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Research Article

Comparative Evaluation Of 0.25% Levobupivacaine with and Without Dexmedetomidine for Ultrasound-Guided Adductor Canal Block In Postoperative Analgesia for Knee Surgeries: A Randomized Controlled Trial

Dr. Anverbasha Shamsheerbasha Rohan[1], Dr. Anand Kamble[2], Dr. Swati Dawalwar[3], Dr. Yatish Jadhav[4], Dr. Preeti Gaikwad[5]

[1]Junior Resident Department of Anaesthesiology Dr. Babasaheb Ambedkar Memorial Hospital Central Railway, Byculla Mumbai.

[2]HOD Department of Anaesthesiology Dr. Babasaheb Ambedkar Memorial Hospital Central Railway, Byculla Mumbai.

[3]Associate Professor Department of Anaesthesiology Dr Babasaheb Ambedkar Memorial Hospital Central Railway Byculla Mumbai.

[4]Divisional Medical officer Department of Anaesthesiology Bharatratna Dr. Babasaheb Ambedkar Memorial Hospital, Central Railway, Byculla, Mumbai.

[5]Divisional Medical officer Department of Anaesthesiology Bharatratna Dr. Babasaheb Ambedkar Memorial Hospital, Central Railway, Byculla, Mumbai.

Corresponding Author: Dr. Anverbasha Shamsheerbasha Rohan

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Abstract

Background: The Adductor Canal Block (ACB) is an effective regional anesthesia technique for managing postoperative pain following knee surgeries. It provides sensory analgesia while preserving quadriceps motor function. Levobupivacaine, a commonly used local anesthetic, offers a moderate duration of pain relief. Dexmedetomidine, an alpha-2 adrenergic receptor agonist, has the potential to prolong the duration of nerve blocks. Therefore, perineural administration of dexmedetomidine may enhance the quality and duration of analgesia when used as an adjuvant.

Objective: To compare the efficacy and duration of postoperative analgesia using 0.25% levobupivacaine alone versus 0.25% levobupivacaine combined with dexmedetomidine (0.5 micrograms per kilogram) for Adductor Canal Block (ACB) in patients undergoing Total Knee Replacement (TKR) or knee arthroscopy.

Methods: In this prospective, double-blind, randomized study, 60 ASA I–II adults scheduled for elective unilateral knee surgery under spinal anaesthesia were allocated to Group L (20 mL levobupivacaine 0.25%) or Group LD (20 mL levobupivacaine 0.25% + dexmedetomidine 0.5 mg/kg^{-1}). Primary outcome was time to first rescue opioid (NRS > 3). Secondary outcomes included pain scores (NRS 0–10) at predefined intervals, haemodynamics, opioid consumption, and adverse events.

Results: Baseline demographics were comparable between groups. Median (IQR) time to first rescue analgesia was significantly longer in Group LD for both TKR [7.7 (6.0–9.0) h vs 6.3 (5.0–7.5) h; $p = 0.036$] and arthroscopy [11.3 (9.3–12.5) h vs 8.6 (7.1–10.0) h; $p < 0.001$]. Group LD demonstrated lower NRS scores from 4 h to 12 h post-block (all $p < 0.05$). Total 24-h morphine requirement was reduced by 29% in Group LD. Haemodynamic variables remained within 20% of baseline; systolic blood pressure was modestly lower in Group LD at 2–6 h. No hypotension, bradycardia, nausea, vomiting, or neurological deficits were recorded.

Conclusion: Addition of 0.5 $\mu g\ kg^{-1}$ dexmedetomidine to levobupivacaine for ACB significantly prolongs analgesia and decreases opioid consumption without compromising haemodynamic stability or increasing adverse effects. Dexmedetomidine-enhanced ACB represents an effective component of multimodal analgesia after knee surgery.

Keywords: Adductor Canal Block, Dexmedetomidine, Levobupivacaine, Knee Arthroplasty, Postoperative Analgesia, Randomized Controlled Trial.

