

Comparative Evaluation of Dexmedetomidine and Clonidine as Adjuvants to Ropivacaine in Ultrasound-Guided Supraclavicular Brachial Plexus Block: A Prospective Double-Blind Randomized Controlled Trial

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ABSTRACT

Background: Ultrasound-guided supraclavicular brachial plexus block is a widely used regional anaesthetic technique for upper limb surgeries. The addition of α_2 -adrenergic agonists to local anaesthetics has been shown to improve block characteristics and postoperative analgesia. Dexmedetomidine and clonidine are commonly used adjuvants; however, evidence comparing their efficacy with ropivacaine remains limited. **Aim:** To compare the efficacy and safety of dexmedetomidine and clonidine as adjuvants to 0.5% ropivacaine in ultrasound-guided supraclavicular brachial plexus block. **Materials and Methods:** This prospective, randomised, double-blind controlled study was conducted in the Department of Anaesthesiology, CSI Redfern Memorial Hospital, Hassan, Karnataka, over a period of two years. A total of 100 adult patients (ASA physical status I–II) undergoing elective upper limb surgeries were randomly allocated into two groups of 50 each. Group D received 29 mL of 0.5% ropivacaine with dexmedetomidine (1 μ g/kg), diluted with normal saline to a final volume of 30 mL, whereas Group C received 29 mL of 0.5% ropivacaine with clonidine (1 μ g/kg), also diluted to a total volume of 30 mL. The primary outcome was duration of postoperative analgesia. Secondary outcomes included onset and duration of sensory and motor block, postoperative Visual Analogue Scale (VAS) scores, rescue analgesic requirement, hemodynamic parameters, sedation score, and adverse events. **Results:** Baseline demographic characteristics and laboratory parameters were comparable between the two groups. Dexmedetomidine produced a significantly faster onset of sensory block (8.2 ± 1.3 vs. 10.5 ± 1.6 minutes; $p < 0.001$) and motor block (11.1 ± 1.8 vs. 13.7 ± 2.1 minutes; $p < 0.001$). The duration of sensory block (846.8 ± 81.3 vs. 684.5 ± 74.1 minutes), motor block (764.2 ± 72.5 vs. 616.4 ± 68.3 minutes), and postoperative analgesia (921.6 ± 88.2 vs. 748.9 ± 79.5 minutes) was significantly longer in Group D ($p < 0.001$ for all). Patients receiving dexmedetomidine had significantly lower postoperative VAS scores, delayed first rescue analgesia, fewer analgesic requirements, and better sedation scores. Hemodynamic parameters remained stable in both groups, and no significant difference in adverse events was observed. **Conclusion:** Dexmedetomidine is a superior adjuvant to 0.5% ropivacaine compared with clonidine for ultrasound-guided supraclavicular brachial plexus block. It provides faster onset, prolonged sensory and motor blockade, extended postoperative analgesia, improved postoperative pain control, reduced rescue analgesic requirements, and satisfactory sedation while maintaining a favourable safety profile. These findings support the routine use of dexmedetomidine as an effective adjuvant for upper limb surgeries performed under ultrasound-guided supraclavicular brachial plexus block.

Keywords: Dexmedetomidine, Clonidine, Ropivacaine, Supraclavicular brachial plexus block, Ultrasound-guided regional anaesthesia, Postoperative analgesia, Peripheral nerve block.

INTRODUCTION

Peripheral nerve blocks have become an essential component of modern regional anaesthesia because

they provide excellent intraoperative anaesthesia, prolonged postoperative analgesia, reduced opioid consumption, early mobilisation, and improved patient

satisfaction. Among the various approaches to the brachial plexus, the supraclavicular brachial plexus block is regarded as the "spinal of the upper limb" due to its rapid onset, dense neural blockade, and high success rate for surgeries involving the upper extremity below the shoulder. The introduction of ultrasound guidance has revolutionised regional anaesthesia by enabling real-time visualisation of neural structures, surrounding vessels, needle advancement, and local anaesthetic spread, thereby improving block success while significantly reducing complications such as vascular puncture and pneumothorax (1,2).

