



A Review of Literature on Epidural Technique for Lower Limb Surgeries

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ABSTRACT:

The present study was aimed to compare the efficacy of dural puncture epidural technique with the conventional epidural technique for adequate anesthesia and analgesia in lower limb orthopedic surgeries. A review of literature was conducted to accomplish our study.

Introduction

Epidural anaesthesia and analgesia is one of the many advances that has gained rapid acceptance due to evidence based reduction in morbidity and overall patient satisfaction in anaesthesia practice. The use of epidural analgesia in the US has tripled between 1981 and 2001, with 60% of women using this technique in large hospitals. Use of epidural anaesthesia is associated with fewer hypoxemic events in elderly patients undergoing lower extremity orthopaedic procedures. The use of systemic and epidural opioids was associated with a higher incidence of hypoxemic events compared with epidural analgesia with a local anaesthetic alone. The technique has minimal adverse effects but can be associated with slow onset and occasional, variable blockade qualities including inadequate sacral spread, unilateral or patchy sensory blockade, motor impairment and epidural catheter failure. Combined Spinal and Epidural Anaesthesia (CSE) offers advantages over the epidural or single injection spinal anaesthesia alone. CSE combines the benefits of certainty with a definitive end point (the appearance of cerebrospinal fluid) that is characteristic of spinal anaesthesia with flexibility of continuous epidural anaesthesia. It involves the use of a minimal dose of spinal anaesthetic for a shorter duration but allows flexibility of epidural reinforcement if necessary. It has been advocated over the conventional epidural technique by several authors for the advantages of its rapid onset, profound analgesia, high patient satisfaction and verification of epidural space by definitive return of cerebrospinal fluid (CSF) via the spinal needle, causing reduction in epidural catheter failures. CSE is like "to paint the fence" from both its sides. The spectrum of indications is those of the spinal or epidural alone or even more and range from labour analgesia to high abdominal and even thoracic and head operations by the adjuvant use of an endotracheal tube ventilation. The commonest indications are hip replacement surgery followed by hysterectomy, knee surgery, cesarean section, femur fracture in elderly, prostatectomy. This technique has been used for about 15 years without any reports of a unique or major complication attributed to the technique. However, the CSE technique has the potential of causing haemodynamic instability and other side effects of intrathecally given local anaesthetics and opioids. In order to minimize these side effects while retaining the advantages, a novel method of dural puncture epidural (DPE) is suggested by several authors in which a dural hole is created without intrathecal administration of drugs, prior to epidural injection of drugs. DPE technique is performed by creating a single dural perforation via a spinal needle placed through the shaft of an epidural needle, followed by placement of a catheter into the epidural space. However, unlike the CSE technique, where medications are directly administered through the spinal needle into the subarachnoid space, all medications for analgesia or anaesthesia are introduced through the epidural catheter into the epidural space.

Literature Review

Neuraxial techniques are the most effective form of labor analgesia, with significant rates of epidural (EPL) and combined spinal epidural (CSE) technique use in contemporary obstetric anesthesia practice. Although the medication combinations used in these techniques have evolved, the onset, block quality, and side effect profiles of both techniques warrant further optimization. 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. 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. 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. and followed by other investigators' experiences in the obstetric population. 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.

The dural puncture epidural (DPE) technique is performed by creating a single dural perforation via a spinal needle placed through the shaft of an epidural needle, followed by placement of a catheter into the epidural space. However, unlike the CSE technique, where medications are directly administered through the spinal needle into the subarachnoid space, all medications for analgesia or anesthesia are introduced through the epidural catheter into the epidural space. The dural puncture creates a conduit for translocation of medications from the epidural to subarachnoid spaces, a process that is believed to be responsible for the unique characteristics that are observed with the DPE technique.

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 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. Better hemodynamic stability and improved epidural catheter function would be possible because of no intrathecal drugs are administered in DPE.

In lower limb surgeries, spinal anesthesia, epidural anesthesia or combined spinal and epidural techniques are preferred due to the fact that only the desired region undergoes nerve blockade, which results in early mobilization and good patient satisfaction.

