RESEARCH PAPER

Comparative Evaluation of Dexmedetomidine and Dexamethasone as Adjuvants to Ropivacaine in Ultrasound-Guided Interscalene Brachial Plexus Block for Upper Limb Surgery: A Randomized Controlled Trial

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ABSTRACT
Background and Aim: Ultrasound-guided interscalene brachial plexus block (ISBPB) provides effective anaesthesia and postoperative analgesia for shoulder and upper limb surgeries. However, the limited duration of analgesia following single-shot local anaesthetic administration has led to the use of various adjuvants. This study aimed to compare the efficacy of dexmedetomidine and dexamethasone as adjuvants to ropivacaine in improving block characteristics and postoperative analgesia following ultrasound-guided ISBPB**. Methods:** This prospective, randomized, double-blinded comparative study included 80 patients aged 18–60 years with ASA physical status I–II undergoing upper limb orthopedic surgeries under ultrasound-guided ISBPB. Patients were randomly allocated into two groups (n=40 each). Group A received 20 mL of 0.5% ropivacaine with dexamethasone 8 mg, while Group B received 20 mL of 0.5% ropivacaine with dexmedetomidine 0.5 µg/kg; the total volume was adjusted to 25 mL in both groups. The primary outcome was duration of effective analgesia. Secondary outcomes included onset and duration of sensory and motor blockade, haemodynamic changes, sedation, and adverse events. **Results:** Demographic characteristics and surgical duration were comparable between the two groups. Patients receiving dexmedetomidine demonstrated a significantly faster onset of sensory blockade compared with dexamethasone (11.50 ± 1.42 min vs. 12.71 ± 1.52 min; $P < 0.001$). The onset of complete motor blockade was also earlier in the dexmedetomidine group (15.28 ± 1.36 min vs. 17.83 ± 2.08 min; $P < 0.001$). Duration of sensory blockade was significantly longer with dexmedetomidine (687.37 ± 35.48 min vs. 603.83 ± 42.99 min; $P < 0.001$), as was duration of motor blockade (842.03 ± 45.79 min vs. 615.62 ± 31.25 min; $P < 0.001$). The duration of effective analgesia was significantly prolonged in the dexmedetomidine group compared with the dexamethasone group (1052.65 ± 7.48 min vs. 842.03 ± 45.79 min; $P < 0.001$). Dexmedetomidine was associated with greater reductions in heart rate and blood pressure; however, no clinically significant adverse events requiring intervention were observed. **Conclusion:** Dexmedetomidine as an adjuvant to ropivacaine provides superior block characteristics compared with dexamethasone in ultrasound-guided interscalene brachial plexus block, with faster onset and prolonged sensory, motor, and analgesic duration. Dexmedetomidine may be a valuable adjuvant for enhancing postoperative analgesia in patients undergoing upper limb surgeries, with appropriate monitoring for haemodynamic effects.
Keywords: Dexmedetomidine; Dexamethasone; Ropivacaine; Interscalene brachial plexus block; Postoperative analgesia.
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INTRODUCTION

Ultrasound-guided interscalene brachial plexus block (ISBPB) is widely used to provide perioperative anesthesia and postoperative analgesia for shoulder and proximal upper limb surgeries. Compared with general anesthesia alone, ISBPB offers superior pain control, reduces perioperative opioid requirements, facilitates early rehabilitation, and improves patient satisfaction.(1) The introduction of ultrasound guidance has further enhanced the safety and success of the technique by allowing real-time visualization of neural structures, needle placement, and local anesthetic spread.(2)

Ropivacaine is one of the preferred local anesthetics for interscalene block because of its favourable pharmacological profile, including prolonged sensory blockade, lower cardiotoxicity, and reduced motor blockade compared with bupivacaine. However, the analgesic duration of a

single-injection interscalene block is often limited and may not provide adequate pain relief during the first postoperative day, when pain following shoulder surgery is usually most severe.[3] Although continuous perineural catheter techniques can prolong analgesia, their routine use is restricted by technical complexity, catheter-related complications, increased cost, and the need for postoperative monitoring.[4]

