Section: Anaesthesia

Original Research Article

POST-OPERATIVE EPIDURAL ANALGESIA AFTER TKR: A DOUBLE-BLIND RANDOMIZED COMPARISON OF ROPIVACAINE 0.2% AND LEVOBUPIVACAINE 0.125%

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Received *: 24/01/2026*
Received in revised form *: 05/03/2026*
Accepted *: 22/03/2026*

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DOI: 10.70034/ijmedph.2026.2.5

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (2); 27-32

ABSTRACT

Background: Total knee replacement (TKR) is associated with significant postoperative pain, which can delay rehabilitation and prolong hospital stay. Epidural analgesia using long-acting local anesthetics like levobupivacaine and ropivacaine is widely used for effective pain control. The aim is to compare the analgesic efficacy of epidural levobupivacaine (0.125%) and ropivacaine (0.2%) in patients undergoing TKR.

Materials and Methods: This prospective, double-blind randomized study included 110 patients undergoing TKR, divided into two groups: Group L (levobupivacaine 0.125%, n=55) and Group R (ropivacaine 0.2%, n=55). Postoperative epidural infusion was administered, and patients were evaluated using Visual Analogue Scale (VAS) scores at rest and on movement at different time intervals. Hemodynamic parameters, sensory regression, motor blockade (Modified Bromage Scale), and adverse effects were also recorded.

Results: Demographic parameters were comparable between groups. VAS scores at rest and during movement were similar at all time intervals ($p>0.05$). Group R demonstrated significantly lower pulse rate and systolic blood pressure at multiple time points ($p<0.05$), indicating better hemodynamic stability. Sensory regression to L1 was significantly prolonged in Group R (28.53 ± 13.463 hrs) compared to Group L (22.78 ± 11.263 hrs; $p=0.018$). Motor blockade and incidence of side effects were comparable in both groups.

Conclusion: Both levobupivacaine and ropivacaine provide effective postoperative epidural analgesia following TKR. However, ropivacaine offers better hemodynamic stability and longer sensory blockade, making it a preferable choice.

Keywords: Total knee replacement, Epidural analgesia, Ropivacaine, Levobupivacaine, Visual Analogue Scale, Postoperative pain.

INTRODUCTION

Total knee replacement (TKR) is a commonly performed orthopedic procedure for end-stage degenerative joint diseases such as osteoarthritis and rheumatoid arthritis. Despite advances in surgical techniques and perioperative care, postoperative pain following TKR remains significant and can impede early mobilization, prolong hospital stay, and negatively affect functional recovery and patient satisfaction.[1] Effective postoperative analgesia is therefore a cornerstone in enhanced recovery protocols, facilitating early ambulation, reducing complications such as deep vein thrombosis, and improving overall outcomes.[2]

Epidural analgesia has long been considered one of the most effective modalities for postoperative pain control after major lower limb surgeries, including TKR. It provides superior analgesia compared to systemic opioids by blocking nociceptive transmission at the spinal level while minimizing systemic side effects such as sedation, respiratory depression, nausea, and vomiting.[3] Continuous epidural infusion of local anesthetics, either alone or

in combination with adjuvants, allows for titratable and prolonged pain relief, thereby improving patient comfort and rehabilitation outcomes.[4]

Among the local anesthetics used for epidural analgesia, ropivacaine and levobupivacaine have gained popularity due to their favorable safety profiles and reduced cardiotoxicity compared to bupivacaine. Ropivacaine, a pure S-enantiomer, is characterized by differential blockade with greater sensory-motor separation, making it particularly suitable for postoperative analgesia where preservation of motor function is desirable.[5] Levobupivacaine, the S(-)-enantiomer of bupivacaine, also offers a safer pharmacological profile with less central nervous system and cardiovascular toxicity while providing potent and long lasting analgesia.[6]

The choice between ropivacaine and levobupivacaine for epidural analgesia after TKR has been a subject of ongoing research. Ropivacaine at a concentration of 0.2% has been widely used due to its ability to provide effective sensory blockade with minimal motor impairment, thereby facilitating early mobilization.[7] On the other hand, levobupivacaine at lower concentrations, such as 0.125%, is believed to provide comparable analgesia with a similar or slightly higher degree of motor blockade, depending on the dose and infusion regimen.[8] Comparative studies have yielded mixed results, with some suggesting superior motor-sparing properties of ropivacaine, while others demonstrate equivalent analgesic efficacy between the two agents.[9]

