

Minimum effective volume of normal saline for epidural volume extension

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Abstract

Background: Rescue strategies like changes in tilt of table are used to raise the level of an inadequate sensory block following intrathecal injection. Epidural volume extension (EVE) refers to an injection of normal saline through epidural catheter following an intrathecal block. It results in a rapid increase in the sensory level of subarachnoid block. Thus, it has been postulated that EVE may be used as a rescue strategy for an inadequate post-spinal sensory block. However, the minimum effective volume (MEV) of normal saline for EVE induced increase in level of spinal block has not been researched till date. We proposed to determine the MEV of normal saline required for EVE induced increase in post-spinal block sensory level.

Materials and Methods: This prospective sequential allocation study was conducted in consenting adult males after institutional ethical committee approval scheduled for lower limb surgery under combined spinal epidural (CSE) anesthesia, who had an inadequate level of sensory block. Herein, an inadequate level was defined as lower than T_{10} at 10 min after the intrathecal injection, with no ascent for two consecutive readings taken 2 min apart. The EVE was performed with normal saline injected through epidural catheter, and was considered successful if the level of sensory block increased by two or more dermatomal segments within 5 min of the injection. The volume of normal saline for EVE was decided by using the up-and-down method, with the first patient receiving 10 mL and a dosing interval of 1 mL in subsequent patients. The analysis was done using the formula of Dixon and Massey, which enabled calculation of the MEV with 95% CI. Quantitative parametric data is represented as mean \pm SD and nonparametric data as median (range).

Results and Conclusion: The MEV of normal saline to raise the level of sensory block by two or more dermatomal segments within 5 min of EVE is 7.4 mL (95% CI: 5.5-9.9 mL).

Key words: Central neuraxial blockade, combined spinal epidural block, epidural volume extension, minimum effective volume, normal saline

Introduction

Rescue strategies such as change in patient position by tilting the head end of the table are used to raise the level of an inadequate post-spinal sensory block.^[1] Epidural volume extension (EVE) refers to injection of normal saline into epidural space closely after a subarachnoid block,^[2,3] aiming to rapidly increase the sensory block level resulting from intrathecal injection. Thus EVE may be used as a rescue strategy to raise the level of an

inadequate post-spinal sensory block.^[4] However, the minimum effective volume (MEV) of normal saline required to produce a rapid increase in the sensory level has not been investigated. In previously published studies on the subject of EVE, the volume of normal saline used for EVE ranges from 5 to 20 mL,^[3,5-7] but there is very little data comparing the effect of various volumes of normal saline on the sensory block level *per se*.^[3,8]

Against this background, the present prospective sequential allocation design study was designed to determine the MEV of normal saline when EVE was used as a rescue strategy for raising the sensory level following an inadequate intrathecal block. Herein, we defined an inadequate block as a sensory level of lower than T_{10} despite waiting for 10 min after intrathecal injection, with no ascent in the level during two consecutive observations made 2 min apart.

Materials and Methods

This prospective sequential allocation study was conducted over a 6 months period after approval of Institutional Ethics

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Committee and written informed consent from all patients. The MEV of normal saline was represented by the effective dose (ED)₅₀. The concept of ED₅₀ representing minimum volumes or concentrations in anesthetic practice has been used earlier by various authors.^[9-11]

The study was planned in adult male patients aged between 18 and 60 years, belonging to American Society of Anesthesiologists (ASA) physical status I/II scheduled for lower limb surgery under combined spinal epidural (CSE) anesthesia. Those with an inadequate intrathecal block were included in the study. Herein, an inadequate block was defined as sensory level lower than T₁₀ at 10 min after intrathecal injection with no ascent in the level of the last two consecutive readings taken every 2 min following intrathecal injection. Patients wherein the intrathecal injection resulted in an adequate sensory level, that is, greater than T₁₀ at 10 min or with an ascent in level during the last two consecutive readings was excluded from the study. Also, patients with any contraindication to CSE blockade, such as history of spinal disease, coagulation abnormality, or sensitivity to local anesthetic and skin infection at site of injection were excluded from the study.

