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Original Research Article

A Prospective Comparative Study between Dural Puncture Epidural and Lumbar Epidural in Knee and Hip Arthroplasty

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Abstract:

Objective:

General Objective: To compare the effectiveness of Dural puncture epidural with Lumbar epidural techniques regarding onset, duration and regression of analgesia in knee and hip arthroplasty.

Specific Objective:

1. To compare onset of sensory (T8 level) and motor block between Dural puncture epidural and Lumbar epidural group in knee and hip arthroplasty.
2. To compare duration of analgesia between dural puncture epidural and lumbar epidural group in knee and hip arthroplasty.
3. To find out hemodynamic variables (arrhythmia, hypotension, palpitation) and nausea and vomiting.
4. To see any adverse effects.

Background: Disease of knee and hip is very common in older patients. Previously these surgeries were done under general anaesthesia. But due to postoperative complications after general anaesthesia, scope of neuraxial anaesthesia has been increased. Dural Puncture Epidural (DPE) is Modified Epidural which has faster onset of analgesia and long duration of analgesia and anaesthesia. So, in this study we will be able to differentiate between Dural Puncture Epidural and Lumbar Epidural regarding onset, duration and regression of anaesthesia.

Materials and Methods: The Sample Consists of a total of Eighty (80) ASA Grade I AND II patients of either sex and age group of 50-65 years, scheduled for Knee and Hip Arthroplasty in Orthopaedic Operation Theatre was observed. Patient undergone Dural Puncture Epidural was included in Group A and patient undergone Lumbar Epidural was included in Group B. After obtaining informed consent the data collection was done intra operatively through a pre-designed pre tested questionnare. The data was by statistical methods, P VALUE<0.5 was considered significant.

Results: Dural Puncture Epidural technique produced faster onset of sensory block than in group Lumbar Epidural without affecting patient's outcome.

Conclusion: Both techniques were effective in producing adequate sensory block however, the use of Dural Puncture Epidural technique produced faster onset of sensory block than in group Lumbar Epidural when continuous epidural infusion was used in both groups without affecting patient's outcome.

Keywords: Dural puncture epidural, Lumbar epidural, Knee arthroplasty, Hip arthroplasty

Introduction

Lumbar Epidural provides excellent analgesia. Dural Puncture Epidural is another technique to expedite neuraxial anaesthesia and analgesia onset. Dural Puncture Epidural is a modification of the Epidural technique that involves firstly the identification of the Epidural space [1] (space between periosteum and dura) with a Tuhoy needle, secondly the creation of dural hole with a spinal needle inserted through Tuhoy needle and thirdly the Epidural insertion of a catheter. The dural hole allows the epidurally administered medication to pass into subarachnoid space, which can result in a faster onset of analgesia.

The frequency of major Hip and Knee surgeries is forecasted to increase dramatically in the next 20 year, and the anaesthetic options have become increasingly more complex and costly. Unlike major abdominal or cardiac surgeries that require general anaesthesia, major lower extremity orthopaedic surgeries can be performed under neuraxial anaesthesia [2]. Value in health care delivery is directly proportional to cost. Determining evidence

based practice for orthopaedic anaesthesia has been hindered by previous experimental and observational studies showing conflicting data on differences in major morbidity and mortality outcomes depending on anaesthesia types [3]. Memtsoudis and colleagues in a large observational study of more than 500000 patients, found that major morbidity and mortality may be significantly reduced among patients receiving neuraxial anaesthesia (DPE OR LE) [4,5]. The candidate for Total Knee and Total Hip Arthroplasty is usually elderly patients with different other systemic comorbidities. Dural Puncture Epidural effectively manages postoperative pain, allows early ambulation and reduces mortality in these surgeries by decreasing deep vein thrombosis and thromboembolism [6,7]. Patient can walk early in post operative period which was possible with the help of 'Walking Epidural'[8].

Materials and Methods

Study Design: Institution based comparative prospective interventional study.

Study settings and timelines: Was conducted in Orthopaedic Operation (Elective) theatre of NRS Medical College and Hospital.

Timeline: March 2021- August 2022.

Place of study: Anaesthesiology Department, NRS Medical College and Hospital.

Study population: Patients of either sex of ASA I and II, ageing 50-65 years, posted for total knee and Total hip replacement.

Sample Size:

We took onset of sensory block as primary outcome measure in our study. Sample size was calculated from a randomized control trial conducted by Yadav et al.[9] Sample size of each group was determined by the following formula:

$N = 2 \times \sigma\text{^}2 \times (Z\alpha + Z_\beta)\text{^}2 / (\mu_1 - \mu_2)\text{^}2$

Here, $Z\alpha$ = 1.96 (considering 95% confidence interval)

$Z\beta$= 0.84 (considering 80% power of the test)

Now considering a previous study, pooled S.D. = 13 Mean differences would be taken as 2.3.

Putting all the data in the formula a minimum sample size of 37.5 which approximates to 38 was achieved. By rounding the figure, it was taken as 40.