To overcome these limitations, several adjuvants have been added to local anesthetics to enhance the quality and duration of peripheral nerve blocks.(5) Among these, dexmedetomidine and dexamethasone have gained considerable attention because of their ability to prolong postoperative analgesia without substantially increasing the incidence of serious adverse effects.[5] Dexmedetomidine, a highly selective α2adrenergic receptor agonist, enhances analgesia by reducing norepinephrine release and suppressing nociceptive transmission, resulting in prolonged sensory and motor blockade.[6] In contrast, dexamethasone, a long-acting corticosteroid, is believed to prolong nerve block through its anti-inflammatory effects and modulation of neuronal function, thereby extending postoperative analgesia.

Although both agents have demonstrated efficacy as adjuvants in brachial plexus blocks, studies comparing their relative effectiveness have yielded inconsistent results. Some investigations have reported a faster onset of blockade with dexmedetomidine, whereas others have suggested that dexamethasone provides a longer duration of postoperative analgesia with fewer hemodynamic effects. Moreover, evidence specifically evaluating these adjuvants in ultrasound-guided interscalene brachial plexus block remains limited.

Therefore, the present study was undertaken to compare dexmedetomidine and dexamethasone as adjuvants to 0.5% ropivacaine in ultrasound-guided interscalene brachial plexus block. The primary objective was to compare the onset and duration of sensory and motor blockade. Secondary objectives included comparison of postoperative analgesia, hemodynamic variables, sedation, rescue analgesic requirements, and the incidence of adverse events.

METHODS

This prospective, randomized, double-blind comparative study was conducted over a period of 18 months at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee (**30/IEC/Department of pharmacology/VDGMC).** The study adhered to the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment.

The primary objective was to compare the duration of postoperative analgesia produced by dexmedetomidine and dexamethasone when used as adjuvants to ropivacaine in ultrasound-guided interscalene brachial plexus block (ISBPB). Secondary objectives included comparison of sensory and motor block characteristics, hemodynamic parameters, rescue analgesic requirements, and the incidence of adverse events.

A total of 80 patients aged 18–60 years, belonging to the American Society of Anesthesiologist (ASA) physical status I or II, and scheduled for elective upper humeral surgeries under ultrasound-guided ISBPB were enrolled. Surgical procedures included proximal humerus fracture fixation, shoulder dislocation, greater tuberosity fixation, humeral shaft surgery, surgical neck fractures, implant removal, and revision plating.

Patients with pre-existing peripheral neuropathy, known hypersensitivity to study medications or local anesthetics, pregnancy, resting heart rate ≤60 beats/min, chronic corticosteroid therapy within the preceding six months, inability to comprehend the Visual Analog Scale (VAS), or contraindications to interscalene block such as coagulopathy, infection at the injection site, severe pulmonary disease, contralateral diaphragmatic paralysis, or systemic infection were excluded.

Participants were randomly allocated in a 1:1 ratio into two groups (n = 40 each) using a computer-generated randomization sequence prepared by an investigator not involved in patient recruitment or data collection. Allocation concealment was ensured using sequentially numbered, sealed opaque envelopes, which were opened immediately before the procedure. Both the patients and the investigator assessing block characteristics and postoperative outcomes were blinded to group allocation.

During the pre-anesthetic assessment, patients were instructed regarding the use of the 10-cm Visual Analog Scale (VAS), where 0 represented no pain and 10 represented the worst imaginable pain. Standard fasting guidelines were followed. On arrival in the operating room, an intravenous cannula was secured, and Ringer's lactate infusion was initiated. Standard monitoring, including electrocardiography, non-invasive blood pressure, pulse oximetry, and heart rate, was instituted, and baseline values were recorded. All patients received intravenous midazolam (0.03 mg/kg) and ondansetron (0.1 mg/kg) as premedication.