In the operating room; electrocardiography, pulse oximetry, and noninvasive blood pressure monitoring was instituted. Intravenous access was established and 10 mL/kg of lactated Ringer's solution was infused over 5-10 min. CSE block by median approach was performed using needle-through-needle technique with a CSE set (Portex®). With patient in sitting position, the epidural space was identified at L₄₋₅ level with a 16-gauge Touhy needle using loss of resistance to air technique, limiting the total amount of air to <2 mL. A 26-gauge pencil-point spinal needle was advanced through the epidural needle into the subarachnoid space and 10 mg of hyperbaric bupivacaine injected with the bevel facing cephalic. The spinal needle was withdrawn and epidural catheter inserted 4 cm inside epidural space through the Touhy needle, followed by confirmed negative aspiration for blood and cerebrospinal fluid. The catheter was secured while no injections were made through it, and patient was put in supine position.

Sensory and motor blockade were assessed every 2 min after placing the patient supine until 10 min after intrathecal injection had passed. Following application of EVE, the block characteristics were assessed every 5 min till two identical sensory levels were recorded (S_{max}). All block assessments were done by a dedicated anesthesiologist, who was blinded to the volume of normal saline injection. Sensory level was assessed by complete lack to pinprick sensation with a 23-gauge needle in the midline. Motor blockade was

graded by using the modified Bromage score wherein score 1 = complete block, unable to move feet or knees; 2 = almost complete block, able to move feet only; 3 = partial block, just able to move knees; 4 = detectable weakness of hip flexion while supine, full flexion of knees; 5 = no detectable weakness of hip flexion while supine; and 6 = able to perform partial knee bend.^[12]

In patients with inadequate blocks, EVE was performed with normal saline injected through epidural catheter. The volume of normal saline was decided by using the up-and-down sequential allocation method of Dixon and Massey.^[13] While the first patient with an inadequate block included in the study received 10 mL of normal saline, in successive patients, the volume of epidural saline was determined by the outcome of EVE in previous patient. In case of the EVE application being successful the volume of normal saline was decreased by 1 mL in next patient, and in case of a failure it was increased by 1 mL. Herein, the success of EVE was defined as an increase in sensory level by two dermatomal segments within 5 min of the injection.

Presence of intraoperative adverse effects such as hypotension, defined as fall in systolic blood pressure >20% from basal value, nausea or vomiting, and shivering were also noted.

While the primary outcome measure was the volume of normal saline used for successful EVE, secondary outcome measures recorded included height of sensory block at the time of performing EVE (S_E) and at 5 min after EVE; as well as the maximum level achieved following EVE (S_{max}); dermatomal ascent caused by EVE (S_{max}-S_E); maximum motor block at the time of performing EVE and following application of EVE; and the time taken to make the patient supine after completion of the intrathecal injection. The time taken to achieve the S_{max} was also noted.

If local anesthetic when given for rescue analgesia through epidural catheter was not effective, the patient was excluded from the study. The next patient then received the same volume of normal saline as the excluded patient.

Statistical analysis

The up-and-down sequences of volume of normal saline were analyzed using the formula of Dixon and Massey, which enabled calculation of the MEV with 95% CI. Quantitative parametric data was analyzed as mean ± SD, and nonparametric data as median (range).

Sample size

When using up-and-down method for determination of MEV, sample size is considered adequate once six pairs of reversal of

sequence are achieved.^[9] Six pairs of reversal were obtained after 17 patients with inadequate block had been studied. Total of 23 patients had to be enrolled to obtain 17 patients with an inadequate block.

Results

The mean age, height, weight, and baseline systolic blood pressure are shown in Table 1.

The MEV of normal saline volume for successful block augmentation with EVE was 7.4 mL (confidence interval (CI) 95% = 5.5-9.9 mL). The sequence of volume of normal saline used to rapidly increase the sensory level is depicted in Figure 1.

Block characteristics amongst patients with successful block augmentation following EVE are depicted in Table 2. The application of EVE resulted in an ascent in median sensory block level from L₃ (T₁₂ to L₅) to T₁₀ (T₉ to T₁₂). The median increase in dermatomal spread was of 4.5 segments was achieved within 5 min of the normal saline injection and no further increase in median level was seen beyond this time [Table 2]. The modified Bromage score increased with EVE signifying greater motor blockade [Table 2]. The time taken from completion of intrathecal injection to positioning the patients supine ranged from 1.5 to 4.4 min. The maximum sensory block level following EVE was achieved by a median time of 6 (2-8) min.

