DURAL PUNCTURE EPIDURAL ANALGESIA IS NOT SUPERIOR TO CONTINUOUS LABOR EPIDURAL ANALGESIA

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Abstract

Background: Some anesthesiologists consider combined spinal epidural (CSE) analgesia as superior alternative to continuous labor epidural (CLE) analgesia. However, during CSE, even small doses of intrathecally administered local anesthetics with opioids induce almost instant analgesia that precludes the testing of epidural catheters as well as early appreciation of failed epidural catheters. To overcome the shortcomings of CSE analgesia, dural puncture epidural (DPE) analgesia had been devised.

Objectives: The goals for the present study were to test whether DPE technique would provide superior and safer labor analgesia as compared to CLE technique.

Materials and Methods: 131 ASA Class I, II and III pregnant patients who requested labor epidural analgesia consented for their participation in this prospective randomized study. Group A patients received CLE analgesia for labor pain. Group B patients received DPE analgesia for labor pain.

Results: After exclusion of nineteen patients, final comparative data was available for 112 patients only [Group A (n = 63) versus Group B (n = 49)]. Per our analysis, the only positive aspect for DPE analgesia as compared to CLE analgesia was that patients who received DPE analgesia reported lower incidence for immediate failures of labor analgesia (P = 0.04). However, there was higher incidence of paresthesias while performing successful dural punctures (P <0.0001). Pre-insertion epidural depth assessment with ultrasound (n = 112) correlated positively with the air-filled loss of resistance syringe technique (r = 0.88; P <0.0001).

Conclusion: DPE technique did not provide superior labor analgesia as compared to CLE technique. Technically, fewer immediate failures in labor analgesia but higher incidence of paresthesias were observed with DPE technique.

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Introduction

Presently, combined spinal epidural (CSE) analgesia is revered by many anesthesiologists at various labor and delivery centers as a potentially superior alternative to continuous labor epidural (CLE) analgesia[1]. However, during CSE, even small doses of intrathecally administered local anesthetics with opioids can induce almost instant analgesia that precludes the testing of epidural catheters as well as early appreciation of failed epidural catheters[2-3].

To overcome the shortcomings of CSE analgesia, dural puncture epidural (DPE) analgesia had been devised[4-7]. With DPE technique, after dural puncture with 25G spinal needle through 17G Tuohy needle, intrathecal analgesics are not administered. Therefore, DPE technique allows confirmation of epidural space as similar to CSE technique[8-12] [cerebrospinal fluid (CSF) flow from spinal needle confirms that Tuohy needle is in epidural space]; however, testing for early epidural catheter failure is not delayed in DPE analgesia as the masking effects of intrathecal analgesics are avoided. It has been theorized that enhancement of labor analgesia by intrathecal transfer of epidural analgesics across the dural puncture occurs in both CSE and DPE techniques[13-17].

The aims for the present study were to test whether DPE technique can provide superior and safer labor analgesia as compared to CLE technique, and whether visual appreciation of intrathecal transfer of epidural analgesics would be feasible with ultrasound with the DPE technique.

Materials and Methods

After institutional review board approval, 131 ASA Class I, II and III pregnant patients at an academic university women's hospital who requested labor epidural analgesia were included in this prospective randomized study. Patients' written and informed consents were taken for their participation in the study. ASA class IV and V patients, patients with history of back surgery or central nervous system disease, and patients' who refused to have dural puncture were excluded from the study. For lumbar ultrasound examinations, VENUE 40 ultrasound machine (GE Healthcare, Wauwatosa Wisconsin, United States) was used with curvilinear probe (Model 4C, 1.5-4.5 MHz, GE Healthcare, Wauwatosa, Wisconsin, United States). The study participants were randomized (via a computer generated program) into two groups:

Group A (CLE technique): Using transverse lumbar ultrasound at L2-L3 or L3-L4 interspaces, the depth of epidural space was assessed. Under sterile conditions and after local anesthetic infiltration, a 17 gauge Tuohy needle and loss of resistance technique with air was used to enter the epidural space. The actual depth of the epidural space was compared with the depth of the epidural space determined with the ultrasound. A 19 gauge epidural catheter was threaded through the needle with 5 cm of catheter left in the epidural space. Following a negative aspiration and a negative response to test dose (3 ml 1.5% lidocaine with 1:200,000 epinephrine), loading epidural dose of 0.125% bupivacaine with 10mcg/ml fentanyl was administered in two incremental doses of 5 ml each. The ultrasound examination was performed in the sagital orientation to assess any intrathecal movement of the epidural solution across the ultrasonic landmark of posterior ligament complex. After five minutes of continuous ultrasound observation, the epidural catheter was secured and attached to the continuous epidural infusion of the 10 ml/hr 0.125% bupivacaine with 2.5 mcg/ml fentanyl.

