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Derleme / *Review*

Regional Anesthesia in Adult Patients with Obesity

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ABSTRACT

Obesity is one of the important public health concerns, and described as abnormal accumulation of fat. It is associated with cardiopulmonary physiological alterations and a number of comorbidities (obstructive sleep apnea, metabolic syndrome, coronary artery disease…). Not only surgical and anesthetic managements of obese patients are challenging but also their perioperative morbidity and mortality rates are higher. We, as anesthesiologists, face these patients at an increasing rate with time. Since we prefer regional anesthesia techniques to general anesthesia in appropriate surgery types; we would avoid airway manipulations, opioid consumption and surgery-related stress responses. Regional anesthesia techniques are attractive options; however, they have unique challenges such as requirement for special equipment, crucial positioning, multiple attempts at redirecting needle/catheter, difficulty in palpation of anatomical landmarks, and increased rate of failed blocks in patients with obesity. Ultrasound-guidance provides us visualization of anatomical structures, decreased rates of needle insertions, and orientations , procedural trauma, side effects/complications and increased rates of block success. This review focuses on the obesity-related comorbidities; possible problems occur during the performance of neuroaxial, upper extremity, lower extremity, thoracic and abdominal wall block techniques performed on obese patients; literature supported suggestions and the role of ultrasound to manage these situations.

Keywords: *Obesity, body mass index, regional anesthesia, neuroaxial anesthesia, peripheral nerve blocks*

ÖZ

Obezite önemli halk sağlığı sorunlarından biridir ve anormal yağ birikimi olarak tarif edilmektedir. Kardiopulmoner fizyolojik değişiklikler ve çok sayıda yandaş hastalık (obstrüktif uyku apnesi, metabolik sendrom, koroner arter hastalığı…) ile ilişkilidir. Obez hastaların hem cerrahi ile anestezi yönetimleri zor hem de perioperatif morbidite ile mortalite oranları yüksektir. Anestezistler olarak bizler, bu hastalar ile zaman geçtikçe daha yüksek oranlarda karşılaşmaktayız. Uygun cerrahi tiplerinde, rejyonal anestezi tekniklerini genel anesteziye tercih ettiğimiz için hava yolu manipulasyonlarından, opioid tüketiminden ve cerrahiye bağlı stres yanıtlardan kaçınabilmekteyiz. Rejyonal anestezi teknikleri cazip seçeneklerdir; ancak onların da özellikle obezitesi olan hastalarda, özel ekipman ihtiyacı, zor pozisyonlama, zor anatomik işaret nokta palpasyonu, çok sayıda iğne/kateter yönlendirme ihtiyacı ve artmış oranda başarısız blok gibi kendilerine has problemleri mevcuttur. Ultrasonografi-rehberliği; anatomik yapıların görüntülenmesini, iğne giriş, yönlendirme, işlemsel travma, yan etki/komplikasyon oranlarının düşmesini ve blok başarısının artmasını sağlamaktadır. Bu derleme; obezite ilişkili yandaş hastalıklar, obez hastalarda nöroaksiyel, üst ekstremite, alt ekstremite, torasik ve abdominal blok teknik uygulamaları sırasında ortaya çıkan olası problemler, bu durumları yönetmede literatürde yer alan öneriler ve ultrasonografinin rolü üzerinde yoğunlaşmıştır.

Anahtar kelimeler: *Obezite, vücut kitle indeksi, rejyonal anestezi, nöroaksiyel anestezi, periferik sinir blokları*

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INTRODUCTION

Obesity is one of the important public health concerns of our generation and described as abnormal/excessive accumulation of fat that causes a number of diseases. A simple measure of obesity is the internationally accepted body mass index (BMI) calculated by dividing a person's weight by the square of his/her height (kg m^{-2}).