Total of 23 patients were enrolled in the study of which six had adequate sensory block, that is, showed sensory block level of T₁₀ or greater at 10 min after intrathecal injection, and were thus not included. As per routine clinical protocol,

Table 1: Patient characteristics

Characteristic	Value
Age (years)	40.4 ± 14.9
Height (cm)	161.6 ± 5.5
Weight (kg)	58.3 ± 5.4
Systolic blood pressure (mmHg)	126 ± 2

Values are mean ± standard deviation (SD)

Table 2: Block characteristics for patients with successful epidural volume extension (EVE)

Characteristic	Value
Sensory level when EVE planned (S _E)	L ₃ (T ₁₂ -L ₅)
Sensory level 5 min after EVE (S ₅)	T ₁₀ (T ₉ -L ₁)
Maximum sensory level after EVE (S _{max})	T ₁₀ (T ₉ -T ₁₂)
Dermatomeal increase*	4.5 (2-7)
Maximum Bromage score before EVE	3 (1-4)
Maximum Bromage score after EVE	1 (1-3)

their sensory levels were monitored every 5 min thereafter till block height stabilized. None of these patients showed an ascent in sensory block height of two or more dermatomes within a 5 min period. One patient with post-spinal sensory block level lower than T₁₀ at 10 min of intrathecal injection failed to show two identical dermatomal levels prior to time for EVE application and was thus also excluded.

None of the patients developed intraoperative hypotension, nausea, vomiting, or shivering.

Injection of local anesthetic through the epidural catheter resulted in adequate pain relief in all patients.

Discussion

EVE is known to exert its effects by various mechanisms including a “volume effect”. The application of EVE causes thecal compression by the “volume” of normal saline injected, causing an upward displacement of intrathecal drug in subarachnoid space; thus raising the sensory block level.^[2,14] Imaging studies show the degree of thecal compression to be directly proportional to the volume injected into epidural space,^[15,16] with larger epidural volumes producing greater compression. Takiguchi *et al.*, demonstrated “thecal compression” following EVE in a myelographic study conducted in healthy volunteers in an upright (45 degree) posture.^[15] The upper level of the contrast medium in the subarachnoid space was observed to rise progressively when 5 mL aliquots of normal saline were injected into epidural space. The diameter of subarachnoid space decreased to 40% of initial diameter after the first aliquot and to 25% following the second aliquot. With the third and fourth aliquots, the diameter of subarachnoid space decreased further; but the maximum decrement occurred after the first injection. In another study by Higuchi *et al.*,^[16] epidural injections of 5,

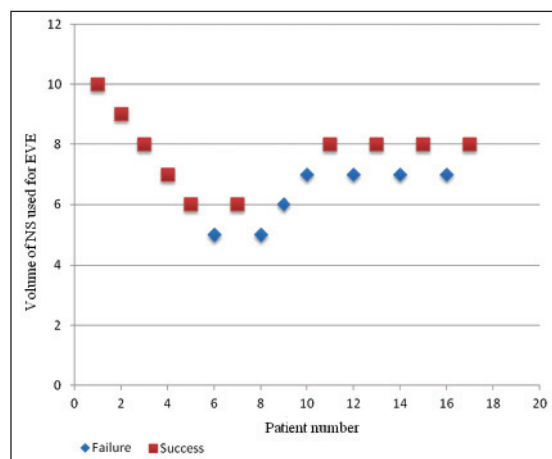


Figure 1: Sequence of volume used for epidural volume extension (EVE)

10, and 15 mL normal saline caused a significant reduction in the lumbosacral cerebrospinal fluid volume visualized using magnetic resonance imaging. The reduction increased with an increasing volume of epidural injectate, being 2.0 ± 1.0 mL after a 5 mL injection ($n = 10$), 4.4 ± 1.4 mL after 10 mL ($n = 9$), and 7.2 ± 2.6 mL after a 15 mL injection ($n = 9$). These imaging studies suggest that incremental volumes of normal saline should result in a progressive increase in post-spinal sensory block level.