Data was presented in mean and standard deviation and P value less than 0.5 will be considered significant.

Study Group

80 patients were taken and divided in two groups of 40 patients in each as following.

Group DPE: Undergone Dural Puncture Epidural technique (DPE) Group LE: Undergone Lumbar Epidural technique.

Inclusion Criteria

ASA grade I and II patients of age group (50-65) year of either sex and patients with written informed consent who were undergoing Total knee and Total hip arthroplasty.

Exclusion Criteria

Patient refusal, Infection at the site of needle insertion, Bleeding disorder, Allergic reaction to any anaesthetic drugs, Patients on tranquilizers, hypnotics, sedatives, Mentally retarded patients, Alcohol and drug abuse, any comorbid conditions like neurological, neuromuscular, cardiovascular, pulmonary, hepatic and renal disorder.

Study Variables

- Onset of sensory block
- Duration of analgesia
- Regression of analgesia (from max height to one segment regression)

Laboratory Investigation

During Pre anaesthetic checkup all routine investigations done and special investigations if needed in any patient.

Study Tools

- Consent form
- Case report form
- Monitor to show SpO_2, ECG, Heart rate, Etco2, NIBP
- No 18 I.V line 0.5% Bupivacaine CSE needle
- 19 G epidural catheter 18 G epidural needle 25 G spinal needle

Study Technique

Data collection was started after getting necessary clearance from Institutional ethical committee.

(IEC). Study subjects were explained about the purpose of the study and their Informed consent was taken prior to data collection. They were assured about the confidentiality and anonymity of the information. Participants were interviewed using predesigned and pretested interview schedule.

A total of 80 patients, undergoing total knee and total hip arthroplasty under regional anaesthesia was selected, using the inclusion and exclusion criteria that have been prepared.

18 G cannulas was used to establish intravenous access for every patients. Monitoring of patients within the operating room was done continuously by using ECG leads, BP cuff, HR, SpO_2 at frequent

interval.

Patients were randomly allocated in two groups i.e; Dural puncture epidural (DPE) and Lumbar epidural (LE) group.

All neuraxial procedure was performed in the L3-4 or L4-5 interspace using a 18G Tuhoy needle of combined spinal epidural set. DPE subjects were received a dural puncture using 25 G spinal needle through the Tuhoy needle and free flow of CSF was observed but no medication was administered. All epidural (19G) were inserted 4 to 5 cm into the epidural space. Epidural catheters were dosed with 10 ml bolus (0.5% bupivacaine) followed by epidural infusion (0.5% Bupivacaine, 2mcg/mL Fentanyl) at the rate of 5 mL/hour.

LE subjects were received 10 ml of epidural bolus drugs followed by infusion as the same rate like DPE subjects.

Patients were monitored for onset of sensory block, duration of analgesia and for hemodynamic variables (arrhythmia, hypotension, palpitation), nausea, vomiting. Sensory and motor block was assessed. Sensory block was assessed by blunt pin prick, cold and warm saline. Motor block was assessed by modified Bromage score[10]. Potential side effects were examined including hypotension, nausea, pruritus, occurance of headache characteristics of post dural puncture at 24 hours. Occurance of pruritus, headache (if any) was collected by patient follow up with a verbal interview at 24 hours.

Ethics

Approval was obtained from Institutional ethical committee (IEC) (No/NMC/382) of Nil Ratan Sircar Medical College & Hospital, Kolkata. Written permission from the institutional ethical committee was obtained prior to beginning of the study.

Patients or relatives of patient were explained in their own language about nature of study and procedures. They were also assured about the confidentiality of information and its anonymity. No additional investigation or intervention was undertaken other than what the subjects require for management purpose of the illness. Informed consent from the legal guardian of the subjects were taken after they understand participant information sheet (PIS), which were provided to them printed in their own language. No economic burden was imposed on the patients and all the investigations were done at free of cost by the institution.

Statistics

The data was tabulated in Microsoft excel and analysed with SPSS V.24 software. The continuous variables are expressed with mean and standard deviation. The categorical variables are expressed with frequency and percentage. Independent t test and chi square test are used for the comparisons. The p value ≤ 0.05 is considered as statistically significant.

