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CLINICAL TRIAL REPORT

The Effectiveness and Safety of Dural Puncture Epidural for Aged Patients Undergoing Orthopedic Surgery: A Randomized Controlled Trial

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Objective: The dural puncture epidural (DPE) technique is a novel approach for neuraxial anesthesia. While effective for cesarean sections and labor analgesia, its use in orthopedic surgery for elderly patients remains unexplored. This study evaluates the efficacy and safety of DPE in elderly patients undergoing orthopedic surgery.

Methods: A total of 126 elderly patients were randomly assigned to three groups: epidural block (EPL), combined spinal epidural block (CSE), and DPE. The primary outcome was the onset time of anesthesia. Secondary outcomes included maximum anesthesia level, Onset time of motor block, blood pressure, and heart rate at key points, anesthetic efficacy, and adverse reactions such as hypotension, respiratory depression, nausea and vomiting, chills, and bradycardia.

Results: The onset time of anesthesia in the DPE group was significantly shorter than in the EPL group (17.6±4.0 min vs 19.2 ±3.9 min, P=0.037) but longer than in the CSE group (17.6±4.0 min vs 7.0±2.8 min, P<0.001). The Onset time of motor block was notably longer in the DPE group compared to the CSE group (20.6±3.8 min vs 9.2±3.9 min, P<0.001). At five minutes post-anesthesia, mean arterial pressure was significantly higher in the DPE group than in the CSE group (88.2±7.0 mmHg vs 84.4±7.6 mmHg, P=0.018); however, no significant difference was found between the EPL and DPE groups. Additionally, there were no significant differences among all three groups regarding hemodynamic parameters at other assessed time points, incidence of adverse reactions, or anesthetic effects.

Conclusion: The onset time of DPE is faster than that of EPL, its impact on the circulatory system is less than that of CSE, and it has a satisfactory anesthetic effect, which may improve the anesthesia management in elderly orthopedic surgeries.

Keywords: dural puncture epidural block, combined spinal epidural block, epidural block, neuraxial anesthesia, orthopedic surgery

Introduction

As society continues to age, the elderly population in China is experiencing rapid growth.[1] Concurrently, there is a decline in bone mineral density and an increased risk of falls among older adults. Consequently, fractures among the elderly have emerged as a significant public health concern. With societal advancements, improvements in medical technology, and extended life expectancy, an increasing number of elderly patients opt for surgical interventions. This has resulted in a notable rise in orthopedic surgeries performed on this demographic.[2,3] Neuraxial anesthesia is characterized by its minimal use of anesthetic agents and low incidence of perioperative complications. Furthermore, it has been shown to have little effect on postoperative cognitive dysfunction. As such, it has become a common anesthetic technique for orthopedic surgeries involving elderly patients.[4]

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Epidural block (EPL) and combined spinal epidural block (CSE) are commonly employed neuraxial anesthesia techniques in clinical practice. CSE is characterized by its rapid onset and precise anesthetic effects; however, it significantly impacts hemodynamics.[5,6] In contrast, EPL has a minimal effect on circulation but is associated with a slower onset time and incomplete sacrococcygeal block and requires a larger volume of local anesthetics.[7] For elderly patients with compromised physiological reserves, it is advisable to select drugs and methods that exert less physiological interference while adequately addressing the requirements of surgical procedures. Consequently, neither technique emerges as an ideal choice for elderly orthopedic patients.

In recent years, a novel neuraxial anesthesia technique known as dural puncture epidural block (DPE) has gradually gained attention in the medical community. In the context of obstetric anesthesia, DPE has demonstrated superior blocking quality, faster onset time, and reduced local anesthetic dosage compared to EPL while also exhibiting less impact on circulatory function than CSE.[8–10] However, the current clinical application of DPE is primarily focused on obstetrics, with a notable lack of relevant research on elderly orthopedic surgery. This study aims to investigate whether this technology can yield comparable outcomes in elderly orthopedic patients.

