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Original Article

Anaesthesia Section

Efficacy of Dexmedetomidine as an Adjuvant to Ropivacaine plus Lignocaine-adrenaline Combination for Ultrasound-guided Popliteal Sciatic and Femoral Nerve Blocks in Lower Limb Surgeries: A Double-blinded Randomised Clinical Study

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ABSTRACT

Introduction: Single-injection peripheral nerve blocks provide effective perioperative analgesia for lower limb surgery, but the duration of local anaesthetic action may be insufficient for the early postoperative painful period. Dexmedetomidine may improve block quality when used as a perineural adjuvant.

Aim: To evaluate the efficacy of dexmedetomidine as an adjuvant to a ropivacaine plus lignocaine-adrenaline mixture for ultrasound-guided popliteal sciatic and femoral nerve blocks in patients undergoing below-knee lower limb surgeries.

Materials and Methods: This double-blinded randomised clinical study included 86 adults aged 18-60 years with American Society of Anesthesiologists Physical Status I-III. Patients were allocated into two equal groups. Group-RL received 20 mL of 0.5% ropivacaine and 10 mL of 2% lignocaine with adrenaline. Group-RLD received the same mixture with dexmedetomidine 5 microgram, with total volume maintained at 30 mL. Twenty millilitres was used for popliteal sciatic block and 10 mL for femoral nerve block. Sensory and motor onset and duration, time to first analgesic request, Visual Analogue Scale (VAS) scores, haemodynamic variables, sedation, satisfaction and adverse events were recorded. Continuous variables were expressed as mean±standard deviation and compared using independent t-test or appropriate non-parametric tests. Categorical variables were analysed using Chi-square test. A p-value <0.05 was considered statistically significant.

Results: Baseline characteristics were comparable between Group-RL and Group-RLD. Dexmedetomidine significantly shortened sensory onset (6.5±2.1 vs 9.8±2.6 minutes, p <0.001) and prolonged sensory duration (478.6±31.2 vs 332.7±24.5 minutes, p<0.001). Motor onset was faster in Group-RLD (8.3±2.8 vs 11.4±3.2 minutes, p<0.001), while motor duration was longer (289.4±34.7 vs 254.9±29.8 minutes, p<0.001). Time to first analgesic request was delayed with dexmedetomidine (528.3±33.5 vs 348.5±30.9 minutes, p<0.001). VAS scores were lower from two to 12 hours. Satisfaction rate was higher in Group-RLD (88.4% vs 55.8%, p<0.001). Bradycardia, hypotension and sedation were more frequent with dexmedetomidine, but no respiratory depression, local anaesthetic systemic toxicity, nerve injury or infection occurred.

Conclusion: Dexmedetomidine added to ropivacaine plus lignocaine-adrenaline for ultrasound-guided popliteal sciatic and femoral nerve blocks improved onset, prolonged sensory and motor block and enhanced postoperative analgesia, with a higher but manageable incidence of bradycardia, hypotension and sedation.

Keywords: Analgesic duration, Haemodynamic response, Pain score, Rescue medication, Sedation, Surgical anaesthesia

INTRODUCTION

Effective perioperative analgesia is an essential component of anaesthetic care in patients undergoing lower limb surgery. Below-knee procedures, including fracture fixation, arthroscopy, soft tissue repair and other reconstructive surgeries, are commonly associated with moderate-to-severe postoperative pain during the early recovery period. Inadequate pain control may delay mobilisation, increase sympathetic stress response, increase rescue analgesic consumption and reduce patient satisfaction. Peripheral nerve blocks have therefore become an important component of multimodal analgesia because they provide site-specific anaesthesia, reduce systemic opioid requirement and support smoother postoperative recovery [1,2]. For below-knee lower limb surgeries, combined femoral and popliteal sciatic nerve blocks provide a logical regional anaesthetic approach. The femoral nerve block provides anaesthesia and analgesia to the anterior thigh and knee region, while the popliteal sciatic nerve block covers the distal leg, ankle and foot. When both blocks are used together, they can provide effective surgical anaesthesia and meaningful postoperative analgesia for selected lower limb procedures. Ultrasound guidance has further improved the quality and safety of peripheral nerve blockade by enabling direct visualisation of the nerve, surrounding vascular structures, needle tip and spread of local anaesthetic. This improves block precision and may reduce complications such as vascular puncture, inadvertent intraneural injection and inadequate local anaesthetic deposition [1,2].