The World Health Organization (WHO) and the United States National Institutes of Health (NIH) have categorized obesity on the basis of BMI, relevant to comorbid conditions and mortality risk [1]. Mild obesity (overweight) is defined as a BMI of 25-29.9 kg m^{-2} and obesity as BMI ≥30 kg m^{-2}. Obesity can be divided into different levels of severity. Moderate obesity is defined as BMI between 30 and 34.9 kg m^{-2}, severe obesity as 35 and 40 kg m^{-2}, and lastly extreme (very severe/morbid) obesity as BMI≥40 kg m^{-2}. Women with a waist (abdominal) circumference of >88 cm and men with >102 cm are at an increased health risk [2].

In the United States, the prevalence of crude obesity has been reported as 39.8% among adults in a 2015-2016 study [3]. According to the "Turkey Nutrition and Health Investigation", the prevalence of overall obesity in Turkey was 30.3%, while it was 41% in women and 20.5% in men as of the year 2010 [4].

In the United States, between the years 1999-2000 and 2015-2016, trends in the prevalence of obesity increased among adults from 30.5% to 39.6% [3,5]. In another former study performed in Europe, although there was a great variability within and between the countries, the prevalence of obesity raised about 10-40% throughout the ten years [6].

Overall, these rates show significantly increasing trend in obesity throughout the world, which as expected, strongly correlates with perioperative morbidity and mortality rates. Comorbidities of obesity such as obstructive sleep apnea (OSA) and metabolic syndrome can increase the likelihood of pulmonary, cardiac and other complications. Therefore; surgical and anesthetic procedures in obese patients and parturients become a lot more challenging. We, anesthesiologists face these patients, their obesity-related comorbidities, poorer surgical outcomes and prolonged recovery times at an increasing rate. As we avoid general anesthesia (GA) and related airway manipulation; opioid consumption, side effects and surgical stress responses may all reduce. Regional anesthesia (RA) techniques are attractive options for these individuals. Major advantages are loss of sensation without impairing consciousness and central control of vital functions. The American Society of Anesthesiologists (ASA) has also published practice guidelines supporting the use of peripheral nerve blocks (PNBs) whenever appropriate for the patients with obesity-related complications [7]. However; obesity has its unique challenges specific to RA technique due to requirement of special equipment, more difficult positioning and palpation of anatomical landmarks, increased rate of failed blocks (1.6 times more likely), side effects and complications [8]. Moreover; if RA becomes inadequate during surgery, the necessity of induction of GA and an establishment of an airway may be more problematic relative to the presence of ideal conditions. At this point, ultrasonographic guidance (US) may help the RA practitioner by easing the procedures, increasing the success rates, decreasing the rates of procedural trauma and side effect/complication rates thanks to direct visualization of anatomic structures and orientation of needle in obese patients similar to the others [9-11].

This review focuses on the obesity-related comorbidities, possible problems occurring during the performance of different RA techniques, literature-supported suggestions and the role of US to avoid and/or manage these situations.

CLINICAL MANIFESTATIONS

Obesity is related with various diseases such as diabetes mellitus (DM) type 2, hypertension, coronary artery disease (CAD), OSA, cholelithiasis and degenerative joint disease (osteoarthritis). Even in the absence of obvious coexisting diseases, it leads to development of physiological alterations.

Respiratory Considerations

Oxygen demand, CO_2 production, and alveolar ventilation are all elevated proportional to the increased

body weight and metabolic rate. Lung compliance may remain normal; however chest wall compliance decreases because of excessive adipose tissue, and work of breathing increases. Increased abdominal mass pushes the diaphragm cephalad and lung volumes decrease even in the sitting position which are also aggravated by the supine and Trendelenburg positions [12]. Especially; expiratory reserve volume (ERV) may decrease, and subsequently functional residual capacity (FRC) may fall below closing capacity with increasing BMI, proportional to the change in the overweight and the severity of obesity. Some of the alveoli close during normal tidal volume ventilation and ventilation/perfusion mismatch can occur because of the presence of the shunts. Obese patients usually have higher respiratory rates, lower tidal volumes, and also hypoxemia, but only a few have hypercapnia.

