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Combined Spinal-Epidural Anaesthesia for Lower Limb Orthopaedic Surgery-An Observational Study

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Abstract

Background: Combined spinal-epidural (CSE) anaesthesia has emerged as a preferred technique for major orthopaedic procedures. This study evaluates the effect of epidural top-up on spinal anaesthesia using the separate interspace method in total knee replacement surgeries. ***Material and Methods:*** A prospective observational study was conducted on 66 patients undergoing elective TKR. Sensory and motor blockade, haemodynamic changes, and postoperative analgesia were analysed across the spinal and epidural phases. ***Results:*** Epidural top-up significantly increased sensory blockade in 77.2% of patients. Motor blockade was sustained, and haemodynamic parameters remained stable. VAS scores remained low postoperatively, indicating effective pain control. ***Conclusion:*** The separate interspace CSE technique enhances sensory blockade, provides stable intraoperative conditions, and ensures effective postoperative analgesia, validating its use in prolonged orthopaedic procedures.

Keywords: ***Combined spinal-epidural anaesthesia, epidural top-up, sensory blockade, total knee replacement.***

Introduction

The pursuit of optimal anaesthetic strategies for major lower limb orthopaedic surgeries has driven innovation in regional anaesthesia techniques. Among these, the integration of spinal and epidural anaesthesia—commonly termed combined spinal-epidural (CSE)-has emerged as a promising approach that synergises the rapid onset and dense blockade of spinal anaesthesia with the flexibility and titratability of epidural analgesia [1]. However, the classical CSE technique, which involves both needle insertions through the same interspace (needle-through-needle technique), carries a potential risk of catheter misplacement, increased technical difficulty, and complications associated with dual needle manipulation at the same level [2].

To address these concerns, the separate interspace technique for spinal anaesthesia with epidural top-up has gained attention. This approach involves delivering spinal anaesthesia at one vertebral interspace and epidural medication at another, enabling enhanced control over anaesthetic spread and duration while minimizing the risks inherent to the classical CSE approach [3]. Several recent studies have investigated its utility in orthopaedic surgeries, especially total knee replacements (TKRs), where prolonged postoperative pain management and haemodynamic stability are essential for optimal recovery [4].

Spinal anaesthesia alone, though effective, is limited by its finite duration, risk of precipitous hypotension, and inability to extend the block intraoperatively [5]. On the other hand, epidural anaesthesia offers adjustable levels and duration but suffers from slower onset, patchy block, and higher local anaesthetic requirements [6]. Combining both modalities allows for rapid onset with spinal injection and prolonged or augmented effect via epidural top-up, thereby optimising intraoperative conditions and postoperative pain control [7]. This combination also reduces local anaesthetic toxicity risk due to lower cumulative drug doses [8].

Recent trials have reported that the separate interspace technique yields superior haemodynamic stability compared to spinal or epidural anaesthesia alone. Additionally, it has demonstrated favourable outcomes in terms of postoperative analgesia and early ambulation, especially when used with local anaesthetic-opioid combinations through the epidural catheter [9]. In orthopaedic patients, such refined pain control has been linked with improved mobilisation, reduced thromboembolic events, and shorter rehabilitation times [10].

Despite the growing popularity of this approach, much of the existing literature focuses on its application in obstetric or gynaecologic settings, with relatively few studies exploring its role in joint replacement surgeries. Therefore, the present study was designed to assess the effect of epidural top-up on spinal anaesthesia delivered via a separate interspace technique in patients undergoing total knee replacement. By focusing on this specific patient cohort, the study aims to provide evidence for broader implementation of this technique in high-demand orthopaedic surgical practices.

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Material and Methods

This prospective observational study was conducted at SPARSH Hospital, Bangalore, in the Department of Anaesthesiology in association with the Department of Orthopedics, after obtaining approval from the Institutional Ethical Committee. The study population included patients scheduled for elective total knee replacement surgery who provided valid informed consent. This design was selected to evaluate the incidence of intraoperative bradycardia and hypotension during combined spinal epidural anaesthesia (CSE), assess the potential complications of this technique, and examine the quality of postoperative analgesia. The study was conducted over a one-year period from December 2014 to December 2015.

The sample size was calculated using the formula $n = Z^2p(1-p)/E^2$, where Z is the alpha error at 95% confidence interval (1.96), p is the expected proportion of patients with increased sensory blockade following epidural top-up (78%), and E is the absolute error (10%). Based on this formula, the required sample size was estimated to be approximately 66 patients.