Methods

Study Design and Population

This prospective randomized controlled trial (RCT) was conducted at TongLiang Traditional Chinese Medicine Hospital, Chongqing, from August 2022 to September 2023. The Ethical approval for this study (tlqzyy202214) was provided by the Ethical Committee and was registered in the Chinese Clinical Trial Registry (ChiCTR2300074584). Written informed consent was obtained from all eligible participants or their legal representatives.

Inclusion criteria: 1. Age ≥ 60 years; 2. Undergoing lower extremity orthopedic surgery; 3. Receiving neuraxial anesthesia; 4. ASA classification of I–III; 5. Availability of complete clinical data and informed consent obtained.

Exclusion Criteria: 1. Patients with either a documented history of hypertension requiring regular antihypertensive medication, or preoperative systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg on two consecutive measurements; and those with a history of severe cardiovascular or cerebrovascular diseases, such as myocardial infarction, cerebral stroke, or heart failure (NYHA class III or IV), or other comparable serious conditions; 2. Patients with allergies to local anesthetics; 3. Patients contraindicated for neuraxial anesthesia due to abnormal coagulation, skin infections or lesions at the puncture site, or severe spinal deformities; 4. Patients with cognitive impairments or mental disorders; 5. Patients exhibiting poor compliance who are unable to cooperate effectively.

Randomization and Blinding

The patients were randomly assigned to three groups: the DPE group, the CSE group, and the EPL group. Before the commencement of the study, Researcher 1 numbered all 126 patients from 1 to 126 and utilized SPSS version 25.0 software to generate a corresponding set of 126 random numbers. These random numbers were then ranked and sorted, leading to their division into three distinct groups: Group 1, Group 2, and Group 3 (which corresponded to DPE, CSE, and EPL, respectively). The subjects associated with each random number were allocated accordingly. Investigator 2 prepared a total of 126 envelopes labeled from 1 to 126 and placed the assignment scheme into each envelope based on the generated random-number assignment table Investigator 3 sequentially opened these envelopes in accordance with the patient enrollment order; they determined the type of anesthesia required based on group assignments before administering it. Data collection was conducted by Investigator 4, who remained unaware of group assignments throughout this process. Subsequently, data assessment and analysis were performed by independent statisticians (Investigator 5) to ensure the effective implementation of investigator blinding. Although patients were informed of the three anesthesia techniques during the informed consent process, the anesthesia consent form only stated "neuraxial anesthesia" without disclosing the specific assigned technique. Meanwhile, all groups adopted standardized intraoperative management, postoperative care, and follow-up protocols to avoid leaking relevant clues, ensuring the effective maintenance of patient blinding throughout the study period.

Intervention and Intraoperative Management

One day before surgery, patients underwent interviews and educational sessions regarding the surgical procedure and anesthesia. All patients were routinely fasted for 8 hours and prohibited from consuming any liquids for 2 hours before the operation. Upon entering the operating room, non-invasive blood pressure (NIBP), pulse oxygen saturation (SpO2), electrocardiogram (ECG), body temperature (T), and heart rate (HR) were monitored as standard practice. The upper limb vein was accessed, and a crystalloid solution of 500 mL was infused before the initiation of anesthesia. Subsequent fluid administration was managed based on the anesthesiologist's clinical judgment.

Before the initiation of anesthesia, the patient assumes a lateral recumbent position, with knees flexed and the waist curved. The patient's back is flush with the edge of the operating table The L3-4 interspace is localized based on the intersection of the line joining the highest points of both iliac crests (Tuffier's line) and the spine. The spinous process interspace one position cephalad is the L2-3 interspace. If the intersection is a spinous process, it is identified as the L4 spinous process, and the interspace one position cephalad to the spinous process is the L3-4 interspace. The puncture point is preferably selected at the L3-L4 intervertebral space, and the second puncture point is chosen at the L2-L3 intervertebral space. When the puncture at the L3-4 intervertebral space fails twice in a row, the second puncture point is selected for the puncture instead. After reevaluation by the anesthesiologist and confirmation of no contraindications, the anesthesia plan is implemented according to the random grouping:

