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MINIREVIEWS

Critical care of obese patients during and after spine surgery

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Abstract

Obesity is one of the most prevalent health problems facing the United States today, with a recent JAMA article published in 2014 estimating the prevalence of one third of all adults in the United States being obese. Also, due to technological advancements, the incidence of spine surgeries is growing. Considering these overall increases in both obesity and the performance of spinal surgeries, it can be inferred that more spinal surgery candidates will be obese. Due to this, certain factors must be taken into consideration when dealing with spine surgeries in the obese. Obesity is closely correlated with additional medical comorbidities, including hypertension, coronary artery disease, congestive heart failure, and diabetes mellitus. The pre-operative evaluation may be more difficult, as a more extensive medical evaluation may be needed. Also, adequate radiographic images can be difficult to obtain due to patient size and equipment limitations. Administering anesthesia becomes more difficult, as does proper patient positioning. Post-operatively, the obese patient is at greater risk for reintubation, difficulty with pain control, wound infection and deep vein thrombosis. However, despite these concerns, appropriate clinical outcomes can still be achieved in the obese spine surgical candidate. Obesity, therefore, is not a contraindication to spine surgery, and appropriate patient selection remains the key to obtaining favorable clinical outcomes.

Key words: Obesity; Spine sugary; Critical care

Core tip: Obesity is one of the most prevalent health problems facing the United States today. Due to technological advancements, the incidence of spine surgeries is also growing. This is particularly true for spinal fusion procedures, as rates were noted to triple from 1990 to 2000. There are potential increased complication risks during and after spine surgery due to associated comorbidities. Spine surgery can be performed safely in obese patients with appropriate management of comorbidities and proper patient selection.

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INTRODUCTION

Obesity is one of the most prevalent health problems facing the United States today. Recent studies indicate that 32.2% of adult men and 35.5% of adult women in the United States are considered obese[1,2]. The prevalence of obesity has also increased, notably among adolescents and adult men[3]. Additionally, due to technological advancements, the incidence of spine surgeries is also growing. This is particularly true for spinal fusion procedures, as rates were noted to triple from 1990 to 2000[4]. Spinal fusion was the 19th most common inpatient procedure performed in 2003, rising from 41st in 1997[5]. The purpose of this article is to review the effects that obesity has on spinal surgery patients both during and after surgery and highlight the factors that must be taken into consideration when dealing with these surgeries in the obese.

OBESITY AND ASSOCIATED CO-MORBIDITIES

Most clinicians today define obesity according to a standardized formula known as the body mass index (BMI). This formula was created by Belgian statistician Adolphe Quetelet in 1832 and had been mostly abandoned[6]. It was then thrust to the front of obesity research in 1972 by Keys *et al*[7], who evaluated the methods available at the time for describing the relative weight of patients or populations. He chose the easiest and most reproducible method, which he renamed the BMI. This simple formula requires no special tools or data, as it is simply the patient's weight (kg) divided by the square of their height (m^2). From this information there have been guidelines set to classify patients as underweight, normal weight, overweight, obese, or morbidly obese (Table 1)[8].

Obesity has been shown to be closely correlated to multiple medical comorbidities such as increased rates of diabetes mellitus, hypertension, coronary artery disease, obstructive sleep apnea, and overall mortality[3,9-11]. This has specifically been shown in the surgical spine patient, as Vaidya *et al*[12] found averages of 5.1 and 8.1 comorbidities in obese and morbidly obese patients, respectively, that underwent posterior decompression and fusion with instrumentation. Thus not only does the presence of obesity play a role in the incidence of medical comorbidities, but the degree of obesity is also important. The increased rates of diabetes in these populations must also be carefully considered, as diabetic patients have been noted to have an increase in wound complications[13,14].

OBESITY AND THE PRE-OPERATIVE EVALUATION

The presence of obesity can also affect the diagnostic assessment of a patient being evaluated for spine surgery. Patients that undergo spinal surgery typically have multiple pre-operative imaging studies. These usually include plain radiographs, computed tomography (CT) scan and magnetic resonance imaging (MRI), which offer better detail of bone and soft tissue structures, respectively. All of these methods contribute to accurate diagnosis and appropriate pre-operative planning. Obtaining proper images, however, may be difficult in the obese patient. Plain radiographs are available in most clinics and are relatively easy for the patient to obtain. However, the presence of obesity may result in higher radiation doses and poorer image quality due to decreased tissue penetration. Digital imaging and good technicians can help minimize these issues.

