Review Article

Regional anesthesia in obese patients: Challenges, considerations, and solutions

ABSTRACT

The increasing global prevalence of obesity has significant implications for anesthesiologists, particularly in the context of regional anesthesia. Anesthesiologists face numerous challenges during anesthesia in obese patients, including compromised respiratory function, altered pharmacokinetics of local anesthetics, and difficulties in identifying anatomical landmarks. Obesity often leads to reduced respiratory reserve, increased risk of hypoventilation, and conditions such as obstructive sleep apnea syndrome and obesity hypoventilation syndrome, which increase the likelihood of postoperative complications. Additionally, altered body composition in obese patients affects the distribution of local anesthetics, requiring adjustments in dosing based on lean body weight rather than total body weight. Furthermore, excess adipose tissue complicates the identification of anatomical landmarks and the use of ultrasound for regional block procedures, as the increased tissue depth and reduced image resolution hinder needle placement. Proper positioning, the use of low-frequency transducers, and harmonic imaging techniques are essential for optimizing ultrasound guidance. Additionally, the use of longer needles and the application of trigonometric calculations based on ultrasound scans can help determine the appropriate needle length. To overcome these challenges, anesthesiologists should adopt strategies that involve adjusting drug dosages, utilizing specialized equipment, and continuously monitoring patients for potential complications. A holistic approach involving knowledge of these technical and pathological challenges, as well as adapting techniques and equipment, is crucial for ensuring the safety and effectiveness of regional anesthesia in obese patients.

Key words: Obese, regional anesthesia, review, ultrasound

Introduction

The global prevalence of obesity has risen dramatically, reaching a concerning level. According to the World Health Organization, in 2022, 43% of adults were overweight and 16% were living with obesity.[1] This rising trend has significant consequences for individuals, families, healthcare systems, and the global economy. If the current trajectory continues, the economic impact of overweight and obesity is projected to reach US$3 trillion per year by 2030 and exceed US$18 trillion by 2060.[2]

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Obesity has profound effects on multiple organ systems, leading to significant health complications. It impairs the respiratory system by increasing the risk of conditions such as obstructive sleep apnea syndrome (OSAS) and reduced lung function. In the circulatory system, obesity contributes to hypertension, atherosclerosis, and an increased risk of heart disease and stroke. Metabolically, it is a major factor in the development of type 2 diabetes, insulin resistance, and fatty liver disease. Beyond physical health, obesity is also strongly linked to psychological conditions such as depression, anxiety, and low self-esteem, which can further impact overall well-being and quality of life.

These challenges pose significant difficulties for anesthesiologists. While treating patients with severe obesity was once rare in clinical practice, the rising prevalence of obesity has made it a routine occurrence. The increasing number of obese individuals has led to a corresponding rise in the number of patients requiring surgical interventions, further emphasizing the need for specialized anesthetic considerations.

In this framework, it is important to point out that regional anesthesia offers several advantages for obese patients, including reduced systemic opioid requirements and avoidance of airway manipulation[3] and international guidelines suggest that regional anesthesia should be offered to obese patients, especially if they are suffering from the obstructive sleep apnea syndrome.[4] However, the administration of regional anesthesia in this population is fraught with challenges originating from both technical and pathological factors. Understanding these difficulties and implementing effective strategies to overcome them is crucial for anesthesiologists.

The aim of this narrative review article is to explore and discuss the potential difficulties encountered when performing regional anesthesia in patients with obesity, providing insights into best practices and strategies to optimize patient care.

Definitions

Clinicians typically use body mass index (BMI) with a threshold of 30 kg/m^2 to define clinical obesity and a threshold of 40 kg/m^2 to define morbid obesity. In this review we will also use this threshold, however, we would like to highlight to readers that BMI has several limitations and can sometimes lead to misdiagnosis, particularly in athletes with high muscle or bone mass relative to fat. Therefore, clinicians should not rely solely on BMI but should consider alternative measures, such as waist circumference or body fat percentage, which may provide a more accurate assessment of excess adiposity and obesity-related health risks.[5] Moreover, when discussing obese patients, we will refer to ideal body weight (IBW) and lean body weight (LBW). The most commonly used formulas for calculating these are provided in Table 1 for reference.

