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Research Article

Dissociation between Sensory and Motor Blockade Durations in Supraclavicular Brachial Plexus Regional Anesthesia: A Comparative Analysis of Perineural Dexmedetomidine versus Dexamethasone as Adjuvants to Ropivacaine

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ABSTRACT

Background: Supraclavicular brachial plexus block is widely used for anesthesia and postoperative analgesia in upper-limb surgeries because of its high success rate and excellent perioperative pain control. The addition of adjuvants to long-acting local anesthetics has become an effective strategy to improve block quality, prolong analgesia, and reduce postoperative opioid consumption. Among the various adjuvants, dexmedetomidine, a highly selective α_2-adrenergic agonist, and dexamethasone, a long-acting corticosteroid, have consistently demonstrated favourable effects on peripheral nerve blockade. However, direct comparisons have largely focused on overall block duration rather than the differential effects on sensory and motor blockade, an outcome that has important implications for postoperative recovery and early mobilization.[1-6]

The present study aimed to compare the efficacy of perineural dexmedetomidine and dexamethasone as adjuvants to ropivacaine in supraclavicular brachial plexus block, with particular emphasis on the dissociation between sensory and motor blockade durations.

Methods: The current study was conducted in ninety adult patients with American Society of Anesthesiologists (ASA) physical status I and II undergoing elective upper-limb surgery under supraclavicular brachial plexus block. Patients received supraclavicular brachial plexus block using 30 mL of 0.5% ropivacaine combined with either dexmedetomidine 50 µg or dexamethasone 8 mg (total volume 32 mL).

The primary outcome was the duration of sensory blockade. Secondary outcomes included onset of sensory blockade, onset and duration of motor blockade, duration of postoperative analgesiaand sensory–motor dissociation nanalysis**.**

Results: Baseline demographic characteristics, ASA physical status, body weightand duration of surgery were comparable between the two groups. Dexmedetomidine produced significantly earlier onset of both sensory and motor blockade compared with dexamethasone. Furthermore, sensory block duration, motor block duration, and postoperative analgesia were significantly prolonged in the dexmedetomidine group ($P<0.05$).[7-12]

Although both sensory and motor blockade were prolonged with dexmedetomidine, sensory blockade demonstrated a proportionately greater extension than motor blockade, suggesting a favorable sensory–motor dissociation profile. No serious neurological complications or major adverse events were observed.[13-15]

Conclusion: Both dexmedetomidine and dexamethasone are effective adjuvants to ropivacaine for supraclavicular brachial plexus block. Dexmedetomidine provides faster block onset, prolonged postoperative analgesia, and superior sensory blockade while maintaining an acceptable safety profile. The observed sensory–motor dissociation may represent an additional clinical advantage by extending analgesia without proportionately delaying motor recovery.

Keywords: Supraclavicular Brachial Plexus Block, Dexmedetomidine, Dexamethasone, Ropivacaine, Regional Anesthesia, Peripheral Nerve Block, Sensory Blockade, Motor Blockade, Postoperative Analgesia.

INTRODUCTION

Supraclavicular brachial plexus block is one of the most commonly performed peripheral nerve blocks for upper-limb surgeries because it provides rapid onset, dense anesthesia, excellent muscle relaxation, and effective postoperative analgesia.[1,2] Ropivacaine is widely preferred for this block owing to its favorable sensory selectivity and lower cardiotoxicity compared with bupivacaine.[3] However, the duration of analgesia following a single-shot brachial plexus block remains limited, often necessitating rescue analgesics during the postoperative period.[4]

