JURNAL KOMPLIKASI ANESTESI
E-ISSN 2354-6514
VOLUME 11 NOMOR 1, NOVEMBER 2023

TINJAUAN PUSTAKA

Epidural Volume Extension (EVE)

Indriyani Wijaya[1*], Mahmud[1]

[1]*Anesthesiology and Intensive Care Department, Faculty of Medicine, Public Health and Nursing Gadjah Mada University/ Dr. Sardjito Hospital Yogyakarta*
*Coresponden author : indriyani.wijaya@mail.ugm.ac.id

Article Citation : Indriyani Wijaya, Mahmud. Epidural Volume Extension (EVE). Jurnal Komplikasi Anestesi 11(1)-2023.

ABSTRAK

Teknik Epidural Volume Extension (EVE) menyuntikkan normal saline ke ruang epidural segera setelah injeksi anestesi lokal ke intratekal (atau setelah blok subarachnoid / spinal). Penyuntikan normal saline akan melebarkan ruang epidural sehingga membuat penyebaran anestesi lokal pada penyuntikan intratekal sebelumnya dan distribusi cairan serebrospinal menjadi lebih tinggi (lebih cephalad), atau dapat dikatakan teknik EVE ini memanfaatkan efek volume dari normal saline yang menekan volume ruang intratekal. Teknik EVE mungkin berguna untuk mengurangi dosis anestesi lokal yang diinjeksikan intratekal dengan tetap mencapai ketinggian blok yang adekuat untuk operasi, serta untuk pemulihan blokade motorik yang lebih cepat. Sayangnya, terhadap risiko hipotensi, teknik EVE tidak mengurangi risiko ini secara signifikan. Hipotensi tetap terjadi meskipun teramati hemodinamik (penurunan tekanan darah arteri rerata) lebih stabil.

Kata kunci: Epidural Volume Extension (EVE), Combined Spinal – Epidural (CSE), hipotensi

ABSTRACT

Epidural Volume Extension (EVE) technique injects normal saline into the epidural chamber immediately after injection of local anesthesia into the intrathecal (or after subarachnoid/spinal block). Normal saline injection would widen the epidural space thus making the spread of local anesthesia in previous intrathecal injections and the distribution of cerebrospinal fluid to be higher (more cephalad), or it could be said that this EVE technique utilizes the volume effect of normal saline that decreases the volume of intrathecal space. The EVE technique may be useful for reducing the dose of local anesthesia injected intrathecally while still achieve an adequate block height for surgery, as well as for faster recovery of motor blockades. Unfortunately, for the risk of hypotension, the EVE technique does not significantly reduce this risk. Hypotension persists even though the hemodynamics (arterial blood pressure drop mean) is observed to be more stable.

Keywords: Epidural Volume Extension (EVE), Combined Spinal – Epidural (CSE), hypotension

Introduction

Epidural block provides anesthesia for either surgical or analgesic treatment in post-surgery and intrapartum pains. The presence of adipose tissue in epidural space affects the spread of injected local anesthetic agent, even it remains obscure if this prolongs the block duration (for its function as reservoir) or reduces the amount of available local anasthesia agents, thereby slowing the onset, or both. Notably, the onset of epidural block in the targeted dermatome is detectable in 5 – 15 minutes (Chloroprocaine) and 15 – 20 minutes (Bupivacaine, Ropivacaine, and Levobupivacaine). This onset is considered quite slow and wastes the time for starting a surgery in an emergency situation.[1]

In the last two decades, the combination of epidural and subarachnoid/spinal blocks is expected to solve the slow onset issue. This technique is known as Combined Spinal-Epidural (CSE). Faster onset is not the only benefit of CSE technique. The other benefits are: low failure rate, more intense motoric blockade compared with only epidural block, epidural catheter enables the blockade extension and supplementation when subarachnoid/spinal block is inadequate, including to enable the administration of low-dose local anesthetic agent on cesarean section for preventing the tendency of anesthesiologist to administrate a high dose to ensure the block's completion (the presence of epidural catheter becomes a kind of "protective net" for anesthesioloigist to administrate lowe dose).[1]