In the EPL group, the L3-4 interspace was chosen for epidural puncture with an 18G epidural needle. When the puncture needle pierced the ligamentum flavum, the resistance sensation vanished, and no cerebrospinal fluid was withdrawn; it was confirmed that the puncture needle had entered the epidural space, indicating a successful puncture. If L3-4 puncture failed twice, L2-3 was used instead. Subsequently, a disposable epidural catheter was inserted cephalad into the epidural cavity, with an insertion length of 4 cm. After no blood or cerebrospinal fluid was aspirated, 50 mg of 1% lidocaine was injected. After 5 minutes of observation with no abnormalities, a mixture of 50 mg of 0.5% ropivacaine and 100 mg of 1% lidocaine was continuously injected.

In the DPE group, the L3-4 interspace was selected for epidural puncture using an 18G epidural needle; if L3-4 puncture failed twice, L2-3 was used instead. Once the epidural space was reached, a 25G spinal needle was placed through the epidural needle, and further dural puncture was carried out. Upon experiencing a breakthrough sensation, the core of the spinal needle was withdrawn, and the presence of cerebrospinal fluid flow was observed to confirm a dural puncture. After extracting the spinal needle, a disposable epidural catheter was inserted into the cephalad epidural space, with an insertion length of 4 cm. After confirming no blood or cerebrospinal fluid by aspiration, 50 mg of 1% lidocaine was injected. After 5 minutes of observation without any abnormal conditions, a mixture of 50 mg of 0.5% ropivacaine and 100 mg of 1% lidocaine was continuously injected.

In the CSE group: The L3-4 interspace was chosen for performing epidural puncture with an 18G epidural needle; if L3-4 puncture failed twice, L2-3 was used instead. Once the epidural space was reached, a 25G spinal needle was inserted through the epidural needle, and further dural puncture was conducted. After experiencing a breakthrough sensation, the core of the spinal needle was withdrawn. After observing the efflux of cerebrospinal fluid, the bevel of the spinal needle was oriented cephalad, and 12 mg of 0.5% ropivacaine + 1.2 mL of sterilized water for injection was injected through the spinal needle at a rate of 0.2 mL/s. After the injection was completed, the spinal needle was removed, and a disposable epidural catheter was placed cephalad into the epidural space, with an insertion length of 4 cm.

Intraoperative rescue analgesia was administered via the epidural catheter if patients in any group reported incisional pain at any time, or if, upon assessment at 60 minutes after the initial administration, the sensory block level had receded by more than two dermatomes from the maximum level achieved. The rescue regimen consisted of a 10 mL epidural bolus containing a mixture of 25 mg ropivacaine and 50 mg lidocaine. Sensory block level and pain scores were reassessed 10 minutes after the rescue dose administration to ensure efficacy and avoid excessive or insufficient blockade.

Management of Adverse Events

(1) Hypotension, defined as a systolic blood pressure below 90 mmHg, should be treated with vasopressors (6 mg ephedrine), which can be given repeatedly until stabilization. (2) If the heart rate drops below 50 beats per minute, administer atropine at 0.5 mg; this may also be repeated until stabilization. If there is no response, an immediate small dose of epinephrine (5–10 μg) is necessary, and cardiopulmonary resuscitation must begin immediately upon cardiac arrest. (3) Respiratory depression occurs when the respiratory rate falls below 8 breaths per minute or SpO2 levels drop below 90%. In these cases, provide oxygen inhalation or mask-assisted ventilation. If SpO2 cannot be maintained above 90%, establish an artificial airway and initiate mechanical ventilation. (4) Patients may show symptoms like unconsciousness, respiratory arrest, muscle weakness, hypotension, bradycardia, and potentially ventricular arrhythmias or cardiac arrest after total spinal anesthesia. Immediate treatment should involve securing an artificial airway and administering vasoactive drugs to ensure stable circulation. (5) For nausea and vomiting not attributable to hypotension, 4 mg of ondansetron should be administered intravenously immediately, accompanied by oxygen inhalation and positioning the patient's head to the side to prevent aspiration. Additionally, monitoring blood pressure and anesthesia depth is crucial for timely interventions. (6) Shivering indicates involuntary muscle contractions in patients; therefore, attention must be given to perioperative heat preservation strategies along with intravenous administration of tramadol at a dosage of 1–2 mg/kg. (7) For postoperative headaches, instruct the patient to lie flat without a pillow and ensure adequate fluid repletion, while administering 500–1000 mg of oral acetaminophen, supplemented with 10 mg of metoclopramide if nausea or vomiting is present.

