity, increased tissue factor, increased clotting factors, impaired fibrinolysis and activation of endothelial cells.[34] Obese patients are more prone to develop deep vein thrombosis (DVT) and pulmonary thromboembolism. Elderly patients, carcinoma, intracranial surgery, presence of motor deficit, large tumours, chemotherapy and duration of surgery more than 4 h, all carry a high risk of DVT and pulmonary thromboembolism.[35,36] Incidence of DVT in general population undergoing neurosurgery is estimated to be 2.2–6%.[35] Epstein reviewed the risks and benefits of mechanical and pharmacological prophylaxis in neurosurgical patients, though mechanical measures provide prophylaxis against DVT in many series, the risks of major and minor haemorrhage still persists. Hence, the choice of pharmacological prophylaxis should be individualised after assessing the risks and benefits.[37]

Table 2: Estimation of ideal and estimated body weight

IBW (Devine formula)[17]
Male: 50 kg + 2.3 kg × (height in inches - 60)
Female: 45.5 kg + 2.3 kg × (height in inches - 60)
Estimated lean body formula (James formula)[18]
Male: 1.1 × weight (kg) - 128 × (weight in kg/height in cm)^2
Female: 1.07 × weight (kg) - 148 × (weight in kg/height in cm)^2

IBW=Ideal body weight

Table 3: Drug dosage based on weight calculation

Drug	Recommended dosage
Thiopentone	TBW
Propofol	Induction: LBM[19] Maintenance: TBW[20]
Midazolam	TBW
Vecuronium	IBW
Rocuronium	IBW
Cisatracurium	TBW
Succinylcholine	TBW
Neostigmine	TBW
Fentanyl	TBW
Morphine	IBW
Remifentanil	LBW
Dexmedetomidine	Yet to be assessed[21]
Paracetamol	IBW

TBW=Total body weight, IBW=Ideal body weight, LBW=Lean body weight

POST-OPERATIVE CONCERNS AND COURSE

Obese patients with multiple co-morbidities when undergo a surgery are expected to have more complications than normal individuals. However, literature has conflicting data in this regard. Impaired pulmonary and cardiac function can impair the immediate post-operative care for the anaesthesiologist. Kalanithi *et al*.[38] found higher in-hospital complications rate and significantly higher mean total hospital charges for posterior lumbar fusion in obese patients than normal weight patients ($128 661 vs. $108 569, $P < 0.001$). Yadla *et al*.[39] found no correlation between patients' BMI and the incidence of perioperative minor or major complications in patients undergoing surgery for degenerative thoracolumbar procedures. Schultheiss *et al*. and Juvela *et al*. found no difference on outcome after subarachnoid haemorrhage and intracranial surgeries between normal patients and in those with high BMI.[40,41] Wound infection is common in obese patients. Incidence of stretch injury in severely obese patients

Table 4: Various positions for surgery and their implications

	Physiological effects	Neurosurgical implications
Supine	Decreased FRC Increased closing volume Increased V/Q mismatch Increased atelectasis Increased resistance Decreased chest wall compliance due to excessive fat tissue Increased preload - poorly tolerated in patients with poor cardiac reserve	Excessive neck rotation - kinking of IJV and increased ICP OSA and excessive sedation in post-operative period - hypoxia, hypercarbia - increases ICP Excessive neck flexion and excessive soft tissue in front of neck - kinking of endotracheal tube
Lateral	Dependant lung is better perfused and non-dependant lung is better ventilated - increased V/Q mismatch Better off loading of the panniculus - improves compliance and resistance	Dependent arm - axillary artery compression and brachial plexus compression Head is supported and cervical spines are maintained in line with the dorsal spines
Sitting	Increased FRC and vital capacity Venous pooling in lower limbs	Hypotension - if not adequately preloaded Venous stasis and deep vein thrombosis Excessive neck flexion - kinking of endotracheal tube and airway oedema and quadriplegia Increased risk for VAE and pneumocephalus
Prone	Though difficult technically –better respiratory mechanics Better recruitment of dorsal alveoli Improved V/Q matching	IVC compression - increased pressure in vertebral venous plexus and increased bleeding Excessive neck rotation to one side - increased ICP Head is positioned in line or above the dorsal spines to promote venous drainage from the head Endotracheal tube and invasive lines should be taken care of pressure over the eyes should be avoided by all means - POVL Hyperextension of arms should be avoided

