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Original Research Article

Comparative Evaluation of Dexmedetomidine and Dexamethasone as an Adjuvant to Bupivacaine in Supraclavicular Brachial Plexus Block for Upper Limb Surgeries

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Abstract

Background: Supraclavicular brachial plexus block is commonly used for upper limb surgeries. Various adjuvants have been added to local anaesthetics to improve block characteristics and prolong postoperative analgesia. Dexmedetomidine and dexamethasone are frequently used additives to bupivacaine, but their comparative efficacy remains an area of interest.

Methods: This ambispective randomised double-blind controlled study was conducted in 60 adult patients (ASA I–II) undergoing elective upper limb orthopaedic surgeries. Patients were randomly divided into two groups of 30 each. Group A received 25 ml of 0.25% bupivacaine with dexamethasone 8 mg, while Group B received 25 ml of 0.25% bupivacaine with dexmedetomidine 1 µg/kg for ultrasound-guided supraclavicular brachial plexus block. Onset and duration of sensory and motor block, sedation score, haemodynamic variables, time to first rescue analgesia, and total analgesic consumption over 24 hours were recorded and analysed.

Results: Dexmedetomidine significantly hastened the onset of sensory (6.4 ± 1.3 min vs 9.8 ± 1.5 min) and motor block (8.1 ± 1.4 min vs 12.2 ± 1.6 min) compared to dexamethasone ($p < 0.001$). Duration of sensory block (10.2 ± 1.3 hrs vs 7.6 ± 1.1 hrs) and motor block (9.1 ± 1.1 hrs vs 6.3 ± 1.0 hrs) were also prolonged in the dexmedetomidine group ($p < 0.001$). Time to first rescue analgesia was longer (12.7 ± 1.4 hrs vs 9.8 ± 1.2 hrs), and analgesic requirement over 24 hours was significantly reduced. Sedation scores were higher with dexmedetomidine. Mild bradycardia and hypotension occurred more frequently with dexmedetomidine but were manageable.

Conclusion: Dexmedetomidine is a superior adjuvant to dexamethasone when combined with bupivacaine for supraclavicular brachial plexus block, providing faster onset, prolonged block duration, improved postoperative analgesia, and acceptable haemodynamic stability.

Keywords: Dexmedetomidine, Dexamethasone, Bupivacaine, Supraclavicular brachial plexus block, Postoperative analgesia, Upper limb surgery.

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Introduction

Upper limb surgeries are commonly performed procedures in orthopaedic practice and require adequate anaesthesia, optimal muscle relaxation, and effective postoperative analgesia. Regional anaesthesia has gained increasing popularity over general anaesthesia for such procedures because it provides excellent intra-operative operating conditions, prolonged postoperative pain relief, reduced opioid consumption, early mobilisation, and fewer systemic complications. Among the various regional techniques, the supraclavicular brachial plexus block is considered one of the most reliable approaches for anaesthetising the upper limb distal to the shoulder and is often referred to as the "spinal anaesthesia of the upper limb."[1]

The brachial plexus is formed by the anterior rami of spinal nerves C5–T1. At the level of the supraclavicular fossa, the trunks are compactly arranged around the subclavian artery, making this site particularly suitable for a single-injection technique that provides dense sensory and motor blockade of the radial, median, ulnar,

musculocutaneous, and axillary nerves.[2] With the advent of ultrasound guidance, the safety and success rate of supraclavicular block have markedly improved by allowing real-time visualisation of neural structures, needle placement, and local anaesthetic spread, thereby reducing complications such as pneumothorax and vascular puncture.[3]

Local anaesthetics form the cornerstone of regional anaesthesia. Bupivacaine, an amide-type long-acting local anaesthetic, is widely used for peripheral nerve blocks due to its prolonged duration of action and high potency. It produces differential blockade by preferentially blocking sensory fibres before motor fibres through inhibition of voltage-gated sodium channels, thereby preventing propagation of action potentials.[4] However, when used alone, bupivacaine provides limited duration of postoperative analgesia, which may necessitate early administration of rescue analgesics.

