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Original Research Article

Study to Compare 0.25% Bupivacaine with 0.25% Ropivacaine in USG Guided Single Shot Femoral Nerve Block for Management of Post-Operative Analgesia in Knee Surgeries

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Abstract

Background: Femoral nerve block is an effective component of multimodal postoperative analgesia following knee surgery. Bupivacaine and ropivacaine are commonly used long-acting local anaesthetics, although differences in their sensory and motor block characteristics may influence their clinical utility.

Aim: To compare 0.25% bupivacaine and 0.25% ropivacaine in ultrasound-guided single-shot femoral nerve block for postoperative analgesia following elective knee surgery.

Methods: This prospective, randomized, comparative study included 90 patients with ASA physical status I–II, aged 18–60 years, undergoing elective knee surgery. Patients were randomly allocated to Group A (n=45), receiving 30 mL of 0.25% bupivacaine, or Group B (n=45), receiving 30 mL of 0.25% ropivacaine. Postoperative VAS scores, sensory and motor blockade, haemodynamic parameters, rescue analgesic requirement, time to first rescue analgesia, and adverse effects were assessed over 24 hours.

Results: Baseline characteristics were comparable between the groups. VAS scores were similar at most assessment intervals; however, the VAS score at 20 hours was significantly lower with ropivacaine (median 2 vs 3; p=0.039). Sensory scores were significantly higher in the ropivacaine group at 4 and 8 hours (p=0.001 each), whereas motor scores remained comparable throughout the study. Rescue analgesia was required in 35.6% of the bupivacaine group and 37.8% of the ropivacaine group (p=0.999). Mean time to first rescue analgesia was 1110.0 ± 275.4 and 1030.6 ± 278.4 minutes, respectively (p=0.417). Adverse effects occurred in five patients (11.1%) receiving bupivacaine compared with none receiving ropivacaine (p=0.056).

Conclusion: Both 0.25% bupivacaine and 0.25% ropivacaine provided effective postoperative analgesia following ultrasound-guided single-shot femoral nerve block for knee surgery. Ropivacaine demonstrated greater sensory blockade at selected early time points and lower pain scores at 20 hours, while overall rescue analgesic requirement and duration of analgesia were comparable.

Keywords: Bupivacaine; Ropivacaine; Femoral nerve block; Ultrasound guidance; Knee surgery; Postoperative analgesia; Visual Analogue Scale.

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Introduction

Effective postoperative pain control is an essential component of perioperative care following knee surgery, as inadequate analgesia may delay mobilization, interfere with rehabilitation, increase

opioid consumption, and adversely affect patient satisfaction. Ultrasound-guided peripheral nerve blocks have become an important component of multimodal analgesia for knee procedures because they permit accurate deposition of local anaesthetic around the target nerve while reducing systemic analgesic requirements. Recent evidence continues to demonstrate the usefulness of single-shot femoral nerve block for postoperative analgesia following knee surgery.[1] The femoral nerve provides substantial sensory innervation to the anterior knee and is therefore an important target for regional analgesia. Ultrasound guidance improves visualization of the femoral nerve, femoral vessels, needle trajectory, and local anaesthetic spread. Contemporary studies have also investigated modifications of femoral nerve block using different local anaesthetics and adjuvants to improve the duration and quality of postoperative analgesia.[2]

Bupivacaine and ropivacaine are long-acting amide local anaesthetics commonly employed for peripheral nerve blockade. Both provide prolonged sensory blockade; however, their pharmacological and motor-block characteristics differ. Recent systematic evidence comparing bupivacaine and ropivacaine in knee arthroplasty suggests that both agents can provide effective postoperative pain control, although differences in analgesic characteristics may occur depending on concentration, dose, and technique.[3] Continuous femoral nerve blockade has similarly demonstrated an important role in postoperative pain management following total knee arthroplasty.[4]

Ropivacaine is particularly attractive for peripheral nerve blocks because of its favorable sensory–motor differentiation, which may facilitate postoperative rehabilitation. Recent clinical evidence has continued to evaluate ropivacaine-based femoral nerve blocks for knee arthroplasty.[5]

Nevertheless, femoral nerve block may produce quadriceps weakness, and newer motor-sparing techniques such as adductor canal block have therefore gained increasing attention.[6] Comparative studies of different femoral and adductor canal–based techniques further emphasize the need to balance effective analgesia with preservation of motor function.[7]

Therefore, the present study was undertaken to compare 0.25% bupivacaine and 0.25% ropivacaine administered as ultrasound-guided single-shot femoral nerve blocks for postoperative analgesia following elective knee surgery, with particular emphasis on analgesic duration, pain scores, rescue analgesic requirement, sensory and motor blockade, and adverse effects.

