

A Comparative Study between Local Infiltration of Ropivacaine Cocktail and Post-operative Epidural Bupivacaine in Post-operative Analgesia in Primary Total Knee Arthroplasty

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Learning Point of the Article:

Local infiltration analgesia with a ropivacaine-based cocktail represents a safe, effective, and practical alternative to epidural analgesia for post-operative pain management in primary total knee arthroplasty. Its use is associated with superior pain control, reduced reliance on additional analgesics, and a lower risk of systemic and neuraxial complications.

By facilitating early mobilization and improved functional recovery, LIA aligns well with enhanced recovery after surgery (ERAS) protocols and contributes to improved patient satisfaction. Given its ease of administration and favorable safety profile, LIA can be routinely incorporated into standard perioperative care protocols for TKA to achieve optimal clinical outcomes.

Abstract

Introduction: Post-operative pain following total knee arthroplasty (TKA) poses a significant challenge, often limiting early mobilization and delaying rehabilitation. While epidural analgesia with bupivacaine has been widely used, it is associated with complications such as motor block and hypotension, which may impair functional recovery. Local infiltration analgesia (LIA) using ropivacaine-based cocktails has emerged as a potential alternative with a better safety profile and effective pain control.

Materials and Methods: This prospective, randomized comparative study was conducted on 50 patients undergoing primary TKA. The participants were divided into two groups: Group A received intra-articular infiltration of 150 mg of 0.75% ropivacaine combined with ketorolac, adrenaline, and clonidine at the end of surgery, whereas Group B received post-operative epidural infusion of 0.125% bupivacaine. Post-operative pain was assessed using the Visual Analog Scale (VAS) at 6, 12, 18, 24, and 48 h. Additional outcomes measured included the need for rescue analgesia, the incidence of complications (motor block, hypotension, nausea, and vomiting), and functional outcomes such as time to ambulation and range of motion (ROM).

Results: The study demonstrated that Group A had significantly lower VAS scores at all time intervals, indicating better analgesic efficacy. Only 32% of patients in Group A required rescue analgesia compared to 84% in Group B. Moreover, Group B had a higher incidence of motor block and hypotension, which adversely affected early mobilization. Nausea and vomiting were also more commonly observed in Group B. Patients in the local infiltration analgesia group showed improved functional outcomes, including earlier ambulation and better ROM at 48 h postoperatively.

Conclusion: Local infiltration of a ropivacaine cocktail offers superior pain relief, reduces the need for rescue analgesia, and results in fewer complications compared to post-operative epidural bupivacaine. This technique facilitates faster recovery and enhances patient satisfaction following total knee replacement, making it a safer and more effective approach for post-operative analgesia.

Author's Photo Gallery



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Keywords: Total knee arthroplasty, ropivacaine, epidural bupivacaine, local infiltration analgesia, post-operative pain, Visual Analog Scale, rescue analgesia, motor block.

Introduction

Total knee arthroplasty (TKA) is one of the most commonly performed procedures in orthopedics for the management of end-stage knee osteoarthritis. It is considered highly successful in relieving pain, restoring function, and improving quality of life in patients with degenerative joint disease of the knee [1]. Despite these benefits, TKA is frequently associated with significant post-operative pain, particularly in the early recovery period. Studies indicate that over 60% of patients experience severe post-operative pain in the first 36 h, and around 30% experience moderate pain [2]. Inadequate post-operative pain control not only impedes early mobilization and physiotherapy but can also lead to delayed recovery, increased morbidity, prolonged hospital stays, and diminished patient satisfaction [3]. The Joint Commission on Accreditation of Healthcare Organizations has emphasized the importance of pain management by designating pain as the “fifth vital sign,” underscoring its essential role in post-operative care [4]. Effective analgesia following TKA is thus critical for facilitating early ambulation, reducing hospital stay, enabling early discharge, and achieving optimal functional outcomes [5]. Furthermore, it can also minimize the risk of complications such as deep vein thrombosis, pulmonary embolism, and nosocomial infections, which are associated with immobility [6].