Despite these advantages, the duration of analgesia after a single-injection peripheral nerve block remains limited. Once the block regresses, patients may experience breakthrough pain, which often requires rescue analgesics during the early postoperative period. Continuous perineural catheter techniques can prolong analgesia, but they require additional equipment, technical expertise, monitoring and catheter care. In many routine clinical settings, especially where day-care turnover, resource availability or patient acceptance are

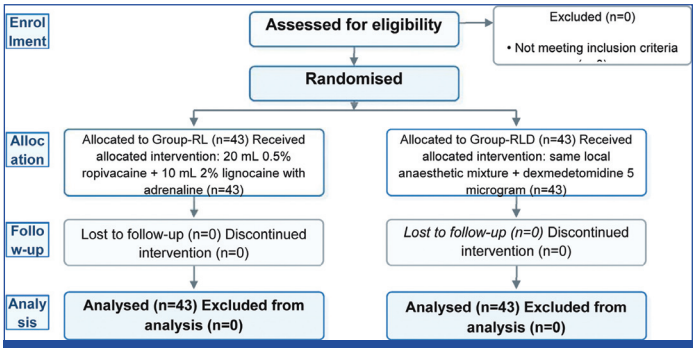
practical concerns, single-shot blocks continue to be widely used. Therefore, improving the quality and duration of a single-injection block remains clinically relevant [3].

Ropivacaine is frequently preferred for peripheral nerve blocks because it provides prolonged sensory analgesia with comparatively lower cardiotoxic and neurotoxic potential than bupivacaine. Lignocaine has a faster onset of action and, when combined with adrenaline, may reduce systemic absorption through local vasoconstriction. The combination of ropivacaine with lignocaine-adrenaline is therefore used to obtain both relatively rapid onset and reasonable duration of anaesthesia. However, this combination may still not cover the entire period of postoperative pain after below-knee surgery. This has encouraged the evaluation of adjuvant drugs that can enhance block onset, prolong analgesic duration and reduce postoperative rescue analgesic requirement without producing unacceptable adverse effects [4,5]. Dexmedetomidine, a highly selective alpha-2 adrenergic receptor agonist, has been studied as an adjuvant to local anaesthetics in different regional anaesthesia techniques. Experimental studies have shown that perineural dexmedetomidine may prolong local anaesthetic action by peripheral mechanisms, including inhibition of hyperpolarisation-activated cation currents and enhancement of nerve membrane hyperpolarisation [6,7]. Clinical studies have also reported that dexmedetomidine, when added to local anaesthetics, can prolong sensory and motor blockade and improve postoperative analgesia [8-10]. However, systemic absorption may produce bradycardia, hypotension and sedation, which makes simultaneous assessment of efficacy and safety necessary [11-15].

Several previous studies and systematic reviews have reported that dexmedetomidine improves the onset and duration of peripheral nerve blocks and reduces postoperative analgesic requirement when used as a perineural adjuvant [11-15]. In lower limb regional anaesthesia, Hu X et al., observed that dexmedetomidine added to a lidocaine-ropivacaine mixture enhanced onset and prolonged the duration of popliteal sciatic nerve blockade [16]. Ahuja V et al., reported improved postoperative analgesia with dexmedetomidine in sciatic popliteal and adductor canal blocks among trauma patients undergoing below-knee procedures [17]. Sharma B et al., found that dexmedetomidine added to ropivacaine improved analgesic duration in femoral nerve block, while Zhao ZF et al., confirmed similar benefits in a systematic review and meta-analysis of femoral nerve block studies [18,19]. However, important gaps still remain. Many available studies have evaluated dexmedetomidine with a single long-acting local anaesthetic or in isolated nerve blocks [18,20]. Comparatively fewer data are available on its use with a combined ropivacaine plus lignocaine-adrenaline mixture during combined ultrasound-guided popliteal sciatic and femoral nerve blocks for below-knee lower limb surgeries [17-19]. In addition, the balance between improved analgesic duration and haemodynamic adverse effects needs further assessment in this specific block combination. Hence, the present study was planned to evaluate whether adding dexmedetomidine to ropivacaine plus lignocaine-adrenaline improves sensory and motor block characteristics, prolongs postoperative analgesia, delays first rescue analgesic request and improves patient satisfaction, while also assessing haemodynamic changes, sedation and adverse events. The primary objective was to compare the duration of sensory block between patients receiving ropivacaine plus lignocaine-adrenaline with dexmedetomidine and those receiving ropivacaine plus lignocaine-adrenaline alone. The secondary objectives were to compare sensory onset time, motor onset time, duration of motor block, time to first analgesic request, postoperative VAS scores, haemodynamic parameters, sedation score, patient satisfaction, block success rate and adverse events between the two groups.

