Epidural Volume Extension with Saline in Combined Spinal–Epidural Anesthesia for Hip Surgeries Using Low Dose of Intrathecal Hyperbaric Bupivacaine

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Abstract

Background and Aims: The aim of the study was to evaluate the effectiveness of epidural volume extension (EVE) technique in terms of sensory and motor block characteristics along with hemodynamic parameters as a part of combined spinal–epidural anesthesia (CSEA).

Materials and Methods: A total of 60 patients undergoing hip surgeries were assigned to one of the two groups containing 30 patients each. Group I (the CSE–EVE group) patients were anesthetized using CSE with EVE and Group II (the CSE group) patients were anesthetized using CSE without EVE, using the same technique and low dose of intrathecal hyperbaric bupivacaine. Sensory block characteristics were recorded using pinprick method, whereas motor blockade was assessed by modified Bromage scale. Results: There was a statistically significant difference between the two groups regarding the level of maximum sensory block ($P < 0.001$), as Group I showed sensory block level extending to up to T4, whereas in Group II, it was limited to below T6. Time required for maximum sensory blockade was faster in Group I, ranging from 7 to 12 min (mean ± standard deviation [SD]: 9.83 ± 1.72), whereas in Group II, it ranged from 9 to 15 min (mean ± SD: 12.33 ± 1.83; $P < 0.001$). Two-segment regression was faster in Group II, ranging from 50 to 70 min (mean ± SD: 60.0 ± 6.30), whereas in Group I, it ranged from 80 to 105 min (mean ± SD: 89.67 ± 8.19; $P < 0.001$). The time required to reach the maximum motor block was faster in Group I, ranging from 2 to 4 min (mean ± SD: 2.67 ± 0.84), whereas in Group II, the time ranged from 2 to 6 min (mean ± SD: 3.50 ± 1.31; $P < 0.001$). Conclusion: CSEA with EVE is associated with early onset of sensory and motor blockade, high level of sensory block, and longer time of two-segment regression while maintaining hemodynamic stability due to decreased dose of intrathecal local anesthetic.

Keywords: Combined spinal–epidural anesthesia, epidural volume extension, intrathecal injection, low-dose hyperbaric bupivacaine, normal saline

INTRODUCTION

Combined spinal–epidural anesthesia (CSEA) is a regional anesthetic technique that has become increasingly popular over the past few decades. It has gained popularity as a preferred technique for cesarean sections and orthopedic surgeries mainly hip surgeries due to its rapid onset through the spinal component and extension of anesthesia and postoperative pain relief through epidural component while avoiding the disadvantages of both.[1] The use of epidural or spinal anesthesia during major hip surgery has been linked to a reduced risk of perioperative complications such as deep-venous thrombosis, less deterioration of cerebral and pulmonary functions in patients who are at a higher risk for complications, decreased blood loss, early ambulation, and a higher patient satisfaction.[2] Moreover, only a single prick is required in the needle through needle type of CSE technique hence causing lesser trauma to the patient. The epidural volume extension (EVE) technique is a modification of CSE in which the onset and level of block obtained by subarachnoid block are increased by a small volume of saline or local anesthetic administered through the epidural catheter soon after the intrathecal dose as a part of CSEA, thereby increasing its safety.

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With this background, we planned this study to evaluate the effectiveness of EVE technique in CSEA in terms of the level of maximum sensory block, time to reach maximum sensory block (min), two-segment regression time of sensory block (min), and time to reach maximum motor block (min), which is the primary outcome of our study. The total dose of bupivacaine top-up doses in milliliters given through epidural catheter in case of ineffective doses for spinal anesthesia and requirements of atropine and mephentermine were considered the secondary outcome of our study.

Materials and Methods

The present study was conducted in the Department of Anaesthesiology, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University, Dehradun, after approval from Institutional Ethical Committee (SRHU/HIMS/ETHICS/2017/130). Ours was an interventional study. Sixty patients of either sex aged between 20 and 60 years, The American Society of Anesthesiologists (ASA) physical status Class I and II posted for hip surgery were included in the study. Considering the sampling frame to be all the patients coming for hip surgeries, every second patient was assigned to one group. The rest of the sample formed another group. Patients were divided into two groups, and we took 30 patients per group for our study who came to our institute over a 12-month period: Group I (the CSE–EVE group) and Group II (the CSE group). Patients who refused for regional anesthesia; with ASA physical status 3 and 4; age <20 years and >60 years; having major hepatic, renal, or cardiovascular system dysfunction; having known allergy to drug; having local sepsis at the site of proposed injection; having spinal deformity or unstable spinal fracture; and having raised intracranial pressure, coagulopathy, preexisting neurologic disease, severe hypovolemia, and fixed cardiac output states were excluded from the study. Patients were explained in detail about the anesthetic technique during preanesthetic evaluation, and a written and informed consent was taken. Diagnostic workup included random blood sugar, complete hemogram, coagulation profile, renal profile, electrocardiogram (ECG), and spine examination. Patients were kept nil per oral 6 h before surgery. On the day of surgery, after establishing an intravenous access, all patients were preloaded with 500 ml of crystalloid. Patients were monitored for noninvasive blood pressure, heart rate (HR), ECG, and oxygen saturation. Group I (the CSE–EVE group): thirty patients were anesthetized using CSE with EVE. All patients received CSE in the sitting position with an 18-G Tuohy needle at L3–L4 interspace using the loss of resistance technique to air. A 27-G pencil-point spinal needle was then introduced through the Tuohy needle into the subarachnoid space. After confirming the free flow of cerebrospinal fluid (CSF), 2 ml (10 mg) hyperbaric bupivacaine was injected over 20 s. An epidural catheter was then inserted into the epidural space after removing the spinal needle, and the patient was made to lie down in the supine position followed by immediate injection of 10 ml sterile preservative-free 0.9% normal saline into the epidural space through the catheter within 5 min of performing the block.