To overcome this limitation, various adjuvants have been combined with local anesthetics to prolong analgesia and improve block characteristics. Among these, dexmedetomidine and dexamethasone have gained considerable attention because of their ability to prolong sensory blockade, enhance postoperative analgesia, and reduce analgesic requirements without significantly increasing adverse effects.[5–8] Dexmedetomidine is a highly selective α_2-adrenergic agonist that prolongs peripheral nerve blockade through inhibition of hyperpolarization-activated cation currents, modulation of nociceptive transmission, and local vasoconstriction.[9] Dexamethasone, a potent corticosteroid, prolongs analgesia by suppressing perineural inflammation, reducing ectopic neuronal discharge, and decreasing systemic absorption of local anesthetics.[10] Both agents have demonstrated favorable outcomes when used as adjuvants to long-acting local anesthetics in peripheral nerve blocks.[11–13]

Several studies have compared dexmedetomidine and dexamethasone as adjuvants in brachial plexus block, with both agents shown to improve block characteristics and prolong postoperative analgesia.[14,15] However, most investigations have focused on overall block duration and analgesia, while limited attention has been paid to the differential effects on sensory and motor blockade. From a clinical perspective, prolonged sensory analgesia with earlier motor recovery is desirable because it provides effective pain relief without unnecessarily delaying limb mobilization and functional recovery.

Therefore, the present study was undertaken to compare dexmedetomidine and dexamethasone as adjuvants to ropivacaine in supraclavicular brachial plexus block. The primary objective was to compare the onset and duration of sensory blockade. Secondary objectives included comparison of motor blockade, duration of postoperative analgesia, hemodynamic parameters, adverse effects, and the pattern of sensory–motor blockade dissociation between the two adjuvants.

MATERIALS AND METHODS

Study Design and Participants

The current study was conducted in the Department of Anaesthesiology at NRI Medical College and General Hospital .Written informed consent was obtained from all participants before enrolment. Ninety patients with American Society of Anesthesiologists (ASA) physical status I or II, aged 15–60 years, scheduled for elective upper-limb surgeries below the shoulder under supraclavicular brachial plexus block were included in the study.[16]

Patients with ASA physical status III or IV, infection at the injection site, peripheral neuropathy, first-, second-, or third-degree heart block, pregnancy, coagulopathy, or known hypersensitivity to local anaesthetic agents or study drugs were excluded.[17]

Randomization and Blinding

All patients underwent a detailed pre-anaesthetic evaluation including clinical examination and routine laboratory investigations. Standard fasting guidelines were followed.

After arrival in the operating room, intravenous access was secured and standard monitoring, including electrocardiography, non-invasive blood pressure measurement, pulse oximetry, and heart rate monitoring, was instituted. Baseline hemodynamic parameters were recorded before administration of the block.

With the patient in the supine position and the head turned to the contralateral side, supraclavicular brachial plexus block was performed under strict aseptic precautions .After eliciting the desired distal motor response, the study solution was injected incrementally following negative aspiration to avoid inadvertent intravascular injection. Patients received supraclavicular brachial plexus block using 30 mL of 0.5% ropivacaine combined with either dexmedetomidine 50 µg or dexamethasone 8 mg (total volume 32mL).

Outcome Measures

The primary outcome was the duration of sensory blockade.

Secondary Outcomes Included:

- Onset time of sensory block
- Onset time of motor block
- Duration of motor block
- Duration of postoperative analgesia Anaesthetic Technique

Sensory blockade was assessed using pinprick sensation in the distributions of the median, ulnar, radial, and musculocutaneous nerves at regular intervals until complete sensory loss was achieved. Motor blockade was evaluated using standard motor function assessment of the corresponding nerve territories. The onset of sensory and motor block was defined as the time from completion of drug injection to complete sensory loss and complete motor paralysis, respectively.

The duration of sensory blockade was defined as the interval between completion of drug administration and return of normal sensation. Duration of motor blockade was defined as the time from onset of complete motor block until complete recovery of motor function. Duration of analgesia was defined as the time from completion of the block to the first request for rescue analgesia.

Heart rate, mean arterial pressure, and peripheral oxygen saturation were recorded at predetermined intervals throughout the intraoperative period. Patients were observed for complications including bradycardia, hypotension, nausea, vomiting, respiratory depression, local anaesthetic toxicity, and neurological deficits.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using an appropriate statistical software package. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were expressed as frequencies and percentages.