MATERIALS AND METHODS

This double-blinded randomised clinical study was conducted in the Department of Anaesthesiology, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India, over a period of 18 months from June 2024 to November 2025. The sample size was calculated by considering duration of sensory block as the primary outcome variable. Based on pilot observations and previously published literature on dexmedetomidine as an adjuvant in peripheral nerve blocks [20], the sample size was calculated using the formula for comparison of two independent means: $n=2(Z\alpha/2+Z\beta)^2\sigma^2/d^2$, where $Z\alpha/2=1.96$ at 95% confidence level, $Z\beta=0.84$ at 80% power, $\sigma=55$ minutes as the estimated pooled standard deviation and $d=35$ minutes as the minimum clinically relevant difference in sensory block duration between the two groups. Therefore, $n=2(1.96+0.84)^2(55)^2/(35)^2=38.7$, which was rounded to 39 patients in each group. After considering an anticipated dropout or protocol deviation rate of approximately 10%, the sample size was increased to 43 patients per group. Thus, the final sample size was 86 patients, with 43 patients in Group-RL and 43 patients in Group-RLD. The study was approved by the Institutional Ethics Committee (Protocol Number 303/2023-2024), Krishna Vishwa Vidyapeeth, vide approval number KVV/IEC/05/2024, dated 15/04/2024. Written informed consent was obtained from all eligible participants before enrolment. The recruitment, allocation, follow-up and analysis of participants are shown in [Table/Fig-1].



[Table/Fig-1]: CONSORT flow diagram.
RL: Ropivacaine + lignocaine with adrenaline; RLD: Ropivacaine + lignocaine with adrenaline + dexmedetomidine.

Study population: A total of 86 adult patients scheduled for below-knee lower limb surgeries under combined ultrasound-guided popliteal sciatic and femoral nerve block were assessed for eligibility. All 86 patients fulfilled the eligibility criteria, were enrolled, randomised and included in the final analysis. No patient was excluded after randomisation, lost to follow-up or omitted from analysis.

Inclusion criteria: Patients aged 18-60 years, of either sex, belonging to American Society of Anesthesiologists Physical Status I, II or III, and scheduled for below-knee lower limb surgeries under combined ultrasound-guided popliteal sciatic and femoral nerve block were included in the study.

Exclusion criteria: Patients who refused to participate or did not provide written informed consent, had known hypersensitivity to ropivacaine, lignocaine, adrenaline or dexmedetomidine, coagulopathy or bleeding disorder, local infection at the proposed injection site, pre-existing neurological or neuromuscular disorder, pregnancy, lactation, severe hepatic or renal dysfunction, uncontrolled cardiovascular disease, significant bradyarrhythmia, or inability to understand the VAS were excluded.

Preoperative Assessment and NPO Protocol

All patients underwent detailed preoperative evaluation, including history taking, general physical examination, airway assessment, systemic examination and routine laboratory investigations as per institutional protocol. Baseline heart rate, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), oxygen saturation and respiratory rate were recorded. The preoperative checklist included confirmation of written informed consent, surgical site verification, allergy history, intravenous access, availability of resuscitation drugs, airway equipment and confirmation of nil per oral status.

Patients were advised to avoid solid food or light meals for at least six hours and clear fluids for at least two hours before surgery, as per standard preoperative fasting guidelines [21]. The study procedure, drugs used, possible benefits, adverse effects, VAS and right to withdraw from the study were explained to each patient in an understandable language.

Randomisation, Allocation Concealment and Blinding

Random allocation sequence was generated using a computer-generated random number table by an independent person who was not involved in patient enrolment, block administration, perioperative management, outcome assessment or statistical analysis [Table/Fig-1]. Sequentially numbered, opaque, sealed envelopes were used for allocation concealment. Eligible patients were enrolled after confirming inclusion and exclusion criteria. The assigned envelope was opened immediately before preparation of the study drug by an anaesthesiologist who was not involved in block performance or outcome assessment.

Patients were randomly allocated into two equal groups. Group-RL received 20 mL of 0.5% ropivacaine with 10 mL of 2% lignocaine with adrenaline. Group-RLD received 20 mL of 0.5% ropivacaine with 10 mL of 2% lignocaine with adrenaline and dexmedetomidine 5 µg. The final injectable volume was maintained at 30 mL in both groups. The study drug regimen was selected according to the approved institutional study protocol, and the use of dexmedetomidine as a perineural adjuvant was supported by previously published studies on peripheral nerve blocks [20].

The study was double-blinded. The study drug was prepared in identical syringes by an anaesthesiologist who was not involved in block performance, intraoperative management, postoperative assessment, data collection or statistical analysis. The patient, anaesthesiologist performing the block, intraoperative and postoperative assessor, data collector and statistician were blinded to group allocation. Bias was reduced by computer-generated randomisation, allocation concealment, identical drug volume and syringe appearance, standardised ultrasound-guided block technique, uniform monitoring, predefined outcome definitions and use of the same postoperative analgesic protocol in both groups.