Given the importance of optimizing postoperative analgesia while minimizing adverse effects, there is a need for well-designed, double-blind randomized controlled trials comparing these agents in specific surgical settings such as TKR. Evaluating parameters such as pain scores, motor blockade, hemodynamic stability, requirement of rescue analgesia, and incidence of side effects can help determine the ideal agent and concentration for epidural use.[10]

The present study aims to compare the postoperative analgesic efficacy of epidural levobupivacaine (0.125%) and ropivacaine (0.2%) in patients undergoing total knee replacement, using the Visual Analogue Scale (VAS). Additionally, it evaluates secondary outcomes including hemodynamic stability, extent of sensory and motor blockade, and the incidence of side effects such as postoperative nausea and vomiting (PONV), dizziness, and pruritus, to determine the overall safety and effectiveness of both agents.

MATERIALS AND METHODS

Study Design: Randomized, prospective, double-blind study

Sample Size: A total of 110 patients undergoing Total Knee Replacement (TKR) under Combined Spinal Epidural (CSE) anaesthesia were recruited.

Drugs Used in Spinal–Epidural Anesthesia and Rationale for Levobupivacaine vs Ropivacaine

In combined spinal epidural anesthesia for TKR, the spinal component is typically achieved with 0.5% hyperbaric bupivacaine to provide rapid and dense anesthesia, while the epidural component is used to maintain the sensory level during surgery. For this, low concentrations such as 0.125% levobupivacaine or 0.2% ropivacaine are preferred. Levobupivacaine is more potent and provides effective analgesia at a lower concentration with reduced cardiotoxicity, whereas ropivacaine offers better sensory–motor differentiation, leading to minimal motor blockade and improved hemodynamic stability. These concentrations are chosen to ensure adequate analgesia with enhanced safety and early postoperative mobilization.

Group Allocation

- Group R: Ropivacaine 0.2%
- Group L: Levobupivacaine 0.125%

Inclusion Criteria

- Age: 40–70 years
- Both male and female patients
- ASA I and II
- Weight: 50–90 kg
- Height: 150–190 cm

Exclusion Criteria

- Patient refusal
- Allergy to local anesthetics/opioids
- ASA III/IV
- Contraindications to epidural anesthesia
- Communication difficulties affecting postoperative assessment

Statistical Analysis: We put the data into Microsoft Excel and then used SPSS software version 27.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5 to look at it. Mean ± standard deviation was used to show continuous variables, and frequencies and percentages were used to show categorical variables. The unpaired t-test was utilized to examine continuous variables between independent groups, whereas the paired t-test was employed for comparisons within the same group. The Chi-square test or Fisher's exact test was used to look at categorical variables, depending on which one was better. A p-value of less than 0.05 was seen to be statistically important.

RESULTS

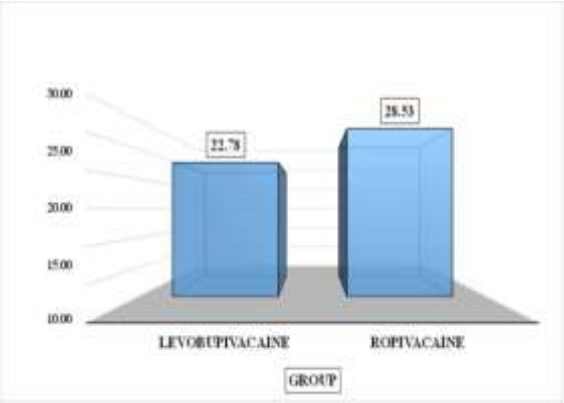

Figure 1: Comparison of mean time taken to achieve l1 in sensory block between both the groups.

Table 1: Demographic Profile of Study Population

Parameter	Category	Group L (n=55)	Group R (n=55)	Total (n=110)	P value
Age (years)	Mean ± SD	59.45 ± 7.547	59.27 ± 7.780	—	0.901
Gender	Male	42 (51.2%)	40 (48.8%)	82	0.662
	Female	13 (46.4%)	15 (53.6%)	28	
ASA Class	I	8 (34.8%)	15 (65.2%)	23	0.101
	II	47 (54.0%)	40 (46.0%)	87	

Table 2: Comparison of Mean Pulse Rate (bpm)