As the other blocks, CSE is able to affect body's physiology. Subarachnoid/spinal block in CSE could trigger hypotension (Spinal Anesthesia–Induced Hypotension /SIH) whose severity is affected by the dose of the injected local anesthetic agent. Decreasing the dose until below the median effective dose (ED50) and combined with adjuvant opioid, are considered capable in decreasing SIH incidence, including reducing the complications on the mother and her infant. However, the dose reduction has the potential to increase the need for intraoperative analgesic supplementation, conversion to general anesthesia and incomplete motor blockade, and inadequate anesthesia (patient still feels pain)[1] thus these drawbacks ultimately seem putting the benefit of rapid onset from subarachnoid/spinal block in vain.

52 In response to this situation, a modification of CSE technique has been developed, namely by injecting a normal saline into epidural space immediately after injecting local anesthesia into intrathecal (or after subarachnoid/spinal block). Theoretically, normal saline injection would widen the epidural space thus the spread of local anesthesia in the previous intrathecal injection and the distribution of cerebrospinal fluid become higher (more cephalad), or in other words, EVE technique utilizes the volume effect of normal saline which surpresses the intrathecal space's volume. Ultimately, EVE technique is expected to reduce the severity of hypotension while the ensuring adequate block and elevation to be achieved.[2] What and how to do this EVE technique will be discussed in more detail in this *referat*.

Hypotension Incidence in Neuraxial Block and Its Effects

Table 1. Factors which Affect the Height of Subarachnoid/Spinal Block [4]

Primary Factors	Secondary Factors
• Barisity of local anesthetic agents • Patient's position: during injection, immediately after injection • Drug dosage • Injection point	• Age • Cerebrospinal fluid • Spine Curvature • Drug volume • Intra-abdominal Pressure • Injection angle • Patient's height • Pregnancy

Different from subarachnoid/spinal block, epidural block height is achieved by the injected volume of local anesthesia, which is 1 ml (adult with below normal height) to 2 ml (adult with normal height) for every segment which would be blocked. One of secondary factors is age. Old age is associated with decreased epidural space volume and compliance thus with the same volume, the block height can be higher.[4]

Epidural Volume Extension (EVE) : Technique and Mechanism

Medulla spinalis is the extention of medulla oblongata. Medulla spinalis has three layers : dura mater, arachnoid mater and pia mater. These three concentrically arranged membranes form compartments, namely: the epidural space, the subdural space and the subarachnoid space. The subarachnoid space is formed by the arachnoid mater and pia mater. Here there are spinal nerves, dorsal and ventral nerve roots, and cerebrospinal fluid. The epidural space is the potential space between the dura mater and attached to the ligamentum flavum. Here there are fat, epidural veins, nerve fiber roots, and connective tissue.[1]

The Epidural Volume Extension (EVE) technique involves injecting normal saline into the epidural space immediately after intrathecal injection of local anesthesia (or after subarachnoid/spinal block). Theoretically, normal saline injection would widen the epidural space in order to make the spread of local anesthesia on the previous intrathecal injection and the distribution of cerebrospinal fluid to be higher (more cephalad), or in other words, this EVE technique utilizes the volume effect of normal saline which suppresses the volume of the intrathecal space.

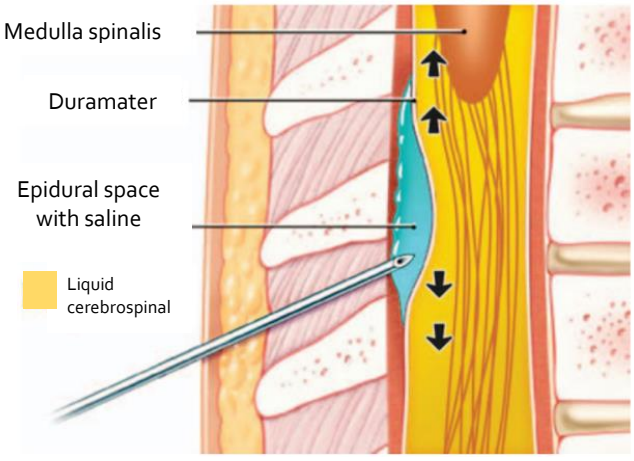


Figure 1. Epidural Volume Extension (EVE) Mechanism. The black arrows show the cerebrospinal fluid flow (including local anesthesia) after saline injection into epidural space [5]