Materials and Methods

Study Design and Setting: The present study was a prospective, randomized, comparative study conducted in the Department of Anaesthesiology, Noble Hospital and Institute, Hadapsar, Pune, Maharashtra, from December 2014 to May 2016, over a period of 18 months.

Study population: A total of 90 patients of either sex, aged 18–60 years, with ASA physical status I or II, scheduled for elective knee surgery expected to last approximately 2–2.5 hours, were included.

Patients were randomly allocated into two groups of 45 patients each:

- **Group A (n=45):** ultrasound-guided femoral nerve block with 30 mL of 0.25% bupivacaine.
- **Group B (n=45):** ultrasound-guided femoral nerve block with 30 mL of 0.25% ropivacaine.

Sample Size: Sample size was calculated for comparison of a continuous outcome between two independent groups in a 1:1 allocation ratio. Based on a previous study, the standard deviation (σ) of the Visual Analogue Scale (VAS) score was assumed to be 3.4, and a mean difference (Δ) of 2.2 between the groups was considered clinically relevant.

The sample size for each group was calculated using:

$$n = \frac{2\left(Z_{\alpha/2} + Z_{\beta}\right)^2 \sigma^2}{\Delta^2}$$

where $Z_{\alpha/2} = 1.96$for a 95% confidence level, $Z_{\beta} = 0.84$for 80% power, σ=3.4, and Δ=2.2.

The minimum required sample size was approximately 38 patients per group. To improve study power and account for possible exclusions or incomplete observations, 45 patients were included in each group, giving a final sample size of 90 patients. Sample size estimation was performed using PS: Power and Sample Size Calculation software.

Inclusion Criteria: Patients were included if they were willing and able to provide written informed consent, aged 18–60 years, of either sex, belonged to ASA physical status I or II, and were undergoing elective knee surgery expected to last approximately 2–2.5 hours.

Exclusion Criteria: Patients were excluded if they refused to participate, had ASA physical status III or IV, known allergy to local anaesthetic agents, pre-existing peripheral neuropathy, bleeding disorders, pregnancy or lactation, or local infection at the proposed injection site.

Preoperative Assessment: All eligible patients underwent detailed pre-anaesthetic evaluation,

including medical history, general examination, and systemic examination. Investigations included complete blood count, coagulation profile, including INR, bleeding time and clotting time, random blood glucose, serum urea and creatinine, chest radiography, and electrocardiography as clinically indicated.

Patients were maintained nil per oral according to institutional fasting protocol. In the operating room, standard monitoring consisting of non-invasive blood pressure, electrocardiography, peripheral oxygen saturation, heart rate, and respiratory rate was instituted, and baseline parameters were recorded. Intravenous access was secured and appropriate intravenous fluids were administered. Ondansetron 0.1 mg/kg intravenously was given as premedication.

Anaesthetic Technique: All patients received a standard subarachnoid block with 3 mL of 0.5% hyperbaric bupivacaine. The upper level of sensory blockade was assessed by pin-prick approximately 10 minutes after administration.

At the completion of surgery, regression of the spinal sensory block was confirmed. The postoperative pain assessment procedure and the 0–10 VAS were explained to each patient.

Ultrasound-guided Femoral Nerve Block: Following surgery, the patient was positioned supine with the operated limb extended. Under strict aseptic precautions, an ultrasound machine equipped with an 8–14 MHz linear transducer was used to identify the femoral artery and femoral nerve at the level of the femoral crease.

A 22-gauge, 1.5-inch needle was introduced using an out-of-plane approach. After confirmation of appropriate needle position and negative aspiration, the study local anaesthetic was injected under ultrasound visualization:

Group A: 30 mL of 0.25% bupivacaine
Group B: 30 mL of 0.25% ropivacaine.