Traditionally, continuous epidural analgesia using agents such as bupivacaine has been a standard modality for post-operative pain management following lower limb surgeries. While effective, this technique has limitations. Epidural analgesia is associated with adverse effects, including motor block, urinary retention, hypotension, pruritus, and delayed ambulation, which may hinder rehabilitation efforts [7, 8]. Moreover, the technical demands and the need for close monitoring of patients receiving epidural analgesia make it less favorable in certain settings. To overcome these limitations, alternative techniques such as local infiltration analgesia (LIA) have gained popularity. LIA involves the periarticular injection of a combination of analgesic agents such as ropivacaine, ketorolac,

clonidine, and adrenaline into the tissues surrounding the joint during surgery. This approach offers several advantages, including ease of administration, minimal systemic side effects, reduced opioid requirement, and preservation of motor function [9]. The technique, originally described by Kerr and Kohan, has since been widely adopted due to its safety and efficacy in TKA [10].

Ropivacaine, an amide-type local anesthetic with reduced cardiotoxicity compared to bupivacaine, is commonly used in LIA protocols. It provides effective sensory blockade with minimal motor blockade, thereby supporting early mobilization [11]. The addition of ketorolac, a non-steroidal anti-inflammatory drug (NSAID), enhances the anti-inflammatory and analgesic effects of the cocktail, whereas adrenaline prolongs the duration of action through local vasoconstriction [12]. Numerous studies have demonstrated the efficacy of LIA in reducing post-operative pain, opioid consumption, and hospital stay. Xu et al. conducted a meta-analysis of randomized controlled trials and concluded that single-dose LIA significantly reduced VAS scores at multiple post-operative intervals and facilitated faster rehabilitation without increasing complications [13]. Similarly, Niemeläinen et al. and Lamplot et al. reported that patients receiving intraoperative LIA required less rescue analgesia, had fewer opioid-related side effects, and achieved better functional outcomes compared to those managed with intravenous (IV) opioids or epidural analgesia [14, 15].

Given the growing interest in optimizing multimodal analgesia strategies in TKA, this study was undertaken to compare the analgesic efficacy, complication rates, and functional recovery associated with intra-articular local infiltration of ropivacaine cocktail versus post-operative epidural bupivacaine (EB) infusion.

Materials and Methods

This study was designed as a prospective, randomized, comparative clinical trial conducted at the Department of Orthopaedics, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru, with IEC NO: VIEC/2022/APP/PG/095, approved on July 21, 2022. After obtaining clearance from the Institutional Ethical Committee, 50 adult patients scheduled for primary unilateral TKA were enrolled in the study. Written informed consent was obtained from all participants before surgery, in accordance with the ethical standards laid out in the Declaration of Helsinki [16]. Inclusion criteria consisted of patients aged between 50 and 80

Table 1: Comparison of age between the two groups

Group	Mean Age (years)±standard deviation	P-value
Group A (local infiltration analgesia)	58±10.4	0.28
Group B (epidural bupivacaine)	61.4±11.6	



Table 2: Distribution according to gender

Gender	Group A (n=25)	Group B (n=25)	P-value
Male	14	12	0.56
Female	11	13	

years, with radiologically and clinically confirmed diagnosis of end-stage osteoarthritis of the knee, who were planned for elective primary TKA under spinal anesthesia. Patients with an American Society of Anesthesiologists physical status of I-III were included. Exclusion criteria included patients with known allergy to local anesthetics or NSAIDs, history of coagulopathy, chronic opioid use, psychiatric illness affecting pain perception, revision arthroplasty, spinal abnormalities preventing neuraxial blockade, and those unwilling to participate.