Results

The results section has been described as follows:

Demographic profile

Table 1: Distribution of study subjects (n=40) according to age among the group of patients

Parameters	Grou p	N	Mean	SD	P value
Age (years)	DPE	40	59.35	3.468	0.465
	LE	40	58.80	3.220	

Table 2: Distribution of study subjects(n=40) according to sex among the group of patients

Parameter	Group	N	N (%)	P-value
Sex (%)	DPE	40	Male: 23 (57.5%), Female: 17 (42.5%)	0.251
	LE	40	Male: 19 (47.5%), Female: 21 (52.5%)	

Table 3: Distribution of study subjects (n=40) according to ASA grading

Parameter	Grou p	N	N (%)	P-value
ASA (%)	DPE	40	ASA I: 27 (67.5%), ASA II: 13 (32.5%)	0.311
	LE	40	ASA I: 30 (75%), ASA II: 10 (	

Table 4: Distribution of study subjects (n=40) according to weight

Parameter	Group	N	Mean	SD	P-value
Weight (kg)	DPE	40	66.78	4.622	0.750
	LE	40	66.43	5.153	

Table 5: Distribution of study subjects (n=40) according to height

Parameter	Grou p	N	Mean	SD	P-value
Height (cm)	DPE	40	158.50	3.968	0.134
	LE	40	160.33		

Comparison of Block Characteristics:

Table 6: Distribution of study subjects according to onset of sensory block in both groups expressed in minutes

Parameters	Group	N	Mean	SD	P-value
Onset of sensory (T8) block (min)	DPE	40	10.33	0.859	0.000*
	LE	40	15.60	0.591	

*Statistically significant difference exists (p<0.05)

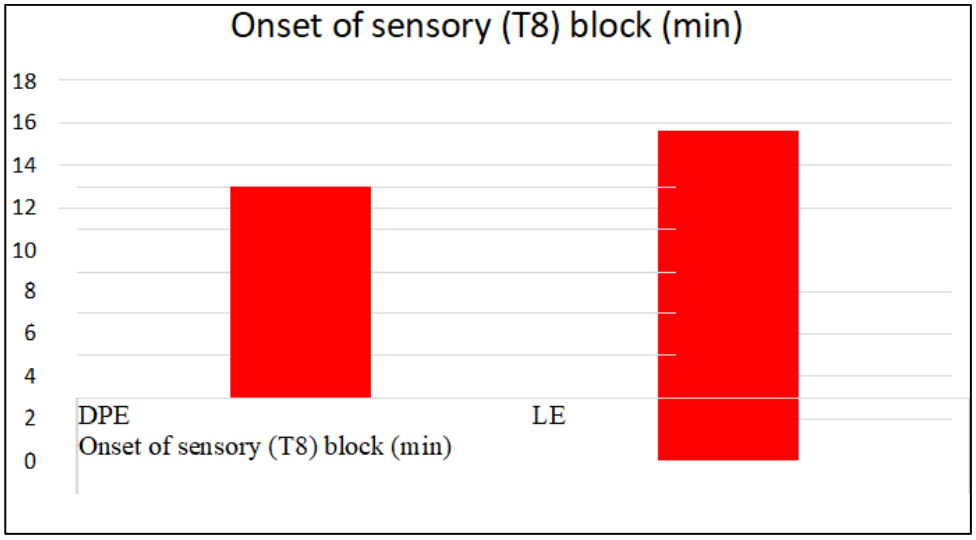

Figure 1: shows onset of sensory block was earlier in group DPE than in group LE and it was statistically significant

Table 7: Distribution of study subjects according to height of sensory block

Parameters	Grou p	N	N (%)	P value
Height of sensory block (level)	DPE	40	T6: 3 (7.5%), T8: 36 (90%), T10: 1 (2.5%)	0.091
	LE	40	T6: 0 (0%), T8: 36 (90%), T10: 4 (10%)	

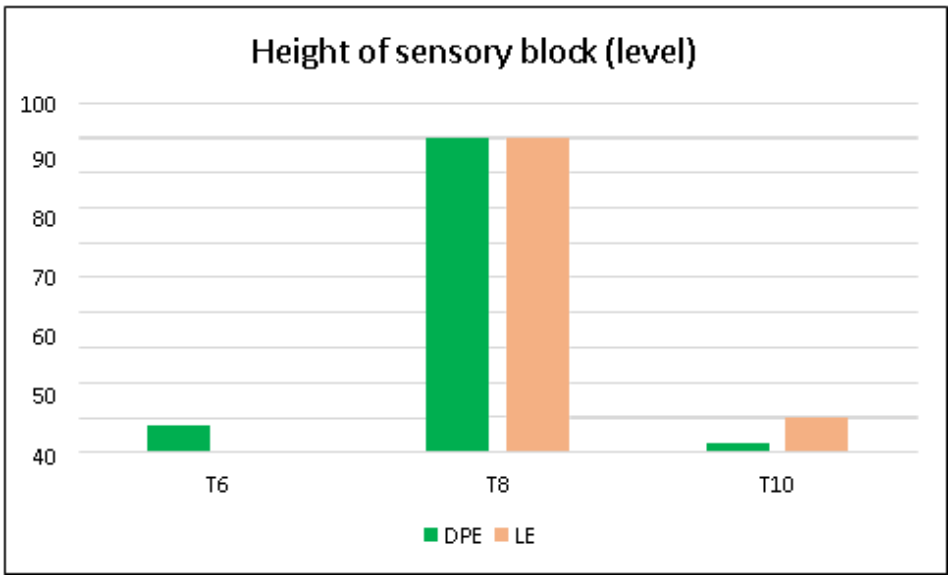

Figure 2: shows height of sensory block was comparable and was not statistically significant in both groups (p=0.091)