Time	Group	N	Mean	SD	P value
Baseline	L	55	78.45	3.711	0.216
	R	55	77.6	3.489	
6 hrs	L	55	109.67	7.222	0.0001
	R	55	100.4	8.196	
12 hrs	L	55	99.76	8.647	0.0001
	R	55	92.64	8.964	
24 hrs	L	55	91.69	8.333	0.0001
	R	55	86.89	7.428	
36 hrs	L	55	88.73	7.051	0.0001
	R	55	83.47	5.821	
48 hrs	L	55	85.24	5.464	0.001
	R	55	81.95	5.064	

Table 3: Comparison of Mean Systolic Blood Pressure (mmHg)

Time	Group	N	Mean	SD	P value
Baseline	L	55	116.11	7.031	0.057
	R	55	113.76	5.699	
6 hrs	L	55	131.4	7.581	0.004
	R	55	126.78	9.03	
12 hrs	L	55	125.51	6.104	0.031
	R	55	122.53	8.041	
24 hrs	L	55	118.38	6.905	0.004
	R	55	114.58	6.557	
36 hrs	L	55	114.53	6.719	0.043
	R	55	111.91	6.684	
48 hrs	L	55	115.47	7.052	0.0001
	R	55	110.6	7.062	

Table 4: Comparison of Mean Diastolic Blood Pressure (mmHg)

Time	Group	N	Mean	SD	P value
Baseline	L	55	76.47	4.145	0.084
	R	55	75.05	4.378	
6 hrs	L	55	86.22	4.387	0.03
	R	55	84.36	4.478	
12 hrs	L	55	81.09	4.766	0.738
	R	55	81.42	5.456	
24 hrs	L	55	81	5.326	0.241
	R	55	79.73	5.986	
36 hrs	L	55	79.09	7.053	0.571
	R	55	78.33	7.027	

48 hrs	L	55	79.18	5.979	0.0503
	R	55	76.62	7.519	

Table 5: Time for Sensory Regression to L1

Group	N	Mean (hrs)	SD	P value
L	54	22.78	11.263	0.018
R	53	28.53	13.463	

Table 6: Motor Block (Modified Bromage Scale)

Time	Group	N	Mean	SD	P value
6 hrs	L	55	2.53	0.573	0.051
	R	55	2.73	0.489	
12 hrs	L	55	3.51	0.69	0.376
	R	55	3.62	0.593	
24 hrs	L	55	4.4	0.655	0.768
	R	55	4.44	0.631	
36 hrs	L	55	5.22	0.534	0.19
	R	55	5.36	0.62	
48 hrs	L	55	5.84	0.373	0.794
	R	55	5.85	0.356	

Table 7: VAS Score at Rest

Time	Group	N	Mean	SD	P value
6 hrs	L	55	5.85	0.848	0.604
	R	55	5.76	0.981	
12 hrs	L	55	4.73	0.827	0.575
	R	55	4.64	0.868	
24 hrs	L	55	3.67	0.84	0.326
	R	55	3.51	0.9	
36 hrs	L	55	2.71	0.712	0.61
	R	55	2.64	0.778	
48 hrs	L	55	2.15	0.405	0.222
	R	55	2.02	0.652	

Table 8: VAS Score on Movement

Time	Group	N	Mean	SD	P value
6 hrs	L	55	6.71	0.712	0.32
	R	55	6.56	0.811	
12 hrs	L	55	5.47	0.663	0.794
	R	55	5.44	0.788	
24 hrs	L	55	4.36	0.704	0.805
	R	55	4.4	0.83	
36 hrs	L	55	3.42	0.629	0.901
	R	55	3.4	0.873	
48 hrs	L	55	2.71	0.533	0.255
	R	55	2.58	0.629	

[Table 1] Demographic Profile of Study Population

The demographic characteristics were comparable between both groups. The mean age in Group L was 59.45 ± 7.547 years, while in Group R it was 59.27 ± 7.780 years, with no statistically significant difference (p = 0.901). Gender distribution was also similar, with 42 males (51.2%) and 13 females (46.4%) in Group L, and 40 males (48.8%) and 15 females (53.6%) in Group R (p = 0.662). ASA physical status distribution showed no significant difference between groups (p = 0.101), with the majority of patients belonging to ASA class II in both groups. This indicates that both groups were demographically comparable.

[Table 2] Comparison of Mean Pulse Rate (bpm)

Baseline pulse rates were comparable between Group L (78.45 ± 3.711 bpm) and Group R (77.6 ± 3.489 bpm), with no significant difference (p = 0.216). However, at 6 hours, Group L showed a significantly higher pulse rate (109.67 ± 7.222 bpm) compared to Group R (100.4 ± 8.196 bpm) (p = 0.0001). This trend persisted at 12 hours (99.76 ± 8.647 vs 92.64 ± 8.964), 24 hours (91.69 ± 8.333 vs 86.89 ± 7.428), and 36 hours (88.73 ± 7.051 vs 83.47 ± 5.821), all showing statistically significant differences (p = 0.0001). At 48 hours, the difference remained significant (85.24 ± 5.464 vs 81.95 ± 5.064, p = 0.001). Overall, Group R demonstrated better pulse rate control postoperatively.