Ropivacaine is a long-acting amide local anaesthetic that is widely used for peripheral nerve blocks because of its favourable pharmacological profile. Compared with bupivacaine, ropivacaine has lower cardiotoxicity and neurotoxicity while providing excellent sensory blockade with relatively less intense motor blockade. These characteristics make ropivacaine particularly suitable for ambulatory upper limb surgeries where prolonged analgesia with an acceptable safety profile is desirable. However, despite its advantages, the duration of postoperative analgesia provided by ropivacaine alone is often insufficient, leading to early requirement of rescue analgesics. Therefore, various adjuvants have been investigated to enhance the quality and duration of peripheral nerve blocks without increasing the dose of local anaesthetic (3,4).

Among the available adjuvants, α_2 -adrenergic receptor agonists have emerged as one of the most effective options because of their analgesic, sedative, anxiolytic, and sympatholytic properties. These drugs enhance the effects of local anaesthetics by inhibiting norepinephrine release at presynaptic nerve terminals, suppressing neuronal firing, and producing hyperpolarisation of peripheral nerves. They also reduce perioperative stress responses and decrease postoperative opioid requirements while maintaining respiratory stability (5).

Clonidine, a partial α_2 -adrenergic receptor agonist, has been extensively studied as an adjuvant to local anaesthetics in regional anaesthesia. It prolongs both sensory and motor blockade through inhibition of action potential propagation and local vasoconstriction, thereby delaying systemic absorption of the anaesthetic solution. Although clonidine improves postoperative analgesia, its relatively lower α_2 receptor selectivity and dose-dependent adverse effects such as hypotension, bradycardia, and sedation have encouraged the search for more selective alternatives (6,7).

Dexmedetomidine is a highly selective α_2 -adrenergic receptor agonist with approximately eight-fold greater affinity for α_2 receptors than clonidine. Owing to its greater receptor selectivity, dexmedetomidine provides superior analgesia, prolonged duration of sensory and motor blockade, improved sedation, and greater hemodynamic stability while preserving respiratory function. Experimental studies have suggested that

dexmedetomidine enhances peripheral nerve blockade by inhibiting hyperpolarisation-activated cation currents, reducing inflammatory mediator release, and potentiating the action of local anaesthetics around peripheral nerves (8,9).

Several randomised controlled trials have evaluated dexmedetomidine and clonidine as adjuvants to local anaesthetics for brachial plexus block. Most studies have reported that dexmedetomidine provides earlier onset of sensory and motor blockade, longer duration of postoperative analgesia, and lower postoperative pain scores compared with clonidine. Nevertheless, considerable variation exists among published studies regarding local anaesthetic concentration, adjuvant dosage, block technique, patient population, and outcome measures, making direct comparison difficult. Furthermore, relatively limited prospective randomised data are available from Indian tertiary care hospitals using ultrasound-guided supraclavicular brachial plexus block with ropivacaine (10–12).

The present prospective, randomised, double-blind, controlled study was therefore undertaken to compare dexmedetomidine and clonidine as adjuvants to 0.5% ropivacaine in ultrasound-guided supraclavicular brachial plexus block in patients undergoing elective upper-limb surgery. The study aimed to evaluate the onset and duration of sensory and motor blockade, duration of postoperative analgesia, postoperative pain scores, rescue analgesic requirements, hemodynamic parameters, sedation profile, patient satisfaction, and incidence of adverse events. The findings of this study may help identify the more effective adjuvant for improving the quality of regional anaesthesia and postoperative pain management while maintaining patient safety.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomised, double-blind, controlled clinical trial was conducted in the Department of Anaesthesiology at CSI Redfern Memorial Hospital, Hassan, Karnataka, India, over a period of 2 years. The study was undertaken after obtaining approval from the Institutional Ethics Committee (IEC), and written informed consent was obtained from all participants before enrollment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and Good Clinical Practice (GCP) guidelines.

Study Population

A total of 100 adult patients scheduled for elective upper limb surgeries requiring ultrasound-guided supraclavicular brachial plexus block were included in the study.

Sample Size

The sample size was calculated based on the expected difference in duration of postoperative analgesia

between the two groups, with a power of 80%, α error of 5%, and an anticipated effect size derived from previous published studies. A minimum of 45 patients per group was required; therefore, 50 patients were enrolled in each group to compensate for possible dropouts.

- **Group D (n = 50):** Received 30 mL of 0.5% ropivacaine with dexmedetomidine as an adjuvant.
- **Group C (n = 50):** Received 30 mL of 0.5% ropivacaine with clonidine as an adjuvant.

Inclusion Criteria

Patients fulfilling the following criteria were included:

- Age between 18 and 65 years.
- Either gender.
- American Society of Anesthesiologists (ASA) physical status I or II.
- Scheduled for elective upper limb surgery below the shoulder requiring supraclavicular brachial plexus block.
- Ability to understand the study protocol and provide written informed consent.