To improve block quality and prolong postoperative analgesia, various adjuvants have been added to local anaesthetic solutions. The ideal adjuvant should hasten onset, prolong duration of analgesia, reduce analgesic requirement, and maintain haemodynamic stability without increasing complications.[5] Among the many adjuvants studied, dexamethasone and dexmedetomidine have emerged as two of the most effective and widely investigated agents.

Dexamethasone is a potent synthetic glucocorticoid with anti-inflammatory and anti-emetic properties. When administered perineurally with local anaesthetics, it prolongs the duration of sensory and motor blockade and delays the onset of postoperative pain. The proposed mechanisms include reduction of perineural inflammation, inhibition of nociceptive transmission in C-fibres, and vasoconstrictive effects that decrease vascular absorption of local anaesthetic.[6] Previous studies have demonstrated that dexamethasone significantly prolongs analgesia and reduces postoperative opioid requirement in brachial plexus blocks.[7]

Dexmedetomidine is a highly selective α2-adrenergic receptor agonist with sedative, anxiolytic, and analgesic properties without significant respiratory depression. It prolongs nerve blockade by hyperpolarisation of nerve tissues, inhibition of norepinephrine release, and local vasoconstriction, which delays systemic absorption of the local anaesthetic.[8] Perineural dexmedetomidine has been shown to hasten the onset of block, prolong the duration of analgesia, and improve patient satisfaction in peripheral nerve blocks.[9] However, it may also be associated with side effects such as bradycardia and hypotension due to sympatholysis.

Although both dexamethasone and dexmedetomidine are effective adjuvants to bupivacaine in supraclavicular brachial plexus block, the superiority of one over the other remains a subject of ongoing research. Direct comparative studies evaluating their relative efficacy in terms of onset, duration of block, postoperative analgesia, sedation, and haemodynamic stability are limited.

Therefore, the present study was undertaken to comparatively evaluate dexmedetomidine and dexamethasone as adjuvants to bupivacaine in supraclavicular brachial plexus block for upper limb surgeries, with emphasis on block characteristics, duration of analgesia, haemodynamic parameters, sedation, and adverse effects.

Materials and Methods

Study Design: This study was designed as an ambispective randomised controlled trial.

Study Setting: The study was conducted in the Institute of Anaesthesiology and Critical Care (Orthopaedics Operation Theatre), Rajiv Gandhi Government General Hospital, Madras Medical College, Chennai, India.

Study Population: The study population consisted of adult patients posted for elective upper limb orthopaedic surgical procedures under supraclavicular brachial plexus block.

Sample Size: A total of 60 patients were enrolled in the study and randomly allocated into two equal groups:

- Group A (n = 30): Bupivacaine + Dexamethasone
- Group B (n = 30): Bupivacaine + Dexmedetomidine

Sampling Technique: Participants were selected using simple random sampling. Randomisation was done using computer-generated random numbers, and allocation concealment was maintained.

Inclusion Criteria

- Patients aged 18–60 years
- Either sex
- ASA physical status I or II
- Patients providing written informed consent

Exclusion Criteria

- Refusal to participate
- Known allergy to local anaesthetics
- Coagulation disorders
- Psychiatric illness
- Pre-existing nerve palsy

Pre-Anaesthetic Evaluation: All patients underwent a detailed pre-operative assessment, including:

- Medical history
- Physical examination
- Airway assessment
- Routine laboratory investigations
- Weight measurement and risk stratification

Written informed consent was obtained from all participants.

Randomisation and Blinding: Patients were randomly assigned to two groups of 30 each. The study was conducted as a double-blind study:

- The study drug was prepared by an anaesthesiologist not involved in patient assessment.
- Both the patient and the observing anaesthesiologist were blinded to the drug administered.

Study Interventions: All patients received supraclavicular brachial plexus block under ultrasound guidance. A total volume of 27 ml solution was administered.

Group A

- 0.25% Bupivacaine 25 ml
- Dexamethasone 8 mg (2 ml)

Group B

- 0.25% Bupivacaine 25 ml
- Dexmedetomidine 1 µg/kg (2 ml)

Block Technique: Patients were positioned supine with the head turned to the opposite side.