Table 8: Distribution of study subjects according to regression of sensory block

Parameters	Grou p	N	Mean	SD	P value
Regression of sensory (T8) block (min)	DPE	40	303.38	6.640	0.000*
	LE	40	281.25	6.380	

*Statistically significant difference exists (p<0.05)

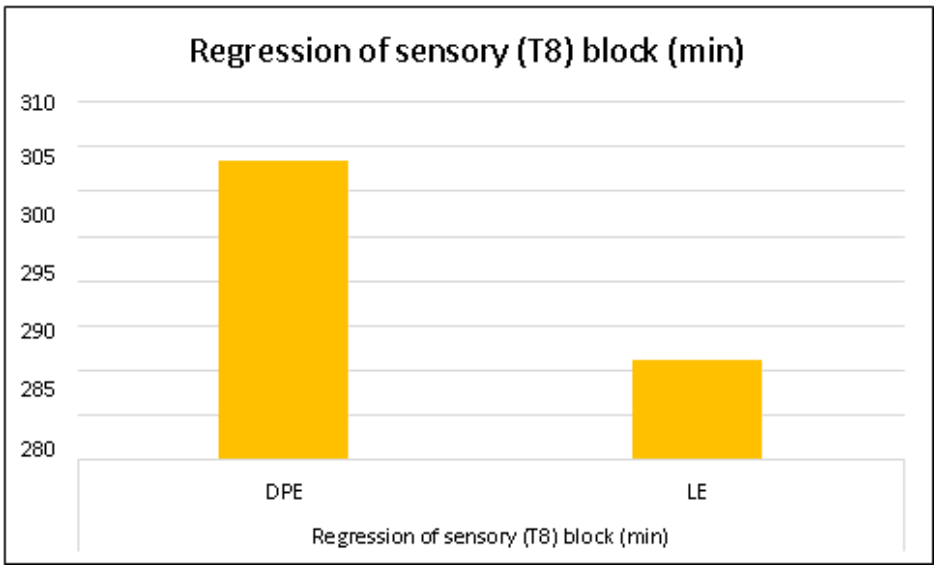

Figure 3: shows regression of sensory block was later in DPE group than in LE group and it was statistically significant

Table 9: Distribution of study subjects according to onset of motor block (in minutes)

Parameters	Grou p	N	Mean	SD	P value
Onset of motor block (min)	DPE	40	12.25	0.707	0.000*
	LE	40	17.13	0.791	

*Statistically significant difference exists (p<0.05)

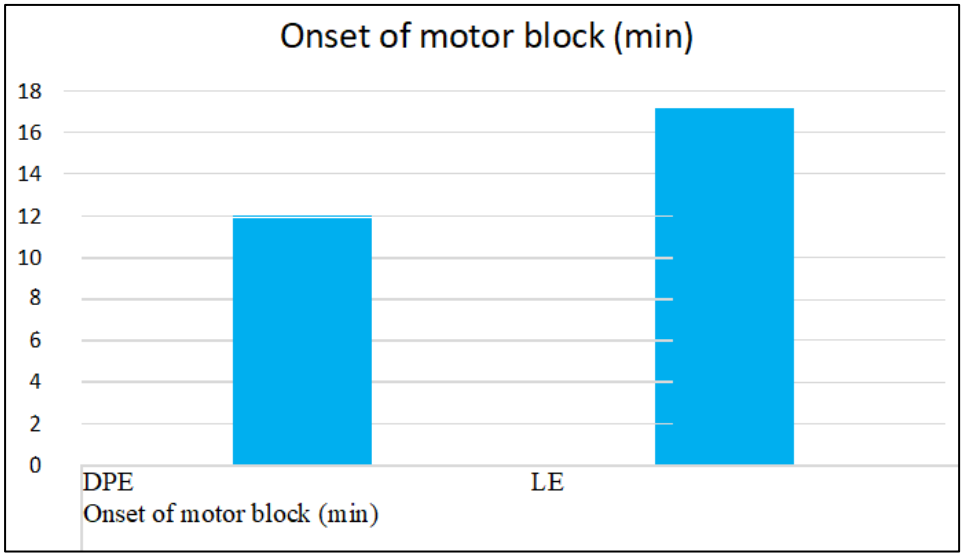

Figure 4: shows onset of motor block was earlier in DPE group (12.25±0.70) than in LE group (17.13±0.791) and it was statistically significant

Table 10: Distribution of study subjects according to duration of analgesia

Parameters	Grou p	N	Mean	SD	P value
Time of 1st analgesic request (minutes)	DPE	40	376.23	14.296	0.000*
	LE	40	310.50	6.869	

*Statistically significant difference exists (p<0.05)