Study Procedure and Parameters Studied

On arrival in the operation theatre, standard monitors were attached, including electrocardiography, non-invasive blood pressure and pulse oximetry. Intravenous access was secured. Premedication was administered with intravenous ranitidine, metoclopramide and midazolam 1 mg according to institutional practice. Resuscitation drugs, airway equipment and lipid emulsion were kept ready before block administration. All nerve blocks were performed under strict aseptic precautions using a Sonosite ultrasound machine with a 12 MHz linear probe and a 21G short-bevel insulated needle. In both groups, 20 mL of the prepared drug solution was used for popliteal sciatic nerve block and 10 mL was used for femoral nerve block. Femoral nerve block was performed in the supine position at the femoral crease. The femoral nerve was identified lateral to the femoral artery beneath the fascia iliaca. After negative aspiration, the local anaesthetic solution was injected slowly with real-time ultrasound confirmation of perineural spread. Popliteal sciatic nerve block was performed in the lateral decubitus position. The sciatic nerve or its tibial and common peroneal components were visualised in the popliteal region. The drug solution was injected incrementally after repeated negative aspiration, aiming for adequate circumferential perineural spread. Patients were observed for 30 minutes after completion of the block. Surgery was allowed after confirmation of adequate sensory and motor blockade.

Outcome Measures and Assessment

The primary outcome measure was the duration of sensory block, defined as the time from sensory onset to complete return of pinprick sensation in the relevant femoral and sciatic nerve distributions.

The secondary outcome measures included sensory onset time, motor onset time, duration of motor block, block success rate, postoperative VAS score, time to first analgesic request, haemodynamic parameters, oxygen saturation, sedation score, patient satisfaction and adverse events.

Sensory onset time was defined as the time from completion of local anaesthetic injection to loss of pinprick sensation in the femoral and sciatic nerve distributions. Motor onset time was defined as the time from completion of injection to inability to move the toes or ankle for sciatic nerve distribution and reduced knee movement for femoral nerve distribution, assessed using the Modified Bromage Scale. Duration of motor block was defined as the time from motor onset to complete recovery of motor function. Block success was defined as adequate surgical anaesthesia without requirement of supplemental analgesia or conversion to general anaesthesia within 20 minutes of block completion.

Haemodynamic parameters, including heart rate, SBP, DBP and oxygen saturation, were recorded before block and at 1, 3, 5, 10, 15, 20 and 30 minutes after block administration, and subsequently as per perioperative monitoring protocol. Pain was assessed using the VAS at 0, 2, 4, 6, 8 and 12 hours. Rescue analgesia was administered when the VAS score was ≥4 or when the patient requested analgesia. Time to first analgesic request was calculated from completion of block to the first request for rescue analgesia.

Sedation was assessed using the Ramsay Sedation Scale [22]. Patient satisfaction was assessed at 24 hours using a five-point Likert scale, where one indicated very dissatisfied, two dissatisfied, three neutral, four satisfied and five very satisfied. Adverse events and complications were documented throughout the study period, including nausea, vomiting, bradycardia, hypotension, sedation, respiratory depression, local anaesthetic systemic toxicity, nerve injury, persistent paraesthesia and infection at the injection site. Bradycardia was defined as heart rate <50 beats/minute, hypotension as SBP <90 mmHg and respiratory depression as respiratory rate <8/minute or oxygen saturation <90%.

STATISTICAL ANALYSIS

Data were entered in Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) version 26.0. Continuous variables were assessed for normality using Shapiro-Wilk test. Normally distributed continuous variables were expressed as mean±standard deviation and compared using independent samples t-test. Non-normally distributed continuous variables were expressed as median and interquartile range and analysed using Mann-Whitney U test. Categorical variables were presented as frequency and percentage and compared using Chi-square test. Repeated haemodynamic parameters were analysed using repeated-measures analysis of variance or Friedman test, depending on data distribution. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 86 patients were included and analysed, with 43 patients in each group. Both groups were comparable in age, sex distribution, weight, height, body mass index, American Society of Anesthesiologists Physical Status, type of surgery, baseline oxygen saturation and respiratory rate, indicating effective baseline balance [Table/Fig-2].

Sensory block onset was significantly faster in Group-RLD than Group-RL. Duration of sensory block was also significantly longer in Group-RLD. The time to first analgesic request was delayed by nearly three hours in the dexmedetomidine group [Table/Fig-3].

Motor onset was faster in Group-RLD, and motor duration was significantly prolonged. Block success rate was high in both groups and did not differ statistically [Table/Fig-4].

Variable	Category	Group-RL (n=43)	Group-RLD (n=43)	p-value
Age (years)	Mean±SD	45.3±12.7	46.1±11.9	0.762
Sex	Male	24 (55.8%)	22 (51.2%)	0.683
	Female	19 (44.2%)	21 (48.8%)	
Weight (kg)	Mean±SD	68.5±10.3	70.2±9.8	0.432
Height (cm)	Mean±SD	165.4±8.2	166.1±7.9	0.681
BMI (kg/m²)	Mean±SD	25.1±3.4	25.4±3.2	0.671
ASA physical status	ASA I	12 (27.9%)	14 (32.6%)	0.841
	ASA II	24 (55.8%)	22 (51.2%)	
	ASA III	7 (16.3%)	7 (16.3%)	
Type of surgery	Fracture fixation	18 (41.9%)	20 (46.5%)	0.912
	Arthroscopy	12 (27.9%)	11 (25.6%)	
	Soft tissue repair	8 (18.6%)	7 (16.3%)	
	Other procedures*	5 (11.6%)	5 (11.6%)	
Baseline oxygen saturation, SpO_2 (%)	Mean±SD	98.1±1.2	98.0±1.1	0.687
Baseline respiratory rate (breaths/min)	Mean±SD	15.8±1.6	16.0±1.5	0.552

