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INVITED REVIEW ARTICLE

# How neuraxial labor analgesia differs by approach: dural puncture epidural as a novel option

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## Abstract

**Background and aim** Neuraxial analgesia techniques are not limited to just standard epidural and CSE blocks. A novel approach called dural puncture epidural (DPE) which is a modification of CSE in terms of practice has gained popularity after its description and use in the obstetric population. The aim of this review is to address the practice of DPE technique as a novel option by reviewing its benefits as well as side and/or adverse effects and to understand how neuraxial labor analgesia differs by approach based on the information available in the current literature

**Discussion** Despite controversies and concerns, more rapid onset of analgesia, early bilateral sacral analgesia, lower incidence of asymmetric block and fewer maternal and fetal side effects are provided with DPE when compared to epidural.

**Conclusion** DPE offers a favorable risk–benefit ratio for management of neuraxial analgesia as a novel option.

**Keywords** Labor pain · Neuraxial analgesia · Dural puncture epidural · Epidural · Combined spinal epidural

## Introduction

Labor pain is one of the most painful events in lifetime of a woman and either epidural or combined spinal epidural (CSE) neuraxial analgesia has been the most effective pain relief method during childbirth in contemporary clinical practice [1]. However, neuraxial analgesia techniques are not limited to just standard epidural and CSE blocks. While the debate has been going on which neuraxial technique is superior to the other, a novel approach called dural puncture epidural (DPE) has recently gained popularity after the cornerstone study that compared standard epidural and CSE with DPE for labor analgesia [2, 3]. Hereby, practice of DPE technique will be reviewed based on the information available in the current literature to understand better its benefits as well as side and/or adverse effects.

It has been awarded the ESA 2017 Young Teaching Recognition Award and presented at Euroanaesthesia 2018 as well.

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## Definition

The concept of subarachnoid spread of epidural local anesthetic following dural puncture was first noticed in a primiparous pregnant woman after an inadvertent dural puncture with an epidural Tuohy needle by Leach and Smith [4]. Later on, the DPE technique, which is a modification of CSE in terms of practice was first described for non-obstetric surgical patients in 1996 by Suzuki et al. [5] and followed by other investigators' experiences in the obstetric population [6–10]. Basically, epidural space is identified with an epidural needle using loss of resistance technique followed by perforating the dura with a spinal needle likewise in the CSE technique. After confirming the free flow of cerebrospinal fluid (CSF), the spinal needle is withdrawn without administering any drug to subarachnoid space. Then, epidural catheter is placed into the epidural space to induce neuraxial analgesia via catheter which was further maintained almost in a similar way as it is in the standard epidural analgesia [2–10] (Fig. 1).

## Mechanism of action

According to the currently accepted mechanism of the DPE, the conduit created by dural puncture most likely plays a key role in providing the translocation of the medications

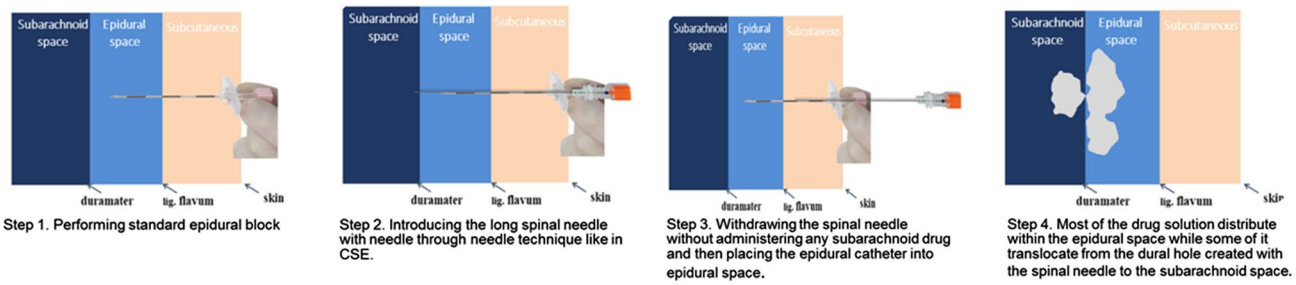


**Fig. 1** Schematic display of performing dural puncture epidural step by step. Step (1): performing standard epidural block. Step (2): introducing the long spinal needle with needle through needle technique like in CSE. Step (3): withdrawing the spinal needle without administering any subarachnoid drug and then placing the epidural catheter into epidural space. Step (4): most of the drug solutions are distributed within the epidural space while some of it is translocated from the dural hole created with the spinal needle to the subarachnoid space

from the epidural space to the subarachnoid space. Resulting unique characteristics of the technique include better sacral block onset and bilateral analgesia in comparison to standard neuraxial analgesia techniques like epidural and CSE. Additionally, backflow of CSF might serve as a definitive end point to position the tip of the epidural needle within the epidural space [7]. Better hemodynamic stability and improved epidural catheter function would be possible because of no intrathecal drugs are administered in DPE.