Cross-sectional imaging modalities have special concerns related to patient size and weight. The tables required in these machines are finely calibrated and larger patients may "tweak" the table, resulting in decreased image quality. Additionally, a tube must be entered in order to obtain these images. CT scanners have traditionally been roomier, with apertures approximately 70 cm in diameter. MRI scanners, due to their magnets, are smaller, with standard machine diameters averaging around 60 cm. Obese patients may not fit into these confined spaces or may also have issues with claustrophobia. Due to these concerns standing, or "open", MRI has been developed. These machine diameters average about 70 cm, but also have reduced magnet sizes that may limit image quality. There are also some newer, traditional style MRI machines with table limits at or above 550 pounds with 70 cm diameter tubes. Unfortunately, availability of these machines may be limited[15].

Obesity and its commonly associated comorbidities alter the pre-operative medical evaluation necessary for surgical clearance. For instance, hypertension is a commonly present comorbidity which has been shown to lead to left ventricular hypertrophy. This may contribute to the development of ischemic cardiomyopathy and subsequent ventricular dysfunction. Furthermore, obesity increases the risk of arrhythmias likely through fatty and ischemic changes of the myocardium. Respiratory function may be altered as obese patients exhibit decreased chest wall compliance secondary to adiposity of the chest wall and abdomen. This results into a higher workload of breathing and a decreased functional residual capacity. Obese patients also have a high rate of obstructive sleep apnea. Other considerations include an increase in gastroesophageal reflux disease, fatty changes to the liver, endocrine and metabolic disturbances, including hypercholesterolemia and diabetes, and potential coagulopathies.

Table 1 Patient weight classification according to body mass index

Body mass index (kg/m^2)	Degree of obesity
Below 18.5	Underweight
18.5-24.9	Normal
25.0-29.9	Overweight
30.0-39.9	Obese
40.0 and above	Morbidly obese

Due to these factors the pre-operative evaluation require blood work that includes hemoglobin, electrolyte panel, liver function test, blood glucose level, and a clotting profile. A chest radiograph, pulmonary function tests, and electrocardiogram (ECG) are also recommended. If abnormalities are noted on the ECG further evaluation is likely needed, including an echocardiogram, cardiac stress test, and consultation with a cardiologist[16,17].

ANESTHESIA CONSIDERATIONS FOR SPINAL SURGERY IN OBESE AND MORBIDLY OBESE PATIENTS

Establishing intravenous access may be more difficult in an obese individual. Initial difficulties may be encountered with the administration of anesthesia. The decreased functional residual capacity of obese patients has important considerations for anesthesia. Patients with severely reduced functional residual capacity can develop premature airway closure and ventilation-perfusion mismatches, with resultant hypoxemia. During induction of anesthesia, these results into a shortened duration of nonhypoxic apnea, the period of time between paralysis and intubation before hypoxia occurs. Furthermore, large tongues and narrow airways, commonly seen in patients with obstructive sleep apnea, may make securing an airway more difficult, and fiber-optic intubation techniques may be necessary. Rapid induction of anesthesia is imperative in obese patients because of the high risk of aspiration. Esophageal reflux is common; 75% of obese patients have a high-volume, low-pH gastric residue that places them at risk for pneumonia. In severely obese patients, use of positive airway pressure during preoxygenation and induction may minimize hypoxia associated with the apneic phase of standard intubation. The increased adiposity provides a larger distribution area for certain anesthetic agents, which may make appropriate dosing more difficult[18].

CRITICAL CARE OF OBESE PATIENTS IN THE OPERATING ROOM

Due to higher rates of wound sepsis preoperative antibiotics is strongly recommended in obese patients. The current recommendations for the use of prophylactic antibiotics in spine surgery are: Cephalosporin (cefazolin 1-2 g; 2 g for patient weighing > 86 kg) and if B-lactam allergy, use clindamycin or vancomycin (dosing based on patient weight). It is recommended to start up to 60 min before incision, completed at the time of incision and re-dose antimicrobial intraoperatively every 4 h for prolonged procedure or significant blood loss. When using postoperative doses, discontinue within 24 h after wound closure as continuing of antibiotic prophylaxis longer than 24 h after wound closure has not proved to be beneficial; indeed, it may contribute to the development of antimicrobial resistance[19,20].