Exclusion Criteria

Patients with any of the following were excluded:

- Refusal to participate.
- Allergy or hypersensitivity to ropivacaine, dexmedetomidine, clonidine, or local anaesthetics.
- Coagulopathy or anticoagulant therapy.
- Infection at the injection site.
- Severe hepatic, renal, respiratory, or cardiac disease.
- Neurological disorders involving the upper limb.
- Pregnancy or lactation.
- Body mass index (BMI) >35 kg/m².
- History of psychiatric illness or inability to communicate pain scores.

Ethical Approval

The study protocol was reviewed and approved by the Institutional Ethics Committee (IEC) of CSI Redfern Memorial Hospital, Hassan, Karnataka, India. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision), the International Council for Harmonisation-Good Clinical Practice (ICH-GCP) guidelines, and applicable national ethical standards. Written informed consent was obtained from all participants before enrolment.

Clinical Trial Registration

The study was not prospectively registered in any clinical trial registry before patient enrolment. The findings should therefore be interpreted considering the absence of prospective trial registration.

Randomisation and Blinding

Patients were randomised into two groups using a computer-generated randomisation sequence. Allocation concealment was maintained using sequentially numbered opaque sealed envelopes.

The study was conducted in a double-blind manner. The study drug was prepared by an anesthesiologist who was not involved in patient management or data collection. Both the anesthesiologist performing the block and the patient were unaware of the group allocation. The investigator recording perioperative observations and postoperative outcomes was also blinded to the study drugs.

Preoperative Assessment

All patients underwent detailed pre-anaesthetic evaluation including:

- Medical history.
- Physical examination.
- Airway assessment.
- Routine laboratory investigations:
 - Complete blood count.
 - Blood glucose.
 - Renal function tests.
 - Liver function tests (if indicated).
 - Coagulation profile.
 - Electrocardiogram (ECG).
 - Chest radiograph when clinically indicated.

Patients were kept fasting according to standard preoperative fasting guidelines.

Study Drugs

Dexmedetomidine and clonidine were diluted with preservative-free normal saline to obtain identical total volumes of 30 mL. Both study solutions were colourless and prepared in identical syringes labelled only with the patient randomization number to ensure maintenance of blinding.

Group D

Patients received **29 mL of 0.5% ropivacaine combined with dexmedetomidine (1 µg/kg), and the total volume was adjusted to 30 mL with preservative-free normal saline.**

The total drug volume was adjusted to **30 mL** with normal saline.

Group C

Patients received **29 mL of 0.5% ropivacaine combined with clonidine (1 µg/kg), and the total volume was adjusted to 30 mL with preservative-free normal saline.**

The final volume was adjusted to **30 mL** using normal saline.

Anaesthetic Technique

Upon arrival in the operating room, intravenous access was secured using an 18G cannula.

Standard ASA monitoring included:

- Heart rate (HR).
- Non-invasive blood pressure (NIBP).
- Electrocardiography (ECG).
- Pulse oximetry (SpO₂).

Baseline vital parameters were recorded.

Patients received intravenous Ringer's lactate solution before the block.

The supraclavicular brachial plexus block was performed under strict aseptic precautions using a high-frequency linear ultrasound probe (6–13 MHz). After identifying the brachial plexus lateral to the subclavian artery, a 22-gauge insulated nerve block needle was inserted using the in-plane technique. Following negative aspiration for blood, the study drug was injected incrementally under continuous ultrasound visualisation to ensure proper spread around the nerve trunks.

Patients were monitored continuously throughout the procedure.

Outcome Measures

Primary Outcome

- Duration of postoperative analgesia.

Secondary Outcomes

- Time of onset of sensory block.
- Time of onset of motor block.
- Duration of sensory block.
- Duration of motor block.
- Requirement of rescue analgesia.
- Hemodynamic parameters.
- Sedation score.
- Incidence of adverse effects and complications.
- Patient satisfaction.
 - Patient satisfaction was assessed at **24 hours postoperatively** using a **validated five-point Likert scale**, with the following categories: **Very satisfied, Satisfied, Neutral, Dissatisfied, and Very dissatisfied**. The satisfaction scores were recorded by a blinded investigator and compared between the two study groups.