Group II (the CSE group): thirty patients were anesthetized using CSE without EVE using the same technique and the same dose of intrathecal hyperbaric bupivacaine.

An effective dose was the one that resulted in a sensory block height of T10 level within 15 min of the intrathecal injection with no epidural top-up requirements within this 15 min. All ineffective doses were managed by administering epidural top-ups of 10 ml plain bupivacaine (0.5%) and excluded from our study. Postoperative pain was managed through the indwelling epidural catheter. Age (years), height (cm), weight (kg), sex, and duration of operation from skin incision to skin closure (min) were recorded. Systolic blood pressure (SBP) in mmHg and HR in beats/min were recorded after performing spinal anesthesia every 5 min for 15 min then every 15 min for 1 h. Level of the maximum sensory block, time to reach maximum sensory block (min), and two-segment regression time of sensory block (min) (by pinprick method) were recorded. Time to reach maximum motor block (min) (Bromage 3), (using modified Bromage scale: 0 = able to move hip, knee, and ankle; 1 = unable to move hip, able to move knee and ankle; 2 = unable to move hip and knee, able to move ankle; and 3 = unable to move hip, knee, and ankle) was also recorded. The total dose of bupivacaine top-up doses in milliliters given through epidural catheter and requirements of injection atropine and mephentermine were also recorded.

Statistical analysis

Statistical testing was conducted with the Statistical Package for the Social Science System version SPSS 17.0 (Inc., Chicago, IL, USA). Continuous variables are presented as mean ± standard deviation (SD), and categorical variables are presented as absolute numbers and percentage. The comparison of normally distributed continuous variables between the groups was performed using Student’s t-test. Nominal categorical data between the groups were compared using Chi-square test or Fisher’s exact test as appropriate. P < 0.05 was considered statistically significant and P < 0.001 was considered highly significant.

Results

A total of 60 patients completed this study. There was no statistically significant difference between the two groups regarding the age, height, weight, sex, and duration of operation.

Regarding the level of maximum sensory block, in Group I, all patients showed sensory block level extending to T4–T6 whereas in Group II, the sensory level in all patients was limited below T6. Comparing between the two groups, there was a statistically significant difference regarding the level of maximum sensory block (P < 0.001) [Table 1].

Regarding the time to reach maximum sensory block, it was faster in Group I ranging from 7 to 12 min (mean ± SD: 9.3 ± 0.9 min) when compared to Group II (12–17 min; mean ± SD: 14.2 ± 0.9 min), which is statistically different with P < 0.001.

With the same methodology, the time taken to reach maximum motor block was also shorter in Group I (10–12 min; mean ± SD: 11.2 ± 1.0 min) compared to Group II (11–15 min; mean ± SD: 13.8 ± 0.8 min), which was also a statistically significant difference (P < 0.001).

The two-segment regression time of sensory block was also faster in Group I (7–10 min; mean ± SD: 8.5 ± 0.9 min) compared to Group II (9–11 min; mean ± SD: 9.8 ± 0.9 min), which was also a statistically significant difference (P < 0.001).

Postoperative pain was managed through the indwelling epidural catheter and requirements of atropine and mephentermine were also recorded.
9.83 ± 1.72), whereas in Group II, it ranged from 9 to 15 min (mean ± SD: 12.33 ± 1.83); hence, there was a statistically significant difference between the two groups (P < 0.001). Regarding two-segment regression time of sensory block, it was faster in Group II ranging from 50 to 70 min (mean ± SD: 60.0 ± 6.30), whereas in Group I, it ranged from 80 to 105 min (mean ± SD: 89.67 ± 8.19); hence, there was a statistically significant difference between the two groups (P < 0.001).