The injection site was infiltrated with 1 ml of 2% lignocaine subcutaneously.

Using a high-frequency ultrasound probe, the brachial plexus was identified in the supraclavicular region. A 22-gauge insulated needle was inserted under direct visualisation. After negative aspiration, the drug was injected in divided doses with aspiration after every 5 ml to avoid intravascular injection.

Monitoring

Standard monitoring included:

- Heart rate (HR)
- Non-invasive blood pressure (NIBP)
- Electrocardiogram (ECG)
- Oxygen saturation (SpO_2)

Baseline vitals were recorded before the block.

Outcome Assessment

Sensory Block: Evaluated using pin-prick method and Visual Analogue Scale (VAS):

- 0 – No pain
- 2 – Mild pain
- 5 – Moderate pain
- 8 – Severe pain
- 10 – Unbearable pain

Motor Block: Assessed using Modified Bromage Scale.

Sedation: Assessed using Ramsay Sedation Scale.

Observation Schedule

- Every 5 minutes for first 30 minutes
- Every 15 minutes during first hour
- Every 2 hours up to 24 hours

Haemodynamic parameters were recorded at: 0, 5, 10, 15, 20, 25, 30, 45 minutes, 1 hour, 2 hours and then every 4 hours up to 24 hours.

Parameters Recorded

- Onset of sensory block
- Onset of motor block
- Duration of sensory block
- Duration of motor block
- Sedation level
- Haemodynamic variables (HR, SBP, DBP, SpO_2)
- Time to first rescue analgesia
- Total analgesic consumption in 24 hours
- Adverse effects and complications

Duration of block was defined as the time from drug injection to the first complaint of pain or return of full motor power.

Postoperative Analgesia: The time to first request for rescue analgesia and the total analgesic requirement during the first 24 postoperative hours were recorded.

Statistical Analysis: Data were entered into statistical software and analyzed accordingly.

- Quantitative variables were expressed as mean ± standard deviation
- Qualitative variables were expressed as frequency and percentage
- Student's t-test was used to compare differences between the two groups
- ANOVA was used for repeated haemodynamic and VAS score comparisons

A p-value < 0.05 was considered statistically significant.

Result and Observations

Both groups were comparable in baseline characteristics, thereby ensuring randomisation and minimising selection bias. No statistically significant differences were found in age, weight, gender distribution, or ASA physical status between the groups ($p > 0.05$).

Table 1: Demographic profiles

Parameter	Group A (Dexamethasone)	Group B (Dexmedetomidine)	P-value
Mean Age (years)	38.5 ± 11.2	37.9 ± 10.7	0.82
Weight (kg)	63.4 ± 8.5	62.7 ± 9.1	0.71
Male: Female	18:12	19:11	0.79
ASA I/II	22/8	21/9	0.84

Table 2: Block characteristics

Parameter	Group A (Dexamethasone)	Group B (Dexmedetomidine)	P-value
Onset of Sensory Block (min)	9.8 ± 1.5	6.4 ± 1.3	<0.001
Onset of Motor Block (min)	12.2 ± 1.6	8.1 ± 1.4	<0.001
Duration of Sensory Block (hrs)	7.6 ± 1.1	10.2 ± 1.3	<0.001
Duration of Motor Block (hrs)	6.3 ± 1.0	9.1 ± 1.1	<0.001

Table 3: Postoperative analgesia

Parameter	Group A (Dexamethasone)	Group B (Dexmedetomidine)	P-value
Time to First Rescue Analgesia (hrs)	9.8 ± 1.2	12.7 ± 1.4	<0.001
Number of Rescue Analgesics in 24 hrs	2.0 ± 0.6	1.1 ± 0.3	<0.001

Table 4: Sedation Scores (Ramsay Sedation Scale)

Time Post Block	Group A (Dexamethasone)	Group B (Dexmedetomidine)	P-value
At 30 minutes	2.1 ± 0.3	3.2 ± 0.4	<0.001
At 1 hour	2.0 ± 0.2	3.0 ± 0.3	<0.001
At 2 hours	2.0 ± 0.2	2.8 ± 0.2	<0.001