Sedation and respiratory complications

Challenge: Obesity is associated with decreased respiratory reserve and increased risk of hypoventilation and hypoxemia during sedation for regional anesthesia.

Overview: One of the many health risks associated with obesity is its impact on respiratory function. In particular, obesity is related to decreased respiratory reserve and an increased risk of hypoventilation and hypoxemia, especially during sedation.[6] These respiratory complications arise due to various physiological changes induced by obesity that affect the respiratory system.

The first key factor in understanding how obesity impairs respiratory function is the effect of excess body fat on the chest wall and diaphragm. In obese individuals, excess fat accumulates not only around the abdomen but also within the thoracic cavity, leading to increased pressure on the diaphragm. This pressure reduces the functional capacity of the lungs, impairing the ability to expand the lungs fully

Table 1: Common formula used for Ideal Body Weight and Lean Body Weight

Formula	Men	Women
Ideal Body Weight		
Broca	(Height - 100)	(Height - 104)
Lorenz	(Height - 100) - [(Height - 150)/4]	(Height - 100) - [(Height - 150)/2]
Devine	50+0.9 × (Height - 152.4)	45.5+0.9 × (Height - 152.4)
Robinson	52+0.75 × (Height - 152.4)	49+0.67 × (Height - 152.4)
Miller	56.2+1.41 × (Height - 152.4)	53.1+1.36 × (Height - 152.4)
Lean Body Mass		
Boer	(0.407×weight) + (0.267×height) - 19.2	(0.252×weight) + (0.473×height) - 48.3
James	(1.1×weight) - (128 × (weight^2/height^2))	(1.07×weight) - (148 × (weight^2/height^2))
Hume	(0.32810×weight) + (0.33929×height) - 29.5336	(0.29569×weight in kg) + (0.41813 × height in cm) - 43.2933

Height in cm, weight in kg

during inspiration. The result is a reduced tidal volume, which diminishes the respiratory reserve.[7] This limited reserve is critical during sedation, where respiratory drive and control are often compromised due to the depressant effects of anesthetic agents.

Moreover, compared to the general population obese patients have physiological alterations associated with higher BMI, including OSAS and obesity hypoventilation syndrome (OHS). OSAS is particularly prevalent among patients with a BMI greater than 35, with an estimated incidence of approximately 20%.[8] These patients are more likely to experience postoperative complications such as desaturation, respiratory failure, and cardiovascular events.[9,10]

OHS, on the other hand, is defined by the presence of a BMI greater than 30 kg/m², daytime hypercapnia, and sleep-disordered breathing, after excluding other causes of alveolar hypoventilation.[11] This syndrome results from multiple physiological changes in obese patients, including a reduced functional residual capacity and a marked decrease in expiratory reserve volume due to excess adipose tissue[12] and ventilation/perfusion mismatches caused by premature airway closure.[13] Additionally, these patients are known to have a blunted central respiratory drive that contributes to impaired responses to both hypercapnia and hypoxemia.[14,15]

In clinical settings, especially when sedation is administered, it is essential to recognize these risks in obese patients. Regional anesthesia typically allows for the preservation of consciousness and airway reflexes. However, when sedation is added, these reflexes can be suppressed, leading to a higher likelihood of respiratory complications. Continuous monitoring of respiratory parameters, such as oxygen saturation, end-tidal CO2 levels, and respiratory rate, is crucial to identify and mitigate risks early.[16]

Preventive measures can be taken to reduce the likelihood of hypoventilation and hypoxemia in obese patients undergoing sedation for regional anesthesia. These include ensuring proper airway management, providing supplemental oxygen, and employing techniques to optimize ventilation, such as positive pressure ventilation if necessary. Furthermore, patient positioning should not be underestimated. Utilizing the "ramp position," which involves tilting the bed and using pillows to elevate the head and shoulders, aligns the external acoustic meatus with the sternal notch. This approach enhances lung compliance, increases functional residual capacity, and ultimately improves ventilation.[17] Additionally, using lower doses of sedatives and adjusting them to ideal body weight or lean body weight[18] and closely monitoring the patient's respiratory status (respiratory rate, end-tidal CO2, and peripheral oxygen saturation) can help minimize the risk of complications.