Patient positioning is more difficult, as many spine surgeries are performed prone. The degree of obesity plays a role, study showed that morbidly obese patients have longer surgical set up times[12]. Placement on the appropriate operative table is also crucial. Use of a closed frame table, such as a Wilson frame, may contribute to an increase in intra-abdominal pressures. This may cause elevation of the diaphragm, resulting in an increased intra-thoracic pressure, leading to a decrease in venous return[21]. This in turn can cause venous congestion, particularly along the epidural veins, and result in an increase blood loss. Due to these concerns it is often recommended to allow the abdomen to hang free using an open-frame table. Jackson spinal table (MIZUHO OSI, Union City, CA)® commonly used in spine surgery has a patient weight capacity of 500 lb (227 kg). A large abdominal pannus requires further modifications to allow for free passage of intra-operative fluoroscopy machines. Bariatric security straps are available that provide a comfortable hold of the pannus and accommodates up to 1000 lb (454 kg) patient (Figure 1)[22,23].

Peripheral nerve palsies have been noted in this population most likely secondary to increased pressure on contact points and difficulty with positioning[24]. Stretch injuries to the brachial plexus may occur with shoulder abduction more than 90°. Arm boards should be positioned to keep shoulder abduction less than 90° and this should be frequently checked by the anesthesia team during the surgical procedure. All bony prominence should all be carefully padded to avoid any pressure points.

Higher doses of radiation are also needed for adequate tissue penetration, thus exposing both the patient and the operative personnel to higher levels of radiation[25]. Larger patients require longer incisions, more extensive soft tissue dissection, and may present certain technical difficulties, such as obtaining the appropriate angles for pedicle screw placement[26]. Peng *et al*[27], evaluated different factors in obese and non-obese patients undergoing anterior lumbar surgery, concluding that obese patients required a longer duration of both exposure time and total surgical time. They also had longer incision lengths, as well as deeper skin to fascia and fascia to spine depths. Estimated blood loss, however, was not significantly different[27]. Rosen *et al*[28] noted no difference in the operative outcome between obese and non-obese patients that underwent minimally invasive spine surgery for lumbar fusion. This may be due to the tubular retraction system utilized in these procedures, which allows similar sized skin incisions in all patients[28]. Reducing operative times in spinal surgery is important, as longer times increase infection risk and the risk of blindness when the patient is prone,

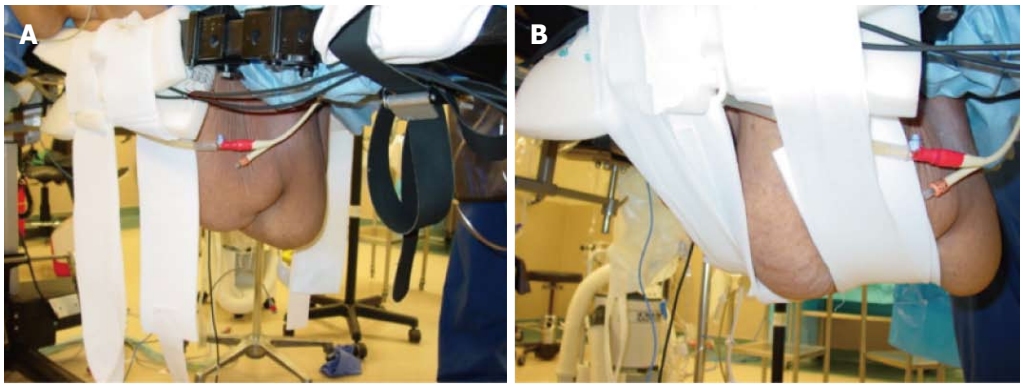

Figure 1 Patient in prone position on the Jackson spinal table. A: A large abdominal pannus will interfere with free passage of intra-operative fluoroscopy; B: Bariatric security straps are used to provide a comfortable hold of the pannus to the table. Foam is used to cover the metal edges of the table and protect the skin from pressure sores.

as this complication has been observed in long lasting surgeries[29,30].