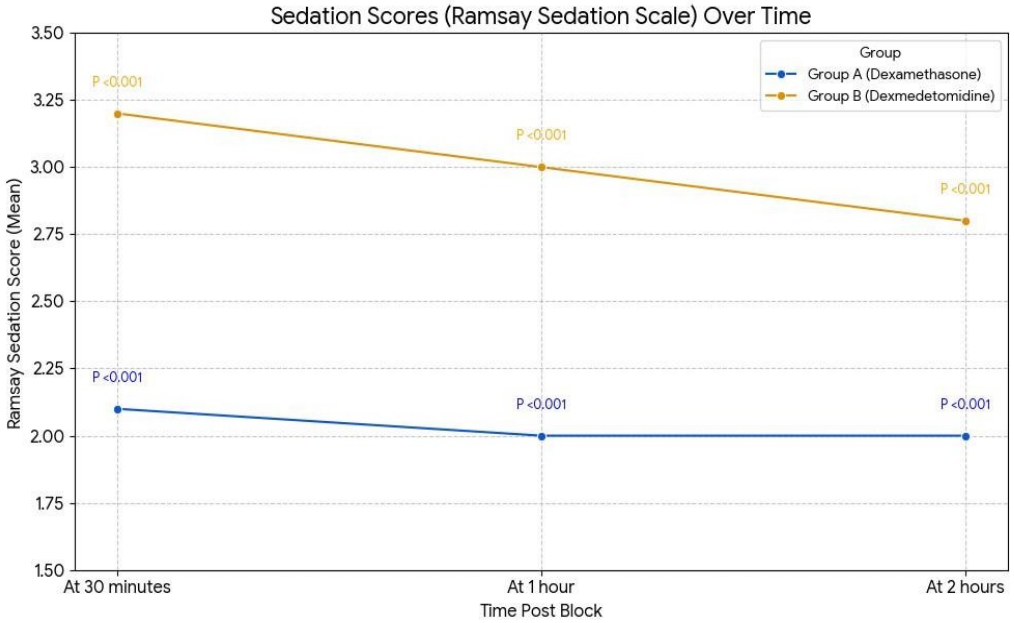

Table 5: Hemodynamic parameters

Parameter	Group A (Dexamethasone)	Group B (Dexmedetomidine)	Total (n=60)	P-value
Patients with HR decrease>20%	1 (3.3%)	5 (16.7%)	6 (10%)	0.04
Patients with SBP decrease >20%	0 (0%)	3 (10%)	3 (5%)	0.08
Mean ± SD Heart Rate (bpm)	78 ± 5	72 ± 7	—	—
Mean ± SD Systolic BP (mmHg)	123 ± 8	114 ± 10	—	—
Mean ± SD Diastolic BP (mmHg)	79 ± 5	73 ± 6	—	—
Mean ± SD Mean Arterial Pressure (mmHg)	92 ± 6	85 ± 8	—	—