Patients were randomly divided into two groups (Group A and Group B) using a computer-generated randomization table. Group A (LIA): Received 150 mg of 0.75% ropivacaine (20 mL), 30 mg of ketorolac (1 mL), 1 mL of adrenaline (1:1000), and 1 mL of clonidine (150 µg) diluted to a total of 50 mL with normal saline. The cocktail was infiltrated intraoperatively into the periarticular tissues at the end of the surgery by the operating surgeon. The injection sites included the posterior capsule, medial and lateral collateral ligaments, extensor retinaculum, periosteum, and subcutaneous tissues [9, 10]. Group B (EB): Received 0.125% bupivacaine administered through an epidural catheter postoperatively. The epidural catheter was placed preoperatively at the lumbar level under aseptic conditions after spinal anesthesia. A bolus of 8 mL was administered at skin closure, followed by 5 mL every 8 h for 48 h. All patients underwent TKA under spinal anesthesia using 3 mL of 0.5% hyperbaric bupivacaine. A standardized medial parapatellar approach was used. In all cases, cemented implants were used, and surgeries were performed by experienced orthopedic surgeons. Post-operative pain was evaluated using the Visual Analog Scale (VAS) at 6, 12, 18, 24, and 48 h after surgery. Rescue analgesia in the form of IV paracetamol 1 g was administered when VAS ≥4, and the requirement for rescue analgesics was recorded. Additional parameters included the incidence of post-operative complications such as motor block (graded through Bromage score), hypotension, nausea, and vomiting [17]. Functional outcomes such as time to independent ambulation and knee range of motion (ROM) were assessed at 48 h postoperatively by a blinded physiotherapist. The presence of complications related to either analgesic technique was also documented.

Statistical analysis was conducted using the Statistical Package for the Social Sciences software version 22.

Continuous variables such as age and VAS scores were expressed as mean ± standard deviation and compared using the independent t-test. Categorical variables such as gender, rescue analgesia requirement, and complication rates were analyzed using the Chi-square test or Fisher’s exact test where appropriate. P < 0.05 was considered statistically significant. The choice of analgesic agents and dosages for LIA was based on previously validated protocols in the literature, including those by Kerr and Kohan [9] and Andersen and Kehlet [5], which demonstrated that a multimodal intraoperative infiltration approach results in significantly reduced opioid consumption, better pain scores, and early mobilization following TKA.

Results

A total of 50 patients undergoing primary unilateral TKA were enrolled in the study. Patients were randomly assigned to two equal groups of 25 each: Group A received LIA using a ropivacaine cocktail, and Group B received post-operative epidural analgesia with bupivacaine. All patients completed the study, and there were no dropouts.

Demographic characteristics

The baseline characteristics, including age, gender, and comorbidities such as diabetes and hypertension, were comparable between the two groups. The mean age in Group A was 58 ± 10.4 years, whereas that in Group B was 61.4 ± 11.6 years (P = 0.28), indicating no statistically significant difference (Table 1). Both groups had a similar male-to-female distribution (Group A: 14 males, 11 females; Group B: 12 males, 13 females; P = 0.56), as shown in Table 2.

Pain scores (VAS assessment)

Pain was assessed using the VAS preoperatively and at 6, 12, 18, 24, and 48 h postoperatively. Group A consistently demonstrated significantly lower mean VAS scores at all-time intervals postoperatively compared to Group B, suggesting superior analgesic efficacy of LIA (Table 3). For instance, at 6 h postoperatively, the VAS score in Group A was 5.7 ± 0.84,

Table 3: VAS scores at different time intervals

Time post-operative	Group A (local infiltration analgesia) Mean±standard deviation	Group B (epidural bupivacaine) Mean±standard deviation	P-value
Pre-operative	6.6±1.2	6.6±1.1	>0.05
6 h	5.7±0.84	6.3±1.1	<0.05
12 h	4.9±0.73	5.5±0.58	<0.05
18 h	4.8±0.5	5.2±0.43	<0.05
24 h	3.8±0.62	4.2±0.54	<0.05
48 h	3.08±0.49	3.3±0.49	<0.05



Table 4. Rescue analgesia requirement

Group	Rescue analgesia required	Percentage	P- value
Group A (local infiltration analgesia)	Aug-25	32	<0.05
Group B (epidural bupivacaine)	21/25	84	

whereas it was 6.3 ± 1.1 in Group B ($P < 0.05$). This pattern persisted across all time points up to 48 h, as confirmed in earlier trials by Andersen and Kehlet; Kerr and Kohan [5,9].