Group B (DPE technique): Similar to Group A, transverse lumbar ultrasound examination was used to assess the depth of epidural space and this was compared with the actual depth of epidural space as identified with air-filled loss of resistance syringe. The 25 gauge Pencan needle was introduced through the Tuohy needle to make an intentional dural puncture. Subsequently, after intrathecal space was identified by the free CSF flow, the Pencan needle was removed without giving any medications intrathecally and a 19 gauge epidural catheter was threaded through the needle with 5 cm of catheter left in the epidural space. Following a negative aspiration and a negative test dose (3 ml 1.5% lidocaine with 1:200,000 epinephrine), loading epidural dose of 0.125% bupivacaine with 10 mcg/ml fentanyl was administered in two incremental doses of 5 ml each. The ultrasound examination was performed in the sagital orientation to assess

any intrathecal movement of the epidural solution across the ultrasonic landmark of posterior ligament complex. After five minutes of continuous ultrasound observation, the catheter was secured and attached to the continuous epidural infusion of the 10 ml/hr 0.125% bupivacaine with 2.5mcg/ml fentanyl.

The following observations were recorded: (a) pre-procedure: participant's age, height and weight, (b) intra-procedure: the time taken for epidural placement, depth of epidural space (by ultrasound), number of skin insertion attempts at the epidural placement, number of changes in the orientation of the epidural needle to find epidural space, intrathecal flow of epidural solution as assessed on ultrasound examination, and any complications including but not limited to inadvertent dural puncture with Tuohy needle, intravascular catheter placement, paresthesias and immediate headaches, (c) post-procedure (initial 2 hours after procedure): incidence of failure of epidural analgesia, epidural boluses or augmentation of the rate of continuous epidural infusion, and any rescue ephedrine doses for hypotension secondary to neuraxial blockade, and (d) post-procedure (day 1): any headaches, backaches, neck-aches, or other adverse events, any persistent paresthesias, and participant's satisfaction scores with ease of epidural placement and with adequacy of epidural analgesia. All of the above data were collected for both groups, and then analyzed and compared between the two groups.

For statistical analysis, initial calculation of adequate sample size[18] was 134 subjects [power (1-beta) = 0.95; alpha error = 0.05] with medium effect (0.3) as predicted difference between the successes of the two analgesia methods (CLE and DPE). However, due to exclusion of withdrawn cases, the secondary statistical calculation ensured that even for power (1-beta) of 0.8 and alpha error of 0.05 with predicted difference as a medium effect (0.3), the minimum sample size required was 82 subjects (41 subjects in each group). ANOVA Single factor was used for comparison between the means and variance of the continuous data. Chi-Square test and a two tailed Fisher exact test were used to compare sample size based proportions. A P-value of <0.05 was considered significant.

Results

A total of 131 patients consented for participation in the study. Two patients were excluded as they delivered within 30 minutes after consenting for study and two pre-term patients were excluded as they were discharged home after failed progression of cervical dilatation. Out of remaining 127 patients, 15 patients in Group B were excluded because dural punctures were not successful. Hence, final comparative data was available for 112 patients only [Group A (n = 63) versus Group B (n = 49)] (Tables 1-4). There was no significant difference in the demographics of the two patient-groups (Table 1). Per our analysis (Table 3), patients who had received DPE analgesia reported lower incidence for immediate failures of labor analgesia (P = 0.04) [Chi-Square Test; power (1-beta) = 0.53]. Additionally, less time was required by the anesthesia-operators to perform DPE (P = 0.03) (Table 1) possibly because the difficult and unsuccessful dural punctures got excluded from the final comparison (n = 15). In regards to adverse effects (Tables 2-4), there was higher incidence of paresthesias while performing successful dural