Assessing the Outcome of Epidural Volume Extension (EVE)

Epidural Volume Extension (EVE) application in daily clinical practice is generally similar to Combined Spinal – Epidural (CSE) usage. Study on EVE is the clinical study which majorly uses cases of cesarean section in parturients and lower limbs orthopedic surgery. Inclusive criteria decided in EVE studies are as follows : elective surgery, ASA physical status 1 and 2, parturition, supine surgery position, the absence of hemodynamic-related comorbids. Demographic characteristics of research subjects are mainly distinguished by age (under 60 years or over 60 years) because age could affect the outcome to be observed (hypertension effect).

Assessing the benefits and outcomes of the EVE technique could be reviewed in various ways, including: the block height achieved, the duration of the block, the need for analgesic supplementation, the presence or absence of side effects (especially hypotension, which is the main effect to be avoided with this technique), and recovery from blockade. On the other hand, many factors also affect the EVE technique, including the volume of fluid used to produce the volume effect, the baricity of the local anesthesia, the position during and after subarachnoid/spinal block, and the obstetric versus non-obstetric patients.[1,5]

The first affecting factor is the fluid used to cause the volume effect. The selection of normal saline to produce a volume effect is based on safety considerations; no side effect of saline is found when large volume is used. Other fluids that have been studied for comparison with normal saline are 6% hydroxyethyl starch (Hespan) and low-dose local anesthesia. The use of Hespan presents an optimal hemodynamic profile (outcome) with normal saline.[6] The volume of normal saline used is quite variable, between 5 – 20 ml. Kane, *et al* (2018) through their systematic review and meta-analysis, discovered that a volume of 10 ml is the most consistent for causing a volume effect, or in other words, proved to increase the level of sensory blockade. In parturients, this volume could be smaller, which is up to 5 ml. Normal saline injection is performed after intrathecal local anesthetic injection, rapidly for 10-15 seconds, and immediately. There is no standardization of how long "immediately" is meant. Existing studies inject normal saline between immediately up to 10 minutes. However, immediate injection and before the patient in supine position has been proved to give the best volume effect. This shows that the EVE technique is basically a time-dependent phenomenon, the sooner normal saline is injected, the better the results. The increase in block height ranged from 3-4 dermatomes from the level that was declared adequate for the operation, however in some studies, there was no increase in block height at all.[7,8,9]

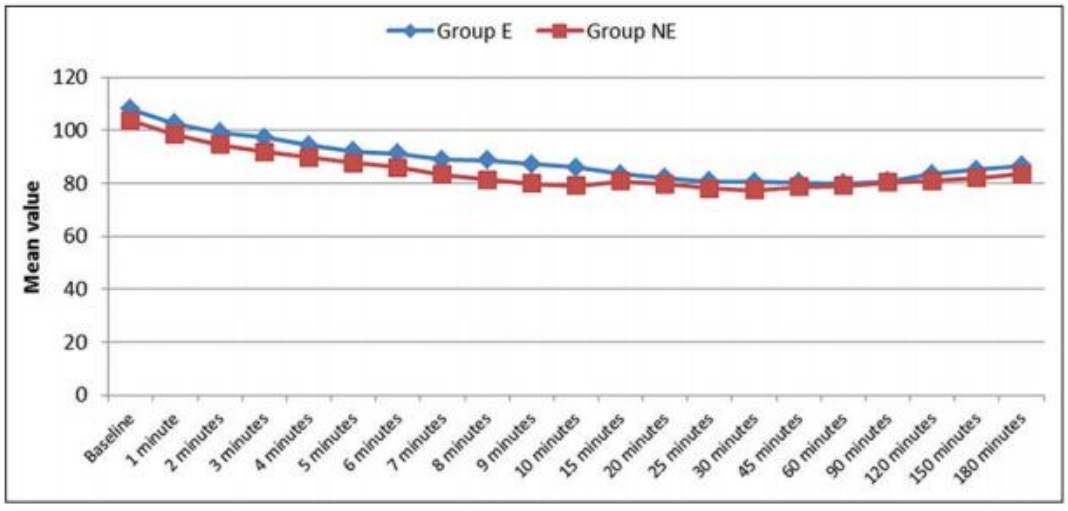
Regarding the local anesthetic used, the questions that must be answered include: what type of drug is it, how much is the dose, how much is the concentration, and how is the baricity. So far, Bupivacaine and Levobupivacaine are the two most frequently studied agents for the use in EVE technique. The greatest variation was found in the concentration and dose used. Existing studies have used hyperbaric Bupivacaine 0.5% at a dose of 6 – 18 mg, where 9 mg was the most common, and Levobupivacine 0.15 – 0.5% at a dose of 6 – 12 mg.[8] In other study,