Possible Solution: Minimize sedation levels to reduce respiratory depression. Position the patient to optimize lung mechanics, such as elevating the head of the bed. Monitor both oxygen saturation and carbon-dioxide end-tidal continuously providing supplemental oxygen as needed.

Pharmacokinetics of local anesthetics

Challenge: Obesity is associated with altered pharmacokinetics of local anesthetics.

Overview: It is important to acknowledge that patients affected by obesity have different pharmacokinetic profiles than normal-weight individuals. To understand these differences it is important to focus the attention on the difference in the body composition in these patients. In the normal-weight individual, the total body weight (TBW) comprises 15–20% fat weight (FW) and 80–85% LBW, or fat-free mass. The LBW includes itself three compartments: the active cellular mass (mostly intracellular water), which represents approximately 55% of the TBW, the extracellular water, which constitutes 25% of the TBW, and the minerals which accounts for less than 5% of the TBW.[19] However, obesity is characterized by excessive fat accumulation, which alters body composition. While TBW increases with excess weight, the distribution among different compartments changes, with LBW accounting for only about 20–40% of the excess weight,[20] and it has been demonstrated an inverse linear relationship between TBW and the percentage of excess body mass in both non-obese and obese individuals with varying degrees of obesity.[21] Obviously LBW/TBW ratio is not influenced only by obesity but even by other factors such age and ethnicity contributing to an important interindividual variability, complicating body composition assessment in obesity.[22]

The volume of distribution of LAs in these patients varies depending on their lipophilic/hydrophilic profile. More lipophilic LAs can distribute throughout the entire fat mass (FM), while more hydrophilic LAs primarily distribute within the LBW. It is important to note that standard local anesthetics contain both hydrophilic and hydrophobic moieties, separated by an intermediate ester or amide linkage. The overall hydrophilic or lipophilic nature of a substance (expressed by the partition coefficient)[23] depends on which moiety predominates. Considering that there are no studies or guidelines to define what are the maximum safe doses for local anesthetics in extremely obese patient[24] as a safety standard, the maximum allowable dose of LAs in obese patients should always be calculated based on LBW, particularly for LAs with a lower partition coefficient, such as chloroprocaine and mepivacaine.[25]

However there are other key factors to consider on the overall distribution and pharmacokinetics of local anesthetics in these patients, obese patients have higher cardiac output, total blood volume and severe changes in regional blood flow, all of them contributing to alteration of peak plasma concentration, clearance and elimination half-life of administered drugs.[26] As last consideration, anesthesiologists should be particularly cautious while performing fascial plane blocks; in fact, while pharmacokinetics of these regional technique are underexplored especially in the obese population, data suggest that they are characterized by a rapid adsorption with a relatively high peak concentration, increasing the risk for local anesthetic toxicity.[27-29] Due to these complexities, a universal dosing formula is difficult to establish, and the lowest effective dose should always be used.

Possible solution: Adjust LA dosages based on lean body weight rather than total body weight. Monitor the patient closely for signs of toxicity or inadequate anesthesia, and be prepared to titrate doses accordingly.

Anatomical and ultrasound landmarks

Challenge: Excess adipose tissue can obscure anatomical landmarks, making it difficult to identify needle insertion sites for regional blocks.

Overview: Performing regional anesthesia in obese patients presents greater technical challenges compared to individuals with normal body weight.[30] While these difficulties were evident in the landmark-based era, they have become even more pronounced in the ultrasound-guided era.[31] The primary challenges stem from the increased depth of target structures and the degradation of ultrasound image quality due to excessive adipose tissue. The greater distance between the skin surface and neural or vascular structures complicates needle placement, while the resolution of ultrasound images deteriorates as the thickness of overlying fat increases. Ultrasound waves are estimated to be attenuated at a rate of approximately 0.63 dB per centimeter of fat,[32] leading to reduced visibility of ultrasound anatomical landmarks and target structures.