Outcome Measures

The primary outcome measure was the onset time of anesthesia, defined as the duration from the completion of epidural or intrathecal local anesthetic injection to the achievement of a sensory block at the T10 level. The level of anesthesia was monitored every 2 minutes following the cessation of administration, and sensory block levels were assessed using skin needling with a 17G needle. The time taken to achieve T10 was recorded, while instances where the highest level of anesthesia did not reach T10 were noted as missing data.

Additional Outcome Measures

Highest Level of Anesthesia: The level of anesthesia was monitored every two minutes following the conclusion of administration. This level is defined as the highest point when there are no increases in block level over three consecutive measurements.

Onset Time of Motor Block: The time from the completion of epidural or spinal local anesthetic injection to achieving a score of 3 on the modified Bromage scale (Appendix Box 1) [10].

Anesthetic Effect: Evaluation of analgesia and muscle relaxation effects (Excellent: No pain, no need for additional anesthetic drugs, and no muscle tone interference; Satisfactory: Tolerable pain, no need for additional anesthetic drugs, and acceptable muscle tone interference; Unsatisfactory: Intolerable pain, requiring additional anesthetic drugs and methods, and unacceptable muscle tone interference). The term "perfect anesthetic effect" was defined as an evaluation of excellent anesthetic efficacy.

Adverse Reactions: Adverse reactions included hypotension (systolic blood pressure <90 mmHg), respiratory depression (respiratory rate <8 BPM or SpO2 <90%), nausea and vomiting, shivering, bradycardia (heart rate <50 BPM), etc.

Mean arterial pressure (MAP) and heart rate were monitored at each designated time point from T0 to T4 (T0: Before anesthesia operation; T1: 5 minutes after anesthesia administration; T2: 10 minutes after anesthesia administration; T3: 30 minutes after anesthesia administration; T4: At the end of the surgery).

Sample Size and Statistical Analysis

The sample size was determined using G*Power version 3.1.9.7. We utilized the time of onset of anesthesia as the primary outcome measure. Based on pre-experimental findings, the average onset times for anesthesia were observed to be 5 minutes in the CSE group, 13 minutes in the DPE group, and 19 minutes in the EPL group. We set a two-sided

significance level (α) at 0.05 and established a statistical power (1-β) of 0.8 for our analysis. The total sample size required for our study was calculated to be N=111 cases; however, accounting for an anticipated withdrawal or dropout rate of 10%, we ultimately determined that a minimum total of 124 subjects would be necessary across all three groups, with at least 41 participants allocated to each group.

The statistical analysis and data processing were conducted using R statistical software (version 4.4.0). Measurement data that followed or approximately followed a normal distribution are presented as mean ± standard deviation (mean ± SD). Group differences were assessed using one-way analysis of variance (ANOVA), with subsequent pairwise comparisons adjusted by the Holm-Bonferroni method. Non-normally distributed measurement data are expressed as a median and interquartile range [M(IQR)]. For intergroup comparisons involving non-parametric data, the Kruskal–Wallis *H*-test was applied. The χ^2-test was used to compare categorical data across groups. A P value of less than 0.05 was deemed statistically significant.

Results

Study Population

From August 2022 to September 2023, a preliminary screening was conducted through electronic medical record reviews and preoperative assessments to exclude patients with known hypertension, severe cardiovascular or cerebrovascular diseases, or other predefined exclusion criteria. Following this screening, a total of 149 patients were assessed for eligibility. Among these, 23 patients were excluded, including 18 who declined to participate and 5 due to newly identified ineligibility (4 with previously undiagnosed hypertension, 1 with coagulation dysfunction). Following this exclusion process, 126 patients were randomly assigned to our study. All 126 patients successfully achieved the target sensory block level (T10) and were thus included in the final analysis. (Figure 1). There was no significant difference observed in gender distribution, age, weight, height, ASA physical status score, puncture space, duration of operation, or intraoperative infusion volume among the three groups (P > 0.05) (Table 1).

