Section: Anaesthesiology

Original Research Article

A PROSPECTIVE STUDY TO ASSESS THE EFFICACY OF EPIDURAL SALINE EXPANSION IN COMBINED SPINAL-EPIDURAL ANESTHESIA FOR LOWER LIMB PROCEDURES UTILIZING LOW-DOSAGE INTRATHECAL HYPERBARIC BUPIVACAINE

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Abstract

Background: Combined spinal-epidural anaesthesia (CSE) is a popular method for caesarean section due to its rapid onset, fewer haemodynamic swings, and postoperative analgesia. Epidural volume extension (EVE) enhances CSE's effectiveness, especially in older patients with multiple medical conditions, and reduces adverse effects. This study aimed to assess the efficacy of using 10 ml of 0.9% saline to extend the epidural volume in conjunction with low-dose intrathecal hyperbaric bupivacaine to achieve satisfactory neuraxial blockade during lower limb orthopaedic operations. **Materials and Methods:** This prospective study included 100 individuals who underwent elective lower-limb orthopaedic procedures in the supine position at Govt. Kilpauk Medical College Hospital, and Govt. Royapettah Hospital for one year. Two groups of 50 patients each were included in this study. Group A received Combined Spinal Epidural Anaesthesia with Epidural Volume Extension of Saline (CSE + saline), whereas Group B received combined Spinal Epidural Anaesthesia alone (CSE standard dose). **Result:** In both groups, the majority of the participants (41-60 years old) were similar. The majority of the participants in both groups were male. In the CSE + Saline group, the average height was 161.4 cm, and the average weight was 64.85 kg. There was a significant difference in sensory loss at the 10th minute, two-segment regression time, time for maximum sensory block, and top-up dose of bupivacaine between the groups ($p < 0.001$). **Conclusion:** Our study indicated that a minimal dose of bupivacaine combined with fentanyl and normal saline results in rapid sensory and motor blockade, high sensory block, and shorter two-segment regression.

INTRODUCTION

Combined spinal-epidural anaesthesia for caesarean section was first reported in 1984, and has since become popular owing to its numerous advantages. Spinal anaesthesia provides a rapid onset of action with a limited duration, whereas epidural anaesthesia is more titratable and results in fewer haemodynamic swings. This method also provides postoperative analgesia. By combining these two techniques, the failure rates of both subarachnoid and extradural anaesthesia decrease when used alone.[1,2] Epidural volume extension (EVE) is an approach that improves the effectiveness of combined spinal epidural anaesthesia by injecting saline or a local anaesthetic through an epidural catheter. This method leverages the volume effect that occurs when saline is administered epidurally, resulting in intrathecal compression and upward movement of spinal anaesthetics.

EVE is particularly useful for older patients with multiple medical conditions who undergo lower-extremity orthopaedic surgery. In these situations, it is crucial to choose appropriate regional anaesthesia techniques that maintain a safe and adequate level of blockade while limiting extensive sympathectomy to ensure hemodynamic stability.[3] EVE is a regional anaesthesia technique that combines the benefits of spinal and epidural anaesthesia with a small amount of local anaesthetic, thereby reducing the risk of adverse effects associated with conventional doses. It eliminates the disadvantages of general anaesthesia in high-risk patients by avoiding the use of antidepressant drugs. Many orthopaedic surgery

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patients are middle-aged and elderly, and their response to surgery and anaesthesia can vary due to age-related decline in functional reserve, affecting multiple organ systems.[4]

Geriatric patients often have unpredictable responses to stress and illness owing to coexisting medical conditions. They may also exhibit alterations in respiratory mechanics, leading to impaired gas exchange efficiency. Structural changes in the upper and lower airways are also common. Cardiovascular and autonomic aging can result in unstable blood pressure and reduced contractility, as evidenced by lower ejection fractions. Geriatric patients may also present with diabetes mellitus, coronary artery disease, ischaemic cardiomyopathy, moderate left ventricular dysfunction, severe right ventricular dysfunction, or severe pulmonary artery hypertension, following trauma. These conditions are frequently referred to in orthopaedic departments.[5,6]

EVE is a technique that offers the benefits of both spinal and general anaesthesia without negative side effects. It provides the necessary level of anaesthesia and pain relief without compromising the patient's blood pressure and can be used as a backup if spinal anaesthesia fails. EVE is preferred over general anaesthesia because it eliminates the need for airway manipulation and the accompanying stress response, which could negatively impact cardiovascular health. This technique is particularly beneficial in patients with isolated left ventricular dysfunction. Combined with careful fluid management and close monitoring, the CSE technique using EVE is a highly effective and tailored approach to anaesthesia.[5,7-9]

This study aimed to assess the efficacy of using 10 ml of 0.9% saline to extend the epidural volume in conjunction with low-dose intrathecal hyperbaric bupivacaine to achieve satisfactory neuraxial blockade during lower limb orthopaedic operations.