Assessment of Sensory Block

Sensory block was evaluated using pinprick sensation over the dermatomes supplied by the median, radial, ulnar, and musculocutaneous nerves.

The sensory block was graded as:

- Grade 0 – Normal sensation.
- Grade 1 – Loss of pinprick sensation (analgesia).
- Grade 2 – Complete loss of sensation (anaesthesia).

The onset time was defined as the interval from completion of injection until complete sensory block (Grade 2).

The duration of sensory block was defined as the time from onset of complete sensory block until return of normal sensation.

Assessment of Motor Block

Motor block was assessed using the Modified Bromage Scale for upper limb:

- Grade 0 – Normal motor function.
- Grade 1 – Reduced motor strength.
- Grade 2 – Complete motor paralysis.

The onset of motor block was defined as the time from injection to complete motor paralysis.

The duration of motor block was calculated from onset until complete recovery of motor function.

Postoperative Pain Assessment

Pain intensity was assessed using the Visual Analogue Scale (VAS) ranging from 0 to 10, where:

- 0 = No pain.
- 10 = Worst imaginable pain.

VAS scores were recorded at:

- 1 hour.
- 2 hours.
- 4 hours.
- 6 hours.
- 8 hours.
- 12 hours.
- 24 hours postoperatively.

Rescue analgesia was administered when VAS ≥ 4 .

The time to first rescue analgesic requirement was recorded.

Rescue analgesia was administered whenever the Visual Analogue Scale (VAS) score was ≥ 4 . Intravenous diclofenac sodium 75 mg (or institutional standard analgesic) was administered as the first-line rescue analgesic. The time to first rescue analgesia and the total number of rescue analgesic doses administered during the first 24 postoperative hours were recorded. Patients with persistent pain despite rescue analgesia received additional analgesic therapy according to institutional postoperative pain management protocols.

Hemodynamic Monitoring

The following parameters were recorded:

- Heart rate.

- Systolic blood pressure.
- Diastolic blood pressure.
- Mean arterial pressure.
- Oxygen saturation.
- Persistent neurological deficit.
- Any other block-related complication.

Appropriate management was instituted whenever required.

Measurements were obtained at:

- Baseline.
- Immediately after block.
- Every 5 minutes for the first 30 minutes.
- Every 15 minutes until completion of surgery.
- Postoperatively at regular intervals.

Sedation Assessment

Sedation was assessed using the Ramsay Sedation Scale (RSS) throughout the intraoperative and postoperative periods.

Adverse Events

Patients were observed for:

- Bradycardia.
- Hypotension.
- Nausea.
- Vomiting.
- Respiratory depression.
- Local anaesthetic toxicity.
- Horner's syndrome.
- Pneumothorax.
- Vascular puncture.

Data Collection

Patient demographic characteristics, intraoperative variables, block characteristics, postoperative analgesia, hemodynamic parameters, adverse events, and patient satisfaction scores were recorded using a standardized case record form by a blinded investigator.

Statistical Analysis

The collected data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were presented as frequency and percentage. The independent Student's *t*-test was used to compare continuous variables between the two groups, and the Chi-square test or Fisher's exact test was applied for categorical variables as appropriate. A *p*-value <0.05 was considered statistically significant.

Data normality was assessed using the Shapiro Wilk test before application of parametric statistical tests.

RESULTS AND OBSERVATIONS

A total of 100 patients undergoing elective upper limb surgery under ultrasound-guided supraclavicular brachial plexus block were enrolled in the study. Patients were randomly allocated into Group D (Ropivacaine + Dexmedetomidine, *n*=50) and Group C (Ropivacaine + Clonidine, *n*=50). All patients completed the study, and no participant was excluded from the final analysis.

Table 1. Demographic Characteristics

Variable	Group D (n=50)	Group C (n=50)	p-value
Age (years)	41.82 $\pm$ 11.34	42.47 $\pm$ 10.92	0.762
Male	32 (64%)	30 (60%)	0.682
Female	18 (36%)	20 (40%)	
Weight (kg)	66.48 $\pm$ 8.15	67.02 $\pm$ 8.31	0.744
Height (cm)	164.82 $\pm$ 7.46	165.31 $\pm$ 7.21	0.736
BMI (kg/m ²)	24.42 $\pm$ 2.84	24.68 $\pm$ 2.76	0.641
ASA Grade I	31 (62%)	29 (58%)	0.681
ASA Grade II	19 (38%)	21 (42%)	
Duration of Surgery (min)	91.82 $\pm$ 16.75	93.41 $\pm$ 17.68	0.648

Observation: Baseline demographic variables were comparable between groups.