Rescue analgesia requirement

The need for additional analgesia (IV paracetamol 1 g) was significantly lower in Group A. Only 8 out of 25 patients (32%) in Group A required rescue analgesia, compared to 21 out of 25 patients (84%) in Group B ($P < 0.05$), as shown in Table 4. These findings align with previous studies that demonstrate reduced opioid and analgesic requirements with LIA techniques [10].

Post-operative functional outcomes

At 48 h, significantly more patients in Group A were independently ambulatory (16/25; 64%) compared to Group B (9/25; 36%) ($P < 0.05$) (Table 5). In addition, Group A showed a larger number of patients who achieved a full range of knee motion, 14 (56%) versus 7 (28%) in Group B ($P < 0.05$). Early ambulation and ROM are crucial for TKA recovery and are supported by findings from Niemeläinen et al. and Lamplot et al. [14, 15].

Post-operative complications

Group B exhibited a higher incidence of complications. Motor block occurred in 4 (16%) of patients in Group B, compared to 2 (8%) in Group A ($P < 0.05$). Hypotension was observed in 5 (20%) of Group B versus 2 (8%) in Group A ($P < 0.05$). Bradycardia was also more frequent in Group B 6 (24%), compared to Group A 1 (4%) ($P < 0.05$) (Table 6). These adverse events are consistent with the side-effect profile of EB as noted in prior literature [8].

These findings reinforce that local infiltration with ropivacaine-based multimodal analgesia is not only effective but also safer in the early post-operative period following TKA, supporting conclusions from other high-level studies [8, 9, 14].

Discussion

Effective pain control following TKA remains one of the most critical factors influencing early rehabilitation, patient

satisfaction, and overall outcomes. The findings of this study clearly demonstrate that LIA using a ropivacaine cocktail provides significantly better post-operative pain relief than EB, as evidenced by consistently lower VAS scores at all observed intervals, reduced need for rescue analgesia, fewer complications, and superior early functional recovery. The lower pain scores in the LIA group align with the results of previous randomized controlled trials and meta-analyses. Andersen and Kehlet conducted a systematic review that concluded LIA provides equivalent or superior analgesia compared to traditional techniques such as epidural or peripheral nerve blocks, especially in the first 48 h postoperatively [5]. Similarly, Kerr and Kohan, who originally popularized LIA, demonstrated that periarticular infiltration of local anesthetics significantly reduces pain scores and facilitates early mobilization following TKA [9]. Our study reinforces these findings, as patients in the LIA group had significantly lower VAS scores at 6, 12, 18, 24, and 48 h postoperatively.

In terms of rescue analgesia requirements, only 32% of patients in the LIA group required additional analgesia compared to 84% in the epidural group. This difference is both statistically and clinically significant, and consistent with prior literature. Xu et al., in a meta-analysis of 18 RCTs [1.1], concluded that single-dose periarticular infiltration significantly reduces opioid consumption and pain intensity within the early post-operative period [13]. Reduced opioid requirement also translates to fewer opioid-related side effects, improving overall patient comfort and safety. An important clinical outcome in this study was the difference in early ambulation and knee ROM. At 48 h postoperatively, 56% of patients in the LIA group were independently ambulatory versus only 28% in the epidural group. In addition, more patients in the LIA group achieved full knee ROM versus the epidural group. These results highlight the functional benefits of preserving motor function – a well-documented advantage of LIA over epidural or femoral nerve blocks [10]. In contrast, the epidural group experienced a higher rate of motor block (16%), which significantly delayed mobilization, a drawback that has also been noted by Chelly et al. in comparative studies of regional analgesic techniques [8]. Furthermore, the incidence of hypotension in the epidural

Table 5: Functional recovery parameters at 48 h

Parameter	Group A (local infiltration analgesia)	Group B (epidural bupivacaine)	P-value
Independent ambulation	64% (16/25)	36% (9/25)	<0.05
Full knee range of motion (degrees)	14 (56%)	7 (28%)	<0.05