## Management of dural puncture epidural (DPE) analgesia

History of DPE starts with its first recognition in patients undergoing lower abdominal surgery in 1996 by Suzuki et al. [5]. Although Thomas et al. [7] seemed to be the first obstetric anesthetists to perform DPE technique in chronological order, their primary hypothesis was to achieve an improved epidural catheter function in comparison to epidural block. However, they were unable to find out either a reduced catheter manipulation/replacement rate or improved quality of epidural analgesia which was the secondary outcome of the study. One year later, 17 G Weiss epidural needle and 12 cm long 25 G Whitacre spinal needle via needle through needle technique was successfully used for providing a labor analgesia and the acronym DPE has been used since then [6]. Therefore, Capiello et al. [6] have been the pioneers of DPE in the introduction of rapid onset of sacral analgesia along with bilateral caudal spread in the obstetric population in 2008.

In addition to the previous studies, most recently published comparative studies have been proved to be successful [9, 10]. However, varying factors might possibly affect the clinical efficacy depending on the different equipments and/or protocols used for the management of DPE analgesia as displayed in Table 1 [2, 5–10].

### Induction of analgesia and epidural test dose

One of the most prominent features of the DPE technique is to provide a favorably superior induction of labor analgesia due to faster onset analgesia and bilateral sacral symmetric block [2, 6, 9, 10]. Equipment used in these studies were either 17 G Weiss epidural needle with 19 G or 20 G catheter or Tuohy epidural needle (16 G or 17 G) with 18 G or 19 G catheter and Whitacre spinal needles of 25 G, 26 G or 27 G (2,6,9,10) (Table 1). Although DPE technique is superior to CSE by allowing to test the epidural catheter, traditional 3 mL test dose including 1.5% lidocaine with epinephrine 5 µg/mL has been only used by Wilson et al. [10]. In other studies, no specific epidural test dose was prepared, but the designated bolus induction solution was injected in fractions by checking clinical signs of either an intravascular or a subarachnoid injection [2, 6, 9].

Induction of analgesia protocols for DPE may vary from one study to the other. Total bolus volumes for induction were 10, 12 or 20 mL of either bupivacaine (0.25% or 0.125%) or ropivacaine (0.2%) including fentanyl (2-2.5 µg/mL) [2, 6, 9, 10] (Table 1).

### Maintenance of analgesia

A number of maintenance protocols including manual top ups and/or PCEA settings for DPE analgesia have been described by the researchers (Table 1) [2, 5–10]. Among them, the DPE protocols that provided improved quality of analgesia with less adverse effects worth mentioning [2, 9, 10]. After induction, analgesia was maintained using bupivacaine (0.125% or 0.1%) or ropivacaine (0.2%) including fentanyl by PCEA and/or manual top ups in three distinct protocols (Table 1). The maintenance protocol with only PCEA including 0.125% bupivacaine with 2.5 µg/mL

**Table 1** Practice of DPE using different equipments and local anesthetic drugs and protocols for induction and maintenance of neuraxial analgesia [2, 5–10]

| References | *n* | Spinal needle size and type | Epidural needle size and type | Epidural catheter size and type | Drug choice for induction and maintenance | Induction protocol | Maintenance protocol (manual top up or PCEA) |
|---|---|---|---|---|---|---|---|
| *Suzuki et al. 1996 [5] | 40 | 26 G Whitacre | 16 G Tuohy | 18 G with 3 lateral outlets | Mepivacaine and mepivacaine | Bolus 15 mL of 2% mepivacaine | 10 mL of mepivacaine top up within 60 min |
| Thomas et al. 2005 [7] | 230 | 27 G 11.9 cm Whitacre | 17 G 8.9 cm Weiss | 19 G Closed tip multiport | Lidocaine and bupivacaine | Bolus 5 mL + 5 mL of 2% lidocaine | 0.11% bupivacaine with 2 µg/mL fentanyl PCEA |
| Capiello et al. 2008 [6] | 80 | 25 G 12 cm Whitacre | 17 G 8.5 cm Weiss | 20 G n/a | Bupivacaine and bupivacaine | Bolus 12 mL of 0.25% bupivacaine with 2.5 µg/mL fentanyl | 0.125% with 2 µg/mL fentanyl PCEA<br>6 mL/h background infusion<br>6 mL bolus on demand<br>15 min lock out<br>No hourly limit |
| Gupta et al. 2013 [8] | 112 | 25 G Pencan | 17 G Tuohy | 19 G n/a | Bupivacaine and bupivacaine | Bolus 5 mL + 5 mL %0.125 bupivacaine with 10 µg/mL fentanyl | 0.125% bupivacaine with 2.5 µg/mL fentanyl top up |
| Chau et al. 2017 [2] | 120 | 25 G 11.9 cm Whitacre | 17 G 8.9 cm Weiss | 19 G Flextip single open end | Bupivacaine and bupivacaine | Bolus 20 mL of 0.125% bupivacaine with 2 µg/mL fentanyl (20 mL in 5 mL aliquots) | 0.125% bupivacaine with 2.5 µg/mL fentanyl PCEA<br>6 mL/h infusion<br>6 mL bolus on demand<br>15 min lock out<br>20 mL/h limit |
| Yadav et al. 2018 [9] | 60 | 27 G Whitacre | 16 G Tuohy | 18 G Multiorifice | Ropivacaine and ropivacaine | Bolus 10 mL of 0.2% ropivacaine with 2 µg/mL fentanyl (10 mL in 2.5 mL fractions) | 10 mL 0.2% ropivacaine with 2 µg/mL fentanyl top up and repeated in case of inadaequate analgesia |
| Wilson et al. 2018 [10] | 80 | 26 G Whitacre | 17 G Tuohy | 19 G n/a | Bupivacaine and bupivacaine | Bolus 12 mL of 0.125% bupivacaine + 50 µg fentanyl (12 mL in 4 mL aliquots) | 0.1% bupivacaine with 2 µg/mL fentanyl<br>10 mL/h background infusion via PCEA<br>Patient administered bolus 5 mL every 10 min with a 32 mL/h limit |