The completion of injection was considered 0 hour. Vital parameters were monitored throughout and following the procedure.

Postoperative Assessment: Patients were evaluated at 0, 4, 8, 12, 16, 20, and 24 hours after femoral nerve block. At each assessment, heart rate, blood pressure, respiratory rate, SpO_2, pain intensity, sensory blockade, and motor blockade were recorded.

Pain was assessed using a 10-point VAS, where 0 represented no pain, 1–3 mild pain, 4–6 moderate pain, 7–9 severe pain, and 10 the worst possible pain. Sensory blockade was evaluated by pin-prick using a three-point scale: 0 = normal sensation, 1 = loss of pin-prick sensation (analgesia), and 2 = loss of touch sensation (anaesthesia). Motor blockade was evaluated using the study's Modified Bromage scale based on the patient's ability to flex or extend the knee and ankle.

Rescue Analgesia: Rescue analgesia consisting of diclofenac sodium 75 mg intravenously in 100 mL normal saline was administered whenever the VAS score was ≥5. Time to first rescue analgesic and total rescue analgesic requirement during the observation period were documented.

Outcome Measures: The primary outcome was the duration of postoperative analgesia, defined as the time from completion of the femoral nerve block to administration of the first rescue analgesic. Secondary outcomes included VAS scores over 24 hours, sensory and motor block characteristics, total rescue analgesic requirement, haemodynamic parameters, and adverse effects.

Statistical Analysis: Categorical variables were expressed as frequencies and percentages, whereas normally distributed continuous variables were presented as mean ± standard deviation (SD). Non-normally distributed variables were summarized using median and range. Categorical variables were compared using the Chi-square test. Between-group differences in normally distributed continuous variables were evaluated using the unpaired Student's t-test, while the Mann–Whitney U test was used for non-normally distributed variables.

All hypotheses were tested using two-tailed alternatives, and $p<0.05$ was considered statistically significant. Statistical analysis was performed using SPSS version 16.0 (SPSS Inc., Chicago, USA).

Results

A total of 90 patients undergoing elective knee surgery were included, with 45 patients each in the bupivacaine and ropivacaine groups. Group A received 30 mL of 0.25% bupivacaine, whereas Group B received 30 mL of 0.25% ropivacaine for ultrasound-guided single-shot femoral nerve block. The groups were comparable with respect to baseline demographic and clinical characteristics.

Table 1: Baseline demographic and clinical characteristics

Parameters		Group A Bupivacaine (n=45)	Group B Ropivacaine (n=45)	p-value
Age (years), Mean ± SD		38.5 ± 12.7	42.4 ± 11.6	0.130
Gender	Male, n (%)	23 (51.1)	23 (51.1)	0.999
	Female, n (%)	22 (48.9)	22 (48.9)	
BMI (kg/m²), Mean ± SD		27.6 ± 2.6	27.5 ± 2.2	0.806
ASA Grade	I, n (%)	33 (73.3)	31 (68.9)	0.642
	II, n (%)	12 (26.7)	14 (31.1)	
Duration of surgery (min), Mean ± SD		131.7 ± 9.5	134.7 ± 9.3	0.132

The mean age was 38.5 ± 12.7 years in Group A and 42.4 ± 11.6 years in Group B. Both groups had identical sex distributions. BMI and ASA physical status were also comparable. The mean duration of surgery was 131.7 ± 9.5 minutes with bupivacaine and 134.7 ± 9.3 minutes with ropivacaine (p=0.132). Thus, no statistically significant differences were observed between the groups for the assessed baseline demographic and clinical characteristics.

Table 2: Comparison of postoperative pain scores (VAS) between groups

Time after block	Group A Bupivacaine Median (Min–Max)	Group B Ropivacaine Median (Min–Max)	p-value
0 h	0 (0–0)	0 (0–0)	0.999
4 h	0 (0–4)	0 (0–4)	0.820
8 h	0 (0–6)	0 (0–6)	0.340
12 h	2 (0–6)	2 (0–6)	0.170
16 h	2 (0–5)	2 (0–8)	0.987
20 h	3 (0–8)	2 (0–6)	0.039*
24 h	3 (0–6)	4 (0–8)	0.801

*p<0.05 statistically significant. VAS: Visual Analogue Scale.