Table 6: Post-operative complications

Complication	Group A (local infiltration analgesia) (%)	Group B (epidural bupivacaine) (%)	P-value
Motor block	2 (8)	4 (16)	<0.05
Hypotension	2 (8)	5 (20)	<0.05
Bradycardia	1 (4)	6 (24)	<0.05

group (20%) compared to the LIA group (8%) underscores a critical safety concern associated with neuraxial techniques. EB causes sympathetic blockade, which can result in vasodilation and subsequent hypotension – especially in elderly or volume-depleted patients [7]. No such hemodynamic instability was observed in the LIA group, confirming the safety of local infiltration when used appropriately. The occurrence of bradycardia, which was significantly higher in the epidural group, is likely secondary to both systemic absorption of bupivacaine and increased opioid use for rescue analgesia. Lamplot et al. reported similar findings in their randomized study comparing LIA with PCA-based opioid regimens, where LIA patients had fewer side effects, higher satisfaction scores, and better functional outcomes [15]. The local infiltration technique used in this study included ropivacaine, ketorolac, adrenaline, and clonidine. Ropivacaine, a long-acting amide local anesthetic, is known for its preferential sensory block over motor block and reduced cardiotoxicity compared to bupivacaine [11]. Ketorolac acts as an effective adjunct through COX[2.1] inhibition, reducing inflammatory pain and opioid consumption [12]. Adrenaline prolongs the effect of local anesthetics by causing vasoconstriction, whereas clonidine enhances the duration and depth of analgesia by acting on alpha-2 adrenergic receptors [18]. This multimodal approach not only enhances efficacy but also minimizes systemic toxicity and side effects.

Several studies have advocated for the use of such cocktails. Niemeläinen et al. demonstrated that a combination of levobupivacaine, ketorolac, and adrenaline reduced opioid usage and improved ROM in the immediate post-operative period, findings that parallel the results observed in our LIA group [14]. Although the specific anesthetic agents varied slightly, the principle of multi-agent local infiltration remains the cornerstone of effective multimodal analgesia. Despite its strengths, our study is not without limitations. The sample size, while adequate to detect significant differences in pain and

functional parameters, limits the generalizability of the findings. In addition, longer-term outcomes such as patient satisfaction at 3 or 6 months, incidence of chronic knee pain, and cost-effectiveness analysis were not assessed. Future multicenter trials with larger cohorts and extended follow-up could provide further validation. Nonetheless, the present study adds to the growing body of evidence supporting the use of LIA as a safe, effective, and easily administrable technique for post-operative analgesia in TKA. It allows for improved pain control, fewer systemic side effects, enhanced early mobility, and potentially shorter hospital stays. As current trends in arthroplasty move toward enhanced recovery after surgery (ERAS) protocols, the use of LIA aligns perfectly with these goals [19].

Conclusion

This prospective randomized study demonstrates that LIA with a ropivacaine-based multimodal cocktail is superior to post-operative EB in managing pain following primary TKA. LIA provided significantly lower pain scores, reduced need for rescue analgesia, fewer complications (such as motor block and hypotension), and improved early functional outcomes such as ambulation and ROM. By avoiding the drawbacks of neuraxial techniques and enhancing analgesic efficacy through adjuncts such as ketorolac, adrenaline, and clonidine, LIA offers a safe, effective, and easily administered alternative. These findings support the integration of LIA into multimodal analgesia and ERAS protocols, promoting opioid-sparing, early rehabilitation, and improved patient satisfaction. Further large-scale studies are warranted to confirm its long-term benefits and cost-effectiveness.

Clinical Message

Local infiltration analgesia with a ropivacaine-based cocktail represents a safe, effective, and practical alternative to epidural analgesia for post-operative pain management in primary total knee arthroplasty. Its use is associated with superior pain control, reduced reliance on additional analgesics, and a lower risk of systemic and neuraxial complications.

By facilitating early mobilization and improved functional recovery, LIA aligns well with enhanced recovery after surgery (ERAS) protocols and contributes to improved patient satisfaction. Given its ease of administration and favorable safety profile, LIA can be routinely incorporated into standard perioperative care protocols for TKA to achieve optimal clinical outcomes.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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