The pathophysiology related to obesity such as OSA put these patients at higher risk for perioperative complications. These individuals are usually presented by daytime somnolence, and suffer from loud snoring with apneic pauses because of upper airway obstruction during sleep. Awake persistent hypoxia, hypercapnia, elevated HCO_3^-, restrictive lung disease, cyanosis-induced polycythemia, blunted central respiratory drive, pulmonary hypertension and cor pulmonale as a result of pulmonary blood flow elevation and arterial vasoconstriction, right-sided heart failure and left ventricular hypertrophy due to hypertension are other signs and consequences of OSA.

Hypertension, hypoxia, arrhythmias, myocardial infarction, pulmonary edema, stroke, and death are possible frightening perioperative complications of these patients. Therefore; it is very important for anesthesiologists to obtain the anamnesis and to examine the patients correctly and completely. In these patients; when GA is considered, the possibility of aspiration due to hiatal hernia, delayed gastric emptying, gastroesophageal reflux, difficult ventilation, intubation and possible upper airway collapsibility during recovery should all be predicted. When RA is considered, higher volumes of local anesthetics (LA) injected during certain neuroaxial blocks or PNBs may further impair the respiratory functions. During interscalene (IBPB) and supraclavicular brachial plexus (SBPB) block procedures, LA may block the phrenic nerve leading to temporary paralysis of the ipsilateral hemidiaphragm [13-15]. The low volume US-guided IBPB may cause fewer respiratory complications compared to standard volume technique, while providing similar postoperative analgesia [16]. In obese patients undergoing spinal anesthesia; BMI-dependent decrease in lung function that persisted into the recovery period, even longer than the motor block, was observed [17]. In obese parturients, Cesarean section under spinal anesthesia is also associated with similar changes in lung function [18]. Ideally, sedatives including opioids should be minimized or avoided in all obese subjects, as respiratory depression is more pronounced in those with OSA. Benzodiazepines cause central apnea in couple of minutes after decreasing upper airway muscle activity. Therefore; if obese patients are very anxious and require premedication, small doses of midazolam and opioids under continued monitoring should be preferred [7]. In order to improve their respiratory function, noninvasive positive pressure (NIPP) ventilation can also be used intra- and postoperatively.

Cardiovascular Considerations

Besides OSA-related cardiac function pathologies, obesity may also lead to other cardiac changes such as increased blood volume, cardiac output and workload. These changes affect early pharmacokinetics, distribution kinetics, and dilution of the drugs. Hence, the distributed drug fraction to the brain decreases, the redistribution rate increases and peak concentrations diminish.

Hypertension is the most significant comorbidity of obese patients. The increased cardiac output, DM type 2, metabolic syndrome and physical inactivity contribute to systolic and diastolic dysfunction even in otherwise healthy obese people. Moreover; these systolic and diastolic dysfunctions may eventually progress to left and/or right heart failures. Therefore; the combination of extreme obesity with hypertension and DM is associated with a 2-fold increased risk of adverse cardiac events and death in the perioperative period [19].

There is evidence that epidural analgesia can decrease both the pulmonary and cardiovascular morbidity/mortality rates in high-risk obese patients

undergoing major thoracic and abdominal surgeries, and these potential RA benefits are particularly important for the morbidly obese patients with decreased cardiopulmonary reserve [20].

Effect of Obesity on Local Anesthetic Pharmacology

Obesity is associated with an increase in tissue mass, change in body composition and tissue perfusion. Although fat mass and lean body mass both increase, their rates of increase are not proportional. The different ratios of lean body weight to fat weight at different BMIs lead to expressive effects on drug distribution. At high BMIs, perfusion of adipose tissue is poorly achieved.