The onset times of anesthesia for the DPE group, CSE group, and EPL group were 17.6 ± 4.0 min, 7.0 ± 2.8 min, and 19.2 ± 3.9 min, respectively. The differences among these groups were statistically significant (P < 0.05) as shown in Table 2. Specifically, the onset time in the DPE group was longer than that in the CSE group (P < 0.001) but shorter than that in the EPL group (P = 0.037), as illustrated in Table 2.

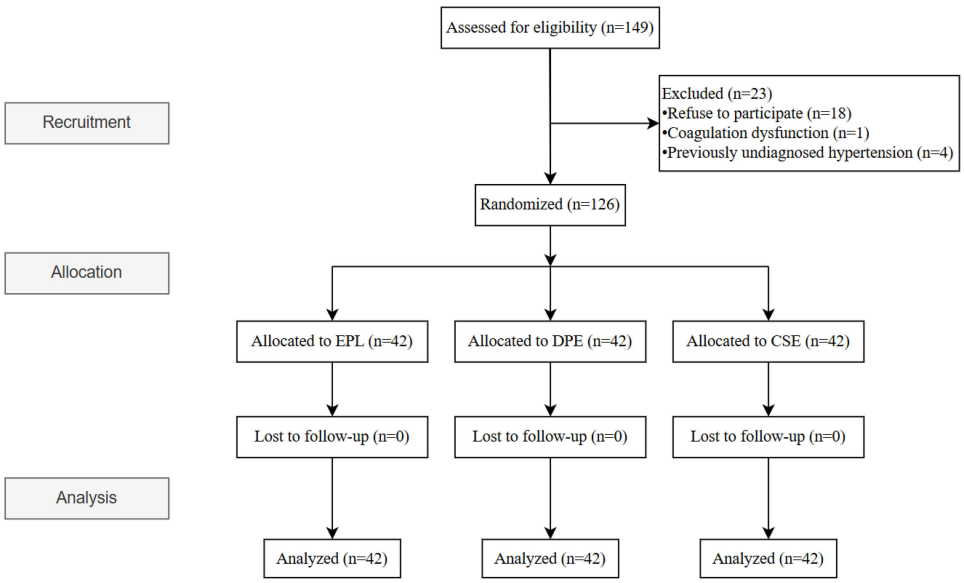

Figure 1 CONSORT diagram of patient flow through the study.

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Table 1 Subject Baseline Characteristics in the Three Groups

	DPE Group (n=42)	CSE Group (n=42)	EPL Group (n=42)	p-value
Sex				0.678
Male	18(42.9)	16(38.1)	20(47.6)	
Female	24(57.1)	26(61.9)	22(52.4)	
Body Weight (kg)	55.8±9.1	56.6±10.2	56.2±9.9	0.992
Height (cm)	158.1±7.2	158.4±7.8	158.1±7.1	0.918
Age (years)	76.6±8.0	72.9±9.0	75.6±8.5	0.125
ASA physical status score				0.513
II	19(45.2)	23(54.8)	24(57.1)	
III	23(54.8)	19(45.2)	18(42.9)	
Intervertebral space for puncture				0.383
L2-3	26(61.9)	24(57.1)	30(71.4)	
L3-4	16(38.1)	18(42.9)	12(28.6)	
Duration of operation (min)	75.9±23.0	84.1±30.8	70.2±32.3	0.09
Intraoperative infusion volume (mL)	641.7±316.6	721.4±258.8	663.8±313.7	0.450

Notes: Data are presented as mean ± SD or numbers (percentages).
Abbreviation: ASA, American Society of Anesthesiologists.

