Journal of MedVerse Research & Practice

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Successful Implementation of the Epidural Volume Extension Technique in High-Risk Obstetric Patients: A Case Series

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Submission Date: 20.05.2024	Accepted Date: 15.06.2024	Published Date: 30.06.2024

Abstract

Epidural volume extension represents a highly advanced and intricate medical intervention, which necessitates the meticulous and precise delivery of a sterile saline solution that is isotonic and devoid of contaminants, into the epidural space immediately after an intrathecal injection, aiming to enhance the sensory block achieved throughout the anesthetic procedure significantly. This particular technique has been demonstrated to exhibit an extraordinary dose-sparing effect, thereby facilitating the maintenance of an adequate and effective level of both anesthesia and analgesia, while concurrently reducing the likelihood of any potential hemodynamic disturbances that could have a detrimental impact on the overall cardiovascular stability of the patient. This comprehensive case series aims to demonstrate the successful application of a novel approach in high-risk cardiac patients undergoing scheduled lower-segment cesarean section surgeries. Our report offers an in-depth analysis of the technique's implementation in this patient population.

Keywords: Epidural, Volume Extension Technique, High-Risk Obstetric Patients

Introduction

Anaesthesiologists face a multitude of significant and complex challenges when tasked with the management of caesarean sections, specifically for obstetric patients who present with underlying cardiac conditions that can adversely affect their cardiovascular stability and overall physiological response during such surgical interventions. These intricate clinical scenarios necessitate that the anaesthesiologist not only possess but also demonstrate a high level of proficiency and expertise in the application of regional anaesthesia techniques, which are paramount in ensuring optimal outcomes [1,2]. The anaesthesia method that is ultimately selected for use in these cases must be meticulously and thoughtfully designed to minimize hemodynamic fluctuations to the greatest extent possible, while simultaneously ensuring the utmost safety and well-being of both the mother and the fetus throughout the entire surgical procedure [3].

In the realm of contemporary anaesthesia practices, the combined spinal epidural (CSE) technique has garnered significant prominence and recognition for its numerous advantages and demonstrated efficacy across a variety of surgical contexts and settings [4,5]. This innovative technique provides not only a rapid onset of analgesia but also an extended duration of analgesic effects, thereby rendering it an optimal and highly effective choice for comprehensive perioperative management, which includes the

critical aspect of postoperative pain control aimed at enhancing patient comfort and facilitating a more expedient recovery process [6,7]. The refinement known as epidural volume extension (EVE) represents a further enhancement of the CSE technique, significantly augmenting its clinical utility and application in practice. This particular approach involves the precise and careful administration followed by the spinal administration of local anesthetics; a quantified amount of standard saline solution is then introduced into the epidural region, thus optimizing and prolonging the analgesic effect experienced by the patient [8,9]. The results demonstrate the effective application of this sophisticated method in treating high-risk pregnant patients, highlighting its advantages and effectiveness in practical clinical settings.

Brief description of cases

Case 1

A 24-year-old primigravida at 36 weeks' gestation was admitted to the obstetrics unit for prenatal care, presenting with a significant clinical complaint of experiencing dyspnea while at rest, which, upon further clinical examination, was found to be indicative of cardiac failure. A comprehensive two-dimensional echocardiogram was performed, which revealed the presence of cardiomyopathy characterized by biventricular systolic dysfunction and Grade I diastolic dysfunction, alongside a notably low ejection fraction of only 2%. Consequently, a definitive diagnosis of peripartum cardiomyopathy was established based on the findings. In response to this critical condition, the patient commenced treatment with oral furosemide and oral Methyldopa. A decision was made to schedule her for a planned cesarean delivery shortly.

Case 2

A 22-year-old primigravida presented to the obstetric department seeking options for safe delivery. The patient had a previous diagnosis of Type III Takayasu arteritis, a condition that had affected both her subclavian and renal arteries, resulting in complications. In addition to her primary condition, she was suffering from renovascular artery hypertension and dilated cardiomyopathy, both of which were secondary effects stemming from her underlying Takayasu arteritis diagnosis. To address the patient's complex medical needs, a structured treatment regimen was implemented, comprising oral nifedipine at a dosage of 10 mg once daily, oral digoxin at 0.25 mg once daily, oral levocarnitine at 500 mg once daily, and oral prednisolone at a daily dosage of 30 mg. A decision was made to proceed with an elective cesarean section as part of her planned obstetric care.