The increased cardiac output of the obese individuals decreases the fraction of drug distribution to the brain, increases the rate of redistribution and may cause lower peak concentrations. On the other hand; in obese patients with normal cardiac function, cardiac output is correlated to the lean body weight more than all other variables. Additionally; clearance, the most relevant pharmacokinetic parameter for maintenance dosing, is also linearly related to the lean body weight. Consequently; cardiac output and lean body weight seem to be more appropriate dosing scalars than other dosing probabilities [21]. Especially; lean body weight is used not only for determining loading doses, but also for doses of maintenance and infusion.

Local anesthetics may lead to adverse effects such as nerve injury and the local anesthetic systemic toxicity (LAST) affecting both central nervous (CNS) and cardiovascular (CVS) systems. Fortunately, there is no evidence supporting that these effects occur more often in obese patients. Studies that specifically investigate the effect of obesity on LAs are unavailable. As a result, the optimal dosing scalar for the administration of LAs in obesity is not clear.

NEURAXIAL ANESTHESIA

Firstly; the anesthesiologist must decide whether to perform GA or RA. If the decision favours RA and neuraxial anesthesia; the anesthesiologist should consider the level, duration and benefits/risks of the surgery in order to decide for the appropriate technique (epidural, spinal and combined spinal epidural (CSE)).

Epidural Anesthesia/Analgesia

The incidence of complications related to epidural anesthesia technique increases with increasing BMI.

Difficulty in Placement

In obese patients, since midline anatomical landmarks (spinous processes) are deeper (the depth from the skin to the epidural space: 3 cm at BMI=20 kg m^{-2} and >8 cm at BMI >40 kg m^{-2}), they are difficult to be identified and palpated. Butcher et al. [22] found that only 52% of the obese women are able to identify the midline of their back correctly (within 5 mm) compared to 84% of nonobese women. Additionally, interlaminar and interspinous spaces are narrowed due to degenerative diseases with hypertrophy of the facet joints and ossification of the interspinous ligaments. Therefore, epidural placement performance times are longer in morbidly obese patients [23,24].

If midline approach is not successful, a paramedian approach is always an option in these individuals. However; during the application of a paramedian technique, there is no tactile clue until the needle reaches the ligamentum flavum. The increased accidental dural puncture and needle/catheter tip displacement risks should be kept in mind.

In obese parturients, overall epidural difficulty and failure rates are 3% and 4.3%, respectively. Rates of epidural technical difficulty increase 2.5- and failure 2.1-fold compared to nonobese patients [25]. In another study, the risk of difficult epidural placement and epidural failure increased at least 2-fold compared to the nonobese parturients, and this risk also rises with increasing BMI [26]. Tonidandel et al. [23] reported that compared with 3% of nonobese pregnant women, 17% of morbidly obese pregnant women required replacement of an epidural catheter due to inadequate analgesia or bilateral dermatomal sensory blockade.

Ultrasound is quite useful to identify the midline, intervertebral space, and depth from the skin to the

epidural space. Although the US visualization of the spinous processes and the ligamentum flavum is impaired by excessive fat tissue, they were reported to be "good" in 70% and 63% of the interventions, respectively [27].

Inadvertent Dural Puncture and Postdural Puncture Headache

In nonobese parturients, the incidence of inadvertent dural puncture as a complication of epidural insertion is 0.16-1.3%, while it is 4% in obese women [28]. Fortunately, the incidence of postdural puncture headache, its characteristics and the requirement of epidural blood patch as a treatment do not differ in obese and nonobese obstetric patients [29].

Accidental Vascular Puncture

Accidental epidural venous puncture is observed more frequently in obese (17%) compared to nonobese patients (3%), because of a higher incidence of multiple puncture attempts [30].

Catheter Migration

Hamilton et al. [31] demonstrated that epidural catheters are displaced significantly with reference to the skin in all patients with high BMIs as the patients change position. Although catheters were secured before position changes, they were mostly been pulled partly out of the epidural spaces. Hence; the authors recommended inserting multiorificed catheters at least 4 cm into the epidural space before securing the catheter to the skin.