Ultrasound-guided interscalene brachial plexus block was performed using a high-frequency (8–13 MHz) linear transducer (Mindray DC N3, Shenzhen, China). With the patient in the supine position and the head turned contralaterally, the brachial plexus roots were identified between the anterior and middle scalene muscles using a distal-to-proximal scanning technique. After aseptic skin preparation, a 23-gauge, 1.5-inch needle was advanced using an in-plane approach under continuous ultrasound visualization, and the study solution was injected following negative aspiration.

Patients in **Group A** received 20 mL of 0.5% ropivacaine with dexamethasone 8 mg, diluted to a total volume of 25 mL. Patients in **Group B** received 20 mL of 0.5% ropivacaine combined with dexmedetomidine 0.5 µg/kg, with normal saline added to achieve a total volume of 25 mL.

Sensory blockade was assessed by pinprick testing over the C5–C7 dermatomes and graded as 0 = normal sensation, 1 = analgesia (dull sensation), and 2 = complete anesthesia (absence of sensation). Motor blockade was evaluated by shoulder abduction and graded as 0 = normal movement, 1 = reduced movement, and 2 = complete inability to abduct the shoulder. Sensory and motor block onset times were defined as the interval from completion of drug injection to Grade 1 blockade, while complete block onset was defined as the time to Grade 2 blockade.

The duration of analgesia was defined as the interval from achievement of sensory block until the first request for rescue analgesia or when the VAS score reached ≥4, whichever occurred first. Rescue analgesia was administered according to the institutional postoperative pain management protocol.

Hemodynamic variables, including heart rate, systolic and diastolic blood pressure, mean arterial pressure, oxygen saturation, and any episode of hypotension or bradycardia, were recorded at predefined intervals during surgery and throughout the postoperative observation period. Sedation was assessed postoperatively using the Ramsay Sedation Scale. Patients were also monitored for block-related or drug-related complications, including Horner's syndrome, hoarseness of voice, diaphragmatic paresis, vascular puncture, local anesthetic systemic toxicity, inadvertent epidural or intravascular injection, pneumothorax, nausea, vomiting, and other adverse events. Postoperative pain was evaluated using the VAS at regular intervals for 24 hours.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation and categorical variables as frequency and percentage. Intergroup comparisons of continuous variables were performed using the independent-samples *t* test or the Mann–Whitney *U* test, as appropriate. Categorical variables were compared using the Chi-square test or Fisher's exact test. Repeated measures analysis of variance (ANOVA) was used to compare serial hemodynamic parameters between the two groups. A *P* value <0.05 was considered statistically significant.

RESULTS

Eighty patients were randomized equally into Group A (ropivacaine + dexamethasone) and Group B (ropivacaine + dexmedetomidine). All patients completed the study and were included in the analysis. Baseline demographic and clinical characteristics were comparable between the groups, with no statistically significant differences (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of the Study Participants

Parameter	Group A (Ropivacaine + Dexamethasone) (Mean±SD)	Group B (Ropivacaine+ Dexmedetomidine) (Mean±SD)	P value
Age in years	45.8±4.94	47.65 ±5.33	0.11
Male(%) : Female(%)	26(65%):14(35%)	24(60%):16(40%)	0.64
ASA I (%) : ASA II (%)	23(57.5%): 17(42.5%)	25(62.5%): 15(37.5%)	0.64
Height in cms	155.45± 6.57	154.85± 6.86	0.69
Weight in kg	58.96 ±9.21	60.44 ±9.83	0.49
BMI kg/m2	24.43± 3.86	25.23 ±4.05	0.37
Duration of surgery (min)	109.7 ±12.3	112.6 ± 9.6	0.24