RESULTS

Study Population

A total of 90 patients undergoing elective upper-limb surgery under supraclavicular brachial plexus block were enrolled in this study.

Demographic and Clinical Characteristics

The baseline demographic and clinical characteristics of the two study groups were comparable (Table 1). The mean age was 35.89 ± 9.90 years in Group DX and 35.22 ± 7.97 years in Group DM, with no statistically significant difference (P = 0.726). Similarly, the sex distribution was comparable between the groups, with males constituting 62.2% of patients in Group DX and 57.8% in Group DM (P = 0.830).

The mean body weight was 76.27 ± 6.57 kg in Group DX and 76.84 ± 7.41 kg in Group DM (P = 0.696). The distribution of ASA physical status was also similar, with 53.3% and 57.8% of patients classified as ASA I in Groups DX and DM, respectively (P = 0.671). The mean duration of surgery was 104.00 ± 9.38 minutes in Group DX and 105.67 ± 9.75 minutes in Group DM, without a statistically significant difference (P = 0.411). These findings indicate comparable baseline characteristics between the two groups.

Comparison of Block Characteristics

The onset of sensory blockade was significantly faster in the dexmedetomidine group than in the dexamethasone group. The mean onset time of sensory block was 10.02 ± 1.48 minutes in Group DM compared with 11.51 ± 1.89 minutes in Group DX, with a mean difference of 1.49 minutes (P < 0.001). Similarly, the onset of motor blockade occurred significantly earlier in Group DM (13.18 ± 1.27 minutes) than in Group DX (17.69 ± 2.01 minutes), corresponding to a mean difference of 4.51 minutes (P < 0.001).

Dexmedetomidine also significantly prolonged the duration of sensory blockade. The mean duration of sensory block was 12.61 ± 1.62 hours in Group DM compared with 10.46 ± 1.21 hours in Group DX, representing a mean prolongation of 2.15 hours (P < 0.001).

Likewise, the duration of motor blockade was significantly longer in Group DM (13.46 ± 1.24 hours) than in Group DX (10.18 ± 1.00 hours), with a mean difference of 3.28 hours (P < 0.001).

The duration of postoperative analgesia was also significantly prolonged with dexmedetomidine. Patients in Group DM experienced analgesia for 891.18 ± 43.96 minutes, whereas those in Group DX had analgesia lasting 699.89 ± 43.69 minutes, resulting in a mean difference of 191.29 minutes (P < 0.001).

Sensory-to-Motor Block Ratio

The sensory-to-motor block ratio was 1.03:1 in Group DX and 0.94:1 in Group DM. While dexmedetomidine significantly prolonged both sensory and motor blockade, the

relatively greater prolongation of motor blockade resulted in a lower sensory-to-motor ratio compared with dexamethasone

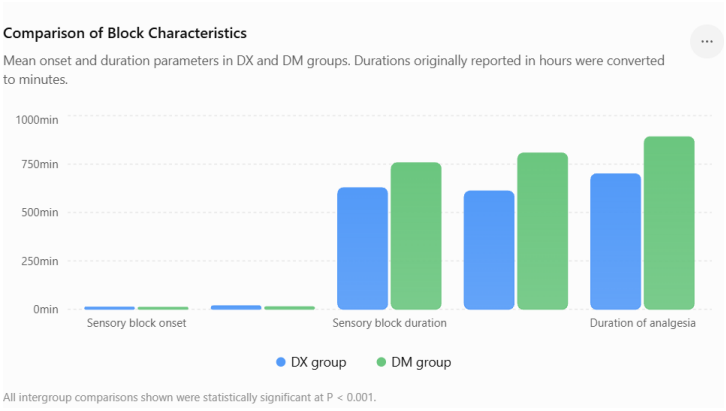
Table 1. Baseline Demographic and Clinical Characteristics of the Study Population