Table 1

Demographic Characteristics of the Study Patients who underwent Labor Analgesia

	Group A Continuous Labor Epidural (n = 63)	Group B Dural Puncture Epidural (n = 49)	P value
Age (yrs)	24.86 ± 5.91	24.78 ± 6.05	0.94
Body Mass Index (Kg/m^2)	33.79 ± 9.64	33.48 ± 8.97	0.86
Time taken for Epidural Placement (min)	8.40 ± 6.36	6.33 ± 2.28	0.03

Table 2
Intra-procedure Characteristics of the Study Patients who underwent Labor Analgesia

	Group A Continuous Labor Epidural (n = 63)	Group B Dural Puncture Epidural (n = 49)	P value
Ultrasound evidence of Epidural Medications Flow	2 (n = 10) (20%)	0 (n = 10) (0%)	0.21
Ultrasound Evidence of Scoliosis	4 (6%)	8 (16%)	0.09
Number of Skin Attempts	1.60 ± 0.89	1.35 ± 0.63	0.09
Number of Needle Orientation Changes during Placement	1.21 ± 1.39	0.61 ± 1.02	0.01
Incidence of Accidental Wet tap	1 (2%)	0 (0%)	0.38
Incidence of Intravascular Placement of Epidural Catheter	2 (3%)	5 (10%)	0.13
Incidence of Paresthesias during Epidural Placement	1 (2%)	14 (29%)	<0.0001
Patient Satisfaction Numerical Rating Scale for Epidural Placement	8.10 ± 2.86	8.08 ± 2.57	0.98

punctures (P <0.0001) (Table 2). Due to the novelty of ultrasound assessment for epidural medication flow to intrathecal space, only two visualizations of epidural medications' flow were observed among the first twenty cases [Group A: first ten cases; Group B: first ten cases] wherein it was attempted (Table 2). However, pre-insertion epidural depth assessment with ultrasound (n = 112) correlated positively with the air-filled loss of resistance syringe technique (r = 0.88; P <0.0001) (see Fig. 1).

Discussion

There has been limited evidence related to DPE. Leach and Smith[4] (1988) reported a case of inadvertent dural puncture and radiologically confirmed subarachnoid spread of epidural solution. Suzuki et al[5] (1996) showed that DPE with 26G spinal needle increases caudal (not cranial) spread of epidural analgesia. However, Thomas et al[6] (2005) did not report any improvements over CLE when DPE was performed with 27G spinal needle. More recently, Cappiello et al[7]

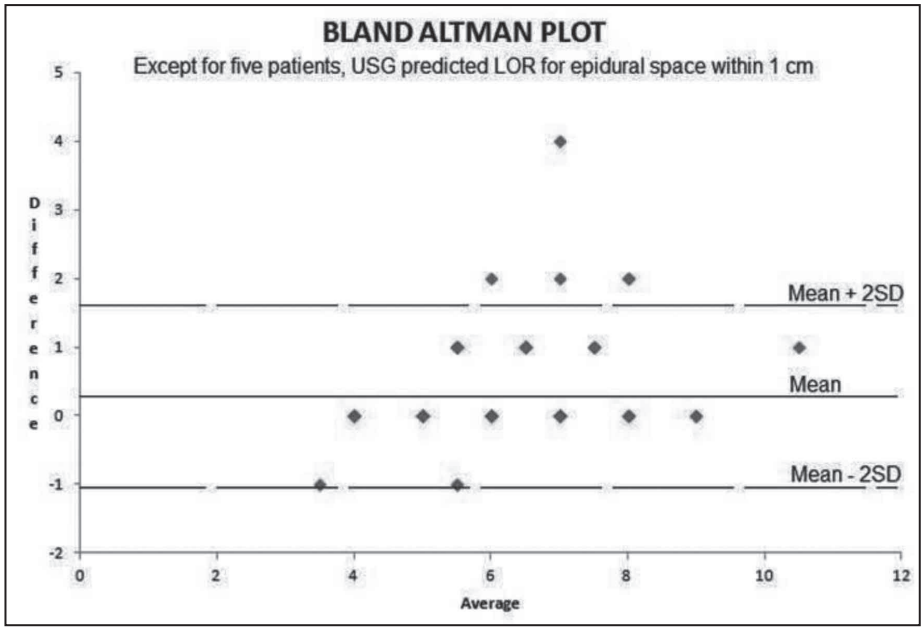

Fig. 1
Correlation between pre-insertion lumbar ultrasound-based estimation and loss of resistance syringe-based actual depth of epidural space in study patients (n = 112)