Naaz et al (2020) used 0.75% Ropvacaine without comparing it to other agents.

The need for analgesic supplementation in the group using normal saline for EVE compared to the control group (without EVE) was found to be not statistically significant. However, when small doses of local anesthetic are added to the EVE solution, it is found that the need for analgesic supplementation may decrease.[5,8]

Recovery from motoric blockade is one of the outcomes measured. In patients with EVE, recovery from motoric blockade assessed by the Bromage score occurs more rapidly. Recovery from motoric blockade, according to researchers, supports the implementation of Enhanced Recovery After Surgery (ERAS): beneficial for early mobilization and faster removal of urinary catheters. The onset of sensory blockade (adequate for surgery) in both groups (EVE and without EVE) was found to be the same. [5,11]

The most important outcome assessed was the incidence of hypotension in EVE. Can EVE reduce the incidence of hypotension? The systematic review and meta-analysis conducted by Heesen et al (217) and Terri et al (2018) showed statistically, the risk of hypotension was not significantly reduced in patients treated by EVE.[5,11] Another study, namely the Randomized Controlled Trial, Naaz, *et al* (2020) found that although the magnitude of hypotension that occurred was the same between the EVE and non-EVE groups, the EVE group was observed to be hemodynamically more stable (Graph 1) and still achieve the intended block height target, compared to using a higher dose in the same patient, therefore the researchers recommend this technique if you look for the better hemodynamic stability caused by the use of a lower dose of local anesthesia. Naaz, *et al* (2020) used a study design on geriatric patients over 60 years old who were undergoing lower limbs orthopedic surgery. In the treatment group, 10 ml of normal saline was injected within 5 minutes after giving 3 ml of Ropivacaine 0.75% intrathecally; while in the control group, normal saline was not injected. The researcher entered the operating teather after the patient was in supine position. Hemodynamic monitoring (systolic blood pressure, diastolic and heart rate) was performed every 5 minutes for 30 minutes after intrathecal injection and thereafter every 15 minutes until surgery was concluded. [10]



Graphic 1. Comparison of Mean Arterial Pressure to Time (Naaz, *et al*, 2020) [10]

Below is the table of the comparison between researchers on EVE published for last 5 years.

DOI: 10.22146/jka.v11i1.12598 e-ISSN 2354-6514

Tabel 2. Comparison of Researches on EVE Published in the Last 5 Years

Study	Studies' Methodologies			EVE Technique		Outcome			
	Study Type	Case Types	Samples	EVE Fluid	Local Anesthetic Agent	Sensoric Block Heights (Maximum)	Analgetic Supplementation Need	Side Effect	Post-Blockade Recovery
Kane, *et al.* (2018)	Systematic Review and Meta-Analysis	• 40 studies (1992 – 2015) • 8 are Randomized Controlled Trial • Elective caesarean section	• ASA 1 and ASA 2 • Sample Total = 1670 people	5 – 10 ml normal saline	• 7,5 – 12,5 mg 0,5% ıyperbaric Bupivacaine • 6 – 12 mg 0,15 – 0,5% Levobupivacaine	• 8 studies achieved T4 • 4 studies achieved T5 • 2 studies achieved T4-T5 • 3 studies achieved T6 • 13 studies achieved 0-4 dermatoms above the adequate block height for surgery • 5 studies achieved 0-3 dermatoms above the adequate block	• 13 studies showed: similar for both EVE and non-EVE groups (p 0,78) • 4 studies showed: in EVE group, analgetic supplementation need is lower (p 0,004)		• 10 studies showed rapid recovery (p 0,04)