Case 3

A 28-year-old woman, who had been pregnant twice previously and was currently at 39 weeks of gestation, presented to the obstetric unit displaying clinical signs consistent with congestive heart failure accompanied by pulmonary edema, indicating a significant deterioration in her cardiovascular status. Following her admission, a two-dimensional echocardiogram was conducted, which provided critical insights revealing The patient was diagnosed with cardiomyopathy, evidenced by an ejection fraction of 43%, along with pulmonary artery hypertension. Given these significant medical issues, treatment was immediately initiated, consisting of oral Lasix and oral digoxin to address the symptoms of heart failure. Furthermore, a cardiac consultation was requested to evaluate her condition more thoroughly, and arrangements were made for her to undergo an elective cesarean section as part of her medical management plan.

Case 4

In the context of this clinical case, a 34-year-old female individual, who is currently experiencing her

inaugural pregnancy, was identified and subsequently diagnosed with Takayasu's arteritis type III, A medical issue severely impacting the blood vessels in her arms, chest, and kidneys, making her pregnancy care more challenging. In light of her medical condition, she proactively sought comprehensive prenatal care within the specialized obstetrics unit, with the primary objective of facilitating a safe and effective delivery process for both herself and her unborn child. The patient was diagnosed with severe renovascular and pulmonary artery hypertension, alongside dilated cardiomyopathy, all secondary complications of her Takayasu's arteritis. As part of a carefully structured therapeutic regimen designed to manage her complex condition, she was prescribed a daily oral dose of prednisolone at 30 mg, along with oral digoxin at 0.25 mg once daily, and oral nifedipine at 10 mg once daily. Following her clinical presentation and the recommendations of her healthcare team, A planned cesarean delivery was arranged for the patient to maximize the well-being of both the mother and the unborn child.

Case 5

A 28-year-old female patient, who has been diagnosed with the significant cardiovascular condition known as rheumatic heart disease (RHD), presented herself to the medical facility with a complex clinical picture featuring severe mitral stenosis, which is a narrowing of the mitral valve opening, as well as severe tricuspid regurgitation, wherein the tricuspid valve fails to close properly, and trivial mitral regurgitation, which, while minimal, still indicates some degree of backflow of blood, all of which were further complicated by the presence of moderate pulmonary artery hypertension, a condition characterized by elevated pressure in the pulmonary arteries that can lead to significant morbidity. Given the circumstances surrounding her obstetric condition, an elective cesarean delivery was planned for her due to issues stemming from cephalopelvic disproportion, where the size of the fetal head is too large to pass through the maternal pelvis, in conjunction with oligohydramnios, a condition defined by a deficiency of amniotic fluid. Upon reaching the six-month milestone of her gestation period, she began to manifest symptoms of breathlessness, prompting further investigation that ultimately led to a diagnosis of RHD and mitral stenosis, the latter of which was quantified by a notably reduced mitral valve area measuring merely 1 cm^2, indicating a significant impairment to normal blood flow. The findings from her electrocardiogram revealed the presence of sinus tachycardia, a condition characterized by an elevated heart rate originating from the sinoatrial node. To effectively manage her right heart failure, which was likely a consequence of the aforementioned cardiac conditions, the treatment plan for the patient included twice-daily injections of 20 mg furosemide and a single daily dose of 5 mg ivabradine, both of which are pharmacological agents aimed at alleviating her symptoms and improving her overall cardiac function.

Application of anesthesia

All patients underwent a meticulous and comprehensive evaluation, ensuring that each individual received aspiration prophylaxis to diminish any potential hazards associated with the procedure. Before their relocation to the operating room (OR), an intravenous administration of 1 mg of midazolam was provided to each patient to promote sedation and alleviate anxiety, thus improving their comfort levels. Upon their entry into the OR, critical monitoring devices were employed with electrocardiogram leads being methodically attached to each patient to facilitate continuous observation of vital parameters throughout the surgical operation. A wide-lumen peripheral intravenous line was carefully established to guarantee sufficient venous access, and patients received a preoperative bolus of 500 mL of crystalloids to sustain optimal hemodynamic stability during the procedure.