Table 2. Baseline Hematological Profile (CBC)

Parameter	Group D	Group C	p-value
Hemoglobin (g/dL)	13.12 $\pm$ 1.26	13.28 $\pm$ 1.19	0.512
RBC Count (million/mm ³)	4.63 $\pm$ 0.42	4.68 $\pm$ 0.39	0.548
Total Leukocyte Count (cells/mm ³)	7412 $\pm$ 1285	7528 $\pm$ 1314	0.658
Neutrophils (%)	63.6 $\pm$ 6.4	64.1 $\pm$ 6.8	0.711
Lymphocytes (%)	29.8 $\pm$ 5.8	29.2 $\pm$ 5.6	0.602
Monocytes (%)	4.5 $\pm$ 1.2	4.7 $\pm$ 1.3	0.438
Eosinophils (%)	2.0 $\pm$ 0.9	2.1 $\pm$ 1.0	0.618
Platelet Count ($\times 10^5$ /mm ³)	2.58 $\pm$ 0.41	2.61 $\pm$ 0.43	0.732

Observation: Haematological parameters were not statistically different.

Table 3. Baseline Liver Function Tests (LFT)

Parameter	Group D	Group C	p-value
Total Bilirubin (mg/dL)	0.73 ± 0.20	0.75 ± 0.22	0.642
Direct Bilirubin (mg/dL)	0.21 ± 0.07	0.22 ± 0.08	0.518
AST (U/L)	27.5 ± 6.3	28.2 ± 6.8	0.593
ALT (U/L)	29.1 ± 7.2	30.4 ± 7.6	0.381
ALP (U/L)	91.8 ± 19.5	93.7 ± 18.6	0.621
Total Protein (g/dL)	7.11 ± 0.46	7.08 ± 0.43	0.734
Serum Albumin (g/dL)	4.23 ± 0.34	4.18 ± 0.31	0.448

Observation: Liver function remained normal and comparable.

Table 4. Baseline Renal Function Tests (RFT)

Parameter	Group D	Group C	p-value
Blood Urea (mg/dL)	27.8 ± 6.1	28.4 ± 6.4	0.638
Serum Creatinine (mg/dL)	0.87 ± 0.16	0.89 ± 0.17	0.541
Serum Uric Acid (mg/dL)	5.0 ± 1.0	5.2 ± 0.9	0.329
Sodium (mmol/L)	138.7 ± 2.5	139.2 ± 2.6	0.334
Potassium (mmol/L)	4.19 ± 0.37	4.23 ± 0.35	0.584

Observation: Renal function and electrolytes showed no significant differences.

Table 5. Block Characteristics

Parameter	Group D	Group C	p-value
Sensory Block Onset (min)	8.2 ± 1.3	10.5 ± 1.6	<0.001
Motor Block Onset (min)	11.1 ± 1.8	13.7 ± 2.1	<0.001
Sensory Block Duration (min)	846.8 ± 81.3	684.5 ± 74.1	<0.001
Motor Block Duration (min)	764.2 ± 72.5	616.4 ± 68.3	<0.001
Duration of Analgesia (min)	921.6 ± 88.2	748.9 ± 79.5	<0.001

Observation: Dexmedetomidine significantly improved block characteristics.

Table 6. Hemodynamic Parameters

Parameter	Group D	Group C	p-value
Heart Rate (beats/min)	70.4 ± 7.3	74.6 ± 7.9	0.011
SBP (mmHg)	118.6 ± 9.4	120.8 ± 8.8	0.226
DBP (mmHg)	74.5 ± 6.7	75.8 ± 6.9	0.342
MAP (mmHg)	89.2 ± 6.5	91.1 ± 6.3	0.149
SpO ₂ (%)	99.1 ± 0.7	99.0 ± 0.8	0.531

Observation: Hemodynamics remained stable.

Table 7. Ramsay Sedation Score

Score	Group D	Group C
2	17 (34%)	31 (62%)
3	29 (58%)	17 (34%)
4	4 (8%)	2 (4%)

p = 0.009

Observation: Better sedation was observed with dexmedetomidine.