[Table 3] Comparison of Mean Systolic Blood Pressure (mmHg)

Baseline systolic blood pressure was comparable between Group L (116.11 ± 7.031 mmHg) and Group R (113.76 ± 5.699 mmHg), with no statistical significance (p = 0.057). At 6 hours, Group L had significantly higher systolic BP (131.4 ± 7.581 mmHg) compared to Group R (126.78 ± 9.03 mmHg) (p = 0.004). Similar statistically significant differences were observed at 12 hours (125.51 ± 6.104 vs 122.53 ± 8.041; p = 0.031), 24 hours

(118.38 ± 6.905 vs 114.58 ± 6.557; p = 0.004), 36 hours (114.53 ± 6.719 vs 111.91 ± 6.684; p = 0.043), and 48 hours (115.47 ± 7.052 vs 110.6 ± 7.062; p = 0.0001). These findings suggest better hemodynamic stability in Group R.

[Table 4] Comparison of Mean Diastolic Blood Pressure (mmHg)

Baseline diastolic blood pressure was comparable between Group L (76.47 ± 4.145 mmHg) and Group R (75.05 ± 4.378 mmHg), with no significant difference (p = 0.084). At 6 hours, Group L had significantly higher DBP (86.22 ± 4.387 mmHg) compared to Group R (84.36 ± 4.478 mmHg) (p = 0.03). However, at 12, 24, and 36 hours, no statistically significant differences were observed (p = 0.738, 0.241, and 0.571 respectively). At 48 hours, the difference approached statistical significance (79.18 ± 5.979 vs 76.62 ± 7.519; p = 0.0503). Overall, diastolic BP remained largely comparable between groups.

[Table 5] Time for Sensory Regression to L1

The mean time for sensory regression to L1 was significantly shorter in Group L (22.78 ± 11.263 hours) compared to Group R (28.53 ± 13.463 hours), with a statistically significant difference (p = 0.018). This indicates a longer duration of sensory blockade in Group R.

[Table 6] Motor Block (Modified Bromage Scale)

Motor block assessment using the Modified Bromage Scale showed no statistically significant differences between the two groups at any time interval. At 6 hours, scores were 2.53 ± 0.573 in Group L and 2.73 ± 0.489 in Group R (p = 0.051). At 12, 24, 36, and 48 hours, the differences remained statistically insignificant (p = 0.376, 0.768, 0.19, and 0.794 respectively). This suggests comparable motor blockade between both agents.

[Table 7] VAS Score at Rest

VAS scores at rest were comparable between the two groups at all time intervals. At 6 hours, Group L had a mean score of 5.85 ± 0.848 compared to 5.76 ± 0.981 in Group R (p = 0.604). Similarly, no significant differences were observed at 12 hours (4.73 ± 0.827 vs 4.64 ± 0.868; p = 0.575), 24 hours (3.67 ± 0.84 vs 3.51 ± 0.9; p = 0.326), 36 hours (2.71 ± 0.712 vs 2.64 ± 0.778; p = 0.61), and 48 hours (2.15 ± 0.405 vs 2.02 ± 0.652; p = 0.222). This indicates similar analgesic efficacy at rest.

[Table 8] VAS Score on Movement

VAS scores during movement were also comparable between both groups at all time points. At 6 hours, Group L had a score of 6.71 ± 0.712 compared to 6.56 ± 0.811 in Group R (p = 0.32). No statistically significant differences were noted at 12 hours (5.47 ± 0.663 vs 5.44 ± 0.788; p = 0.794), 24 hours (4.36 ± 0.704 vs 4.4 ± 0.83; p = 0.805), 36 hours (3.42 ± 0.629 vs 3.4 ± 0.873; p = 0.901), and 48 hours (2.71 ± 0.533 vs 2.58 ± 0.629; p = 0.255). This demonstrates comparable analgesic efficacy during movement in both groups.