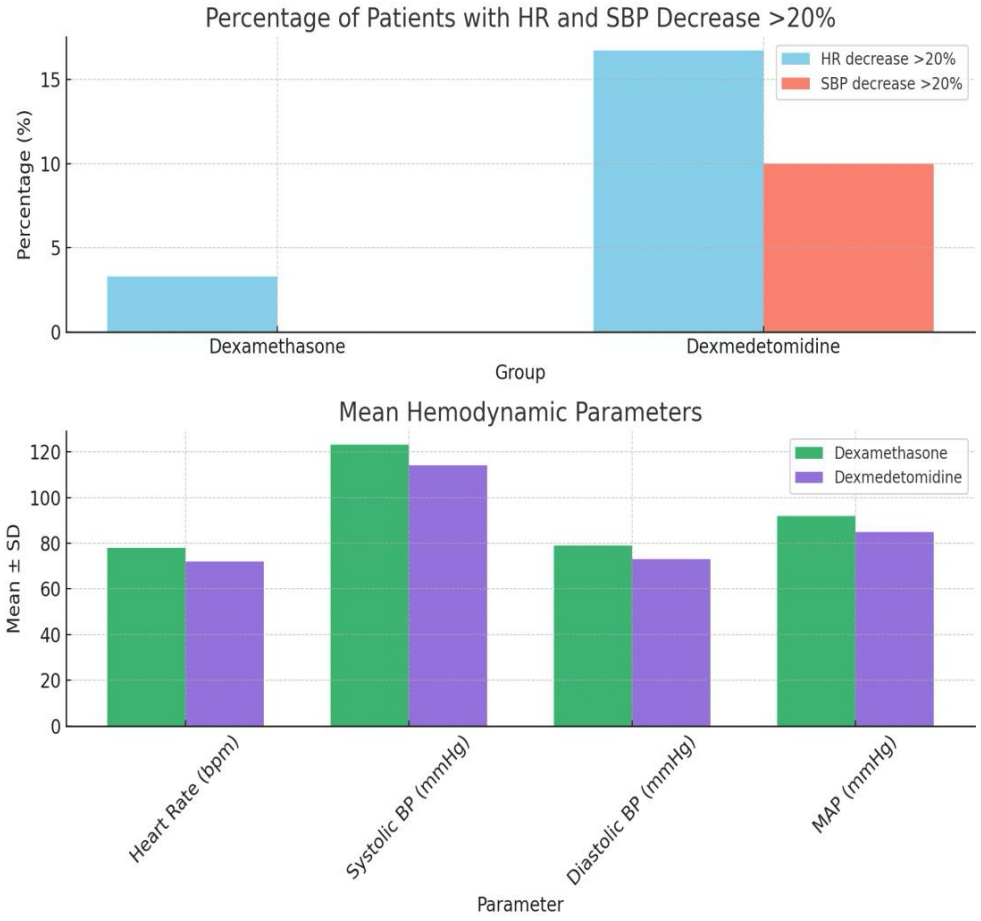

Table 6: Adverse Effects

Adverse Event	Group A (n=30)	Group B (n=30)
Nausea/Vomiting	1	1
Bradycardia	0	3
Hypotension	0	2
Block Failure	0	0

Discussion

The present study compared dexmedetomidine and dexamethasone as adjuvants to bupivacaine in ultrasound-guided supraclavicular brachial plexus block for upper limb surgeries. The major findings of this study were that dexmedetomidine significantly hastened the onset of sensory and motor block, prolonged block duration, increased postoperative analgesia, and reduced rescue analgesic consumption when compared with dexamethasone. However, dexmedetomidine was associated with higher sedation scores and a greater incidence of manageable bradycardia and hypotension.

Supraclavicular brachial plexus block is widely regarded as the most effective peripheral nerve block for surgeries of the forearm and hand because the trunks and divisions of the brachial plexus are densely packed at this level, allowing uniform anaesthetic spread. With the use of ultrasound guidance, block success rate and safety have improved considerably while complications such as pneumothorax and vascular puncture have decreased.[1,2]

Bupivacaine remains one of the most commonly used long-acting local anaesthetics for peripheral nerve blocks because of its high potency and prolonged duration. However, its analgesic duration is still limited, and patients often require rescue analgesia within the early postoperative period. To overcome this limitation, various adjuvants such as opioids, clonidine, dexamethasone, magnesium sulphate, and dexmedetomidine have been studied to enhance block quality and prolong analgesia.[3]

Onset of Block: In the present study, the onset of sensory block (6.4 ± 1.3 min) and motor block (8.1 ± 1.4 min) was significantly faster in the dexmedetomidine group compared to the

dexamethasone group. This finding is consistent with the study by Brummett et al., who demonstrated that perineural dexmedetomidine accelerates nerve blockade by inhibiting hyperpolarisation-activated cation currents and enhancing local anaesthetic action on peripheral nerves.[4]

Dexmedetomidine acts on presynaptic α2-receptors to inhibit norepinephrine release and produces membrane hyperpolarisation, thereby facilitating rapid blockade of nerve conduction. Dexamethasone, in contrast, does not directly influence nerve conduction but acts primarily through anti-inflammatory and vasoconstrictive mechanisms; therefore, it does not significantly hasten onset.[5]