Table 8. Postoperative VAS Score

Time	Group D	Group C	p-value
1 Hour	0.2 ± 0.4	0.5 ± 0.5	0.016
2 Hours	0.5 ± 0.6	0.9 ± 0.7	0.008
4 Hours	1.2 ± 0.7	1.9 ± 0.8	<0.001
6 Hours	2.1 ± 0.9	3.3 ± 1.0	<0.001
8 Hours	3.2 ± 1.0	4.8 ± 1.1	<0.001
12 Hours	4.5 ± 1.1	5.9 ± 1.2	<0.001
24 Hours	2.9 ± 0.8	3.6 ± 0.9	<0.001

Observation: Pain scores remained significantly lower in Group D.

Table 9. Rescue Analgesic Requirement

Variable	Group D	Group C	p-value
Time to First Rescue Analgesia (min)	928.2 ± 91.6	754.3 ± 82.4	<0.001
Total Analgesic Doses (24 hrs)	1.20 ± 0.49	1.92 ± 0.61	<0.001
Patients Requiring Second Dose	8 (16%)	22 (44%)	0.002

Observation: Rescue analgesic requirement was significantly lower in Group D.

Table 10. Adverse Events

Complication	Group D (n=50)	Group C (n=50)	p-value
Bradycardia	5 (10%)	2 (4%)	0.238
Hypotension	3 (6%)	2 (4%)	0.646
Nausea	2 (4%)	3 (6%)	0.646
Vomiting	1 (2%)	2 (4%)	0.558
Dry Mouth	3 (6%)	5 (10%)	0.461
Horner's Syndrome	1 (2%)	1 (2%)	1.000
Vascular Puncture	1 (2%)	2 (4%)	0.558
Pneumothorax	0	0	—
Respiratory Depression	0	0	—
Local Anaesthetic Toxicity	0	0	—

Observation: Both groups demonstrated a favourable safety profile with no serious block-related complications.

Table 11. Comparison of Patient Satisfaction Scores Between Dexmedetomidine and Clonidine Groups at 24 Hours After Surgery

Satisfaction	Group D (n=50)	Group C (n=50)
Very satisfied	34 (68%)	20 (40%)
Satisfied	14 (28%)	24 (48%)
Neutral	2 (4%)	6 (12%)
Dissatisfied	0	0
Very Dissatisfied	0	0
p-value	0.012	

Observation: Patient satisfaction was significantly higher in the dexmedetomidine group.

DISCUSSION

The present prospective, randomised, double-blind, controlled trial compared dexmedetomidine and clonidine as adjuvants to 0.5% ropivacaine in ultrasound-guided supraclavicular brachial plexus block among patients undergoing elective upper-limb surgery. The findings of this study demonstrated that dexmedetomidine was superior to clonidine in terms of faster onset of sensory and motor blockade, prolonged duration of sensory and motor block, significantly longer postoperative analgesia, lower postoperative pain scores, reduced rescue analgesic requirements, and improved sedation while maintaining an acceptable safety profile. These findings indicate that dexmedetomidine is a more effective adjuvant to ropivacaine than clonidine for ultrasound-guided supraclavicular brachial plexus block.

Baseline demographic variables including age, gender distribution, body weight, height, body mass index, ASA physical status, and duration of surgery were comparable between the two groups, indicating successful randomisation and minimising the possibility of selection bias. Similar demographic comparability has been reported in previous randomised studies comparing dexmedetomidine and clonidine as adjuvants in brachial plexus blocks

(10,13). The absence of statistically significant differences in baseline haematological parameters, liver function tests, and renal function tests further confirmed that both groups were clinically comparable before administration of the study drugs, thereby ensuring that postoperative differences could be attributed primarily to the pharmacological effects of the adjuvants rather than patient-related factors.

One of the principal findings of the present study was the significantly faster onset of both sensory and motor blockade in the dexmedetomidine group compared with the clonidine group. Patients receiving dexmedetomidine achieved complete sensory and motor block earlier than those receiving clonidine. This accelerated onset can be explained by the higher α_2 -adrenoceptor selectivity of dexmedetomidine, which enhances hyperpolarisation of nerve fibres, suppresses transmission of nociceptive impulses, and potentiates the action of ropivacaine around peripheral nerves (8,9). Swami et al. similarly demonstrated significantly shorter onset times for both sensory and motor blockade with dexmedetomidine compared with clonidine in supraclavicular brachial plexus block (10). Comparable observations have also been reported by Esmaoglu et al. and Ammar and Mahmoud, who concluded that dexmedetomidine hastens the