Adhering to sterile procedures, an epidural catheter (18 G) was placed at the L2-L3 vertebral space using a Tuohy needle (16 G). The loss of resistance to air method was employed, and the catheter was fixed at

4 cm. Subsequently, a spinal block was administered at the L3-L4 intervertebral space. This involved injecting 1 mL of hyperbaric ropivacaine (0.75%) combined with 25 µg of fentanyl into the subarachnoid space using a Whitacre needle (25 G) to provide effective pain relief.

For all obstetric procedures, a wedge was positioned beneath the right hip to ensure optimal maternal alignment. Five minutes after the subarachnoid block, 8 mL of normal saline was administered through the epidural catheter. To minimize patient discomfort, midazolam and local anesthetic were given before cannulating the right internal jugular vein. Throughout the operation, fluid management was guided by ongoing central venous and direct arterial pressure monitoring, allowing for accurate adjustments.

The dermatomal level of anesthesia was assessed at 3-, 5-, and 10-minutes post-epidural saline administration using the pin prick method. All patients maintained hemodynamic stability during surgery, due to the lower density of sympathetic blockade from this technique compared to classical subarachnoid blockade. After surgery, patients were quickly moved to the intensive care unit for overnight monitoring to promptly address any postoperative complications. Pain relief was maintained with a continuous epidural infusion of 0.2% ropivacaine at 4-6 mL/h to ensure optimal comfort during recovery.

Discussion

Epidural volume extension (EVE) combines the benefits of spinal and epidural anaesthesia, offering a valuable alternative to general anaesthesia, particularly in high-risk patients. This technique reduces the total dose of anaesthetic agents required and minimizes hemodynamic fluctuations, thereby decreasing cardiovascular risks. By avoiding cardio-depressant drugs and the stress associated with airway manipulation, EVE provides an effective regional anaesthesia option while preserving the advantages of both spinal and general anaesthesia [10,11].

EVE ensures rapid, intense, and reliable spinal anaesthesia, with the flexibility to adjust block intensity, prolong anaesthesia duration, and provide effective postoperative analgesia. In situations where spinal anaesthesia may fail, EVE mitigates cardiovascular risks arising from airway instrumentation and systemic anaesthetic agents. Subarachnoid block produces mild vasodilation, which is beneficial for patients with isolated left ventricular dysfunction. Additionally, EVE avoids the negative inotropic effects of anaesthetic drugs and the hemodynamic impact of positive pressure ventilation, thereby reducing perioperative complications compared to general anaesthesia [12,13].

For cardiac patients undergoing lower segment cesarean section (LSCS), both regional and general anaesthesia are viable. However, EVE was selected in this study for its capacity to reduce drug dosage while maintaining adequate anaesthesia and analgesia, minimizing blood flow disruption, and promoting faster recovery of motor function. This technique reliably extends anaesthesia duration when required and provides effective postoperative pain relief, making it preferable to general anaesthesia by avoiding airway manipulation and associated cardiovascular stress [14].

The underlying mechanism of EVE is thought to involve thecal compression caused by epidural saline injection, which enhances the spread of intrathecal drugs. Blumgart et al. [8] demonstrated that EVE produced superior analgesia compared to conventional spinal anaesthesia, attributing this to enhanced intrathecal drug distribution. Mardirosoff et al. [12] observed that EVE administered 5 minutes after intrathecal injection resulted in a significantly higher sensory block, whereas administration at 20 minutes post-injection showed no notable effect. This informed the decision to administer 8 ml of saline 5 minutes after the intrathecal dose. Lew et al. [14] reported faster motor recovery and shorter post-

anesthesia care unit duration with EVE in combined spinal-epidural procedures. Furthermore, Takiguchi et al. [11] confirmed, via myelography, the occurrence of thecal compression following EVE in healthy volunteers.

Overall, these findings support the use of EVE as a safe and effective anaesthetic technique, offering superior block quality, hemodynamic stability, and postoperative analgesia, especially in high-risk obstetric patients.

Conclusion

The EVE technique introduces a new method for surgical anesthesia, enabling effective use of lower local anesthetic doses. This method mitigates the typical adverse effects on blood pressure associated with standard dosages. Through meticulous management of fluid administration and tailoring of regional anesthesia to individual patient requirements, EVE offers a secure anesthetic option for high-risk cardiac patients undergoing lower-segment cesarean section (LSCS).

Financial support and sponsorship: Nil

Conflicts of interest: Nil

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