[Table/Fig-2]: Demographic and baseline clinical characteristics of the study participants.
Footnote: Other procedures included wound debridement, implant removal and minor reconstructive procedures. Continuous variables were compared using independent samples t-test. Categorical variables were compared using Chi-square test or Fisher's-exact test, as appropriate. For ASA physical status and type of surgery, the p-value represents comparison of the overall distribution between the two groups. p<0.05* was considered statistically significant; p<0.001** was considered statistically highly significant. BMI: Body mass index; ASA: American Society of Anesthesiologists; SpO_2: Peripheral oxygen saturation; SD: Standard deviation.

Outcome	Group-RL (n=43)	Group-RLD (n=43)	p-value
Sensory onset time (min)	9.8±2.6	6.5±2.1	<0.001*
Duration of sensory block (min)	332.7±24.5	478.6±31.2	<0.001*
Time to first analgesic request (min)	348.5±30.9	528.3±33.5	<0.001*

[Table/Fig-3]: Sensory block and analgesia outcomes.

Outcome	Group-RL (n=43)	Group-RLD (n=43)	p-value
Motor onset time (min)	11.4±3.2	8.3±2.8	<0.001*
Duration of motor block (min)	254.9±29.8	289.4±34.7	<0.001*
Block success rate	40 (93.0%)	41 (95.3%)	0.642

[Table/Fig-4]: Motor block and procedural success outcomes.

Heart rate was comparable before block. After drug administration, Group-RLD showed a statistically significant reduction in heart rate from one minute onward, persisting up to two hours [Table/Fig-5].

Time interval	Group-RL Mean±SD	Group-RLD Mean±SD	p-value
Before block	78.4±6.2	79.1±5.8	0.621
1 min after block	76.8±5.9	72.5±6.1	0.012*
3 min after block	75.2±5.4	70.3±5.7	0.003*
5 min after block	74.6±5.1	68.9±5.3	<0.001*
10 min after block	73.9±4.8	67.5±5.0	<0.001*
15 min after block	73.5±4.7	66.8±4.9	<0.001*
20 min after block	73.2±4.6	66.5±4.8	<0.001*
30 min after block	73.0±4.5	66.3±4.7	<0.001*
1 hr after block	72.8±4.3	66.0±4.5	<0.001*
1.5 hr after block	72.5±4.2	65.8±4.3	<0.001*
2 hr after block	72.3±4.1	65.6±4.2	<0.001*

[Table/Fig-5]: Heart rate at different intervals.

The SBP and DBP values were similar before block. Group-RLD had significantly lower values at subsequent time points, consistent with the sympatholytic effect of dexmedetomidine [Table/Fig-6].

Time interval	SBP RL Mean±SD	SBP RLD ZMean±SD	p-value SBP	DBP RL Mean±SD	DBP RLD Mean±SD	p-value DBP
Before block	128.5±8.3	127.9±7.9	0.732	82.4±5.6	81.9±5.4	0.674
1 min after block	126.4±7.8	122.1±8.0	0.013*	80.8±5.3	77.5±5.5	0.006*
3 min after block	124.8±7.5	118.7±7.6	<0.001*	79.5±5.1	75.2±5.2	<0.001*
5 min after block	123.2±7.3	116.5±7.4	<0.001*	78.6±4.9	73.8±5.0	<0.001*
10 min after block	122.0±7.1	114.8±7.2	<0.001*	78.0±4.8	72.5±4.9	<0.001*
30 min after block	120.8±6.7	112.8±6.8	<0.001*	76.9±4.5	71.2±4.6	<0.001*
1 hr after block	120.5±6.6	112.4±6.7	<0.001*	76.7±4.4	71.0±4.5	<0.001*
2 hr after block	120.0±6.4	111.7±6.5	<0.001*	76.3±4.2	70.6±4.3	<0.001*

[Table/Fig-6]: Systolic (SBP) and Diastolic Blood Pressure (DBP) at selected intervals.
Footnote: Values are expressed as mean±standard deviation. SBP and DBP were compared separately between Group-RL and Group-RLD at each time point using the independent-samples t-test. *p<0.05 was considered statistically significant. The asterisk (*) refers to the corresponding between-group comparison for either SBP or DBP at the specified time point. SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; RL: Ropivacaine+lignocaine with adrenaline; RLD: Ropivacaine+lignocaine with adrenaline+dexmedetomidine; SD: Standard Deviation.