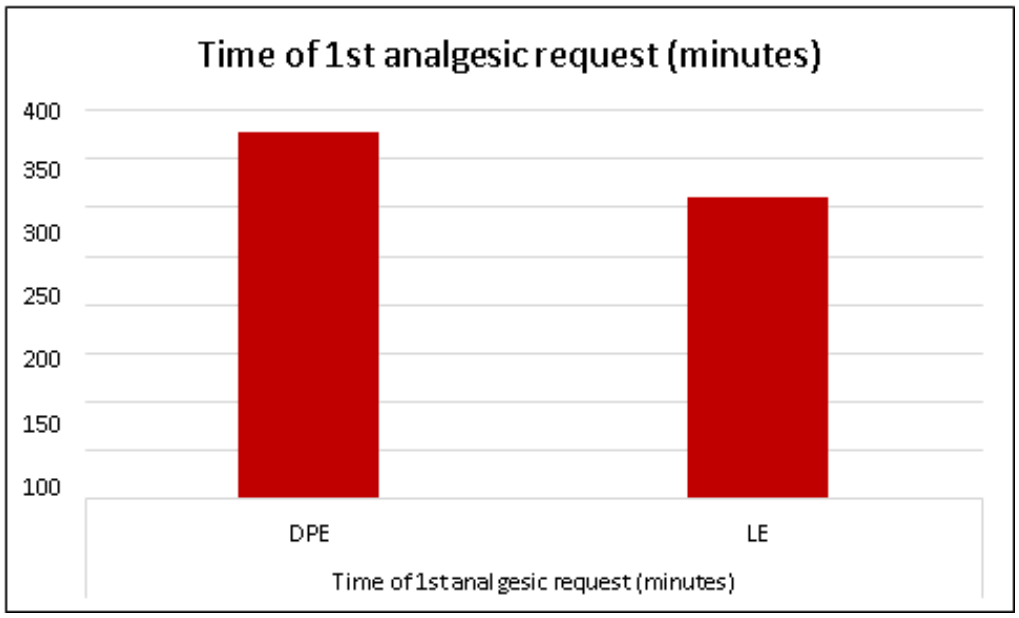

Figure 5: Shows duration of analgesia was more in DPE group (376.23±14.29) than in LE group (310.50±6.86) and p value (<0.05) was statistically significant.

Hemodynamic Variables

Table 11: Distribution of study subjects depending on baseline, intraoperative and post operative HR.

Parameters	Group	N	Mean	SD	P value
HR (BASELINE)	DPE	40	83.98	5.299	0.519
	LE	40	84.73	5.048	
HR AT INCISION	DPE	40	81.30	4.832	0.430
	LE	40	82.15	4.748	
HR 30 MIN	DPE	40	78.43	4.601	0.577
	LE	40	79.00	4.580	
HR 60 MIN	DPE	40	76.53	4.484	0.642
	LE	40	77.00	4.624	
HR 120 MIN	DPE	40	74.95	4.242	0.777
	LE	40	75.23	4.423	
HR 180 MIN	DPE	40	73.45	4.272	0.937
	LE	40	73.38	4.204	
HR POST OP 30 MIN	DPE	40	73.90	4.181	0.289
	LE	40	74.90	4.199	
HR POST OP 60 MIN	DPE	40	73.68	4.293	0.581
	LE	40	74.20	4.183	
HR POST OP 120 MIN	DPE	40	74.45	4.206	0.361
	LE	40	75.35	4.549	
HR POST OP 240 MIN	DPE	40	75.85	4.048	0.251
	LE	40	76.98	4.638	
HR POST OP 360 MIN	DPE	40	79.38	4.143	0.181
	LE	40	80.73	4.772	