Regarding motor block, the time required to reach the maximum block (Bromage 3) was faster in Group I ranging from 2 to 4 min (mean ± SD: 2.67 ± 0.84) compared with Group II in which it ranged from 2 to 6 min (mean ± SD: 3.50 ± 1.31); hence, there was a statistically significant difference between the two groups (P < 0.001) [Table 2].

Regarding the hemodynamic status, in all, 15 patients showed episodes of hypotension (eight in Group I and seven in Group II), which represented 25% of all patients who were treated by intravenous boluses of mephentermine (6 mg/12 mg) and intravenous fluid and it was statistically not significant. There was no significant difference in mean SBP, diastolic blood pressure (DBP), mean arterial pressure, HR, and SpO₂ across various stages between the two groups after performing CSEA.

Regarding the requirement for epidural activation by top-up doses of bupivacaine, 10 ml bupivacaine 0.5% was injected by epidural catheter in 21 patients (70%) in Group II, whereas only eight patients (26.67%) in Group I required the activation of epidural anesthesia. Hence, there was a statistically significant difference between the two groups (P = 0.001).

**DISCUSSION**

The effect of EVE with saline in the enhancement of spinal block includes the volume effect in which the theca is compressed by injected epidural saline, resulting in squeezing of CSF and more cephalic spread of subarachnoid local anesthetic. Injected saline extends the block height by a mechanical volume effect (time-dependent effect) and increases the regression time, thereby providing a longer duration of block with a smaller dose of hyperbaric bupivacaine given in subarachnoid space that may result in better hemodynamic stability and a early motor recovery. Our study evaluated the effectiveness of EVE in CSE to perform adequate neuraxial block by low dose of intrathecal hyperbaric bupivacaine (10 mg) through EVE by 10 ml 0.9% normal saline that was injected within 5 min after performing the block.

Pertaining to demographic data (age, height, weight, sex, and duration of operation) which were not statistically significant between the two groups in our study, similar observations were made by Okasha et al. and Agarwal et al. Regarding the block profile, supporting the results of our study, Salman et al. and Lew et al. concluded that the group with EVE was associated with early onset of motor and sensory block, high level of sensory block, and longer time of two-segment regression while maintaining hemodynamic stability.

Kaur et al. demonstrated a benefit in using EVE with 10 ml normal saline, as a part of a CSE technique by providing a more rapid motor recovery of the lower limbs after elective cesarean section. However, in our study, we did not evaluated the time of motor recovery. The possible factors that may affect the results of EVE are time from intrathecal to epidural injection, volume of epidural injectate used for EVE, intrathecal drug baricity, and patient’s position.

Contrary to our study results, Loubert et al. and Beale et al. have reported that EVE failed to increase the level of sensory block.

Supporting the results of our study, Blumgart et al. injected bupivacaine 0.5% w/v 10 ml and saline 0.9% w/v 10 ml epidurally, 5 min after intrathecal injection, and showed a similar increase in sensory block height of four dermatomal segments compared with the control group. In another study, Takiguchi et al. demonstrated clinical and myelographic extension of sensory block with 5 and 10 ml saline 0.9% w/v injected epidurally following intrathecal block in CSEA.

The limitations of the present study were as follows: time of motor recovery was not assessed which would have been ideal to pick out smaller details. Second, ultrasound was not used for the confirmation of epidural space during the application of epidural block.

**Table 1:** Comparison of level of maximum sensory block in between the two groups

| Level of maximum sensory block | Frequency (%) | P |
|-------------------------------|---------------|---|
|                               | Group I (n=30) | Group II (n=30) |
| T4-T6                         | 30 (100.0)     | 0             | <0.001* |
| Below T6                      | 0              | 30 (100.0)    |
| Total                         | 30 (100)       | 30 (100)      |

Chi-square test, χ²=0.001, *Highly significant

**Table 2:** Comparison of time of maximum sensory block, two-segment regression, and time for maximum motor block in between the two groups

|                          | Group I (n=30) | Group II (n=30) | P     |
|--------------------------|----------------|-----------------|-------|
| Time to reach maximum sensory block (min) | 9.83±1.72      | 12.33±1.83      | <0.001* |
| Two-segment regression time of sensory block (min) by pin prick method | 89.67±8.19     | 60.0±6.30       | <0.001* |
| Time to reach maximum motor block (min) | 2.67±0.84      | 3.50±1.31       | <0.001* |

Student’s t-test, t=0.001, *Highly significant. SD=Standard deviation
Conclusion
We conclude that low-dose intrathecal hyperbaric bupivacaine with EVE is associated with early onset and high level of sensory blockade, longer two-segment regression time, and early onset of motor blockade while maintaining hemodynamic stability due to decreased requirement of intrathecal drug. For all the advantages listed, this technique of CSEA with EVE may also find its use in gynecological, urological, and various surgical procedures of longer duration and requiring a block height of T4–T6 while using a lower dose of intrathecal drug apart from lower limb orthopedic surgeries.

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Conflicts of interest
There are no conflicts of interest.

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