There are very few studies that have compared various volumes of normal saline during EVE.^[3,10] Herein, the comparison of 5, 10, 15, and 20 mL saline produced minimum block height with a significantly longer duration of sensory block with higher volumes.^[8] In another study, no significant difference in block level was noted following 5 or 10 mL of epidural injectate, but it was not powered to detect differences in this end point.^[3]

However, the MEV of normal saline required to achieve a predefined block ascent during EVE has not been researched and the volumes of saline used for EVE have been empirically chosen. In most clinical trials on the subject of EVE conducted in nonobstetric patients, the volume of epidural injectate used is 10 mL;^[7,8,17,18] while in obstetric patients it ranges from 5^[19,20] to 10 mL.^[2,5,6,21] Higher volumes of 15 and 20 mL have also been evaluated in nonobstetric patients in a recent study in nonobstetric patients.^[8]

This study found the MEV of normal saline volume for EVE induced increase in post-spinal sensory block level of two dermatomes within 5 min to be 7.4 mL (CI 95% = 5.5-9.9 mL). A review of all trials evaluating sensory block augmentation with EVE reveals that majority of studies using volumes of 7 mL or lesser normal saline^[5,8,19,20] resulted in failure of block ascent.^[5,19,20] In contrast, all of those using volumes larger than 7 mL resulted in successful block augmentation.^[2,3,17,18,22] Herein, block augmentation was defined as a statistically significant increase in level of sensory block.

We defined an inadequate subarachnoid block requiring EVE application as a block with sensory level lower than T₁₀ that also showed stabilization for at least 4 min prior to the performance of EVE, that is, showed identical sensory levels for two consecutive assessments placed 2 min apart. This was done to minimize the chances of spontaneous ascent in the post-spinal sensory block being attributed to effect of EVE. As per our routine clinical protocol, patients with adequate blocks were also monitored for their sensory levels every 5 min till stabilization. Indeed none of these patients showed ascent in sensory block height of two or more dermatomes within a 5 min period. In one patient with an inadequate block in

whom sensory level had not stabilized until 10 min after spinal injection, the block level was monitored beyond 10 min and it did not show an ascent of two or more dermatomal levels within any 5 min span. This suggests that our criterion of stabilization of an inadequate block for approximately 4 min to rule out spontaneous ascent of sensory block was appropriate in the given circumstances. We waited up to 10 min after the intrathecal injection, before designating the sensory block as adequate or inadequate. The choice of this time limit of 10 min after intrathecal injection was subjective. Given the constraints on operating room time, 10 min seemed a reasonable time limit prior to attempting block augmentation with a rescue strategy such as EVE. It is also known that EVE is a time dependent phenomenon^[7,23] and gives best results if applied early after an intrathecal injection. Mardirosoff and coworkers^[7] showed that for EVE to be effective, the patient should be laid supine within 5 min of completing intrathecal injection. Trautman *et al.*,^[23] showed it to be ineffective when performed 20 min after the intrathecal injection. Hence we waited for a time that was long enough to justify use of rescue strategy for block augmentation, and yet short enough for a successful EVE.

A two dermatomal segment ascent occurring within 5 min was taken to indicate a successful EVE application. We did not wait longer than 5 min after EVE to term it a successful rescue strategy, since waiting any longer after 10 min had already elapsed following the intrathecal injection (total of 15 min) would have defeated the purpose of a rescue strategy. The two segment ascent to define successful EVE was arbitrarily chosen since ascent of less than two dermatomes is unlikely to have a clinical utility.

A limitation of our study is that the MEV of normal saline is likely to be different if the definition of a successful EVE is varied. A dermatomal increase greater than two segments or a spread faster than 5 min, may require a higher MEV of normal saline. To conclude, the MEV of normal saline for EVE induced rise in the post-spinal sensory block of two dermatomal segments within 5 min, is 7.4 mL (CI 95% = 5.5-9.9 mL).

References

1. Brown DL. Spinal, epidural and caudal anesthesia. In: Miller's Anesthesia, 6th ed. Philadelphia: Elsevier; 2005.
2. Blumgart CH, Ryall D, Dennison B, Thomson-Hill LM. Mechanism of extension of spinal anesthesia by extradural injection of local anaesthetic. *Br J Anaesth* 1992;69:457-60.
3. Stienstra R, Dilrosun-Alhadi BZ, Dahan A, van Kleef JW, Veering BT, Burm AG. The epidural "top-up" in combined spinal-epidural anesthesia: The effect of volume versus dose. *Anesth Analg* 1999;88:810-4.
4. Tyagi A, Sharma CS, Kumar S, Sharma DK, Jain AK, Sethi AK. Epidural volume extension: A review. *Anaesth Intensive Care* 2012;40:604-13.