Table 2 Comprehensive Comparison of Anesthesia-Related Parameters and Effects Among the DPE, CSE, and EPL Groups

	DPE Group (n=42)	CSE Group (n=42)	EPL Group (n=42)	p-value (Overall)	Pairwise p-values (DPE vs CSE / DPE vs EPL)
Anesthesia Onset Time (min)	17.6±4.0	7.0±2.8	19.2±3.9	<0.001	<0.001/0.037
Maximum Anesthetic Level (L)	8(6,8)	6(6,8)	8(6,10)	0.003	0.056/0.140
Onset Time of Motor Block (min)	20.6±3.8	9.2±3.9	21.0±3.8	<0.001	<0.001/0.649
MAP (T1)	88.2±7.0	84.4±7.6	88.5±6.9	0.019	0.018/0.867
Anesthetic Effect				0.233	-
Excellent	40(95.2)	42(100)	39(92.9)		
Satisfactory	2(4.8)	0(0.0)	3(7.1)		
Unsatisfactory	0(0.0)	0(0.0)	0(0.0)		
Number of Patients Receiving Additional Epidural Medication	1(2.4)	4(9.5)	1(2.4)	0.365	0.127/1.000

Notes: Data are presented as mean ± SD, median (interquartile range), or numbers (percentages).

The highest level of anesthesia achieved was T8 (T6, T8) in the DPE group, T6 (T6, T8) in the CSE group, and T8 (T6, T10) in the EPL group ($P<0.05$). No significant differences were observed between the DPE and CSE groups ($P=0.056$) or between the DPE and EPL groups ($P=0.140$) (Table 2).

The Onset time of motor block was 20.6 ± 3.8 minutes in the DPE group, 9.2 ± 3.9 minutes in the CSE group, and 21.0 ± 3.8 minutes in the EPL group ($P < 0.05$). The DPE technique demonstrated a significantly longer time to achieve motor block compared to CSE ($P < 0.001$). No significant difference was observed between DPE and EPL ($P = 0.649$). Refer to Table 2 for further details.

In the DPE group, 40 cases (95.2%) exhibited an excellent anesthesia effect; in the EPL group, 39 cases (92.9%) demonstrated an excellent effect; and in the CSE group, all 42 cases (100%) achieved an excellent effect. No significant differences were observed among the three groups in terms of the excellent anesthesia effect rate ($P > 0.05$) or the proportion of patients receiving additional epidural medication ($P > 0.05$) (Table 2).

At T1, the MAP exhibited significant differences among the three groups, with values of 88.2±7.0 mmHg for the DPE group, 84.4±7.6 mmHg for the CSE group, and 88.5±6.9 mmHg for the EPL group ($P < 0.05$) (Table 2). Notably, the MAP in the DPE group was higher than that in the CSE group ($P = 0.018$); however, no significant difference was