Similar findings were reported by Kaygusuz et al. and Swami et al., who observed faster sensory and motor block onset when dexmedetomidine was added to bupivacaine in supraclavicular block.[6,7]

Duration of Sensory and Motor Block: The present study demonstrated a significantly prolonged duration of sensory (10.2 ± 1.3 hrs) and motor block (9.1 ± 1.1 hrs) in the dexmedetomidine group compared to dexamethasone. This prolongation may be attributed to peripheral vasoconstriction and direct inhibition of nerve action potential propagation by dexmedetomidine.[4]

Dexamethasone prolongs block duration mainly by reducing perineural inflammation and decreasing absorption of local anaesthetic from the injection site.[8] However, its effect is less pronounced compared to dexmedetomidine because it lacks direct neural action.

Cummings et al. and Parrington et al. showed that dexamethasone prolongs peripheral nerve block duration, but the magnitude of prolongation was smaller than that observed with α2-agonists.[9,10]

Postoperative Analgesia: Time to first rescue analgesia was significantly longer in the dexmedetomidine group (12.7 ± 1.4 hrs vs 9.8 ± 1.2 hrs), and total analgesic consumption was significantly lower. These findings correlate with studies by Esmaoglu et al. and Swami et al., which reported prolonged postoperative analgesia and reduced analgesic requirements when dexmedetomidine was used as an adjuvant.[7,11]

Dexmedetomidine produces analgesia via both peripheral and central mechanisms. Peripherally, it inhibits C-fiber transmission, and centrally it activates α2 receptors in the locus coeruleus and dorsal horn, suppressing pain signal transmission.[12] Dexamethasone provides prolonged analgesia primarily through suppression of inflammatory mediators such as prostaglandins and bradykinin but lacks central analgesic action.[8]

Sedation: Sedation scores were higher in the dexmedetomidine group at all time intervals. This is expected because dexmedetomidine produces cooperative sedation by acting on α2 receptors in the locus coeruleus without causing respiratory depression.[12] Similar sedation effects were reported by Swami et al. and Esmaoglu et al.[7,11]

Dexamethasone, being a corticosteroid, has no sedative properties; hence sedation scores remained low and stable in Group A.

Hemodynamic Effects: A higher incidence of bradycardia and hypotension was observed with dexmedetomidine. This is explained by decreased sympathetic outflow and enhanced vagal activity caused by α2-agonist action.[12] However, these events were mild and easily treated.

Other investigators have also reported similar haemodynamic changes with dexmedetomidine, confirming that while effective, it must be used cautiously in patients with cardiovascular compromise.[6,7]

Dexamethasone did not produce significant haemodynamic changes, indicating its cardiovascular safety profile.

Adverse Effects: The present study showed no serious complications such as pneumothorax, nerve injury, or block failure. Ultrasound guidance likely contributed to the safety and accuracy of the block technique. Minor adverse effects such as nausea were comparable in both groups, whereas bradycardia and hypotension occurred only in the dexmedetomidine group but remained manageable.

Overall Interpretation: The findings of this study support that dexmedetomidine provides superior block characteristics compared to dexamethasone when used as an adjuvant to bupivacaine in supraclavicular brachial plexus block. The improvement is likely due to its dual peripheral and central analgesic action, whereas dexamethasone acts primarily through anti-inflammatory and vasoconstrictive effects.

However, the choice of adjuvant should also consider patient comorbidities. In patients where sedation and mild haemodynamic changes are acceptable, dexmedetomidine is preferable. In patients with cardiovascular risk, dexamethasone may be safer.

Conclusion

Dexmedetomidine as an adjuvant to bupivacaine in supraclavicular brachial plexus block provided a faster onset and significantly prolonged sensory and motor block compared with dexamethasone. It also increased the duration of postoperative

analgesia and reduced the requirement for rescue analgesics. Although mild bradycardia and hypotension were observed more frequently with dexmedetomidine, they were manageable and clinically acceptable. Thus, dexmedetomidine appears to be a more effective adjuvant than dexamethasone for improving block quality and postoperative analgesia in upper limb surgeries.

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