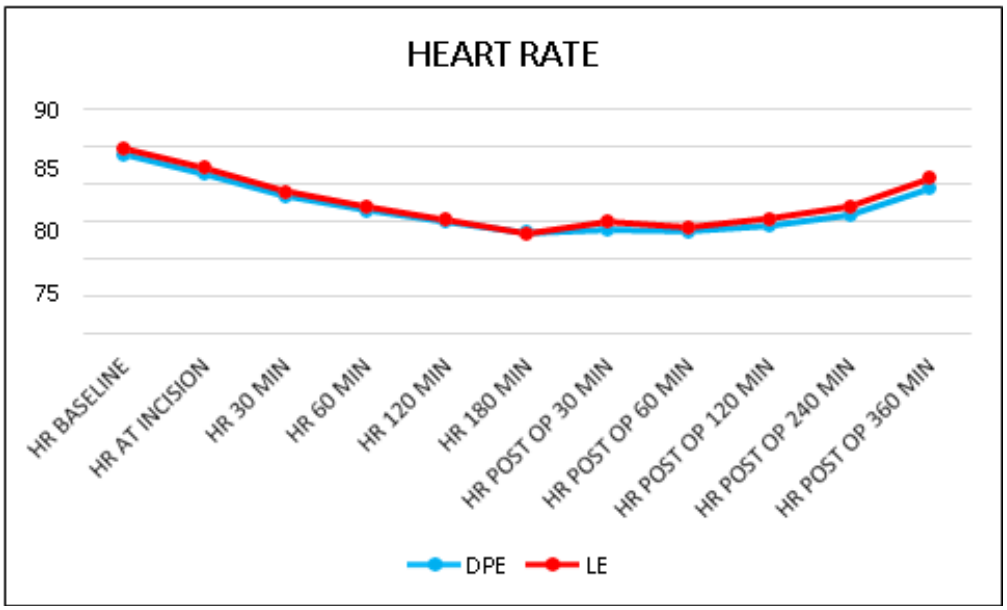

Figure 6: Shows Comparison of heart rate between the groups at different time intervals and it was comparable and statistically not significant.

Table 12: Distribution of study subjects according to Mean arterial pressure (MAP) at different time intervals.

Parameters	Group	N	Mean	SD	P value
MAP (BASELINE)	DPE	40	93.88	3.851	0.415
	LE	40	93.15	4.067	
MAP AT INCISION	DPE	40	90.68	4.097	0.302
	LE	40	89.73	4.076	
MAP 30 MIN	DPE	40	87.78	3.779	0.290
	LE	40	86.85	3.991	
MAP 60 MIN	DPE	40	84.40	3.643	0.886
	LE	40	84.28	4.126	
MAP 120 MIN	DPE	40	81.75	3.699	0.593
	LE	40	82.23	4.203	
MAP 180 MIN	DPE	40	78.33	3.799	0.088
	LE	40	79.90	4.331	
MAP POST OP 30 MIN	DPE	40	80.10	3.774	0.552
	LE	40	80.70	5.100	
MAP POST OP 60 MIN	DPE	40	81.23	3.738	0.013*
	LE	40	83.78	5.142	
MAP POST OP 120 MIN	DPE	40	82.65	3.759	0.000*
	LE	40	87.00	4.946	
MAP POST OP 180 MIN	DPE	40	83.95	4.120	0.000*
	LE	40	89.88	4.805	

*Statistically significant difference exists ($p<0.05$)

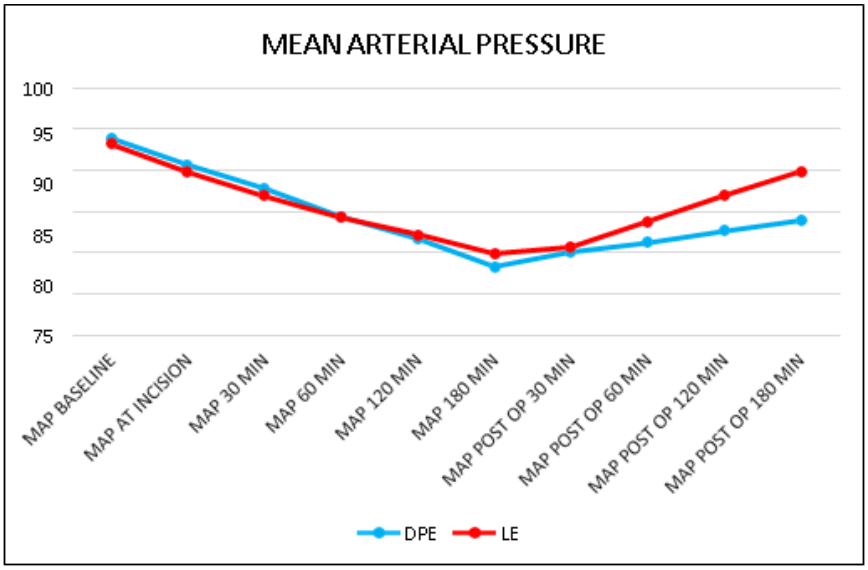

Figure 7: Line diagram showing comparison of mean arterial pressure between the groups at different time intervals.

Table 13: Distribution of study subjects according to VAS score at different intervals

Parameters	Group	N	Mean	SD	P value
VAS BASELINE	DPE	40	8.45	0.749	0.234
	LE	40	8.63	0.540	
VAS POST OP 0 MIN	DPE	40	0.00	0.000	-
	LE	40	0.00	0.000	
VAS 30 MIN	DPE	40	0.00	0.000	-
	LE	40	0.00	0.000	
VAS 1 HR	DPE	40	0.00	0.000	-
	LE	40	0.00	0.000	
VAS 2 HR	DPE	40	0.00	0.000	-
	LE	40	0.00	0.000	
VAS 4 HR	DPE	40	1.48	0.506	0.002*
	LE	40	1.80	0.405	
VAS 6 HR	DPE	40	2.48	0.554	0.000*
	LE	40	3.60	0.496	

*Statistically significant difference exists ($p<0.05$)