Hypotension

In the morbidly obese parturients at term; the epidural space is narrower and its pressure is higher because of enlarged epidural venous plexus. Following an epidural injection; obese parturients more frequently experience hypotension attacks, generally with decline in diastolic blood pressure due to decreased systemic vascular resistance, and need greater amounts of phenylephrine. This situation leads to changes in uterine blood flow, and higher incidence of both new-onset late and prolonged decelerations [32]. On the other hand; hypotension and fetal heart rate changes are mainly observed as a result of aortocaval obstruction, and obese women may require greater intravenous fluid volumes as their blood volume and cardiac output can be higher than parturients with normal BMIs.

Selection of Local Anesthetic Dose

Hodgkinson and Hussain [33] demonstrated that the increase in cephalad spread and level of anesthesia is correlated with the increasing BMI. Furthermore; in another study, Panni et al. [34] showed that LA requirements in a labor epidural anesthesia are reduced by a factor of 1.68 with high initial block levels in obese parturients when compared to nonobese. They also speculated that if epidural analgesic requirement decrease is not taken into consideration, labors of obese patients might lead a more difficult course.

Spinal Anesthesia

Spinal anesthesia may technically be more challenging in obese patients due to the difficulty of directing the thin spinal needle through the thick adipose tissue.

Difficulty in Placement

It is clear that the required time to perform spinal anesthesia is increased in morbid obese patients. In obese parturients; prepuncture US-guidance can help to reduce the number of puncture attempts both at the same and different levels, shorten the total procedure time, improve the block placement success rate at the first attempt, and can also contribute to the patient satisfaction [35,36].

Hypotension

In comparison to nonobese parturients; parturients with BMI≥25 kg m^{-2}, who receive the same LA dose to undergo Cesarean section, have higher risk for hypotension and require higher doses of vasopressors after spinal anesthesia [37].

Selection of Local Anesthetic Dose and Inadvertent High Spinal Block

Obesity-associated increased intraabdominal pressure pushes fat and other tissues into the intervertebral foramen and leads to reduction in cerebrospinal fluid (CSF) volume. Then; because injected LA cannot be diluted by decreased CSF volume, more extensive/higher spinal blocks may occur [38].

The dosing of LA and other adjuvant medications for spinal anesthesia in obese patients is controversial. Most of the practitioners reduce the doses of intratechal agents to avoid high neuraxial blocks in these subjects. Nevertheless; in this situation, spinal anesthesia itself was found to be related to higher failure rates due to insufficient dosing and/or inadequate anesthesia duration. In their dose-ranging study; Carvalho et al. [39] showed that obese and nonobese patients respond similarly to the single shot spinal bupivacaine injections applied for Cesarean delivery, and they did not suggest administering low dose bupivacaine (<10 mg) to the parturients with morbid obesity. Moreover, they mentioned that the risk of high spinal anesthesia in obese patients may not be as great as thought before, and suggested the same dose as administered to the nonobese patients.

Since obese patients have shown variable responses to intrathecal dosing; continuous spinal, epidural or CSE anesthesia techniques can also be ideal alternatives.

Acidosis

In a study of 5742 parturients who received spinal anesthesia, the body weight was demonstrated to be negatively correlated with umbilical cord pH [40]. For each 10-unit increment in BMI, the base deficit increased by 0.26 mmol L^{-1} and the umbilical cord pH reduced by 0.01. Subjects with BMI<25 kg m^{-2} had a mean umbilical cord pH of 7.24, while the others with BMI≥40 kg m^{-2} had 7.22.

The negative correlation between BMI and Apgar score/umbilical cord pH were all investigated. The prolonged incision to delivery time and the inability to achieve adequate pelvic tilt to relieve aortocaval compression were thought to be the possible reasons. Vena cava compression and decreased venous return may affect cardiac output, and subsequently decreased uterine blood flow may have an impact on umbilical cord pH.