Characteristic	DX Group (n = 45)	DM Group (n = 45)	P value
Age (years)	35.89 ± 9.90	35.22 ± 7.97	0.726
Sex			0.830
• Male	28 (62.2%)	26 (57.8%)	
• Female	17 (37.8%)	19 (42.2%)	
Weight (kg)	76.27 ± 6.57	76.84 ± 7.41	0.696
ASA Physical Status			0.671
• ASA I	24 (53.3%)	26 (57.8%)	
• ASA II	21 (46.7%)	19 (42.2%)	
Duration of Surgery (min)	104.00 ± 9.38	105.67 ± 9.75	0.411

Table 2. Comparison of Block Characteristics between DX and DM Groups

Parameter	DX Group (n = 45)	DM Group (n = 45)	Mean Difference	P value
Onset of sensory block (min)	11.51 ± 1.89	10.02 ± 1.48	1.49	<0.001
Onset of motor block (min)	17.69 ± 2.01	13.18 ± 1.27	4.51	<0.001
Duration of sensory block (h)	10.46 ± 1.21	12.61 ± 1.62	2.15	<0.001
Duration of motor block (h)	10.18 ± 1.00	13.46 ± 1.24	3.28	<0.001
Duration of analgesia (min)	**699.89 ± 43.69**	**891.18 ± 43.96**	**191.29**	**<0.001**
Sensory : Motor block ratio	**1.03 : 1**	**0.94 : 1**	—	—

DISCUSSION



The present study compared dexmedetomidine and dexamethasone as perineural adjuvants to 0.5% ropivacaine for supraclavicular brachial plexus block in patients undergoing elective upper-limb surgery. The principal findings were that dexmedetomidine significantly hastened the onset of both sensory and motor blockade while also prolonging the duration of sensory blockade, motor blockade, and postoperative analgesia compared with dexamethasone. Baseline demographic and surgical characteristics were comparable between the two groups, indicating that the observed differences were attributable to the study interventions rather than confounding factors.[1–4]

The demographic profile of the study population was similar in both groups with respect to age, sex, body weight, ASA physical status, and duration of surgery. Similar demographic distributions have been reported in previous studies evaluating adjuvants for brachial plexus block, allowing

meaningful comparison of block characteristics between treatment groups.[5,6]

A notable finding of the present study was the significantly faster onset of sensory blockade with dexmedetomidine. Patients receiving dexmedetomidine achieved complete sensory blockade approximately 1.5 minutes earlier than those receiving dexamethasone. Although this difference appears modest, earlier onset of anesthesia can improve operating room efficiency and reduce waiting time before surgery. Likewise, the onset of motor blockade was significantly faster in the dexmedetomidine group, with a mean reduction of more than four minutes compared with dexamethasone. Similar findings have been reported in randomized studies and recent systematic reviews, which consistently demonstrated that dexmedetomidine accelerates the onset of peripheral nerve blockade when used as a perineural adjuvant.[1,3,7] The proposed mechanism involves activation of peripheral α_2-adrenoceptors, inhibition of hyperpolarization-activated cation currents, and reduction of nerve excitability, thereby enhancing the action of local anesthetics.[7,10]

The present study also demonstrated a significant prolongation of sensory blockade with dexmedetomidine. Patients in the dexmedetomidine group experienced sensory blockade for more than two hours longer than those receiving dexamethasone. Prolonged sensory blockade is clinically desirable because it extends postoperative pain relief and reduces the need for rescue analgesics during the early postoperative period. Previous systematic reviews and meta-analyses have similarly reported that dexmedetomidine consistently prolongs sensory block duration when added to long-acting local anesthetics for brachial plexus block.[1–4]