5. Choi DH, Ahn HJ, Kim JA. Combined low-dose spinal-epidural anesthesia versus single-shot spinal anesthesia for elective caesarean delivery. *Int J Obstet Anesth* 2006;15:13-7.
6. Choi DH, Park NK, Cho HS, Hahm TS, Chung IS. Effects of epidural injection on spinal block during combined spinal and epidural anesthesia for caesarean delivery. *Reg Anesth Pain Med* 2000;25:591-5.
7. Mardirosoff C, Dumont L, Lemédioni P, Pauwels P, Massaut J. Sensory block extension during combined spinal and epidural. *Reg Anesth Pain Med* 1998;23:92-5.
8. Doganci N, Apan A, Tekin O, Kaymak C. Epidural volume expansion: Is there a ceiling effect? *Minerva Anesthesiol* 2010;76:334-9.
9. Sell A, Olkkola KT, Jalonen J, Aantaa R. Minimum effective local anaesthetic dose of isobaric levobupivacaine and ropivacaine administered via a spinal catheter for hip replacement surgery. *Br J Anaesth* 2005;94:239-42.
10. Benhamou D, Ghosh C, Mercier FJ. A randomized sequential allocation study to determine the minimum effective analgesic concentration of levobupivacaine and ropivacaine in patients receiving epidural analgesia for labor. *Anesthesiology* 2003;99:1383-6.
11. Lacassie HJ, Columb MO. The relative motor blocking potencies of bupivacaine and levobupivacaine in labor. *Anesth Analg* 2003;97:1509-13.
12. Breen TW, Shapiro T, Glass B, Foster-Pyane D, Oriol NE. Epidural anesthesia for labor in an ambulatory patient. *Anesth Analg* 1993;77:919-24.
13. Dixon WJ, Massey FJ. Introduction to statistical analysis, 4th ed. New York: McGraw-Hill Book Company; 1983.
14. McNaught AF, Stocks GM. Epidural volume extension and low-dose sequential combined spinal-epidural blockade: Two ways to reduce spinal dose requirement for caesarean section. *Int J Obstet Anesth* 2007;16:346-53.
15. Takiguchi T, Okano T, Egawa H, Okubo Y, Saito K, Kitajima T. The effect of epidural saline injection on analgesic level during combined spinal and epidural anesthesia assessed clinically and myelographically. *Anesth Analg* 1997;85:1097-100.
16. Higuchi H, Adachi Y, Kazama T. Effects of epidural saline injection on cerebrospinal fluid volume and velocity waveform: A magnetic resonance imaging study. *Anesthesiology* 2005;102:285-92.
17. Stienstra R, Dahan A, Alhadi BZ, van Kleef JW, Burm AG. Mechanism of action of an epidural top-up in combined spinal epidural anesthesia. *Anesth Analg* 1996;83:382-6.
18. Tyagi A, Kumar A, Sethi AK, Mohta M. Epidural volume extension and intrathecal dose requirement: Plain versus hyperbaric bupivacaine. *Anesth Analg* 2008;107:333-8.
19. Loubert C, O'Brien PJ, Fernando R, Walton N, Philip S, Addei T, *et al.* Epidural volume extension in combined spinal epidural anesthesia for elective caesarean section: A randomised controlled trial. *Anaesthesia* 2011;66:341-7.
20. Tyagi A, Girotra G, Kumar A, Surendra K, Sethi AK, Mohta M. Single-shot spinal anesthesia, combined spinal-epidural and epidural volume extension for elective caesarean: A randomized comparison. *Int J Obstet Anesth* 2009;18:231-6.
21. Kucukguclu S, Unlugenc H, Gunenc F, Kuvaki B, Gokmen N, Gunasti S, *et al.* The influence of epidural volume extension on spinal block with hyperbaric or plain bupivacaine for caesarean delivery. *Eur J Anaesthesiol* 2008;25:307-13.
22. Yamazaki Y, Mimura M, Hazama K, Namiki A. Reinforcement of spinal anesthesia by epidural injection of saline: A comparison of hyperbaric and isobaric tetracaine. *J Anesth* 2000;14:73-6.
23. Trautman WJ 3rd, Liu SS, Kopacz DJ. Comparison of lidocaine and saline for epidural top-up during combined spinal-epidural anesthesia in volunteers. *Anesth Analg* 1997;84:574-7.

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