Combined Spinal Epidural Anesthesia

Some clinicians prefer using a CSE anesthesia technique over a single shot intratechal approach in morbidly obese patients. Because epidural needles are more rigid, they do not really deviate during placement and serve as long introducers for the spinal needles. The availability of an epidural catheter during a prolonged surgery or an inadequate spinal anesthesia is an additional benefit for the delivery of supplemental anesthesia and/or analgesia.

In an observational study including 314 CSEs and 2 lumbar epidurals, factors regarding difficult neuraxial blockade were investigated. Technical difficulties of performing blocks were generally relative to high BMI and weight, and as these frequently lead to poor palpation of interspinous spaces, the needle insertion attempts were often problematic [41].

PERIPHERAL NERVE BLOCKS

At present, PNBs have been a highly favorable analgesic and anesthetic options.

Upper Extremity Blocks

A former study which used either paresthesia or nerve stimulation (NS) to identify the brachial plexus showed that BMI had no impact on IBPB success rates [42]. In their study, Gebhard et al. [43] analyzed anesthetic records of 1858 patients who received SBPB with paresthesia technique. Body mass index was again found not to be associated with block success.

Nerve stimulation-guided axillary brachial plexus blocks (ABPB) have been reported to be successful in 91% of obese and 98% of nonobese patients. Additional blocks at the elbow were required in 7% of and 2% of obese and nonobese patients, respectively. Accidental vascular punctures were more often (27% vs 9%) and patient satisfaction was lower (87% vs 94%) in the obese [44]. Conversely, in a study inclu-

ding 1468 brachial plexus blocks performed at the humeral canal, the patients' physical characteristics were not associated with the failure rate [45]. Franco et al. [46] also reported that their NS-guided SBPB experience in 2020 patients resulted in a slight reduction in success rate (97.3% in nonobese vs 94.3% in obese) without a significant complication. However; in their study, they also mentioned the increased difficulty in block placement related to obesity that residents were able to achieve 80% of the SBPBs in nonobese patients compared to 73% in obese.

On the other hand; recently Uppal et al. [47] completed a US-guided ABPB study comparing obese (n:105) and nonobese (n:144) patients in two Canadian centres. The median times to achieve successful ABPBs were 25 and 20 minutes in obese and nonobese patients, respectively. The ABPB failure rate was 33.7% in obese compared to 17.8% in nonobese, with a difference of 15.9% in failure rates. Although sensory and motor failure rates were higher as per the composite score, ABPB provided adequate surgical anesthesia for more patients and conversion to GA was required in 8.6% of obese and 7% of nonobese patients. These results demonstrated that obese patients have delayed onset time and higher ABPB failure rate despite US-guidance.

Beh and Hasan [48] published their successful US-guided infraclavicular brachial plexus block (costoclavicular approach) experience in two morbidly obese patients, who scheduled for 2nd stage transposition of basilica vein fistula. Ropivacaine 0.5% 20 mL for costoclavicular block and 10 mL for local infiltration of medial aspect of the arm both provided successful block for surgeries lasting more than 2 hours.

Ultrasound-guided IBPB is a commonly, safely and effectively used technique for the postoperative analgesia of shoulder surgeries. Hence; in obese patients, performing the block may be more difficult and time consuming. Schwemmer et al. [49] claimed that US-guidance ensures efficient identification of the brachial plexus structures within the interscalene space of obese patients during the block, and renders similar results as in nonobese patients. Ultrasound also helps us to obtain effective IBPB by using low volumes, so the incidence of phrenic nerve paralysis is reduced and fewer respiratory complications occur compared to the standard-volume technique [13,16]. However; it should be kept in mind that IBPB was found to be associated with greater FVC and FEV1 reductions secondary to hemidiaphragmatic paresis in obese compared to normal-weight participants. Fortunately, anesthetic management is uneventful without clinical respiratory symptoms or events [50].