DOI: 10.22146/jka.v11i1.12598 e-ISSN 2354-6514

						height for surgery			
Heesen, *et al* (2017)	Systematic Review and Meta-Analysis	• 15 studies • 9 are elective caesarean section • 6 area another surgeries	• High heterogeneity recorded (I = 73%) • Sample total = 1167 total	Normal saline: • 1 study with 18 – 20 ml • 7 studies with 10 ml • 4 study with 5 ml • 1 studi dengan 6 ml	• 4 studies isobaric Bupivacaine • 8 studies hyperbaric Bupivacaine • 1 study with Levobupivacaine • 1 study with Dibucaine	• EVE group achieved 1,37 dermatoms higher than the non-EVE (p < 0,00001)	• 6 of 14 studies showed: similar for both EVE and non-EVE groups (p 0,62)	Hypotension • 10 studies showed: similar for both EVE and non-EVE groups. EVE did not decrease hypotension risk	• 5 studi showed rapid recovery (p < 0,0001)

Study	Studies' Methodologies					Outcome			
	Study Type	Case Types	Samples	EVE Fluid	Local Anesthetic Agent	Sensoric Block Heights (Maximum)	Analgetic Supplementation Need	Side Effect	Post-Blockade Recovery
Naaz, *et al.* (2020)	Randomized Controlled Trial	• Elective lower limbs orthopedic surgery • Supine position surgery	• ASA 1 and ASA 2 • Above 60 years old • 150 – 175 cm height • 40 – 85 kg weight	10 ml normal saline	3 ml 0,75% Ropivacaine	• T_4 in EVE group and T6 in non-EVE group (p 0,01)	• 316.5 minutes after intratechal injection in EVE group • 230.6 minutes after intratechal injection in non-EVE group	Hypotension • Similar for both EVE and non-EVE groups (p 0,3) • EVE showed more stable hemodynamic	• 248.5 minutes in and 171.5 minutes in non-EVE group (p <0,001)

			• Sample Total= 60 people				p <0.001)	due to lower dose usage	
Tyagi, *et al.* (2018)	Randomized Controlled Trial	• Elective lower limbs orthopedic surgery	• ASA 1 and ASA 2 • Age undescribed • 50 –70 kg weight • 150 –180 cm height • Sample Total = 48 people	10 ml normal saline	5 mg and 8 mg Isobaric Bupivacaine	• In dose of 5 mg, block heights for both EVE and Non-EVE groups are inadequate for surgery • In dose of 8 mg, block heights for both EVE and Non-EVE groups are still adequate for surgery • p 0,030	Similar for both EVE and non-EVE groups (p 0,3). p value • for dose of 5 mg (p 0,247) • for dose of 8 mg (p 0,799)	<u>Hypotension</u> Similar for both EVE and non-EVE groups (p 0,3) • for dose of 5 mg (p 0,365) • for dose of 8 mg (p 0,799)	Undescribed

Study	Studies' Methodologies					Outcome			
	Study Type	Case Types	Samples	EVE Fluid	Local Anesthetic Agent	Sensoric Block Heights (Maximum)	Analgetic Supplementation Need	Side Effects	Post-Blockade Recovery
Zaphiratos, *et al.* (2016)	Randomized Controlled Trial	• Labor Analgesia	• Nullipara • ASA 1 and ASA 2 • In labor, Cervical	10 ml normal saline	2 mg 0,25% isobaric bupivacaine with 10 mcg adjuvant	• T6 in EVE group and T7 in non-EVE group p 0,01)	Both EVE and non-EVE groups require Patient-Controlled	<u>Hypotension</u> Similar for both EVE and non-EVE groups (p 0,61)	Similar for both EVE and non-EVE groups. (p 0,06)