Table 3
Early Complications in the Study Patients who underwent Labor Analgesia

	Group A Continuous Labor Epidural (n = 63)	Group B Dural Puncture Epidural (n = 49)	P value
Incidence of Headache immediately after Epidural Placement	1 (2%)	0 (0%)	0.38
Incidence of Failure of Epidural Analgesia within 2 hrs	5 (8%)	0 (0%)	0.04
Incidence of Additional Epidural Boluses within 2 hrs	10 (16%)	5 (10%)	0.38
Incidence of Augmentation of Epidural Infusion Rate within 2 hrs	4 (6%)	3 (6%)	0.96
Incidence of Administration of Ephedrine Rescues for Hypotension within 2 hrs	5 (8%)	4 (8%)	0.97

(2008) conducted randomized controlled trial for DPE with 25G spinal needle and concluded improvement in sacral spread and faster onset of pain relief for DPE analgesia. However our results with 25G spinal needle-induced intentional dural puncture suggest that DPE analgesia was not superior to CLE analgesia in our parturient patient population.

There were some differences in our study design (a possible explanation for the variant results) as compared to previous three studies[5-7]. In the first study, Suzuki et al[5] had performed dural punctures in only 20 patients and observed that the caudal spread of epidural analgesia after the initial epidural bolus (15 ml 2% mepivacaine) was significantly more than analgesia observed in control group (n = 20) at 15 minutes and 20 minutes after the injection; however they did not document whether this advantage in caudal spread was still applicable when they repeated 10 ml 2% mepivacaine bolus at 60 minutes intervals. The mean duration of their surgical procedures was approximately two hours[5]; and our perfect success rates of DPE analgesia in the first two hours after epidural placement compared to 92% success rate with CLE analgesia (Table 3) similarly reflect that DPE analgesia related perfect initial success rates can be related to the caudal and intrathecal spread of initial epidural boluses. This advantage of absence of early failures of epidural analgesia did not transform into a significant difference in overall patients' satisfaction scores between our two groups of patients (Table 4) questioning how long dural hole remains patent or how long intrathecal-epidural pressure gradient allows intrathecal transfer of epidural medications. Therefore we would recommend caution in employing DPE for labor analgesia because compared to CLE analgesia, DPE analgesia had both significantly higher incidence of intra-procedure complication (paresthesias) as well as insignificant but clinically appreciable higher incidence of delayed complications (postpartum headaches and neck-aches) (Table 4).

In the second study, Thomas et al[6] had utilized 27G spinal needle for DPE in 125 patients and observed that dural punctures were not successful (no CSF return observed in spinal needle) in 18 patients (14%). Analogously, we observed that dural punctures failed in 15 patients (23%) of our DPE analgesia group. Though Thomas et al[6] had bigger sample size (CLE: n = 123; DPE: n = 107) for final analysis as compared to our study (CLE: n = 63; DPE: n = 49), incidence of intravascular placement of epidural catheters (CLE group: 6%; DPE group: 10%)[6] were comparable to our study (CLE group: 3%; DPE group: 10%) (Table 2). As compared to our perfect success rates of DPE analgesia in the first two hours precluding the need for epidural replacements (Table 3), epidural replacement rates were 9% with DPE according to Thomas et al[6]. However, as compared to their observed incidence of 9% for intra-procedure paresthesias with DPE[6], we observed 29% incidence of intra-procedure paresthesias with DPE. In summary, Thomas et al[6] had suggested that 27G spinal needle induced dural puncture may be too small for epidural medications to transfer across intrathecally and this may be the explanation for their higher epidural replacement rates

Table 4
Delayed Complications in the Study Patients who underwent Labor Analgesia

	Group A Continuous Labor Epidural (n = 63)	Group B Dural Puncture Epidural (n = 49)	P value
Incidence of Epidural Boluses during Pushing in Labor	10 (16%)	14 (29%)	0.10
Incidence of Conversion to Cesarean Section	10 (16%)	10 (20%)	0.53
Incidence of Failure of Epidural Anesthesia Intraoperatively	3 (n = 10) (30%)	2 (n = 10) (20%)	0.60
Incidence of Failure of Epidural Analgesia Postoperatively	3 (n = 10) (30%)	2 (n = 10) (20%)	0.60
Patient Satisfaction Numerical Rating Scale for Epidural Analgesia	8.68 ± 2.74	8.95 ± 1.96	0.55
Incidence of Postpartum Headaches	2 (3%)	4 (8%)	0.24
Incidence of Postpartum Backaches	37 (59%)	22 (45%)	0.14
Incidence of Postpartum Neck-aches	2 (3%)	5 (10%)	0.12
Incidence of Persistent Postpartum Paresthesia	0 (0%)	1 (2%)	0.25

compared to our perfect success rates with 25G spinal needle induced DPE analgesia.