establishment of effective neural blockade when combined with long-acting local anaesthetics (14,15). The duration of sensory blockade, motor blockade, and postoperative analgesia was significantly prolonged in the dexmedetomidine group. This prolonged analgesic effect represents one of the major clinical advantages of dexmedetomidine. The mechanism is believed to involve peripheral vasoconstriction delaying vascular absorption of the local anaesthetic, inhibition of hyperpolarisation-activated cation currents, suppression of inflammatory mediator release, and direct inhibition of nerve impulse conduction. Collectively, these mechanisms prolong the action of ropivacaine around peripheral nerves (8,9). Similar findings have been consistently demonstrated in several randomised controlled trials and systematic reviews, all of which reported significantly prolonged analgesia with dexmedetomidine compared with clonidine or local anaesthetic alone (11,12,16). The prolonged duration of analgesia observed in the present study is clinically valuable because it delays postoperative pain, minimises opioid consumption, and improves patient comfort during the immediate postoperative period.

Postoperative pain assessment using the Visual Analogue Scale revealed significantly lower pain scores at all postoperative time intervals in patients receiving dexmedetomidine. Consequently, these patients required rescue analgesia much later and received significantly fewer analgesic doses during the first 24 hours following surgery. Effective postoperative pain control remains one of the primary objectives of regional anaesthesia because inadequate analgesia delays mobilisation, prolongs hospital stay, and increases opioid-related adverse effects. The present findings are in agreement with those of Al-Mustafa et al., who demonstrated prolonged analgesia and reduced postoperative analgesic consumption following the addition of dexmedetomidine to local anaesthetics for brachial plexus block (17). Likewise, Abdallah and Brull concluded in their review that perineural dexmedetomidine consistently prolongs postoperative analgesia and significantly decreases rescue analgesic requirements (16).

An important observation of the present study was the superior sedation achieved with dexmedetomidine. Patients receiving dexmedetomidine exhibited significantly higher Ramsay Sedation Scores while remaining easily arousable and maintaining normal oxygen saturation. Dexmedetomidine produces sedation through stimulation of α_2 receptors within the locus coeruleus of the brainstem, resulting in a sleep-like state without clinically significant respiratory depression. This characteristic distinguishes dexmedetomidine from opioids and benzodiazepines, which may impair respiratory function. Similar sedation profiles have been reported by Belleville et al. and Abdallah and Brull, who highlighted the unique

property of dexmedetomidine in providing cooperative sedation during regional anaesthesia (16,18).

Hemodynamic stability is an important consideration when α_2 -adrenergic agonists are used as adjuvants. In the present study, heart rate was modestly lower in the dexmedetomidine group; however, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation remained comparable between groups throughout the perioperative period. Although a few patients experienced bradycardia or hypotension, these events were infrequent, mild, and managed successfully without significant clinical consequences. These findings indicate that dexmedetomidine at a dose of 1 $\mu\text{g/kg}$ provides enhanced analgesia without causing major cardiovascular instability. Similar hemodynamic safety has been reported in previous clinical studies evaluating dexmedetomidine in peripheral nerve blocks (14,15).

The incidence of adverse events in the present study was low and comparable between the two groups. Minor complications such as bradycardia, hypotension, nausea, vomiting, dry mouth, Horner's syndrome, and vascular puncture occurred infrequently and responded to routine management. Importantly, no patient developed pneumothorax, respiratory depression, local anaesthetic systemic toxicity, or persistent neurological deficit. The low incidence of complications may be attributed to the use of ultrasound guidance, which permits real-time visualisation of neural structures and accurate deposition of local anaesthetic while avoiding adjacent vascular and pleural structures. These observations are consistent with the recommendations of the American Society of Regional Anaesthesia regarding the safety advantages of ultrasound-guided peripheral nerve blocks (1,19).

The strengths of the present study include its prospective randomised double-blind design, standardised ultrasound-guided block technique, equal distribution of participants, comprehensive evaluation of block characteristics, postoperative analgesia, sedation, hemodynamic variables, and complications. These methodological strengths improve the reliability and clinical applicability of the findings. However, certain limitations should be acknowledged. The study was conducted at a single tertiary care centre with a relatively limited sample size. Only one dose of dexmedetomidine and clonidine was evaluated, and long-term neurological follow-up was not performed. Future multicenter studies involving larger populations, different dosing regimens, pharmacoeconomic analyses, and long-term safety assessment would provide further evidence regarding the optimal use of α_2 -adrenergic agonists in peripheral nerve blockade.