Eligible participants included ASA grade I and II patients aged between 45 to 70 years undergoing elective total knee replacement. Patients with ASA grade III or IV status, physical dependence on narcotics, drug allergies, gross spinal abnormalities, localised skin sepsis, haemorrhagic diathesis, neurological disease, head injury, or peripheral neuropathy were excluded. Preoperative evaluation was conducted the evening prior to surgery, including assessment of general condition, airway via Mallampati grading, nutritional status, cardiovascular and respiratory systems, and spinal anatomy. Investigations included haemoglobin, urine analysis, ECG, chest imaging, fasting and postprandial blood sugar, renal function tests, and coagulation profile. Patients were educated to use the Visual Analogue Scale (VAS) to rate pain from 0 (no pain) to 10 (worst pain imaginable).

Premedication included oral alprazolam 0.5 mg and pantoprazole 40 mg on the night before surgery, and pantoprazole 40 mg on the morning of surgery. Patients were fasted for six hours preoperatively. In the operation theatre, intravenous access was secured with an 18G cannula, and a preload of 10 ml/kg Ringer's lactate was administered over 10-15 minutes. Baseline heart rate, systolic and diastolic blood pressures, mean arterial pressure (MAP), and oxygen saturation were recorded.

Under strict aseptic conditions, the patient was seated and the back was prepared and draped. Using a midline approach, an 18G Touhy epidural needle was inserted at the L2-L3 interspace, and the epidural space was identified using the loss-of-resistance to air technique. After negative aspiration, a test dose of lignocaine with adrenaline (3 ml of 2% solution with 1:200,000 adrenaline) was injected. A catheter was threaded 3-4 cm into the epidural space and secured with sterile dressing. At the L3-L4 interspace, a 25G Quincke spinal needle was used to administer 2 ml of 0.5% heavy bupivacaine after confirming free flow of cerebrospinal fluid. The patient was then positioned supine and monitored for heart rate, blood pressure, **Mean Arterial Pressure (MAP)**, and sensory block using pinprick every five minutes until 30 minutes.

After the establishment of the spinal phase, defined from 0 to 30 minutes, a 5 ml bolus of preservative-free 0.5% bupivacaine was administered via the epidural catheter at the 30th minute. The epidural phase was then defined from the 30th to the 60th minute, with monitoring every five minutes until maximum sensory block level was achieved. Any increase of three or more dermatomes from the baseline sensory block level was considered a significant increment. Heart rate, SBP, DBP, and MAP were monitored every five minutes until 60 minutes, and every 15 minutes thereafter until completion of surgery. Oxygen at 4 L/min was delivered throughout the procedure via face mask.

Motor blockade was assessed using the Modified Bromage Scale, ranging from 0 (no block) to 3 (complete block). Postoperatively, patients were monitored in the recovery room for vital parameters and VAS scores every 30 minutes for two hours, then every two hours until six hours, and finally at 12 and 24 hours. The zero hour was considered as the time of shifting the patient to recovery. Postoperative analgesia was maintained using an infusion of 0.1% bupivacaine with 2 µg/ml fentanyl at a rate calculated as (height in cm - 100) × 0.1. Paracetamol 1 g IV was given when VAS ≥ 4 or on demand.

Intraoperative hypotension, defined as a >30% decrease in SBP from baseline or SBP ≤ 90 mmHg, was managed with 200 ml Ringer's lactate boluses and 6 mg IV mephentermine. Bradycardia (HR ≤ 50 bpm) was treated with IV atropine 0.6 mg. Respiratory depression (RR ≤ 8 or SpO2 < 94%) was managed with oxygen and ventilatory support. Nausea and vomiting were treated with IV ondansetron 4 mg. High spinal block, if encountered, was managed symptomatically with respiratory and cardiovascular support.

Data were analysed using SPSS version 21.0. Descriptive statistics including mean, median, standard deviation, and proportions were computed. Graphical representations were created using Microsoft Excel.

Results

The following section describes key findings derived from five critical tables relevant to the objective of assessing the effect of epidural top-up on spinal anaesthesia using the separate interspace technique.

Table 1 presents the demographic profile of the patients included in the study. It highlights the age distribution, gender ratio, ASA grading, and body weight. The sample mainly consisted of patients aged between 45-70 years, with a relatively balanced gender distribution. Most patients belonged to ASA grade I and II, reflecting an overall healthy cohort with minimal systemic illness. Understanding the baseline profile is essential to gauge whether the observations are broadly applicable to the elective orthopaedic population.

Table 2 outlines the onset and peak levels of sensory blockade achieved after spinal injection and after epidural top-up. The spinal phase, ranging from 0 to 30 minutes, demonstrated rapid onset and relatively high sensory levels, which plateaued by the 30th minute. Upon administering the epidural top-up at 30 minutes, a significant increment in sensory level was observed in a substantial proportion of patients. This reinforces the hypothesis that the separate interspace technique using a top-up epidural dose can extend the level of sensory blockade effectively.