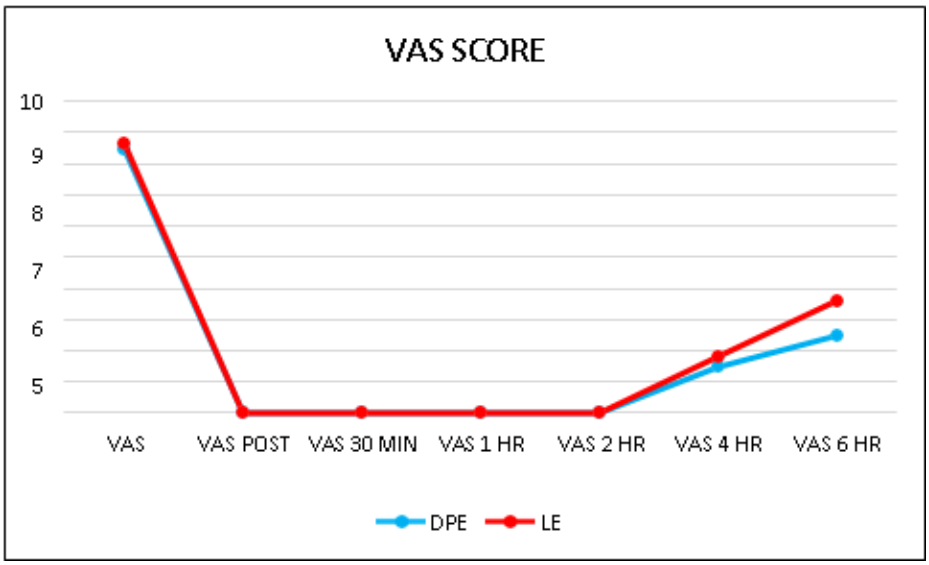

Figure 8: Line diagram showing comparison of VAS scores between the groups at different time intervals and it was statistically significant in post operative 4 hours and 6 hours

Table 14: Comparison of complications between the groups

Complications	Groups		P value
	DPE	LE	
Nausea/Vomiting	4 (10%)	1 (2.5%)	0.165
Hypotension	7 (17.5%)	3 (7.5%)	0.176
Arrhythmia	0 (0%)	0 (0%)	-
Palpitation	0 (0%)	0 (0%)	-

Table shows comparison between two groups according to complications. It was comparable and statistically not significant.

Discussion

This prospective comparative Randomised study was conducted in the department of Anaesthesiology, at Nil Ratan Sircar Medical College and Hospital, Kolkata in the state of West Bengal in the operating room designated for Orthopedic surgery. The study was conducted over one and half year (March 2021- August 2022) after getting permission from Institutional Ethical Committee and approval of The West Bengal University of Health Sciences.

A total of eighty patients, put for Total knee arthroplasty and total hip arthroplasty undergoing Dural Puncture Epidural and Lumbar Epidural were selected, using proper inclusion and exclusion criteria that have been prepared. An 18 G cannula was used to establish intravenous access for every patient. Monitoring of patients within the operating room was done continuously by ECG leads, a BP cuff, SpO_2, Mean arterial pressure, HR was measured at definite interval in intra and post operative period. HR, MAP, VAS score was recorded up to 6hours for post operative analgesia and duration of analgesia.

After random allocation of patient in two groups (Group DPE and Group LE) and after obtaining informed written consent from all patients. After receiving patients in operation theatre ASA standard monitor was attached and baseline values of vitals were obtained.

All neuraxial procedure was performed in the L3-4 or L4-5 interspace using 18 G Tuhoy needle of combined spinal epidural set[11]. DPE subjects were received a dural puncture using a 25 G spinal needle through the Tuhoy needle and free flow of cerebrospinal fluid (CSF) was observed but no medication was administered.

Epidural catheters (19G) were inserted 4 to 5 cm into the Epidural space. After negative aspiration for blood and CSF, 3 ml of test dose administered (1.5% lidocaine with epinephrine 3mcg/ml) to check for proper catheter placement. Epidural catheters were dosed with 10 ml bolus (0.5% Bupivacaine) followed by epidural infusion (0.5% Bupivacaine+ 2 mcg/ml Fentanyl) at the rate 5ml/hour.

LE subjects were received lumbar epidural anaesthesia and after placement of 19 G Epidural catheter and 3 ml test dose given and after that 10 ml of Epidural bolus drugs were given and followed by infusion (0.5% Bupivacaine+ 2mcg/ml Fentanyl) as same rate like in DPE subjects. Patients were monitored for onset of sensory block, duration of analgesia and hemodynamic variables (MAP, HR, SpO_2 etc). Sensory block was assessed by blunt pin prick, cold and warm saline. Motor block was assessed by Modified Bromage score[25/12]. Potential side effects were examined including hypotension, nausea, vomiting, pruritus, occurance of headache i.e; characteristics of post dural puncture headache at 24 hours. Occurance of pruritus, headache (if any) was collected by patient follow up with a verbal interview at 24 hours.

In this study, adequate intraoperative and postoperative analgesia was observed in both groups with no failure rate.