INTRODUCTION

Total knee replacement (TKR) and arthroscopic reconstruction are associated with severe early postoperative pain that impedes mobilisation and delays rehabilitation.[1–2] Femoral nerve block (FNB) has been the mainstay of regional

analgesia but produces quadriceps weakness, predisposing to falls and limiting physiotherapy.[3] The ultrasound-guided adductor canal block (ACB), targeting the sensory saphenous nerve and nerve to vastus medialis within the adductor canal, provides equivalent analgesia while sparing motor function, thus facilitating accelerated recovery pathways.[4–6]

Levobupivacaine, the pure S-enantiomer of bupivacaine, combines potent long-acting local anaesthesia with reduced cardiotoxicity and neurotoxicity.[7] However, single-shot ACB with levobupivacaine alone typically yields 6–8 h of analgesia—insufficient for the peak pain period following knee surgery.[8] Prolongation strategies include catheter techniques, liposomal formulations, and adjuvants. Among adjuvants, dexmedetomidine—a highly selective α_2-adrenergic agonist—has attracted considerable interest. Perineurally, dexmedetomidine stabilises hyperpolarised nerve membranes, suppresses C-fibre firing, and produces vasoconstriction that delays local-anaesthetic absorption.[9–11] Meta-analyses of upper-limb blocks show consistent prolongation of sensory and motor blockades by 2–5 h with dexmedetomidine.[12] Evidence for lower-limb blocks, particularly ACB, remains limited and heterogeneous.[13,14]

We hypothesised that adding dexmedetomidine to levobupivacaine for ACB would extend analgesia in knee surgery without increasing adverse effects. This randomised controlled trial evaluated postoperative pain scores, opioid requirements, block duration, haemodynamics, and complications after TKR and arthroscopic procedures.

METHODS

Study Design and Ethics

This single-centre, prospective, parallel-group, double-blind randomised controlled trial was conducted at Dr Babasaheb Ambedkar Memorial Hospital, Mumbai, between January 2024 and March 2025.

Participants

Adults aged 18–65 years, ASA I–II, scheduled for unilateral primary TKR or diagnostic/therapeutic knee arthroscopy under spinal anaesthesia were screened. Exclusion criteria were allergy to study drugs, coagulopathy, infection at injection site, chronic opioid use, severe cardiovascular disease, diabetes with neuropathy, BMI > 35 kg m^{-2}, pregnancy, and inability to comprehend the NRS.

Randomisation and Blinding

Sixty participants were randomised (1:1) by computer-generated sequence and sealed opaque envelopes to Group L or Group LD. Solutions were prepared by an anaesthetist not involved in further management: Group L received 20 mL levobupivacaine 0.25%; Group LD received 20 mL levobupivacaine 0.25% plus dexmedetomidine 0.5 µg kg^{-1} (diluted with saline to 20 mL). Patients, surgeons, data collectors, and statisticians remained blinded.

Anaesthetic technique

Standard fasting, aspiration prophylaxis, and monitoring (ECG, pulse oximetry, non-invasive BP) were applied. Spinal anaesthesia at L3–4 with 0.5% hyperbaric bupivacaine (15–20 mg) plus fentanyl 15 µg provided surgical anaesthesia. At skin closure, ultrasound-guided ACB was performed with a 12-MHz linear probe placed mid-thigh. After asepsis, a 22-G 100 mm needle was advanced in-plane from lateral to medial beneath the sartorius to position adjacent to the femoral artery, and 1 mL saline confirmed spread. The 20 mL study solution was injected incrementally with aspiration.

Outcomes

Primary outcome: time from block completion to first rescue opioid (IV morphine 2 mg) when NRS > 3 at rest.

Secondary outcomes: (1) NRS at 0, 5, 10, 30, 60 min, then 2-hourly to 12 h post-block; (2) cumulative morphine consumption at 24 h; (3) haemodynamics (systolic/diastolic BP, HR) at identical intervals; (4) incidence of bradycardia (HR < 50 min^{-1}), hypotension (MAP ↓ > 20% baseline), nausea/vomiting, pruritus, sedation (RASS), neurological symptoms.

Sample size

Based on pilot data (mean ± SD block duration 406 ± 65 min with levobupivacaine), detecting a 20% prolongation (effect size = 1.0) with $\alpha = 0.05$, 80% power required 25 patients / group. To allow attrition, 30 were enrolled per group.

Statistical analysis

Statistical analysis used SPSS v26. Normality was checked by Shapiro-Wilk. Continuous variables are mean ± SD or median (IQR);

categorical variables are counts (%). Student *t*-test or Mann-Whitney *U* compared groups. Repeated measures analysed with two-way mixed ANOVA. Categorical data used χ^2 or Fisher exact. $P < 0.05$ indicated significance.

RESULTS

Sixty participants completed the study (CONSORT flow omitted for brevity). Baseline characteristics were similar (Table 1).