*PCEA* patient controlled epidural analgesia

*DPE in lower abdominal surgery

fentanyl was set to deliver 6 mL/h baseline infusion, bolus 6 mL on demand with a 15 min lock-out time interval and 20 mL/h limit [2], while the manual top up protocol included 10 mL of 0.2% ropivacaine with 20 μg fentanyl on patient's request [9]. According to a protocol which combines PCEA and manual top ups, initially 10 mL/h background infusion via PCEA including 0.1% bupivacaine with 2 μg/mL fentanyl is started and then followed by bolus 5 mL administration by the patient every 10 min with a 32 mL/h limit [10].

### Maternal, fetal and neonatal side and/or adverse effects

Maternal satisfaction and the outcomes were reported to be very good based on the available data to date. The incidence of maternal hypotension and pruritus with DPE were less than that of CSE and comparably similar to epidural [2] or did not differ between epidural and DPE [6]. Of note, the need for ephedrine rescue for hypotension was comparable between epidural and the DPE [8]. According to the previous comparative studies, either no postdural puncture headache (PDPH) after DPE has been reported or the rate of PDPH did not differ between the DPE and epidural [2, 6, 10]. Anyway, the incidence of PDPH in these existing studies could have been underpowered to detect a difference.

Additionally, the incidence of maternal adverse effects like backache, neck ache or persistent postpartum paresthesia were similar between epidural and the DPE though superior labor analgesia was not provided with DPE in the same study [8]. The rate of cesarean delivery were similar when epidural and/or CSE were compared with DPE [2, 6, 8–10].

Fetal outcomes might be variable. No fetal bradycardia was observed 20 min after both DPE and epidural [10]. However, there was a greater incidence of FHR abnormalities associated with intrathecal opioid used for CSE as anticipated. Furthermore, the incidence of combined uterine hypertonus and uterine tachysystole was less with DPE than that of epidural and CSE [2]. A couple of noteworthy additions to these results was that none of the participants received tocolysis in the DPE group and none of the participants underwent emergency cesarean delivery due to fetal decelerations in all groups (epidural, CSE and DPE) [2].

Favorable neonatal outcomes were supported by 8 or 9 median Apgar scores at 1 and 5 min or less frequent Apgar scores $< 7$ at 1 and 5 min [2, 6].

## Controversies and concerns

To understand the controversies and concerns related to the DPE studies, all the equipment, drugs and protocols are summarized for comparison (Table 1). Among the DPE studies, Suzuki et al's study [5] is a unique one only, because a 26 G Whitacre spinal and mepivacaine were used for the first time. However, the choice of local anesthetic for both induction and maintenance of analgesia protocols was bupivacaine which has been still a gold standard in our daily practice as it was in all other studies except two [7, 9]. Recently, ropivacaine which is a propyl homologue of bupivacaine has been used successfully for induction and maintenance of neuraxial analgesia as well as 26 G Whitacre spinal needle was preferred for DPE [9]. However, Thomas et al. [7] who used 27 G Whitacre spinal needle could not find DPE to be effective using lidocaine and bupivacaine for induction and maintenance of analgesia, respectively (Table 1).