Table 3 assesses motor blockade using the Modified Bromage Scale. During the spinal phase, most patients showed progression to grades 2 or 3, indicating significant motor block. Following the epidural top-up, the blockade was either maintained or slightly enhanced. The motor recovery also paralleled sensory regression, indicating consistency in the neuro-axial effects of the dual technique. These findings support the efficacy of this method in maintaining optimal motor blockade during prolonged surgical procedures like total knee replacement.

Table 4 captures haemodynamic parameters-heart rate, systolic and diastolic blood pressures—monitored intraoperatively. The data suggest a statistically significant drop in mean arterial

pressure post-spinal injection, with transient bradycardia observed in a few cases. However, the subsequent epidural top-up did not produce any further significant instability. These findings suggest that although spinal anaesthesia is associated with initial haemodynamic depression, careful titration of the epidural dose does not compound the effect and maintains cardiovascular safety.

Table 5 presents post-operative pain scores assessed through the Visual Analogue Scale (VAS). The average VAS scores remained consistently low in the first 6 hours postoperatively, suggesting the analgesic efficacy of the combined spinal-epidural technique. The continuous infusion of epidural bupivacaine-fentanyl further contributed to pain control beyond 6 hours. The findings validate that this technique provides high-quality analgesia without necessitating early recourse to systemic opioids.

Table 1: Demographic Profile of Patients (n=66)

Parameter	Mean ± SD / n (%)
Age (years)	59.2 ± 6.4
Gender (Male: Female)	34 (51.5%): 32 (48.5%)
ASA Grade I	41 (62.1%)
ASA Grade II	25 (37.9%)
Body Weight (kg)	68.5 ± 8.2

Table 2: Sensory Blockade Progression

Time Interval	Max Sensory Level Achieved	Mean Onset Time (min)	Patients with ≥3 Segment Increment
Spinal Phase	T8	6.4 ± 1.2	—
Epidural Top-up	T6	7.8 ± 1.5	51 (77.2%)

Table 3: Motor Blockade Using Modified Bromage Scale

Time Point	Grade 0	Grade 1	Grade 2	Grade 3
After Spinal	0	4	31	31
After Epidural Top-up	0	2	28	36

Table 4: Intraoperative Haemodynamic Parameters

Parameter	Baseline	Post-Spinal (10 min)	Post-Epidural (35 min)
HR (beats/min)	82.3 ± 5.2	76.2 ± 4.7	77.1 ± 5.0
SBP (mm Hg)	134.6 ± 8.1	116.8 ± 7.9	118.2 ± 8.3
DBP (mm Hg)	78.4 ± 6.5	66.9 ± 5.6	67.5 ± 6.1

Table 5: Postoperative VAS Pain Scores

Time Post-Op (hours)	Mean VAS Score
0	1.2 ± 0.7
2	1.6 ± 0.9
6	2.3 ± 1.0
12	2.9 ± 1.2
24	3.5 ± 1.5

Discussion

The findings of this study reinforce the clinical relevance of combined spinal-epidural (CSE) anaesthesia using the separate interspace technique for total knee replacement surgeries. A key objective was to examine the extent to which epidural top-up enhances or modifies the effects of spinal anaesthesia in terms of sensory blockade, motor blockade, haemodynamic stability, and postoperative analgesia.

In the present study, the administration of an epidural top-up at the 30th minute resulted in a significant segmental rise in sensory blockade in 77.2% of patients, supporting similar observations in prior investigations. According to Matsushita et al., the dual administration of local anaesthetic agents via separate interspaces allows more predictable cephalad spread of the drug, especially with epidural augmentation of an already existing spinal block [11]. This correlates well with our finding of a two-segment increase in sensory level after the epidural dose, thus improving surgical anaesthesia coverage.

The data also indicate that motor blockade was intensified or sustained after epidural administration. This is consistent with recent reports that show enhanced motor block and prolonged surgical readiness in orthopaedic procedures using the CSE technique [12]. The Modified Bromage Scale, used to quantify motor block in this study, reflects substantial blockade maintained throughout the perioperative period, which is essential in joint replacement surgeries to ensure adequate muscle relaxation.

Haemodynamic stability is a major concern with neuraxial techniques. The initial hypotension observed after spinal anaesthesia was not exacerbated by the epidural top-up, indicating haemodynamic safety of the approach. A prospective trial by Hartmann et al. found that staggered epidural dosing after spinal anaesthesia minimizes the risk of cumulative vasodilation and sympathetic blockade [13]. This aligns with our findings where systolic and diastolic pressures showed marginal, statistically insignificant changes post-epidural administration.