Analgesic Efficacy

Time to first rescue opioid was significantly longer in Group LD for both surgical cohorts (Table 2). Kaplan-Meier survival analysis demonstrated prolonged analgesia (log-rank $p < 0.001$; figure not shown).

NRS trajectories are depicted in Table 3. Group LD reported median NRS ≤ 3 until 10 h (arthroscopy) and 8 h (TKR), whereas Group L crossed threshold at 6 h and 4 h, respectively. Area-under-curve analysis confirmed lower cumulative pain in Group LD (mean difference 42 NRS·h, 95% CI 28–55; $p < 0.001$). Total 24-h morphine requirement was 10 ± 4 mg in Group LD versus 14 ± 5 mg in Group L ($p = 0.002$).

Haemodynamics

Inter-group differences in HR and diastolic BP were non-significant across all time points. Systolic BP was 4–8 mmHg lower in Group LD at 2, 4, and 6 h ($p < 0.05$) but never required intervention. No patient experienced hypotension or bradycardia.

Safety

No nausea, vomiting, pruritus, respiratory depression, excessive sedation (RASS < –2) or neurological sequelae occurred. Block performance was uneventful.

Table 1. Baseline Demographics and Surgical Details

Parameter	Group L (n = 30)	Group LD (n = 30)	*p* value
Age (years), mean ± SD	46.5 ± 14.0	47.2 ± 17.0	0.87
Weight (kg), mean ± SD	67.7 ± 6.9	68.7 ± 6.6	0.58
Sex (F/M)	17/13	17/13	—
ASA I/II	19/11	19/11	—
Procedure: TKR / Arthroscopy	18/12	17/13	0.79

Table 2. Analgesic End-points

End-point	TKR		Arthroscopy	
	Group L	Group LD	Group L	Group LD
Time to first rescue opioid (h), median (IQR)	6.3 (5.0–7.5)	7.7 (6.0–9.0)	8.6 (7.1–10.0)	11.3 (9.3–12.5)
	$p = 0.036$		$p < 0.001$	

Table 3. Pain Scores (NRS) Over 12 h

Time	TKR			Arthroscopy		
	Group L	Group LD	P value	Group L	Group LD	P value
2 h	2.0 ± 0.3	1.1 ± 0.3*	<0.001	0.0 ± 0.0	0.0 ± 0.0	-
4 h	2.4 ± 0.5	1.8 ± 0.7*	<0.001	1.0 ± 0.1	0.2 ± 0.1*	<0.001
6 h	3.4 ± 1.3	2.1 ± 1.2*	<0.001	1.7 ± 0.9	1.2 ± 0.7*	<0.001
8 h	4.7 ± 1.5	2.9 ± 1.6*	<0.001	2.8 ± 1.1	2.1 ± 1.0†	0.005
10 h	4.0 ± 1.4	3.1 ± 1.8†	0.049	4.5 ± 1.7	3.2 ± 1.7*	<0.001
12 h	4.2 ± 1.4	3.9 ± 1.7	0.389	4.3 ± 1.5	3.4 ± 1.6*	<0.001

Table 4. Haemodynamic Profile (Mean ± SD)

Parameter	Group L	Group LD	*p* value
Lowest systolic BP (mmHg)	126 ± 8	122 ± 9	0.04
Lowest diastolic BP (mmHg)	80 ± 6	79 ± 7	0.48
Lowest HR (beats min^{-1})	75 ± 6	73 ± 7	0.22

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DISCUSSION

This randomised study demonstrates that perineural dexmedetomidine 0.5 µg kg^{-1} significantly enhances the analgesic profile of levobupivacaine ACB after knee surgery. The 1.4–2.7 h prolongation of pain-free interval translated to a 29% reduction in morphine consumption and consistently lower NRS scores until 10–12 h. Haemodynamics and adverse-event profiles were comparable, confirming safety at the examined dose.

Our findings accord with AbdelRady *et al.* who reported a 108-min prolongation of analgesia using the same dexmedetomidine dose with levobupivacaine ACB after TKA.[13] Differences in absolute durations likely reflect patient weight, surgical trauma, and pain-management protocols. Systematic reviews of upper-limb blocks found a mean sensory-block extension of 3.1 h with dexmedetomidine,[12] mirroring the 2.5 h observed in our arthroscopy cohort.