Oxygen saturation remained stable in both groups throughout the observation period. There was no statistically significant difference in oxygen saturation between Group-RL and Group-RLD at any recorded time interval [Table/Fig-7].

Time interval	Group-RL Mean±SD	Group-RLD Mean±SD	p-value
Before block	98.1±1.2	98.0±1.1	0.687
1 min after block	98.0±1.2	98.0±1.0	0.841
3 min after block	98.0±1.1	97.9±1.2	0.684
5 min after block	97.9±1.2	97.9±1.1	1.000
10 min after block	97.9±1.1	97.8±1.2	0.688
15 min after block	97.8±1.2	97.8±1.1	1.000
20 min after block	97.8±1.1	97.7±1.2	0.688
30 min after block	97.7±1.2	97.7±1.1	1.000
1 hr after block	97.8±1.1	97.7±1.2	0.688
1.5 hr after block	97.8±1.0	97.8±1.1	1.000
2 hr after block	97.9±1.0	97.8±1.1	0.661

[Table/Fig-7]: Oxygen saturation at different time intervals.
Values are expressed as mean ± standard deviation. Oxygen saturation values were compared between the two groups using independent samples t-test. p<0.05* was considered statistically significant; p<0.001** was considered statistically highly significant.

Postoperative pain scores were identical at zero hour. From two hours onward, VAS scores were significantly lower in Group-RLD at all measured intervals up to 12 hours [Table/Fig-8].

Time interval	Group-RL Mean±SD	Group-RLD Mean±SD	p-value
0 hours	0.0±0.0	0.0±0.0	1.000
2 hours	1.8±0.9	0.9±0.6	<0.001*
4 hours	3.2±1.1	1.5±0.8	<0.001*
6 hours	4.5±1.3	2.1±1.0	<0.001*
8 hours	5.1±1.4	2.8±1.2	<0.001*
12 hours	5.8±1.5	3.4±1.3	<0.001*

[Table/Fig-8]: Postoperative Visual Analogue Scale (VAS) scores.

Sedation was significantly higher in Group-RLD between 15 minutes and two hours, peaking at 30 minutes and returning to baseline

by four hours. Motor block score was also higher in Group-RLD during the early postoperative period, but motor function returned to baseline by 12 hours in both groups [Table/Fig-9].

Scale/Time	Group-RL Mean±SD	Group-RLD Mean±SD	p-value
Ramsay sedation - baseline	2.0±0.3	2.0±0.2	1.000
Ramsay sedation - 15 min	2.1±0.4	3.2±0.7	<0.001*
Ramsay sedation - 30 min	2.0±0.3	3.5±0.8	<0.001*
Ramsay sedation - 60 min	2.0±0.3	3.0±0.6	<0.001*
Ramsay sedation - 4 h	2.0±0.2	2.0±0.2	1.000
Bromage - 5 min	0.5±0.2	1.2±0.4	<0.001*
Bromage - 30 min	2.4±0.5	3.0±0.2	<0.001*
Bromage - 2 h	1.8±0.5	2.5±0.4	<0.001*
Bromage - 8 h	0.0±0.0	0.4±0.2	<0.001*
Bromage - 12 h	0.0±0.0	0.0±0.0	1.000

[Table/Fig-9]: Sedation and motor block score profile.

Patient satisfaction was significantly better in Group-RLD. The satisfaction rate, defined as Likert score ≥4, was 38 (88.4%) in Group-RLD compared with 24 (55.8%) in Group-RL [Table/Fig-10].

Satisfaction level	Group-RL n (%)	Group-RLD n (%)	p-value
Very dissatisfied (1)	3 (7.0%)	0 (0.0%)	0.076
Dissatisfied (2)	6 (14.0%)	1 (2.3%)	0.045*
Neutral (3)	10 (23.3%)	4 (9.3%)	0.071
Satisfied (4)	18 (41.9%)	22 (51.2%)	0.381
Very satisfied (5)	6 (14.0%)	16 (37.2%)	0.012*
Overall satisfaction score	3.4±1.2	4.2±0.9	<0.001*
Satisfaction rate (≥4)	24 (55.8%)	38 (88.4%)	<0.001*

[Table/Fig-10]: Patient satisfaction score at 24 hrs.

Nausea and vomiting were comparable between the two groups. Bradycardia, hypotension and sedation were more frequent in Group-RLD. No patient in either group developed respiratory depression, local anaesthetic systemic toxicity, nerve injury or infection [Table/Fig-11].

Adverse event/complication	Group-RL n (%)	Group-RLD n (%)	p-value
Nausea	6 (14.0%)	4 (9.3%)	0.496
Vomiting	3 (7.0%)	2 (4.7%)	0.645
Bradycardia (HR <50 bpm)	1 (2.3%)	9 (20.9%)	0.006*
Hypotension (SBP <90 mmHg)	2 (4.7%)	8 (18.6%)	0.042*
Sedation (Ramsay score ≥4)	2 (4.7%)	11 (25.6%)	0.006*

[Table/Fig-11]: Adverse events and complications.