Table 1 shows age difference among both groups and it was not statistically significant. (p=0.465)

Table 2 shows distribution of study subjects according to sex. Males are more among the DPE group and females are more among the LE group although this distribution of sex among both the groups was not statistically significant. (p=0.251)

Table 3 shows distribution of study subjects according to ASA grading and it was not statistically significant. (p=0.311)

Table 4 shows distribution of study subjects according to body weight. It was comparable and non-significant. (p=0.75)

Table 5 shows distribution of study subjects according to height and it was comparable but not statistically significant. (p=0.134)

Yadav et al. [9] reported faster onset of sensory block, analgesia with dural puncture epidural group.

Our study showed an earlier onset of adequate sensory block in DPE group than in LE group even though same epidural bolus and infusion was used. This could be attributed to the subarachnoid spread of epidural drugs through the intentional dural puncture.

Table 6 shows distribution of study subjects according to onset of sensory block in both groups and it was expressed in minutes. Onset of sensory block was earlier in group DPE (10.33± 0.859) than in group LE (15.60± 0.591) and it was statistically

significant. (p=0.00)

A significant difference in the onset of sensory block was noted in both studies, but onset of sensory block in our study was faster as we used 25 G spinal needle for dural puncture instead of 27 G spinal needle in their studies.

Continue epidural infusion was preferred over epidural boluses as in aged patients epidural boluses can cause hemodynamic instability (sudden fall of blood pressure, bradycardia etc), nausea, vomiting and infusion at low dose also provide better hemodynamic stability and better analgesia.

The difference in finding may be due to different gauges of spinal needle as size of dural hole is proportional to distribution of drug intrathecally and produce early onset of sensory block and late regression of sensory block.

Table 8 shows regression of sensory block was earlier in LE group (281.25±6.3) than in DPE group (303.38±6.64) and it was statistically significant. ($p<0.05$)

Some institutions follow intermittent dosing, whereas infusions of local anaesthetic are used elsewhere. In our study we prefer infusion of local anaesthetic for patient's safety and concern.

Wilson et al. [12] used 12 ml of 0.125% bupivacaine epidural boluses and concluded that the DPE technique produced no difference in pain scores. However, they noted a faster reduction of VAS in DPE than traditional lumbar epidural.

In our study we used 0.5% Bupivacaine as epidural boluses followed by infusion and noted significant reduction of VAS score in DPE in compared to LE as drugs percolating from dura to subarachnoid space in case of DPE.

Table 13 shows less post operative VAS score in DPE group than in LE group and it was statistically significant in post operative 4 and 6 hours.

Some studies found no improvement in the onset of analgesia or pain score between DPE & LE.

Dural puncture with small (26 or 27G) spinal needle confers minimal benefits and improved pain scores in the first 10 minutes. But dural puncture with 25 G spinal needle provide better block quality, analgesia as compared to conventional lumbar epidural anaesthesia. In vitro studies performed by Bernards et al. [13] demonstrated that the passage of epidurally given drugs to subarachnoid space via the dural hole was directly proportional to the dural hole's size. DPE results in an improved caudal spread of local anaesthetic, rapid onset of sensory block, onset of analgesia without any major side effects.

In our study, dural puncture epidural (DPE) results in early onset of sensory block in dural puncture epidural group (10.33 ± 0.859 min) than in lumbar epidural group (15.60 ± 0.591 min). (Table 6)

Suzuki et al. [14] reported significantly greater caudal spread of analgesia, earlier onset of sensory analgesia with dural puncture epidural technique.

In our study dural puncture epidural also provide earlier onset of sensory block than lumbar epidural and better spread of analgesia.

Cappiello et al. [15] used 25 G spinal needle to perform dural puncture epidural technique and demonstrated improved sacral spread, earlier onset than lumbar epidural technique. Pain relief is almost similar in both groups. (DPE vs LE).

Another advantage of performing DPE is to confirm the correct Epidural placement of epidural catheter as CSF returns through the spinal needle may ensure proper epidural placement. This is especially important in case of difficult epidurals.

There are differing views regarding superiority of DPE technique over LE for-labour analgesia.

Thomas et al. [16] and Gupta et al. [17] in their study showed that DPE technique did not provide superior labour analgesia when compared to a traditional epidural technique, but Cappiello et al. [15] suggest that DPE technique may benefit parturients by improving sacral spread, onset and bilateral nature of epidural analgesia as compared to conventional lumbar epidural.

Our study shows earlier onset of sensory block to achieve adequate analgesia (VAS ≤5) was 10±0.89 minutes (Table: 6) in group DPE, which was significant lesser than LE group.(15±0.5).

Swenson et al. [18] concluded that passage of epidurally given drugs to subarachnoid space via dural hole was directly proportional to the size of dural hole.

Our study we also used 25 G spinal needle to get an adequate dural hole so that most amount of drug percolates through the hole in subarachnoid space and onset of sensory block become earlier and more dense.

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