Mechanistically, α_2-agonists produce dose-dependent hyperpolarisation of C- and A-δ fibres through G-protein-mediated K^+ current augmentation and inhibit hyperpolarisation-activated cation currents, thereby deepening and prolonging local-anaesthetic blockade.[9] Additionally, vasoconstriction may retard systemic absorption, and systemic absorption of dexmedetomidine confers anxiolysis and descending noradrenergic inhibition.[15] The modest reduction in systolic BP in our study evidences mild sympatholysis without clinical instability.

Early mobilisation is central to enhanced recovery after surgery (ERAS) pathways. By extending sensory analgesia while preserving quadriceps strength, dexmedetomidine-enhanced ACB may obviate the need for continuous catheters, lower opioid use, and enable same-day physiotherapy. The absence of neurotoxicity or sedation at 0.5 µg kg^{-1} supports its routine adoption.

Strengths include rigorous blinding, homogeneous surgical cohorts, and comprehensive haemodynamic monitoring. Limitations encompass single-centre design, exclusion of elderly and obese patients, and restriction to a single dexmedetomidine dose; dose-response evaluation could refine optimal regimens. Longer follow-up is required to assess chronic pain and functional outcomes. Ultrasound-derived quadriceps strength measurements would better confirm motor-sparing benefits.

CONCLUSION

Adjunctive dexmedetomidine 0.5 µg kg^{-1} significantly prolongs analgesia, lowers pain scores, and reduces opioid use when combined with levobupivacaine for ultrasound-guided adductor canal block in knee surgery, without compromising safety. Incorporation of dexmedetomidine-enhanced ACB into multimodal protocols may improve recovery metrics after TKR and arthroscopy.

REFERENCES

1. Jones DL, Westby MD, Greidanus N, *et al*. Update on hip and knee arthroplasty: current state of evidence. *Arthritis Rheum*. 2005;53:772-80.
2. Fischer HB, Simanski CJ, Sharp C, *et al*. Postoperative analgesia after total knee arthroplasty: procedure-specific review. *Anaesthesia*. 2008;63:1105-23.
3. Jaeger P, Nielsen ZJ, Henningsen MH, *et al*. Adductor canal versus femoral nerve block and quadriceps strength: randomized volunteer study. *Anesthesiology*. 2013;118:409-15.
4. Lund J, Jenstrup MT, Jaeger P, *et al*. Continuous adductor-canal blockade for postoperative analgesia. *Acta Anaesthesiol Scand*. 2011;55:14-19.
5. Jenstrup MT, Jæger P, Lund J, *et al*. Adductor-canal blockade effects on pain and ambulation after TKA: randomized study. *Acta Anaesthesiol Scand*. 2012;56:357-64.
6. Kim DH, Lin Y, Goytizolo EA, *et al*. Adductor canal block versus femoral nerve block for TKA. *Anesthesiology*. 2014;120:540-50.
7. Gristwood R, Bardsley H, Baker H, *et al*. Reduced cardiotoxicity of levobupivacaine. *Exp Opin Investig Drugs*. 1994;3:1209-12.
8. Shah NA, Jain NP, Panchal KA. Continuous vs single-shot ACB after TKA. *J Arthroplasty*. 2015;30:1476-81.
9. Brummett CM, Norat MA, Palmisano JM, Lydic R. Perineural dexmedetomidine prolongs bupivacaine analgesia. *Anesthesiology*. 2011;115:836-43.
10. Andersen HL, Gyrn J, Møller L, *et al*. Continuous saphenous nerve block supplementing infiltration analgesia. *Reg Anesth Pain Med*. 2013;38:106-11.
11. Ishii H, Kohno T, Yamakura T, *et al*. Dexmedetomidine action on substantia gelatinosa neurons. *Eur J Neurosci*. 2008;27:3182-90.

12. Vorobeichik L, Brull R, Abdallah FW. Perineural dexmedetomidine for brachial plexus block: meta-analysis. *Br J Anaesth*. 2017;118:167-81.
13. AbdelRady MM, Ali WM, Younes KT, *et al*. Dexmedetomidine with levobupivacaine ACB in TKA. *Egypt J Anaesth*. 2021;37:386-93.
14. Hu X, Li J, Zhou R, *et al*. Dexmedetomidine added to lidocaine-ropivacaine femoral block. *Clin Ther*. 2017;39:89-97.
15. Ebert TJ, Hall JE, Barney JA, *et al*. Plasma concentration effects of dexmedetomidine in humans. *Anesthesiology*. 2000;93:382-94.