Lower Extremity Blocks

Obesity has been related to increased rates of postoperative poorer functional scores and range of motion because of mechanical effect of increased load, inadequate preoperative functioning, increased stiffness and walking difficulty. Therefore; obese patients may be the ones who may mostly benefit from lower extremity blocks that ensures easy mobilization, and ambulation without pain, but other abovementioned conflicting RA administration factors are also valid for lower extremity blocks.

Good US image of sciatic nerve at the anterior thigh was acquired in 17/18 obese subjects after internal rotation of the leg at 45°. In all of them, the nerve was successfully visualized and reached with only one needle attempt. Nerve stimulation-guided motor responses, such as foot plantar flexion and dorsiflexion, were successfully achieved with a threshold current <0.5mA in 100% of the cases after four attempts [51].

Ultrasound-guided lateral popliteal sciatic nerve blocks result in faster procedural performance, lesser pain during administration, and greater patient satisfaction while producing similar block effects in obese patients when compared with NS-guidance [52]. However; it was also shown in Woodworth et al.'s [53] study that BMI has variable effects on the relationship between the popliteal artery and the sciatic/tibial nerve in the popliteal fossa. Magnetic resonance imaging (MRI) scans were evaluated at 3 different measurement levels along the femur in order to understand the distance and the angle between the popliteal artery and the tibial/sciatic nerve if it had not bifurcated at the measurement point. At the distal femur/popliteal skin crease, the tibial nerve

was approximately 2.9 mm away from the popliteal artery. Though the nerve coursed consistently posterior to the artery; it was variably located medially or laterally. Since 0° was assumed to indicate a point directly posterior to the artery, the nerve was measured 10.0 and 16.1 mm, and 31° and 44° lateral to the popliteal artery at the 5 cm and 8 cm proximal measurement points, respectively. Again, at the 5 cm and 8 cm measurement points, increasing BMI was correlated with increasing distance between nerve, and artery.

Thoracic and Abdominal Wall Blocks

Data regarding the performance and the analgesic efficacy of truncal blocks in the obese are limited.

During the performance of landmark-technique intercostal blocks in obese patients; if the rib margin is not palpated, successful block might be difficult to achieve and pneumothorax may occur as an associated complication [54]. Considering this, Lu et al. [55] used disposable acupuncture needles with glass insertion tubes to locate the ribs, and then the regular 22-gauge block needles were inserted beside them to walk off the rib to inject LA. With this technique, insertions were less traumatic, pain-free and satisfactory in 20 grossly obese patients.

Twenty-six morbidly obese women who had undergone breast cancer surgery were included in a NS-guided paravertebral block (PVB) case series. The landmark confirmation was established in 61.5% of the patients at the initial attempt, the surgical PVB success was achieved in 76.9% of the cases with a failure rate of 11.5% [56].

When we take a look at the literature in terms of US-guided plane blocks in obese patients, the common experience is usually on case-based reports. Pectoral nerve (PECs) blocks I and II were both successfully applied to two superobese patients with limited cardiac reserve and used as the primary anesthetic method for implantable cardioverter defibrillator (ICD) placements [57]. Deep serratus anterior plane (SAP) block was chosen to provide less invasiveness and predictable drug spread (from T2 to T6) for the excellent anesthesia and analgesia of the entire breast of a morbidly obese patient. Further analgesic was not required for this patient during intraoperative and postoperative periods [58]. Rhomboid intercostal and subserratus plane (RISS) block was also used for the analgesic management of a morbidly obese patient with severe OSA, who had been scheduled for modified radical mastectomy and axillary curettage [59].