DISCUSSION

In the present study, both groups were comparable in terms of age, gender, and ASA status, indicating homogeneity of the study population. This is consistent with the findings of Maheshwari et al., who also reported no significant demographic differences between levobupivacaine and ropivacaine groups in lower limb orthopedic surgeries.[11] Similarly, another TKR-based study demonstrated comparable baseline characteristics, ensuring that observed differences in outcomes were attributable to the study drugs rather than confounding variables.[12] Thus, the comparability of demographic variables in our study strengthens the validity of the results.

Our study demonstrated significantly higher pulse rates in the levobupivacaine group compared to the ropivacaine group at multiple postoperative intervals. Similar findings were reported in a TKR study where the ropivacaine group exhibited lower pulse rates, suggesting better hemodynamic stability.[12] However, Maheshwari et al. observed comparable heart rate trends between the two drugs, indicating that while both agents are generally stable, ropivacaine may offer slight advantages in attenuating sympathetic responses postoperatively.[11]

The present study showed significantly higher systolic blood pressure in the levobupivacaine group compared to the ropivacaine group at most time intervals. These findings are in agreement with previous studies, where ropivacaine was associated with lower systolic blood pressure, reflecting better hemodynamic control.[12] In contrast, other studies have reported comparable systolic blood pressure profiles between the two agents, suggesting that both drugs are hemodynamically safe when used epidurally.[13] This variation may be due to differences in drug concentration and infusion protocols.

In our study, diastolic blood pressure was largely comparable between the two groups, with only transient differences. This is consistent with findings from previous studies, which demonstrated no statistically significant differences in diastolic blood pressure between levobupivacaine and ropivacaine groups.[13] Similar observations were also reported in other comparative trials, indicating that both agents maintain stable diastolic pressure during postoperative epidural infusion.[11]

The time for sensory regression to L1 was significantly shorter in the levobupivacaine group, indicating a shorter duration of sensory blockade compared to ropivacaine. This finding is in agreement with studies demonstrating prolonged sensory block with ropivacaine.[11,14] Kumar et al. also reported a longer duration of analgesia with ropivacaine, which may contribute to prolonged pain relief and reduced analgesic requirements.[14]

Thus, ropivacaine appears to provide longer-lasting sensory blockade.

Motor blockade was comparable between both groups in our study, with no statistically significant differences at any time interval. This is consistent with previous studies showing similar motor block characteristics between levobupivacaine and ropivacaine.[11] However, some studies have reported earlier motor recovery with ropivacaine, making it more favorable for early mobilization.[15] The comparable motor block observed in our study suggests that both drugs are suitable for postoperative analgesia without significantly delaying ambulation.

VAS scores at rest were comparable between both groups at all time intervals, indicating similar analgesic efficacy. These findings are consistent with prior studies where no significant difference in VAS scores was observed between levobupivacaine and ropivacaine.[12,16] Several authors have concluded that both drugs provide equally effective postoperative pain relief when used in appropriate concentrations.[17]

VAS scores during movement were also comparable between the two groups, with no statistically significant differences. This aligns with previous studies that demonstrated equivalent analgesic efficacy during mobilization.[12,16] However, some authors have suggested that ropivacaine may offer slightly better pain control during movement, although the difference is often not statistically significant.[18] Overall, both agents provide adequate dynamic analgesia necessary for rehabilitation after TKR.

The present study findings are largely consistent with existing literature, which suggests that both levobupivacaine and ropivacaine provide effective and safe postoperative epidural analgesia when given in equipotent doses. However, ropivacaine may offer advantages such as better hemodynamic stability, longer sensory blockade, and earlier motor recovery, making it a preferred choice in enhanced recovery protocols.[12,15,19] Nonetheless, both drugs demonstrate comparable analgesic efficacy and minimal side effects, supporting their clinical utility in TKR patients.[20]

CONCLUSION

We conclude that, the present study demonstrates that both levobupivacaine (0.125%) and ropivacaine (0.2%) provide effective and comparable postoperative epidural analgesia in patients undergoing total knee replacement, as evidenced by similar VAS scores at rest and during movement. However, ropivacaine showed better hemodynamic stability with lower pulse rate and blood pressure values at multiple postoperative intervals. Additionally, it provided a longer duration of sensory blockade, which may contribute to sustained analgesia. Motor blockade was comparable between the two groups, indicating that both agents allow for early mobilization. The incidence of side effects was minimal and similar in both groups, confirming their safety profile. Overall, while both drugs are suitable for postoperative epidural analgesia, ropivacaine may be preferred due to its favorable hemodynamic profile and prolonged sensory effect, making it a more advantageous option in enhanced recovery protocols following total knee replacement.

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