To overcome these technical difficulties and obtain high-quality ultrasound images, several strategies can be employed.[33] First and foremost, proper patient positioning plays a crucial role in the success of regional anesthesia. The use of a positioning pad to better expose the target area can help reduce the depth required to reach the intended site while improving accessibility for the block procedure, such positioning pads should be placed under the guidance of both anesthesiologist and patient in order to facilitate the work of the first one while ensuring the optimal comfort of the second one.[34] Second, using a low-frequency transducer (1.5–2 MHz) enhances ultrasound penetration, improving visualization of deeper structures. Applying firm pressure with the transducer helps compress adipose tissue, effectively reducing the depth that ultrasound waves need to penetrate. Proper transducer placement, ensuring the shortest possible distance to the target structure, can also significantly enhance image clarity. Additionally, the quality of ultrasound machines and transducers varies among manufacturers, and in some cases, switching to a different machine may yield better results. The use of harmonic imaging[35] has also been reported to improve image quality in obese patients by enhancing the signal-to-noise ratio, contrast, and spatial resolution. This technique relies on detecting signals generated by soft tissue reverberation, making it particularly beneficial for individuals with increased adipose tissue.

Possible solution: Utilize additional personnel and specialized equipment, such as positioning devices and padding, to assist in achieving and maintaining the desired position. Ensure clear communication with the patient to enhance cooperation and comfort. Utilize low-frequency transducers to penetrate deeper tissues and adjust machine settings to optimize image quality.

Proper equipment

Challenge: Standard needles and equipment may be inadequate for obese patients due to increased tissue depth.

Overview: Performing RA in obese patients is more challenging than in individuals with normal weight, as evidenced by a higher failure rate.[36] Therefore, optimizing equipment before starting the procedure is crucial.

Although attempts have been made to develop formulas for predicting the depth of target nerves,[37] estimating the required needle length remains challenging. The needle's entry point significantly influences the total subcutaneous trajectory, potentially increasing the distance to the target.[38]

For this reason, conducting a preliminary ultrasound scan is essential to identify both anatomical targets and the optimal needle entry point. With these two key pieces of information,

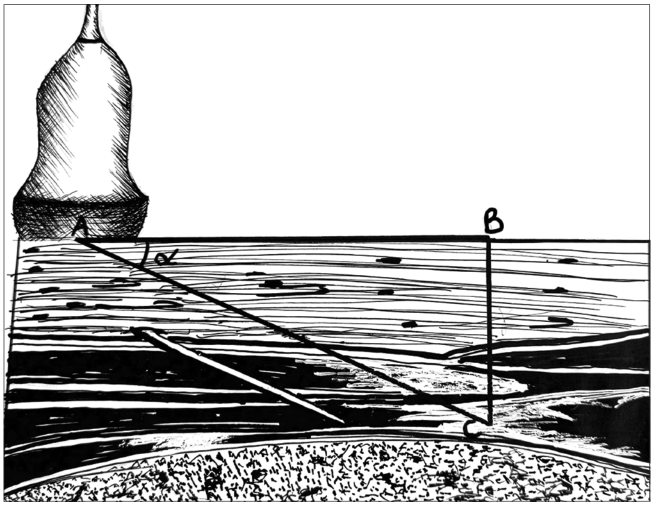

Figure 1: Trigonometric calculation used to estimate the length of the needle path. A represents the needle entrance point, B is the point on the skin directly perpendicular to the target, and C is the target point. BC denotes the depth of the target, while AC indicates the length of the needle path. Hand-drawn by Veronica Busetto

trigonometric calculations can be used to accurately predict the necessary needle length.[39] The needle's path can be considered the hypotenuse of a right triangle, where the vertical distance from the target to the skin represents one side, and the horizontal distance from this projection to the needle entry point represents the other. The minimum required needle length can be determined using the formula: Needle Length = Depth/sin (α) where α is the needle's entry angle [Figure 1].

Possible solution: Use longer needles specifically designed for obese patients to ensure adequate reach to target structures. Ensure availability of a range of equipment sizes to accommodate varying patient anatomies.

Conclusion

Administering regional anesthesia in obese patients presents unique technical and pathological challenges. By understanding these difficulties and implementing targeted strategies, anesthesiologists can enhance the safety and effectiveness of regional anesthesia in this growing patient population. Continuous education and adaptation of techniques are essential to meet the evolving needs of obese patients undergoing regional anesthesia.

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Conflicts of interest

There are no conflicts of interest.

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