MATERIALS AND METHODS

This prospective study was conducted on 100 individuals who were classified as ASA 1 and 2 and underwent elective lower-limb orthopaedic procedures in a supine position at Govt. Kilpauk Medical College Hospital, and Govt. Royapettah Hospital for one year. This study was approved by the Institutional Ethics Committee of Govt. Kilpauk Medical College and written informed consent were obtained from patients and relatives before study initiation.

Inclusion Criteria

Patients aged between 40 and 70 years, with heights ranging from 150 to 170 cm, weight between 40 and 75 kg, male and female, ASA of Anesthesiologists physical status 1 and 2, and patients undergoing elective lower limb orthopaedic surgeries in the supine position were included.

Exclusion Criteria

Patients with ASA physical status 3 and 4, those who refused regional anaesthesia, an increase in intracranial pressure, intrinsic or idiopathic coagulopathy, skin or soft tissue infection at the proposed site of needle insertion, severe hypovolaemia, pre-existing neurological diseases such as lower extremity peripheral neuropathy, emergency orthopaedic surgeries, orthopaedic surgeries not performed in the supine posture, surgeries lasting more than three hours, and patients with a known allergy to the study drugs were excluded.

Two groups of 50 patients each were included in this study. Group A received Combined Spinal Epidural Anaesthesia with Epidural Volume Extension of Saline (CSE + saline), whereas Group B received combined Spinal Epidural Anaesthesia alone (CSE standard dose).

Under strict aseptic precautions, the patient was positioned sitting for the CSE procedure at the L2-L3 or L3-L4 interspace. Intrathecal hyperbaric bupivacaine (10 mg, 2 ml of 0.5%) and fentanyl (25 µg, 0.5 ml) were administered for regional anaesthesia. A Tuohy needle (16 G or 18 G) was used for epidural insertion via the loss of resistance to the air technique. An 18 G or 20 G epidural catheter was inserted 4-6 cm into the epidural space and secured in a cephalad direction. After performing spinal anaesthesia using a Quincke's needle (25 G or 23 G) in a different interspace, 10 ml of sterile preservative-free 0.9% normal saline was injected into the epidural space five minutes later.

In the second group, patients were anaesthetised using a combination of spinal and epidural anaesthesia without extension of the epidural volume. They received the same doses of intrathecal hyperbaric bupivacaine and fentanyl. An effective dose was defined as one that resulted in a sensory block height of the T10 level within 20 minutes of intrathecal injection, without the need for epidural top-up. If hypotension (a decrease in systolic blood pressure of more than 20% from baseline) occurred, it was treated with a titrated intravenous bolus of ephedrine at a dose of 6 mg and intravenous fluids. Bradycardia (a decrease in heart rate > 25% from baseline) was treated with an intravenous bolus of atropine at a dose of 0.6 mg. If an ineffective blockade occurred during the study, surgery was subsequently performed with epidural top-up or conversion to general anaesthesia. After surgery, patients were observed for 48 h for complications such as postdural puncture headache, urinary retention, and infections. The epidural catheter was removed.

The following parameters were determined: sex, height, weight, Sensory Loss at the 10th minute, two-segment regression time, time for maximum sensory block, time for maximum motor block, and top-up dose of bupivacaine.

Statistical Analysis: The data were analysed using SPSS version 23. Descriptive statistics were computed for all data and reported as mean values and percentages. Continuous variables were analysed using the unpaired t-test, whereas categorical

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variables were analysed using the chi-square test and Fisher's exact test. Statistical significance was set at $p < 0.05$.

RESULTS

In both the CSE + Saline and Standard-dose groups, the majority of the participants (41-60 years old) were similar, with no participants aged 40 years or younger in the standard-dose group. The majority of participants in both groups were male, comprising 68% of the CSE + Saline group and 72% of the standard-dose group. Females accounted for 32% and 28% of the participants, respectively. In the CSE + Saline group, the average height was 161.4 cm, and the average weight was 64.85 kg. In the standard-dose group, the average height was slightly higher at 162.8 cm, and the average weight was 65.62 kg [Table 1].

In the CSE + Saline group, 66% of the participants experienced sensory loss at the T5 level, 30% at the T6 level, and 4% at the T8 level, while none reported sensory loss at the T10 level. Conversely, in the Standard-dose group, no participants experienced sensory loss at the T5 or T6 level, 16% reported sensory loss at the T8 level, and 84% experienced sensory loss at the T10 level ($p < 0.0001$).

The mean two-segment regression time for the CSE + Saline group was 69.24±3.92 minutes, while for the Standard-dose group, it was 56.18±4.12 minutes ($p < 0.0001$). The mean time for the maximum sensory block was 9.36±0.92 minutes for the CSE + Saline group and 12.14±1.66 minutes for the Standard-dose group ($p < 0.0001$).

The mean time for the maximum motor block was 3.92±0.68 minutes for the CSE + Saline group and 6.94±0.81 minutes for the Standard-dose group ($p < 0.0001$). Among the participants in the CSE + Saline group, 8% received a top-up dose of bupivacaine, while 92% did not. In contrast, in the standard-dose group, 64% received a top-up dose and 36% did not ($p < 0.0001$) [Table 2].