Song et al (2020) studied the effect of Dural Puncture Epidural Technique Combined With Programmed Intermittent Epidural Bolus on Labor Analgesia Onset and Maintenance: A Randomized Controlled Trial. Nulliparous women with a visual analog scale (VAS) pain score >50 mm and cervical dilation <5 cm were randomly assigned to receive EP+CEI, DPE+CEI, or DPE+PIEB for labor analgesia. A 25-gauge needle was used for dural puncture. Analgesia was initiated with 10 mL of 0.1% ropivacaine with 0.3 $\mu\text{g}/\text{mL}$ of sufentanil and maintained with the same solution at 8 mL/h in all groups. A 5-mL patient-controlled epidural analgesia (PCEA) bolus was programmed with a 20-minute lockout. Breakthrough pain not amendable by PCEA was treated with provider boluses of 5 mL of 0.125% ropivacaine. The primary outcome was "time to adequate analgesia," defined as a VAS pain score ≤ 30 mm during 2 consecutive contractions, and was analyzed using Kaplan-Meier curves and a Cox proportional hazard model. Secondary outcomes included the VAS scores, ropivacaine consumption, sensory block level to ice, PCEA and provider boluses intervention, mode of delivery, duration of labor, Bromage scores, Apgar scores, occurrence of side effects, and maternal satisfaction with the anesthesia. A total of 116 women were included (38 in the EP + CEI group, 40 in the DPE + CEI group, and 38 in the DPE + PIEB group). Adequate anesthesia was achieved faster in the DPE + CEI and DPE + PIEB groups than in the EP + CEI group (hazard ratio = 1.705; 95% confidence interval [CI], 1.039-2.800; $P = .015$; and hazard ratio = 1.774; 95% CI, 1.070-2.941; $P = .012$, respectively). DPE technique with PIEB mode was associated with the fewest PCEA boluses and the lowest hourly ropivacaine consumption (both $P < .001$). There were no differences in the duration of labor, mode of delivery, Bromage scores, newborn Apgar scores, incidence of side effects, and maternal satisfaction scores among the groups.

Heesen et al in 2019 conducted a systematic literature to identify randomized controlled trials (RCT) comparing DPE with epidural analgesia. Five RCTs including 581 patients were identified. One RCT on caesarean section was excluded. Single studies suggested slightly better analgesia by finding a median time to achieve sufficient analgesia of two minutes less in the DPE group, a higher number of women having a pain score $<10/100$ at 20 min, a reduction in the number of epidural top-ups and better sacral spread. The studies did not show a difference between DPE and epidural analgesia for catheter replacement or manipulation rates, the incidence of intravascular placement or unilateral block. There is a lack of clear evidence on either the benefits or the risks of the DPE technique, such that a recommendation for or against its routine use is premature. Two of the three studies showing a beneficial effect of DPE came from the same institution and replication of the findings by other groups is warranted.

Yadav et al (2018) evaluated whether dural puncture improves onset and duration of labor analgesia when compared to conventional epidural technique. Sixty term primigravida parturients of ASA grade I and II were randomly assigned to two groups of 30 each (Group E for conventional epidural and Group DE for dural puncture epidural). In group E, epidural space was identified and 18-gauge multi-orifice catheter was threaded 5 cm into the epidural space. In group DE, dura was punctured using the combines spinal epidural (CSE) spinal needle and epidural catheter threaded as in group E followed by 10 ml of injection of Ropivacaine (0.2%) with 20 mcg of Fentanyl (2 mcg/ml) in fractions of 2.5 ml. Later, Ropivacaine 10 ml was given as a top-up on patient request. Onset, visual analogue scale (VAS), sensory and motor block, haemodynamic variables, duration of analgesia of initial dose were noted along with mode of delivery and the neonatal outcome. Six parturients in group DE achieved adequate analgesia in 5 minutes while none of those in group E ($P < 0.05$) achieved adequate analgesia. The mean VAS score was 4.97 ± 0.85 in group E and 4.33 ± 0.922 in group DE at 5 min ($P < 0.05$). Duration of analgesia of initial bolus dose was 99.37 ± 23.175 min in group E and 98.77 ± 24.955 min in group DE ($P > 0.05$).