OBESITY AND POST-OPERATIVE CARE AND COMPLICATIONS

The post-operative effects of obesity on surgical patients have remained controversial. Studies in general surgery patients indicated an increase in wound infections with open procedures, but no other differences[31]. Obese cardiac surgery patients were found to have an increased rate of superficial sternal and leg infections, as well as atrial dysrhythmias, but not in overall mortality[32]. Total hip and knee replacement patients have been found to have no difference in complications and post-operative course[33].

Post-operative pain and anesthesia will induce respiratory modifications which include atelectasis to due a restrictive syndrome and diaphragm dysfunction. This in turn can lead to hypoxemia and decreased pulmonary capacity. Jaber *et al*[34], stressed the importance of post-operative oxygenation using non-invasive ventilation in an effort to prevent acute respiratory failure. Several studies have shown that there is an increased mortality related to the complications of postoperative reintubation. Risk factors for such complication include COPD, age older than 60, ASA class of Ⅱ or greater, and obesity[34]. Therefore, post extubation it is of vital importance for adequate ventilation in the obese patients for optimizing surgical outcomes. A prospective study performed by Jaber *et al*[35] in 2005 showed that the use of non-invasive ventilation in patients with acute respiratory failure following extubation lowered the incidence of reintubation by 67%. Two methods of to avoid development of acute respiratory failure using non-invasive ventilation are positive end expiratory pressure and pressure support ventilation.

Post-operative pain control in obese patients also has its own specific challenges with a goal of decreasing the requirement for opioids to improve early rehabilitation and reduce the adverse effects of narcotics. With increased body fat, total body water, and plasma volume the pharmacokinetics of analgesics differs from that of those with ideal body weight diluting concentrations and therefore lowering the efficacy. Moreover, a study by Miscio *et al*[36] explored sensitivity to various noxious stimuli in obese subjects and compared those results to those with normal BMI of similar age. They discovered that obese non-diabetic subjects with a had a lower sensitivity to vibration, mechanical, and heat signals suggesting that obesity may affect the pain pathway and further complicate optimizing pain control[36]. Difficulty arises in the post-operative pain management due to the associated comorbidity of obstructive sleep apnea in obese patients and risk of respiratory depression with narcotics.

The development of deep venous thrombosis (DVT) is of particular concern in the post-operative period in this population, as both obesity and recent surgery are independent risk factors for DVT[37,38]. The post-operative spine patient, however, requires special consideration, as use of chemical prophylaxis in the acute post-operative period brings an increased risk of epidural hematoma and subsequent neurologic compression and deficits[39]. Due to this mechanical prophylaxis, such as compression stockings and sequential compression devices, is of the utmost importance. This should be started intra-operatively and continued throughout the post-operative hospital course. Proper fitting of such devices, however, may be difficult with an obese body habitus. Early ambulation is also important, with patients beginning to walk no later than post-operative day one.

The most frequently encountered complication in the obese spine patient is wound infection[40-42]. Other complications, however, have been noted more frequently in the obese. Patel *et al*[24] did find a correlation between BMI and a higher risk of major complications following elective thoracic and lumbar fusion procedures. Patients with a BMI of 25 were found to have a complication rate of 14%, while ones with a BMI of 30 were at 20%, and a BMI of 40 associated with a 36% rate[24]. Shamji *et al*[26] noted an increased transfusion requirement in thoracic and lumbar fusion patients, as well as an increase in the likelihood of discharge to an assisted living facility.

However, no differences were noted in length of stay, infection rates, or overall mortality[26]. Other studies have noted no difference in complication rates between obese and non-obese spine patients[43,44].

CONCLUSION

Obesity does not appear to be a contraindication for spinal surgery however it does pose a unique set of challenges in the perioperative time frame. It is important for the operative surgeon and anesthesia team to be aware of any special considerations that must be undertaken in preoperative evaluation, intraoperative and postoperative management. The potential for increased operative times, difficulties with anesthesia, operative positioning, higher blood loss, post-extubation complications, post-operative pain management, and increase in wound complications must be realized. However, it appears that with appropriate management of comorbidities and proper patient selection that spine surgery can be performed safely in obese patients.

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