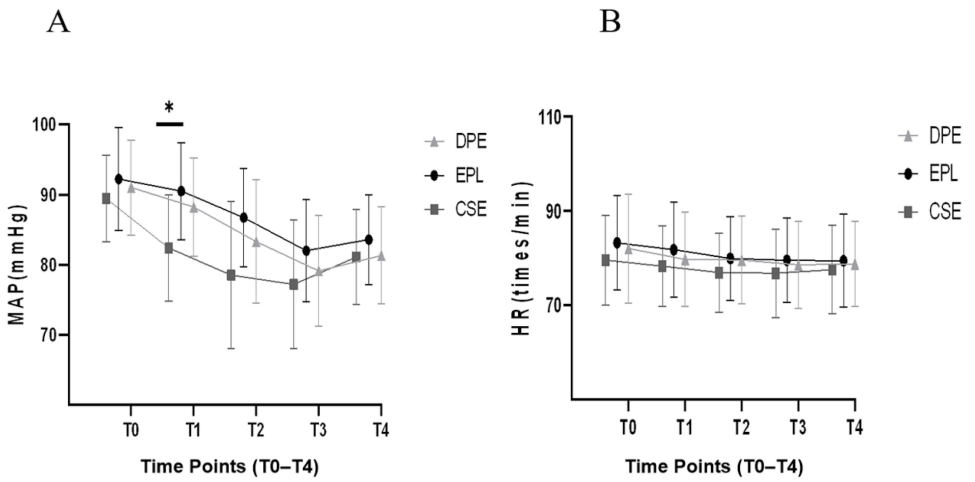

Figure 2 (**A**) Mean arterial pressure and (**B**) heart rate of the three groups (DPE, EPL, CSE) at different time points (T0–T4). T0: before anesthesia; T1: 5 min post-anesthesia; T2: 10 min post-anesthesia; T3: 30 min post-anesthesia; T4: end of surgery. (*p < 0.05).

observed between the DPE group and the EPL group (P = 0.867). The changes in heart rate HR and MAP are illustrated in Figure 2, with detailed values provided in Appendix 2 and Table 2.

The incidence of intraoperative adverse reactions is presented in Table 3, which includes the total number of patients with intraoperative complications (composite of hypotension, nausea and vomiting, shivering) as well as the number of patients with each individual reaction. There were no statistically significant differences in the total number of patients with adverse reactions, or the occurrence of intraoperative hypotension, nausea and vomiting, or shivering among the three groups (P > 0.05).

Discussion

The key findings of this prospective randomized controlled trial (RCT) show that DPE has a smaller impact on the circulation compared to CSE, and it takes effect faster than EPL. This is of great significance for improving anesthesia management in elderly orthopedic patients.

The study conducted by Song et al[11] and Bakhet et al[12] demonstrated that the onset time of DPE was slower than that of CSE but faster than EPL, which aligns with the findings of this investigation, and we also observed that DPE provided a slower onset time of motor block compared to CSE. This phenomenon is predicated on the principle that neuraxial anesthesia exerts its effect through the diffusion of anesthetic solution around the spinal nerve roots, blocking the transmission of autonomic nerve signals to the central nervous system. Therefore, the anesthesia onset time and the onset time of motor block of these three distinct neuraxial anesthesia techniques depend on the time of drug action on spinal nerves. In CSE, anesthetic agents are injected directly into the subarachnoid space, where they mix with cerebrospinal fluid to exert their effects. Conversely, both EPL and DPE are administered within the epidural space; thus, anesthetic drugs must penetrate into the subarachnoid space to become effective. However, the dural puncture in DPE creates

Table 3 Comparison of Adverse Reactions Among the Three Groups

	DPE Group (n=42)	CSE Group (n=42)	EPL Group (n=42)	p-value
Total number of patients with intraoperative complications	9(21.4)	13(31.0)	8(19.0)	0.399
Hypotension	9(21.4)	13(31.0)	8(19.0)	0.399
Nausea and vomiting	5(11.9)	4(9.5)	3(7.1)	0.759
Shivering	0(0.0)	2(4.8)	1(2.4)	0.359

Notes: Data are presented as numbers (percentages).

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additional pathways for drug diffusion compared to EPL, leading to a more rapid anesthetic onset. In contrast, other studies have indicated that DPE does not demonstrate a theoretical advantage over EPL. This may be attributed to the fact that the onset time of DPE is contingent upon the rate at which local anesthetic penetrates into the dura mater, a process influenced by various factors. First, the size of the dural puncture hole is determined by the type of lumbar anesthesia needle used. Contreras et al[13] found that the effective duration of anesthesia with a 25G lumbar anesthesia needle was 1.6 minutes shorter than that achieved with a 27G needle. Secondly, there is a correlation between epidural local anesthetic volume and its effectiveness; specifically, larger volumes generate greater pressure and facilitate more rapid infiltration, thereby accelerating the onset of local anesthesia.[14] Additionally, different types of local anesthetics penetrate through the dura mater at varying rates. Suzuki's experiment confirmed that lidocaine diffuses more readily into the subarachnoid space via the dura mater compared to ropivacaine and bupivacaine.[15] Consequently, current research on DPE's effective time has yielded inconsistent results due to limitations related to puncture needle size and variations in local anesthetic regimens. In this study, we employed a 25G lumbar anesthesia needle for puncture and administered an epidural mixture consisting of 50 mg of 0.5% ropivacaine and 100 mg of 1% lidocaine. It was observed that DPE exhibited a faster effective time compared to EPL.