			dilatatiom < 5cm • Requesting analgetic labor by neuraxial • BMI < 35 kg/m² • Sample total = 54 people		Fentanyl		Epidural Analgesia (PCEA) bolus 6 ml in the first 30 minutes. (p 1,0)		
Kumar, A (2019)	Case report	Caesarean section in pregnant mother with severe pulmonary stenosis berat and mediumtricuspid regurgitation (Class II NYHA)	• 23-year-old mother, G2P1A0 37-week pregnancy • Weight of 60 kg	10 ml normal saline	3 mg of 0,5% hyperbaric bupivacaine with 25 mcg adjuvant Fentanyl	T6 height is achieved	Analgetic Supplementation is absent	Lowest blood pressure of 110/70 mmHg (initial blood pressure 146/88 mmHg)	Undescribe

Conclusion

EVE technique is expected to be useful to reduce the local anasthesia dosage by intratecal injection while keep achieving adequate block height for surgery, and for faster recovery from motoric blockade. Regarding the hypotension risk, conclusion from existing researchers have not shown that EVE technique reduces the risk of hypotension incidence, yet it could provide a more stable hemodynamic (even if hypotension occurs, the drop in blood pressure is not sudden).

This conclusion is based on the significantly limited amounts of studies. The sample amounts of low and high heterogeneity, along with high technique variations become the limitations of the studies which discuss on EVE technique. More future studies are expected to explain the relationship between the outputs found.

Abbreviations

Acknowledgements

Not applicable.

Authors' Contributions

All authors read and approved the final manuscript.

Funding

Not applicable.

Availability of Data and Materials

Not applicable

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

Not applicable.

Conflict of Interests

The author declares that they have no conflict of interests.

References

1. Hadzic A, New York School of Regional Anesthesia, editors. Hadzic's textbook of regional anesthesia and acute pain management. Second edition. New York: McGraw-Hill Education; 2017. p1506.
2. Kane T, Tubog TD, Kane J. Effect of Epidural Volume Extension on Quality of Combined Spinal-Epidural Anesthesia for Cesarean Delivery: A Systematic Review and Meta-Analysis. J American Association of Nurse Anesthetists. 2018;82(2):109-118.
3. Chestnut DH. Chestnut's obstetric anesthesia: principles and practice. 6th edition. St. Louis, MO: Elsevier; 2019. p46.
4. Butterworth JF. Morgan & Mikhail's clinical anesthesiology. Sixth edition. Mackey DC, Wasnick JD, Morgan GE, Mikhail MS, editors. New York: McGraw-Hill; 2018. p1393. (A Lange medical book).
5. Heesen M, Weibel S, Klimek M, Rossaint R, Arends LR, Kranke P. Effects of epidural volume extension by saline injection on the efficacy and safety of intrathecal local anaesthetics: systematic review with meta-analysis, meta-regression and trial sequential analysis. Anaesthesia. 2017 Nov;72(11):1398–411.
6. Gupta S, Sinha N, Surendran K, Naithani U, Doshi V, Bedi V. Comparison of hydroxyethyl starch versus normal saline for epidural volume extension in combined spinal

epidural anesthesia for cesarean section. J Obstet Anaesth Crit Care. 2012;2(1): 16-22

7. Tyagi A, Ramanujam M. Epidural volume extension. Anaesthesia. 2018 May;73(5):645–645.
8. Kane T, Tubog TD, Kane J. Effect of Epidural Volume Extension on Quality of Combined Spinal-Epidural Anesthesia for Cesarean Delivery: A Systematic Review and Meta-Analysis. :10.
9. Zaphiratos V, George RB, Macaulay B, Bolleddula P, McKeen DM. Epidural Volume Extension During Combined Spinal-Epidural Labor Analgesia Does Not Increase Sensory Block: Anesth Analg. 2016 Sep;123(3):684–9.
10. Naaz S, Shukla U, Gupta R, Ozair E, Asghar A. A Randomized Controlled Trial on Epidural Volume Extension in Combined Spinal Epidural Anesthesia for Lower Limb Surgeries Using Intrathecal Ropivacaine in Older Adults. Bali J Anesthesiol. 2020;6.