Table 1: Demographic data of the study

		CSE + Saline	Standard-dose
Age (years)	≤ 40	2 (4%)	0
	41-50	21 (42%)	22 (44%)
	51-60	19 (38%)	20 (40%)
	61-70	8 (16%)	8 (16%)
Sex	Male	34 (68%)	36 (72%)
	Female	16 (32%)	14 (28%)
Height		161.4	162.8
Weight		64.85	65.62

Table 2: Comparison of parameters between groups

		CSE + Saline	Standard-dose	P value
Sensory Loss at the 10th Minute	T5 Level	33 (66%)	0	< 0.0001
	T6 Level	15 (30%)	0	
	T8 Level	2 (4%)	8 (16%)	
	T10 Level	0	42 (84%)	
Two-Segment Regression Time		69.24 3.92	56.18 4.12	< 0.0001
Time for Maximum Sensory Block		9.36 0.92	12.14 1.66	< 0.0001
Time for Maximum Motor Block		3.92 0.68	6.94 0.81	< 0.0001
Top up Dose of Bupivacaine	Yes	4 (8%)	32 (64%)	< 0.0001
	No	46 (92%)	18 (36%)	

DISCUSSION

The present study assessed the efficacy of epidural volume extension in achieving adequate neuraxial blockade through low-dose intrathecal hyperbaric bupivacaine (10 mg) by increasing the epidural volume by 10 ml of 0.9% normal saline administered 5 minutes post-block. Epidural saline administration frequently fails when delayed for > 10 min, as evidenced by Mardirosoff et al. Their study indicated that to achieve effective epidural volume extension, the patient must be placed in a supine position within 5 min of completing the intrathecal injection.[10]

In our study, in both the CSE + Saline and Standard-dose groups, the majority of the participants (41-60 years old) were similar. The majority of the participants in both groups were male. In the CSE + Saline group, the average height was 161.4 cm, and the average weight was 64.85 kg. In the CSE + Saline group, 66% of the participants experienced sensory loss at the T5 level, 30% at the T6 level, and 4% at the T8 level, while none reported sensory loss at the T10 level. Conversely, in the Standard-dose group, no participants experienced sensory loss at the T5 or T6 level, 16% reported sensory loss at the T8 level, and 84% experienced sensory loss at the T10 level ($p < 0.0001$). The use of spinal and epidural anaesthesia in conjunction with epidural volume extension using normal saline has demonstrated a more rapid, pronounced, and effective sensory block than the use of combined spinal epidural anaesthesia alone. This was evidenced by the significantly higher incidence of sensory loss achieved at the 10th minute, extending up to the T5 dermatome.

The mean two-segment regression time for the CSE + Saline group was 69.24±3.92 minutes, while for the Standard-dose group, it was 56.18±4.12 minutes ($p < 0.0001$). The mean time for the maximum sensory

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block was 9.36±0.92 minutes for the CSE + Saline group and 12.14±1.66 minutes for the Standard-dose group ($p < 0.0001$). The use of spinal and epidural anaesthesia, in conjunction with epidural volume expansion through the use of normal saline, has been demonstrated to result in more effective and shorter sensory blocks. This approach also leads to extended and efficient anaesthesia by significantly reducing the time required to achieve the maximum sensory block and increasing the time it takes for the two segments of the block to regress.[11]

Similarly, Bhatia et al. conducted a study that investigated the impact of varying epidural saline volumes (10, 15, and 20 ml) on the level of sensory block during combined spinal epidural anaesthesia. The study concluded that there was a discernible increase in the sensory and motor levels of the dermatomal segments in all patients, which was dependent on the volume of epidural saline administered.[12] Previous research has also been conducted by Tyagi et al., Manouchehrian et al., Guha et al., and Sng et al. in which intrathecal hyperbaric bupivacaine and extradural administration of local anaesthetics were utilised to attain a higher sensory block level.[13-16]

In our study, the mean time for the maximum motor block was 3.92±0.68 minutes for the CSE + Saline group and 6.94±0.81 minutes for the Standard-dose group ($p < 0.0001$). Studies were conducted by Bhati et al., Jain et al., and Preethi et al. to investigate the effects of intrathecal isobaric bupivacaine and extradural supplementation of local anaesthetic on achieving a higher sensory blockade.[17-19] Siddiqui et al. reported that intrathecal dexmedetomidine in combination with hyperbaric bupivacaine resulted in an earlier onset and a more prolonged duration of sensory and motor blocks in lower limb surgeries than magnesium sulfate.[20]

In our study, among the participants in the CSE + Saline group, 8% received a top-up dose of bupivacaine, whereas 92% did not. In contrast, in the standard-dose group, 64% received a top-up dose and 36% did not ($p < 0.0001$). The combination of spinal epidural with epidural volume extension with normal saline provides effective and shorter block time, prolongs analgesia, and requires a lower top-up dose of bupivacaine.

CONCLUSION

Our findings suggest that a minimal dose of intrathecal hyperbaric bupivacaine (10 mg) combined with 25 µg of fentanyl and epidural volume extension (10 ml of normal saline) leads to a prompt onset of both sensory and motor blockade, a high degree of sensory block, and a shorter period for two-segment regression.

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