The DPE analgesia is technically a modification of CSE and a kind of combination of CSE and epidural. However, analgesia management is considered to be both different and same in several ways. The initiation of analgesia is different from CSE because intrathecal dose is omitted but induction and maintenance of analgesia are provided via epidural catheter as it is in standard epidural. Since the efficacy and resulting quality of analgesia is dependent on the size of dural puncture to some extent and there is no specifically manufactured DPE set, use of either original CSE set including 27 G Whitacre spinal needle or a back eye epidural needle with soft catheter having multi-lateral holes and 25 or 26 G Whitacre 11.9/12 cm long spinal needles have been indicated (Table 1).

In spite of issues with either equipment or drugs, patient-related factors could have an impact on the success rate of DPE based on the different practices and/or protocols in the trials [4, 11, 12]. In this regard, the translocation of epidural medications through a conduit that dural puncture created into subarachnoid space could have been a possible underlying mechanism in the improved quality of analgesia [4]. The inflow of contrast from the epidural to the subarachnoid space after dural puncture with a Tuohy epidural needle was confirmed radiologically [4]. A number of patient-related factors might also affect the quality of analgesia. Spread of block could be influenced by the patient's posture and epidural compliance might vary by age [4]. In an in vitro study with dural puncture model, spread of epidurally administered drugs to subarachnoid space has been demonstrated by the flux of local anesthetics depending on the size and the distance of the dural puncture from the site of epidural drug administration [11]. Since the resting CSF pressure is higher than the pressure in the epidural space, a net effux of CSF to epidural space can be expected immediately after the dural puncture. The smaller the dural puncture, the limited the transfer of an epidural drug into the subarachnoid space through the dural hole [12]. However, it could not exactly explain the contradictory results among the clinical trials. Different analgesia management protocols used for initiation and maintenance of DPE could contribute to the quality of

analgesia. Especially two studies showed conflicting results on the success of DPE for labor analgesia [7, 8]. Thomas et al. [7] noted that puncture with 27 G spinal needle may be too small to demonstrate any benefit. On the other hand, Gupta et al. [8] who performed DPE under ultrasound guidance reported that the DPE was not superior than continuous lumbar epidural. However, when 27 G Whitacre spinal needle has been most recently used for performing DPE by Yadav et al. [9], DPE did not only fasten the onset of analgesia but also improved the quality of labor analgesia in contrast to Thomas et al's study [7]. Thus, the assumption about the size of the dural hole with 27 G to explain the failed success was found to be insufficient.

## Clinical practice

According to our preliminary unpublished data, annual delivery rate in our institution was 1764 and nearly 40% of the participants had vaginal delivery where 22% of them had neuraxial labor analgesia last year. After our presentation entitled 'Neuraxial Analgesia for Labour: Standard Techniques versus Novel Approach' was awarded the ESA 2017 [13, 14], we have been using DPE for labor analgesia. In contrast to the studies where 17 G Weiss epidural needle and 25 G Whitacre (11.9/12 cm long) spinal needle were used for performing DPE [2, 6], we prefer using 18 G Tuohy epidural needle with 20 G catheter having 3 lateral holes soft tip (Combifix Standart, Egemen® International, İzmir, Turkey) and a 25 GX120 mm long spinal needle (Anesthesia needle, Egemen® International, İzmir, Turkey) that is available in our unit. Our protocol is a combination of recent last three studies [2, 9, 10] and we induce neuraxial analgesia using 0.125% bupivacaine including 2 µg/mL fentanyl by administering in 5 mL fractions up to 20 mL and checking the upper sensory block level to be T10. After induction dose, we check sensory block level and analgesia quality. We aim to maintain analgesia between 0 and 3 according to an 11 point scale over 10 (10 being the worst pain imaginable, while 0 corresponding to no pain at all) graded by numeric pain rating scale (NPRS). In case of detecting NPRS > 3, we manually top up with the 10 mL of the same solution in 5 mL fractions again. When we retrospectively audited our recent data, we indicated that 73 participants received DPE analgesia and 5 out of 73 women underwent cesarean section due to tachysystole and/or hypertonus. We did not encounter any asymmetric block requiring catheter manipulation. All of the participants were interviewed to ascertain postpartum late complications, and satisfaction rate was roughly assessed as excellent = high, moderate and bad = low. One of our multiparous case with preeclampsia complained of PDPH which was relieved without any intervention. The satisfaction from the quality of the neuraxial analgesia was graded as excellent by all the women.

## Conclusion

In summary, DPE offers a favorable risk–benefit ratio for management of neuraxial analgesia as a novel option because of providing rapid onset of analgesia, early bilateral sacral analgesia with lower incidence of asymmetric block and fewer maternal and fetal side effects. Despite its advantages, the routine use of such a technique might be restricted, since some may have concerns whether the DPE has to take a place between the CSE and epidural to initiate neuraxial labor analgesia. Regarding the maintenance of labor analgesia which is still a very important main issue, some say that the DPE does not seem to add any new information.

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