In this study, it was observed that DPE had a lesser effect on circulation compared to CSE five minutes after the administration of anesthesia. This finding is consistent with previous studies,[16] which suggest that the mechanism underlying the decrease in blood pressure associated with neuraxial anesthesia is related to sympathetic nerve block, skeletal muscle relaxation, and cardiac sympathetic inhibition. Following neuraxial anesthesia, venous volume vasodilation results in a reduction of venous return and consequently decreases cardiac blood volume. Additionally, arterial vasodilation contributes to an overall decrease in vascular resistance, leading to hypotension.[17] However, since DPE does not involve the direct injection of local anesthetics into the subarachnoid space, it mitigates the risk of rapid peripheral vascular dilation and subsequent hypotension. Therefore, DPE exerts a lesser impact on circulation than CSE.

No significant difference in the incidence of complications was observed in this study, and the incidence of hypotension following neuraxial anesthesia was significantly lower than that reported in previous studies.[18] We propose that variations in observational outcomes may be attributed to the distinct populations included in this research. The cohort examined here consisted of elderly patients who had been excluded from hypertension, whereas other relevant studies typically involved maternity groups. For instance, Shusee Visalyaputra's study focused on women with preeclampsia as the research population.[19] Women with preeclampsia are known to exhibit heightened responses to vasomotor stimuli and possess compromised circulatory regulation capabilities. Additionally, during anesthesia, ligamentous laxity and inadequate uterine support can exacerbate supine hypotension among pregnant women. Given these differing factors influencing circulation, the observed results regarding hypotension diverge from those documented in prior investigations.

In the administration of anesthesia for elderly orthopedic patients, it is essential to consider not only the effectiveness of the anesthetic but also its safety. Neuraxial anesthesia represents an anesthetic technique that minimizes interference with neuronal signal transmission in patients.[20,21] This method has a minimal impact on postoperative cognitive function and mental state in elderly individuals undergoing orthopedic surgery, thereby facilitating postoperative recovery.[22,23] In this study, a 25G spinal anesthesia needle was utilized for DPE procedures, which did not result in adverse reactions distinct from those associated with CSE and EPL technique.[13] Furthermore, DPE integrates the benefits of both EPL and CSE by offering a more rapid onset of anesthesia compared to EPL while exhibiting a reduced circulatory effect relative to CSE. This combination provides an optimized anesthetic approach tailored for elderly orthopedic patients.

This study has several limitations. First, there is a notable lack of comprehensive data regarding the optimal type of spinal anesthesia needle for DPE.[13] In this investigation, a 25G spinal anesthesia needle was utilized for the DPE procedure; therefore, the findings may not be directly applicable to all patients undergoing DPE. Additionally, the epidural injection in this study used a mixture of lidocaine and ropivacaine. To further eliminate the potential mutual influence of drug combinations, future studies are recommended to adopt a single-agent protocol. Third, this protocol only included elderly patients without hypertension; future research could be extended to a broader elderly population. Finally, although the sample size in this study meets pre-experimental criteria, additional large-scale and multi-center studies are necessary to validate the accuracy of these conclusions.

Conclusion

In conclusion, our study demonstrates that DPE exhibits a more rapid onset time compared to EPL, has a lesser impact on circulation than CSE, and provides a satisfactory anesthetic effect. These findings suggest that DPE can be safely and effectively utilized in orthopedic surgery for the elderly population.

Data Sharing Statement

Data can be requested by the corresponding author.

Ethics Approval and Consent to Participate

The Ethical approval for this study (tlqzyy202214) was provided by the Ethical Committee and was registered in the Chinese Clinical Trial Registry (ChiCTR2300074584). Written informed consent was obtained from all eligible participants or their legal representatives. This study complies with the Declaration of Helsinki.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors have no relevant financial or non-financial interests to disclose for this work.

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