DISCUSSION

The present study demonstrated that addition of dexmedetomidine to ropivacaine plus lignocaine-adrenaline for ultrasound-guided popliteal sciatic and femoral nerve blocks significantly improved block characteristics and postoperative analgesic profile in patients undergoing below-knee lower limb surgeries. The dexmedetomidine group had faster sensory onset, longer sensory block duration, faster motor onset, longer motor block duration, delayed first analgesic request lower postoperative VAS scores from 2 to 12 hours and higher patient satisfaction. Since both groups were comparable with respect to demographic profile, American Society of Anesthesiologists Physical Status and type of surgery, these differences are likely related to the adjuvant effect of dexmedetomidine rather than baseline variation. These findings support the known role of dexmedetomidine as a perineural alpha-2 adrenergic agonist that can intensify local anaesthetic action, although its benefit must be balanced against haemodynamic and sedative effects [11-19,23].

In the present study, sensory onset was faster in Group-RLD than Group-RL by 3.3 minutes, and sensory block duration was prolonged by 145.9 minutes. This prolongation is clinically relevant because it extends the pain-free period after single-shot peripheral nerve blockade. Similar findings were reported by Hu X et al., who observed that dexmedetomidine added to a lignocaine-ropivacaine mixture enhanced onset and prolonged the duration of popliteal sciatic nerve blockade [16]. Ahuja V et al., also reported favourable postoperative analgesic effects when dexmedetomidine was added to ropivacaine in sciatic popliteal and adductor canal blocks for below-knee trauma surgery [17]. Sharma B et al., found improved analgesic quality and prolonged postoperative pain relief when dexmedetomidine was added to ropivacaine for femoral nerve block in patients undergoing total knee replacement [18]. These observations are further supported by systematic reviews and meta-analyses, which have shown that perineural dexmedetomidine shortens onset time and prolongs sensory blockade across different peripheral nerve blocks [11,12,15,19]. Thus, the present findings are consistent with the broader evidence base and extend it to the combined use of popliteal sciatic and femoral nerve blocks with a ropivacaine plus lignocaine-adrenaline mixture.

Motor block also showed faster onset and longer duration in the dexmedetomidine group. Motor onset was earlier by 3.1 minutes, while motor duration was prolonged by 34.5 minutes. This finding is consistent with previous reports where dexmedetomidine deepened and prolonged motor blockade when used with ropivacaine, bupivacaine or levobupivacaine [8-14,16,18,19,23,24]. However, the clinical interpretation of motor prolongation requires caution. Although dexmedetomidine may improve intraoperative block quality and early postoperative comfort, prolonged motor weakness may delay mobilisation in ambulatory procedures or rehabilitation-focused surgeries. In the present study, mean motor block duration in Group-RLD was 289.4±34.7 minutes, which corresponds to approximately 4.8 hours. A small residual motor score was still observed at eight hours, but complete clinical recovery was recorded by 12 hours in both groups. Therefore, the statement regarding motor recovery should be understood as recovery by the final 12-hour assessment point, not as immediate or very early recovery. Differences in motor recovery across studies may be explained by the dose of dexmedetomidine, concentration and volume of local anaesthetic, type of nerve block, surgical site and method of motor assessment [18,19,25,26].

Postoperative analgesic outcomes also favoured dexmedetomidine. Time to first analgesic request was 528.3±33.5 minutes in Group-RLD compared with 348.5±30.9 minutes in Group-RL, showing a delay of 179.8 minutes, or approximately three hours, in the dexmedetomidine group. This represents about 51.6% prolongation in the time to first analgesic request compared with the control group. VAS scores were also significantly lower in Group-RLD from 2 to 12 hours, indicating better early postoperative pain control. Ahuja V et al., reported lower 48-hour cumulative tramadol consumption in patients receiving dexmedetomidine with adductor canal and sciatic popliteal blocks for below-knee trauma surgery [17]. Zhao ZF et al., in a systematic review and meta-analysis of femoral nerve block studies, found that dexmedetomidine prolonged analgesic duration and reduced postoperative opioid consumption [19]. Jin XB et al., also observed that perineural dexmedetomidine with femoral and sciatic nerve blocks delayed first postoperative pain, reduced opioid requirement and improved satisfaction after total knee arthroplasty [24]. In the present study, the exact reduction in rescue analgesic dose could not be expressed in milligrams because cumulative rescue analgesic dose was not separately quantified in the results. However, the delayed first analgesic request and lower serial VAS scores indicate reduced early postoperative analgesic requirement. Future studies should include total 24-hour and 48-hour rescue analgesic consumption as a predefined quantitative endpoint.