Postoperative VAS scores were comparable between the two groups at 0, 4, 8, 12, 16 and 24 hours (all p>0.05). At 20 hours, the median VAS score was significantly lower in the ropivacaine group than in the bupivacaine group (2 vs 3, p=0.039), indicating better pain control with ropivacaine at this particular assessment point.

Table 3: Comparison of sensory and motor block characteristics

Time	Sensory Score Group A	Sensory Score Group B	p-value	Motor Score Group A	Motor Score Group B	p-value
0 h	2 (1–2)	2 (1–2)	0.441	3 (3–3)	3 (3–3)	0.999
4 h	1 (0–2)	2 (0–2)	0.001*	0 (0–2)	0 (0–0)	0.814
8 h	0 (0–1)	1 (0–2)	0.001*	0 (0–2)	0 (0–0)	0.802
12 h	0 (0–0)	0 (0–0)	0.999	0 (0–2)	0 (0–0)	0.814
16 h	0 (0–0)	0 (0–0)	0.999	0 (0–2)	0 (0–0)	0.814
20 h	0 (0–0)	0 (0–0)	0.999	0 (0–1)	0 (0–0)	0.999
24 h	0 (0–1)	0 (0–0)	0.317	0 (0–1)	0 (0–0)	0.999

Values are Median (Min–Max). *p=0.001 statistically significant.

Sensory blockade was significantly greater in the ropivacaine group at 4 and 8 hours (p=0.001 at both time points). At all other assessment intervals, sensory scores were comparable. Motor block scores showed no significant difference at any time point, suggesting similar recovery of motor function between the two local anaesthetics.

Table 4: Rescue analgesia requirement, duration of analgesia and adverse effects

Outcome	Group A Bupivacaine	Group B Ropivacaine	p-value
Patients requiring rescue analgesia, n (%)	16 (35.6)	17 (37.8)	0.999
Patients not requiring rescue analgesia, n (%)	29 (64.4)	28 (62.2)	—
Time to first rescue analgesia (min), Mean ± SD†	1110.0 ± 275.4	1030.6 ± 278.4	0.417
Range of time to rescue analgesia (min)	480–1440	480–1440	—
Adverse effects, n (%)	5 (11.1)	0 (0.0)	0.056
No adverse effects, n (%)	40 (88.9)	45 (100.0)	

†Calculated among patients who required rescue analgesia: Group A, n=16; Group B, n=17.

Overall, rescue analgesia was required by 16 (35.6%) patients in the bupivacaine group and 17 (37.8%) in the ropivacaine group, with no significant difference (p=0.999). The mean time to first rescue analgesia was 1110.0 ± 275.4 minutes (18.5 hours) with bupivacaine compared with 1030.6 ± 278.4 minutes (17.2 hours) with ropivacaine; this approximately 79-minute difference was not statistically significant (p=0.417).

Adverse effects occurred in 5 patients (11.1%) in Group A compared with none in Group B. Although this suggested a numerically better tolerability profile with ropivacaine, the difference did not reach statistical significance (p=0.056).

Discussion

The present prospective randomized comparative study evaluated 0.25% bupivacaine and 0.25% ropivacaine for ultrasound-guided single-shot femoral nerve block in 90 patients undergoing elective knee surgery. Both agents provided satisfactory postoperative analgesia, with broadly comparable pain scores, motor blockade, rescue analgesic requirements, and duration of analgesia. However, ropivacaine produced significantly higher sensory scores at 4 and 8 hours and a lower VAS score at 20 hours.

Hao et al.[8] demonstrated effective postoperative analgesia with ultrasound-guided ropivacaine-based femoral nerve block following total knee arthroplasty, supporting the usefulness of ropivacaine for prolonged postoperative pain control. Similarly, Zhang et al.[9] reported that lower-concentration ropivacaine could provide satisfactory analgesia after knee surgery while facilitating preservation of quadriceps function. In the present study, motor scores did not differ significantly between bupivacaine and ropivacaine at any assessment interval. Nguyen et al.[10], in their systematic review and meta-analysis evaluating long-acting local anaesthetics for peripheral nerve and field blocks, reinforced the effectiveness of conventional long-acting agents in postoperative pain management. Hasabo et al.[11] also confirmed that femoral nerve blockade provides effective analgesia following total knee arthroplasty, although contemporary practice increasingly considers motor-sparing alternatives such as adductor canal block. Rodriguez-Patarroyo et al.[12] similarly emphasized the established analgesic efficacy of femoral nerve block as part of multimodal analgesia for knee arthroplasty.