Motor blockade was also significantly prolonged in the dexmedetomidine group. Although prolonged motor block may delay complete recovery of limb function, no clinically significant adverse consequences related to delayed motor recovery were observed in the present study. The sensory-to-motor block ratio was 1.03:1 in the dexamethasone group and 0.94:1 in the dexmedetomidine group, indicating that dexmedetomidine prolonged both sensory and motor blockade, with a relatively greater effect on motor block. Therefore, while dexmedetomidine provided superior overall block duration, it did not demonstrate preferential prolongation of sensory blockade over motor blockade in this study. Similar prolongation of both sensory and motor blockade has been described in previous randomized trials evaluating dexmedetomidine as a perineural adjuvant.[3,6]

Postoperative analgesia was significantly prolonged with dexmedetomidine, extending the pain-free period by approximately 191 minutes compared with dexamethasone. This finding is clinically important because prolonged analgesia may reduce postoperative opioid requirements, improve patient comfort, and facilitate enhanced recovery after surgery. Recent network meta-analyses have identified dexmedetomidine as one of the most effective perineural adjuvants for prolonging analgesia following brachial plexus block.[1,3] The analgesic effect is likely mediated through inhibition of norepinephrine release, modulation of nociceptive transmission, and synergistic interaction with local anesthetics at the peripheral nerve.[7]

Both adjuvants have distinct pharmacological mechanisms. Dexmedetomidine acts primarily through selective α_2-adrenoceptor activation, producing analgesic, sympatholytic, and local vasoconstrictive effects that enhance and prolong peripheral nerve blockade. In contrast, dexamethasone prolongs block duration predominantly through anti-inflammatory effects, suppression of ectopic neuronal discharge, and reduction of local anesthetic absorption.[2,4] The multimodal mechanisms of dexmedetomidine may explain its superior performance across most block characteristics observed in the present study.[7]

The strengths of the present study include its comparable baseline characteristics, and standardized block technique. Multiple clinically relevant outcomes, including onset and duration of sensory and motor blockade and duration of postoperative analgesia, were systematically evaluated, providing a comprehensive comparison of the two adjuvants.

Certain limitations should be acknowledged. The study was conducted at a single center with a relatively modest sample size, which may limit the generalizability of the findings. Patient satisfaction, postoperative opioid consumption, and long-term neurological outcomes were not assessed. Additionally, no

ropivacaine-only control group was included; therefore, the absolute contribution of each adjuvant beyond ropivacaine alone could not be determined. Future multicenter studies with larger sample sizes, ultrasound-guided techniques, and assessment of patient-reported outcomes are warranted to further define the optimal adjuvant for supraclavicular brachial plexus block.[9]

In conclusion, the present study demonstrates that 50 µg of perineural dexmedetomidine provides faster onset of anesthesia, longer sensory and motor blockade, and significantly prolonged postoperative analgesia compared with 8 mg dexamethasone when used as an adjuvant to 0.5% ropivacaine for supraclavicular brachial plexus block. These findings support the use of dexmedetomidine when prolonged analgesia is the primary clinical objective, while recognizing its associated prolongation of motor blockade.[1,3,7]

CONCLUSION

The present study demonstrated that both dexmedetomidine and dexamethasone are effective perineural adjuvants to 0.5% ropivacaine for supraclavicular brachial plexus block in patients undergoing elective upper-limb surgery. However, dexmedetomidine provided a significantly faster onset of sensory and motor blockade, prolonged the duration of sensory and motor blockade, and significantly extended postoperative analgesia compared with dexamethasone. Both adjuvants exhibited an acceptable safety profile, with no major adverse events observed during the study period. Although dexmedetomidine was associated with a greater prolongation of motor blockade, its superior analgesic efficacy makes it a valuable adjuvant when prolonged postoperative pain relief is the primary clinical objective. Further multicenter studies with larger sample sizes and long-term follow-up are warranted to validate these findings and establish the optimal adjuvant for peripheral nerve blockade.

Declarations

Ethics Approval and Consent to Participate

The study was approved by the Institutional Ethics Committee of NRI Medical College and General Hospital. Written informed consent was obtained from all participants before enrollment.

Consent for Publication

Not applicable.

Availability of Data

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

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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