Patient satisfaction was significantly higher in the dexmedetomidine group, with 38 (88.4%) patients achieving a Likert score ≥4 compared with 24 (55.8%) patients in the control group. This improvement is likely explained by faster block onset, prolonged sensory analgesia, delayed rescue analgesic request and lower postoperative pain scores. Similar patient-centred benefits were reported in studies where dexmedetomidine was used as a perineural adjuvant in lower limb blocks [17,18,26]. Jin XB et al., found better pain-control satisfaction with perineural dexmedetomidine in lower limb surgery, while Coviello A et al., reported satisfactory postoperative pain control with dexmedetomidine and dexamethasone as adjuvants in ultrasound-guided popliteal sciatic nerve block for hallux valgus surgery [24,25]. Recent evidence also suggests that dexamethasone is an important comparator adjuvant for foot and ankle surgery, and Maagaard M et al., reported prolonged analgesia with dexamethasone-based adjunctive strategies in popliteal and saphenous nerve blocks [26]. However, the present study was not designed to compare dexmedetomidine with dexamethasone. Therefore, the present findings support dexmedetomidine as an effective adjuvant, while future head-to-head trials may clarify whether dexamethasone, dexmedetomidine or their combination offers the best balance between analgesia, motor recovery and adverse effects.

The main safety findings in the present study were higher incidences of bradycardia, hypotension and sedation in the dexmedetomidine group. Bradycardia occurred in 9 (20.9%) patients in Group-RLD compared with 1 (2.3%) patient in Group-RL, hypotension occurred in 8 (18.6%) versus 2 (4.7%) patients, and sedation with Ramsay score ≥4 occurred in 11 (25.6%) versus 2 (4.7%) patients. These effects are pharmacologically plausible because dexmedetomidine reduces sympathetic outflow and has central sedative action. Similar haemodynamic trends have been reported in previous trials and systematic reviews, although the magnitude varies according to dose, route, patient profile and block technique [11,12,15,18,19,23,24]. Zhao ZF et al., found that dexmedetomidine improved analgesia and reduced opioid consumption in femoral nerve block but increased the risk of hypotension [19]. Vorobeichik L et al., and Hussain N et al., also highlighted that improved analgesic duration should be weighed against possible transient bradycardia, hypotension and motor block prolongation [11,12]. In the present study, oxygen saturation remained stable, and no patient developed respiratory depression, local anaesthetic systemic toxicity, nerve injury or infection. This suggests that the adverse effects were manageable with monitoring, but the findings reinforce the need for careful patient selection, dose selection, haemodynamic monitoring and preparedness to treat bradycardia or hypotension.

The present study adds to existing literature in three ways. First, it evaluated dexmedetomidine with a combined ropivacaine plus lignocaine-adrenaline mixture rather than with a single long-acting local anaesthetic alone. Second, it assessed combined ultrasound-guided popliteal sciatic and femoral nerve blocks, thereby covering a clinically relevant approach for below-knee lower limb surgery. Third, it examined both efficacy and safety outcomes, including block onset, block duration, postoperative pain, first analgesic request, haemodynamic changes, sedation, satisfaction and adverse events. What is already known is that dexmedetomidine can prolong peripheral nerve block analgesia and reduce opioid or rescue analgesic requirement. What this study adds is evidence that this benefit is also seen when dexmedetomidine is added to a practical dual local anaesthetic mixture during combined lower limb nerve blockade, with improved satisfaction but a higher incidence of bradycardia, hypotension and sedation. Therefore, dexmedetomidine appears useful as a perineural adjuvant in selected patients, provided that appropriate monitoring and haemodynamic safeguards are followed.

Limitation(s)

This was a single-centre study, which may limit external validity. The sample size was adequate for common efficacy outcomes but may not detect rare adverse events. Dexmedetomidine was administered as a fixed dose rather than a weight-adjusted dose, which can create variable exposure across patients. Follow-up was limited to the early postoperative period, and long-term neurological outcomes were not evaluated. A formal dose-response comparison was not performed.

CONCLUSION(S)

Dexmedetomidine 5 µg, when added to ropivacaine plus lignocaine-adrenaline for ultrasound-guided popliteal sciatic and femoral nerve blocks, improved the overall quality of regional anaesthesia in patients undergoing below-knee lower limb surgeries. It significantly accelerated the onset of both sensory and motor blockade and prolonged the duration of sensory and motor block. The adjuvant also provided better early postoperative analgesia, as shown by lower VAS scores and delayed time to first rescue analgesic request. Patient satisfaction was higher in the dexmedetomidine group, suggesting better postoperative comfort. However, bradycardia, hypotension and sedation were observed more frequently with dexmedetomidine. Therefore, dexmedetomidine may be considered an effective perineural adjuvant in selected patients, provided that careful patient selection and vigilant haemodynamic monitoring are ensured.

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