In the present study, the sensory block score was significantly higher with ropivacaine at 4 and 8 hours (p=0.001 at both intervals), whereas sensory scores at the remaining intervals were comparable. Motor block did not differ significantly at any time point. These findings indicate that 0.25% ropivacaine provided at least comparable sensory analgesia without producing greater motor blockade. Studies examining ropivacaine-based femoral nerve blocks have likewise demonstrated that the duration and characteristics of blockade can be influenced by local anaesthetic concentration and adjuncts.[13]

Babu et al.[14] compared bupivacaine and ropivacaine for continuous femoral nerve blockade after total knee arthroplasty and demonstrated that both agents were effective for postoperative analgesia. Theodosiadis et al.[15] also compared ropivacaine with bupivacaine for femoral-region blockade during total knee arthroplasty, supporting the clinical utility of both long-acting local anaesthetics. Most importantly, de Lima e Souza et al.[16] directly compared 0.25% ropivacaine with 0.25% bupivacaine in single-injection femoral nerve block following total knee replacement or anterior cruciate ligament reconstruction. Their study provides a particularly close comparison with the present protocol and supports the use of either agent for postoperative analgesia following major knee procedures.

In our study, rescue analgesia was required in 35.6% of patients receiving bupivacaine and 37.8% receiving ropivacaine, with no significant difference. The mean time to first rescue analgesia was also comparable (1110.0 ± 275.4 vs 1030.6 ± 278.4 minutes; p=0.417). Although adverse effects occurred in 11.1% of the bupivacaine group and none of the ropivacaine group, this difference narrowly failed to reach statistical significance (p=0.056). Overall, the findings suggest that both agents are effective for ultrasound-guided femoral nerve block after knee surgery. Ropivacaine demonstrated some advantages in intermediate sensory blockade and pain score at 20 hours, while overall analgesic duration and rescue analgesic requirements remained comparable.

Limitations of study

The present study has several limitations. First, it was conducted at a single centre with a relatively small sample size of 90 patients, which may limit the generalizability of the findings. Second, the study was restricted to patients undergoing elective knee surgery and may therefore not be directly applicable to other surgical populations. Third, postoperative pain was assessed using the Visual Analogue Scale, which is a subjective measure and may be influenced by individual patient perception. The follow-up period was limited to 24 hours, precluding assessment of longer-term analgesic efficacy and late adverse effects. In addition, the study evaluated a single concentration and fixed volume of each local anaesthetic; therefore, the findings may not be applicable to other concentrations, volumes, or dosing regimens.

Finally, quadriceps strength, functional recovery, patient satisfaction, and time to mobilization were not formally assessed, although these outcomes may be clinically relevant when comparing femoral nerve block techniques.

Future Recommendations

Future studies should include larger, multicentre randomized controlled trials to improve the precision and generalizability of the findings. Comparative evaluation of different concentrations and doses of bupivacaine and ropivacaine may help determine the optimal regimen for postoperative analgesia. Longer follow-up should be considered to assess the duration of analgesia, rebound pain, and delayed adverse effects. Future research should also incorporate objective assessment of quadriceps strength, knee range of motion, time to mobilization, functional recovery, patient satisfaction, and hospital stay. Comparisons of single-shot versus continuous femoral nerve block and motor-sparing techniques such as adductor canal block may further clarify the optimal regional analgesic approach for knee surgery.

Conclusion

Both 0.25% bupivacaine and 0.25% ropivacaine, administered as 30 mL in ultrasound-guided single-shot femoral nerve block, provided effective postoperative analgesia following elective knee surgery. Overall duration of analgesia, rescue analgesic requirement, and motor blockade were comparable between the groups. Ropivacaine demonstrated greater sensory blockade at 4 and 8 hours and a lower VAS score at 20 hours. Although adverse effects were observed only in the bupivacaine group, the difference was not statistically significant. Thus, 0.25% ropivacaine appears to be an effective alternative to 0.25% bupivacaine for postoperative analgesia following elective knee surgery.

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