FRC=Functional residual capacity, ICP=Intracranial pressure, OSA=Obstructive sleep apnoea, VAE=Venous air embolism, IJV=Internal jugular vein, POVL=Post-operative visual loss, V/Q=Ventilation/perfusion, IVC=Inferior vena cava

Table 5: Operating room accessories with their maximum weight capacity

Table	Maximum weight capacity
Regular operating table	200 kg
Bariatric table	≥455 kg[23]
Pro axis spinal surgery table	227 kg[24]
Jackson table	227 kg[25]
Allen frame	227 kg[26]
Wilson frame	136 kg[27]
Andrews table	159 kg[28]

of more than 20%[42,43] brachial plexus injuries occur in spine surgeries done in prone position.[15] In obese patients, greater support and immobilisation to the upper extremities and excess padding are required around all pressure points in the upper and lower extremities.[39]

A few common neurosurgical procedures and their anaesthetic implications in obese patients are discussed below.

Awake craniotomy

Awake craniotomy is indicated for intractable epilepsy and lesions near eloquent cortex such as the motor strip and Broca's speech area (dominant hemisphere), both in the frontal lobe and Wernicke's speech area (dominant hemisphere) in the temporal lobe. The aim of an anaesthetist in an awake craniotomy is to achieve adequate analgesia and sedation while maintaining the airway and the haemodynamics, and having a calm, cooperative patient for intraoperative neurological testing.

Over sedation should be avoided as it can cause airway obstruction in a not so readily accessible airway. Respiratory depression leads to hypercarbia and brain bulge, which increases surgical difficulty. Patients with OSA can be managed with giving continuous positive airway pressure in the intraoperative period.[44] Aspiration prophylaxis is given to these patients.

Dexmedetomidine is particularly useful considering its dose-dependant sedative action with no respiratory depression.[45-47] 'Asleep-awake' technique with laryngeal mask airway and controlled ventilation during incision, and deep sedation with adjuvant dexmedetomidine after neurologic examination can also be practiced.[48]

Spine surgery

Obesity causes excessive strain of the spine leading to intervertebral disc degeneration. The incidence of low back ache is high in obese patients.[39,49-51] A direct relationship exists between obesity and perioperative complications.[52] The risk of recurrent disc herniation post-surgery is increased in obese patients.[53] Peripheral nerve palsies are common, especially brachial plexus injury in prone position. Stretch injury occurs in >20% of obese patients.[42,54]

Neurotrauma

Osborne *et al*. observed lower incidence of head injury and statistically significant higher incidence of spine injury in obese patients injured by fall.[55] However, Tagliaferri *et al*. inferred that obese passengers are more likely to suffer a more severe head trauma after a frontal collision compared with non-obese subjects.[56] Different authors have demonstrated that obesity did not affect the severity of head injury or even had a protective effect in head trauma.[57,58]

Decreased tissue oxygenation and organ perfusion have been seen in obese trauma patients. Obesity was found to be an independent predictor of compromised brain tissue oxygen tension $P(bt)O_2$ in patients with severe traumatic brain injury.[59]

The co-morbid conditions associated with obesity may increase the morbidity and mortality of the patient. Obesity has been associated with increased incidence of acute respiratory distress syndrome, renal failure and multiple organ failure in trauma patients. They are at higher risk for rhabdomyolysis after trauma. It also complicates patient recovery and rehabilitation.[60,61]

CONCLUSION

Morbidly obese patients are a small subset of our population, but may pose many challenges to the anaesthesiologist for elective and emergency neurosurgeries. Vigilant attention regarding the relevant concerns is crucial for safe perioperative outcome in these patients.

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Conflicts of interest

There are no conflicts of interest.

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