Overall, the findings of the present study demonstrate that dexmedetomidine is superior to clonidine as an adjuvant to 0.5% ropivacaine in ultrasound-guided supraclavicular brachial plexus block.

Dexmedetomidine provides faster onset of sensory and motor blockade, significantly prolongs postoperative analgesia, reduces postoperative pain scores and rescue analgesic requirements, produces satisfactory sedation, and maintains an acceptable safety profile. These advantages support its routine use as an effective adjuvant for upper limb surgeries performed under ultrasound-guided supraclavicular brachial plexus block.

The present findings have important clinical implications. Faster onset of sensory and motor blockade allows earlier commencement of surgery, whereas prolonged postoperative analgesia reduces opioid consumption and improves patient comfort during the immediate postoperative period. Effective pain control also facilitates early mobilisation, reduces postoperative stress response, improves patient satisfaction, and may contribute to enhanced recovery after surgery (ERAS) protocols. Therefore, dexmedetomidine may represent an ideal adjuvant for ultrasound-guided peripheral nerve blocks in routine anaesthesia practice.

Limitations

The present study has several limitations. First, it was conducted at a single tertiary care centre, which may limit the generalisability of the findings. Second, the sample size was relatively modest. Third, only one dose of dexmedetomidine and clonidine was evaluated; therefore, dose-response relationships could not be determined. Fourth, long-term neurological outcomes beyond the immediate postoperative period were not assessed. Finally, cost-effectiveness analysis and quality-of-recovery assessment were not performed.

The study was not prospectively registered in a clinical trial registry, which should be considered while interpreting the findings. Future clinical trials should undergo prospective registration to improve transparency and methodological quality.

Future Recommendations

Future multicentre randomized controlled trials involving larger patient populations are recommended to confirm these findings. Studies comparing different doses of dexmedetomidine and clonidine, evaluating long-term neurological safety, patient-reported outcome measures, pharmacoeconomic analyses, and enhanced recovery protocols would further strengthen the evidence regarding the optimal use of α_2 -adrenergic agonists in peripheral nerve blockade.

Strengths of the Study

The present study has several important strengths. It was designed as a prospective, randomized, double-blind controlled trial, thereby minimizing selection, performance, and observer bias. The use of ultrasound guidance ensured accurate needle placement and precise deposition of the local anaesthetic, enhancing block success while reducing procedure-related

complications. Standardized drug dosages, a uniform block technique, and consistent perioperative monitoring improved the internal validity and reproducibility of the study. Furthermore, comprehensive assessment of block characteristics, postoperative analgesia, pain scores, haemodynamic parameters, sedation, rescue analgesic requirement, and adverse events provided a holistic evaluation of the comparative efficacy and safety of dexmedetomidine and clonidine as adjuvants to ropivacaine in supraclavicular brachial plexus block. These methodological strengths increase the clinical relevance and applicability of the study findings in routine anaesthesia practice.

CONCLUSION

The present prospective randomised double-blind study demonstrated that dexmedetomidine is a superior adjuvant to 0.5% ropivacaine compared with clonidine for ultrasound-guided supraclavicular brachial plexus block in patients undergoing elective upper limb surgery. Dexmedetomidine provided a significantly faster onset of sensory and motor blockade, prolonged the duration of blockade and postoperative analgesia, reduced postoperative pain scores and rescue analgesic requirements, and produced better sedation while maintaining stable hemodynamic parameters and a favorable safety profile. These findings suggest that dexmedetomidine is an effective and safe adjuvant for enhancing the quality of ultrasound-guided supraclavicular brachial plexus block and improving perioperative patient outcomes.

Data Availability Statement

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare that they have no competing interests.

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Author Contributions

Dr. Divyashri C.N.: Conceptualization, study design, patient recruitment, data collection, manuscript preparation.

Dr. Preethi H.N.: Methodology, statistical analysis, interpretation of results, manuscript revision.

Dr. Bharath M.S.: Supervision, critical review of the manuscript, final approval of the submitted version.

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Abbreviations

- ASA – American Society of Anesthesiologists
- BMI – Body Mass Index
- CBC – Complete Blood Count
- ECG – Electrocardiogram
- GCP – Good Clinical Practice
- HR – Heart Rate
- MAP – Mean Arterial Pressure
- NIBP – Non-invasive Blood Pressure
- RSS – Ramsay Sedation Scale
- RCT – Randomized Controlled Trial
- VAS – Visual Analogue Scale

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