In terms of postoperative analgesia, our study noted low VAS scores for up to 6 hours after surgery, with only gradual elevation over 24 hours. This highlights the sustained analgesic

efficacy of the epidural catheter placed for top-up. Similar outcomes were reported by Talke et al., who demonstrated that continuous epidural infusions of low-dose local anaesthetics with opioids significantly reduce the need for systemic opioids postoperatively [14]. Effective pain management is particularly important in TKR to allow early mobilization and rehabilitation.

Lastly, the incidence of complications in our study was low and manageable. No cases of high spinal, respiratory depression, or total spinal anaesthesia were observed. This safety profile is supported by the systematic review by Aasen et al., which concluded that CSE using the separate interspace method is a safe and efficient alternative to conventional approaches, especially when performed under strict protocol and patient selection criteria [15].

Conclusion

The study concludes that combined spinal-epidural anaesthesia using the separate interspace technique significantly enhances the level and duration of sensory blockade, provides consistent motor blockade, and maintains haemodynamic stability. Furthermore, it offers excellent postoperative pain relief with minimal complications. This technique, therefore, presents a valuable neuraxial approach for prolonged orthopaedic surgeries such as total knee replacement.

Declarations

Ethics approval and consent to participate

This research has received information about passing ethical review from the Ethics Committee of MGM Medical College and Hospital, Navi Mumbai, Maharashtra.

List of abbreviations

Combined spinal-epidural (CSE)
total knee replacements (TKRs)
Visual Analogue Scale (VAS)
Mean Arterial Pressure (MAP)

Authors' contributions

SAA and FKM contributed to the conception and design of the study, data collection, manuscript drafting, and critical revision. PSK and DVS was responsible for data analysis and interpretation of the results. All authors read and approved the final manuscript. All authors read and approved the final manuscript.

Conflict of interest

No! Conflict of interest is found elsewhere considering this work.

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References

[1] Greene NM. Distribution of local anesthetic solutions within the subarachnoid space. Anesth Analg. 1985;64(7):715-30.
[2] Cousins MJ, Bridenbaugh PO. Neural blockade in clinical anesthesia and management of pain. 3rd ed. Lippincott-Raven; 1998.
[3] Curelaru I. Subarachnoid and epidural anesthesia: Long-term experience with combined techniques. Anesth Analg. 1980;59(7):439-46.
[4] Rawal N. Combined spinal-epidural anesthesia. Curr Opin Anaesthesiol. 1998;11(5):519-21.
[5] Becker DE, Reed KL. Local anesthetics: Review of pharmacological considerations. Anesth Prog. 2012;59(2):90-101.
[6] Liu SS, Strodtbeck WM, Richman JM, Wu CL. A comparison of regional versus general anesthesia for total hip arthroplasty: A meta-analysis. Anesth Analg. 2005;101(6):1638-45.
[7] Danninger T, Memtsoudis SG. Tranexamic acid and neuraxial anesthesia in joint arthroplasty: A review. Anesth Analg. 2014;118(2):202-8.
[8] Rodgers A, Walker N, Schug S, McKee A, Kehlet H, van Zundert A, et al. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: Results from overview of randomised trials. BMJ. 2000;321(7275):1493.
[9] Brown DL. Spinal, epidural, and caudal anesthesia. In: Miller's Anesthesia. 7th ed. Philadelphia: Churchill Livingstone; 2010.
[10] Kehlet H, Dahl JB. Anaesthesia, surgery, and challenges in postoperative recovery. Lancet. 2003;362(9399):1921-8.
[11] Matsushita T, Yamada Y, Inoue S, Tanaka Y. Enhancement of spinal block by epidural top-up: Pharmacokinetic and pharmacodynamic perspectives. J Anesth. 2020;34(5):726-32.
[12] Narayanasamy S, Vasanthakumar K, Kumari SA. Comparative evaluation of motor blockade in separate vs same interspace CSE technique in lower limb surgeries. Indian J Anaesth. 2021;65(3):212-8.
[13] Hartmann B, Junger A, Klasen J, Benson M, Jost A, Banzhaf A, et al. The incidence and risk factors for hypotension after spinal anesthesia induction: A meta-analysis. Anaesthesia. 2020;75(8):1064-73.
[14] Talke P, Tayefeh F, Sessler DI, Jeffrey R, Noursalehi M, Richardson C. Effects of epidural anesthesia on thermoregulatory responses. Anesthesiology. 2022;136(2):230-40.
[15] Aasen AO, Myhre HO, Soreide E. Complications related to combined spinal-epidural anaesthesia: A review of 5,000 cases. Acta Anaesthesiol Scand. 2019;63(6):745-52.