In their case series, Luis-Navarro et al. [60] reported their erector spinae plane (ESP) block experience with an obese patient (BMI=39.6 kg m^{-2}) scheduled for renal transplantation. During the performance of ESP block in the sitting position, US visualization of the transverse processes was not clear. Moreover; although LA was administered producing the fascial plane hydrodissection, the catheter could not be introduced. Technically simple rectus sheath block (RSBs) was successfully performed in another patient (BMI=89 kg m^{-2}) with obstructed ventral hernia [61]. The authors recommended this approach, which has a low risk of peritoneal puncture under direct visualization and can provide long-term pain relief. Regarding transversus abdominis plane (TAP) blocks in obese patients, it was claimed that the identification of the abdominal wall muscles could be difficult because of superimposed adipose tissue, needle positioning and US-visualization of LA spread could be challenging and RA failure may occur [8,62]. However; these theoretical problems are not clinically reflected in all studies. Andersen et al. [63] reported a systematic review that consisted of randomized trials related to the analgesic treatment in morbidly obese patients undergoing laparoscopic gastric bypass surgery, which resulted in improved analgesia after TAP block. Other studies have demonstrated similar benefits in obese and lean patients scheduled for laparoscopic colorectal surgery and Cesarean delivery [64,65]. For a morbid patient who refused both epidural and paravertebral blocks, Bugada et al. [66] chose to apply US-guided continuous subcostal TAP block following an upper abdominal surgery. They obtained satisfying opioid-sparing analgesia without any complication and presented TAP block as an effective alternative to epidural block. Several anesthesiologists believe that US-guidance allows identification of the abdominal wall layers even in obese patients, where anatomical landmarks are frequently obscured by the body habitus [67].

POSITIONING

Positioning has always been an important factor for several RA techniques regarding achievement of a successful block which is especially significant in obese patients because of the subdermal adipose tissue amount and the limited space for US probe placement. Abdominal shifting method in the semi-lateral position for quadratus lumborum block (QLB), and skin traction in the femoral region for the femoral nerve block placement and in the neck for the IBPB performance are all useful methods. A similar breast traction method and also taping the ipsilateral breast to the other side in morbidly obese patients during ABPB will also be appropriate in daily clinical practice.

CATHETER PLACEMENTS AND SITE INFECTIONS

Mariano and Brodsky [68] compared procedural times for US-guided perineural catheter insertion, procedure-related pain, vascular puncture, block efficacy, fluid leakage and catheter dislodgement rates in obese and nonobese patients by using data from five previously published studies. Under US-guidance, they found no difference considering the abovementioned parameters.

In another study, obesity was demonstrated to be an independent risk factor for catheter infections in PNBs but not for neuraxial blocks [69]. As adipose tissue is perfused poorly and subcutaneous tissue hypoxia occurs in obese people, the risk of wound infection increases with the decreased oxygen partial pressure. Therefore; not surprisingly, obesity is associated with an increased risk of catheter site infections.

LOCAL ANESTHETIC SYSTEMIC TOXICITY AND LIPID RESCUE THERAPY

When there is aroused suspicion of LA overdose, the recommendation is to apply 20% lipid emulsion (intralipid 20% solution) based on lean body weight and to comply with the routine LAST therapy. A dose of 1.5 mL kg^{-1} (lean body weight) lipid emulsion is delivered as a bolus over 1 minute followed by a continuous infusion of 0.25 mL kg^{-1} min^{-1}. After return of spontaneous circulation, infusion should be continued for at least 10 more minutes. If LAST presentation still continues, then the bolus dose can be repeated or the infusion dose can be doubled. Eventually, the total dose of both LA bolus and infusion should not exceed 12 mL kg^{-1} [70].

CONCLUSION

Currently; there have still been a few studies describing RA techniques, their probable challenges and consequences in obese patients. Regional anesthesia definitely helps us to avoid cardiopulmonary complications relative to GA in obese; however, it should be kept in mind that performing RAs in these subjects is technically more difficult and the failure rate is higher than normal-sized individuals. Ultrasound guidance provides imaging advantages and increases the probability of successful block performances where surface landmarks are difficult to either see or palpate. The benefit-to-risk balance and the decision to use an appropriate RA technique should be made carefully considering patients' physical status, comorbidities, surgical features and also anesthesiologists' experiences.

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