Both techniques of labor analgesia are efficacious; dural puncture epidural has the potential to fasten onset and improve quality of labor analgesia when compared with conventional epidural technique. Chau et al (2017) hypothesized that the onset of labor analgesia would follow this order: CSE $>$ DPE $>$ EPL techniques. A total of 120 parturient in early labor were randomly assigned to EPL, DPE, or CSE groups. Initial dosing for EPL and DPE consisted of epidural 20 mL of 0.125% bupivacaine plus fentanyl 2 $\mu\text{g}/\text{mL}$ over 5 minutes, and for CSE, intrathecal 0.25% bupivacaine 1.7 mg and fentanyl 17 μg . Upon block completion, a blinded co-investigator assessed the outcomes. Two blinded obstetricians retrospectively interpreted uterine contractions and fetal heart rate tracings 1 hour before and after the neuraxial technique. The primary outcome was time to numeric pain rating scale (NPRS) ≤ 1 analyzed by using Kaplan-Meier curves and Cox proportional hazard model. Secondary outcomes included block quality, maternal adverse effects, uterine contraction patterns, and fetal outcomes analyzed by using the χ^2 test with Yates continuity correction. There was no significant difference in the time to NPRS ≤ 1 between DPE and EPL. DPE achieved NPRS ≤ 1 significantly slower than CSE. The median times (interquartile range) to NPRS ≤ 1 were 2 (0.5–6) minutes for CSE, 11 (4–120) minutes for DPE, and 18 (10–120) minutes for EPL. Compared with EPL, DPE had significantly greater incidence of bilateral S2 blockade at 10 minutes, 20 minutes, and 30 minutes, a lower incidence of asymmetric block after 30 minutes and physician top-up intervention. Compared with CSE, DPE had a significantly lower incidence of pruritus, hypotension, combined uterine

tachysystole and hypertonus, and physician top-up intervention. Analgesia onset was most rapid with CSE with no difference between DPE and EPL techniques. The DPE technique has improved block quality over the EPL technique with fewer maternal and fetal side effects than the CSE technique for parturient requesting early labor analgesia. Block et al (2003) conducted a study to compare whether epidural analgesia is a better method than parenteral opioids for post-operative pain control and concluded that epidural analgesia, regardless of analgesic agent, location of catheter placement, and type and time of pain assessment, provided better post-operative analgesia compared with parenteral opioids. A study was conducted by Zaric et al in 2006 comparing epidural analgesia with combined continuous femoral-sciatic nerve block in patients undergoing total knee replacement. In this study there was no difference in post-operative analgesia between the two, so CFNB was recommended as a part of multimodal analgesia in patients after total knee replacement. Moraca et al (2003) conducted a study to review the potential and proven benefits and complications of epidural anesthesia/analgesia and concluded that epidural anesthesia/analgesia has been demonstrated to improve postoperative outcome and attenuate the physiologic response to surgery. The CSE technique has been extensively used because it achieves rapid onset and profound blockade with the facility to modify or prolong the block. A controlled study was undertaken by Gupta et al (2013) to compare sequential CSE with epidural block for gynaecological and orthopaedic surgery and concluded that sequential CSE is superior alternative to epidural block, which combines the advantages of spinal and epidural while minimizing their drawbacks. Hence, combined spinal and epidural anesthesia offers the advantages of both the techniques and is becoming a popular clinical technique for obstetric, gynaecologic, orthopedic, and urologic surgery. But DPE has emerged as a HOLE LOT BETTER technique compared to CSE or EPL technique. When compared with the EPL technique, the DPE technique has been demonstrated to improve block onset and spread of anesthesia and analgesia with fewer adverse effects compared with the CSE technique. Suzuki et al (2006) conducted a study on forty patients to study the effect of dural puncture with a 26G needle on spread of analgesia induced by epidural injection of local anesthetics and concluded that the spread of analgesia in a caudal direction was significantly greater in the dural puncture group than in the control group.

Discussion

The dural puncture creates a conduit for translocation of medications from the epidural to subarachnoid space, a process that is believed to be responsible for the unique characteristics that are observed with the DPE technique. When compared with the EPL technique, the DPE technique has been demonstrated to improve sacral block onset and spread of anaesthesia and analgesia. In addition, the process of creating a dural puncture with a spinal needle through an epidural needle uses CSF return as a “confirmatory” definitive end point for the likely positioning of the epidural needle tip within the epidural space. Furthermore, by avoiding direct intrathecal administration of medication, the DPE technique may have fewer adverse effects compared with the CSE technique. DPE as a technique has been used in labour analgesia but has not yet been evaluated in orthopaedic surgeries. With the aim of providing improved onset and duration of epidural anaesthesia and analgesia with fewer side effects and less epidural catheter failure, it was worthwhile to evaluate and compare the DPE technique with conventional epidural technique in patients undergoing lower limb orthopaedic surgeries.

Result

Hence, review of literature revealed number of studies on dural puncture epidural technique in labor analgesia with encouraging results. However, there is a dearth of studies exploiting the advantages of this technique in other surgical specialties. It was hence worthwhile to compare this DPE technique to the conventional epidural technique in patients undergoing orthopedic lower limb surgeries.

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