In the third study, Cappiello et al[7] (CLE: n = 40; DPE: n = 39) observed that 85% patients reported visual analogue scores <10 mm on 100-mm scale at 20 minutes after DPE (with 25G spinal needle induced dural puncture) compared to only 65% patients with CLE (reflecting faster onset of analgesia). Although the sacral spread as denoted by first sacral spinal segment blockade was not significantly different at 20 minutes with DPE[7], the sacral spread was significantly better with DPE (92% patients) at any time during labor compared to only 70% patients achieving sacral spread to first sacral spinal segment with CLE[7]. However the sacral spread beyond first sacral spinal segment was not different with DPE (77% patients) or CLE (65% patients) at any given time point during the study[7]. Epidural catheter replacement rates were higher (DPE: 3%; CLE: 13%)[7] than our study. Though Cappiello et al[7] had observed 31% instrumental vaginal deliveries with DPE as compared to 13% with CLE, we did not collect data reflecting the incidence of instrumentation during vaginal deliveries in our patients. However cesarean section rates observed by Cappiello et al[7] were higher (CLE: 25%; DPE: 31%) as compared to our observations (CLE: 16%; DPE: 20%).

Lumbar ultrasound imaging performed in the transverse plane has been reported to accurately estimate epidural space depth for facilitating the appropriate catheter placement for neuraxial labor analgesia. This pre-insertion screening ultrasound has been investigated in non-obese parturients[19] as well as obese parturients[20]. Additionally, it was our hypothesis during our study design that visual appreciation of intrathecal transfer of epidurally administered medications may be feasible with lumbar ultrasound and may become a great addition to obstetric anesthesiologists' armamentarium. Although our results showed good correlation between ultrasound assessment of epidural space depth and air-filled loss of resistance syringe technique (Figure 1), we were not able to appreciate the ultrasonographic visualization of epidural medication flow (within the epidural space or across the dural puncture into the intrathecal space). This failure may be related to the novelty of visualizing medication flow in epidural and intrathecal spaces; however our failure may not deter future researchers from refining the technique to visualize neuraxial medication flow with lumbar ultrasound.

With DPE technique, dural puncture precipitated

high incidence of intra-procedure paresthesias possibly due to dural tenting by Tuohy needle and subsequent potential fluid waves in the subarachnoid space that might have been minimally compressed (posteriorly) by the tented duramater. However, persistent paresthesias, 24hrs after the procedure, occurred in only one patient. These immediate (intra-procedure) paresthesias may also be explained by the dural puncture needle's proximity to the cauda equina nerve roots because tented duramater might have reduced the anterioposterior diameter of subarachnoid space (free space for cauda equina nerve roots) at the site of subsequent dural puncture. Although long term sequelae of these paresthesias are not known, these paresthesias may deem DPE technique as unwarranted when per our results, DPE technique does not provide superior analgesia compared to CLE technique.

Our study had few limitations. Even though DPE analgesia was not superior to CLE analgesia, high satisfaction scores of the parturients may have been confounded by post-partum elation that might have interfered with patients' overall appreciation of differences, if any, between the analgesia achieved with DPE technique vs. CLE technique. Though headaches and neck-aches were more common with DPE technique (Table 4), they may not have reached level of significance [power (1-beta) of our results: 0.23 for headaches; 0.35 for neck-aches] due to overall very low incidence of these adverse effects. Therefore, per our results, DPE technique may appear to have a very limited role (as a confirmation test only) when accessing difficult epidural space wherein air-filled loss of resistance syringe technique is not providing good depth appreciation and lumbar ultrasound imaging of epidural space is not accessible or appreciable by the obstetric anesthesiologist.

Conclusion

DPE technique did not provide superior labor analgesia as compared to CLE technique. Technically, fewer immediate failures in labor analgesia but higher incidence of paresthesias were observed with DPE technique. Due to novelty of ultrasound examination for epidural medication flow, visualization of intrathecal transfer of epidural analgesics was not appreciated in the present study.

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