Data are presented as mean ± SD or n (%). Continuous variables were compared using the independent Student's t-test, and categorical variables using the Chi-square test. Statistical significance was set at P < 0.05. Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; SD, standard deviation

Patients in the dexmedetomidine group demonstrated a significantly faster onset of sensory and complete motor blockade compared with the dexamethasone group ($P < 0.001$). The duration of sensory blockade, motor blockade, and effective postoperative analgesia was also significantly longer in the dexmedetomidine group than in the dexamethasone group (all $P < 0.001$), indicating superior block characteristics and prolonged analgesic efficacy with dexmedetomidine as an adjuvant to ropivacaine.(Table 2)

Table 2

Parameter	Group A (Ropivacaine+ Dexamethasone) (Mean±SD)	Group B(Ropivacaine + Dexmedetomidine) (Mean±SD)	P value
Onset of sensory	12.71± 1.52	11.5 ±1.42	0.0001

block (min			
Duration of sensory blockade (min)	603.83 ±42.99	687.37± 35.48	0.0001
Onset of complete motor block (min)	17.83± 2.08	15.28 ±1.36	0.0001
Duration of motor blockade (min)	615.62± 31.25	842.03± 45.79	0.0001
Duration of effective analgesia (min	842.03 ±45.79	1052.65±7.48	0.0001

Data are presented as mean ± SD. Comparisons between groups were performed using the independent Student's t-test. A P value <0.05 was considered statistically significant. SD, standard deviation.

Figure 1. Comparison of Mean Heart Rate Between the Two Study Groups

Mean heart rate was comparable at baseline in both groups. Heart rate decreased postoperatively in both groups, with a greater reduction observed in the dexmedetomidine group, reaching its lowest value at 6 hours before gradually returning toward baseline. No clinically significant bradycardia requiring intervention was observed.(fig 1)

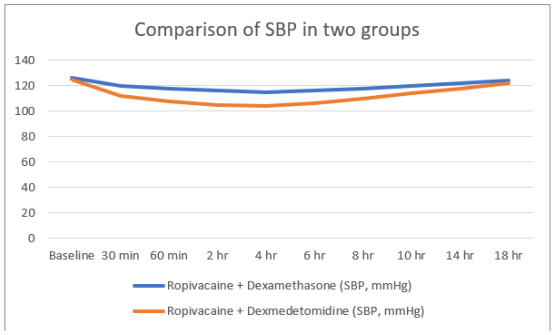

Figure 2. Comparison of Mean Systolic Blood Pressure Between the Two Study Groups

Baseline systolic blood pressure was comparable between the two groups. Systolic blood pressure decreased after block administration in both groups, with a more pronounced decline in the dexmedetomidine group during the early postoperative period. Thereafter, systolic blood pressure gradually increased toward baseline values in both groups, with no clinically significant hypotension requiring intervention.(fig2)

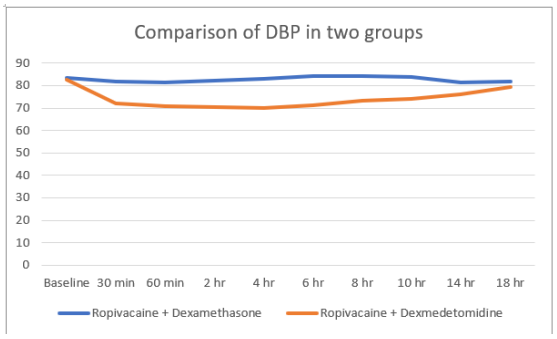

Figure 3. Comparison of Mean Diastolic Blood Pressure Between the Two Study Groups

Baseline diastolic blood pressure was comparable between the two groups. Diastolic blood pressure decreased following block administration in both groups, with a greater reduction observed in the dexmedetomidine group during the early postoperative period. The values gradually returned toward baseline over time, and no clinically significant hypotension requiring intervention was observed(fig3)

DISCUSSION

Brachial plexus block is an established regional anaesthetic technique for upper limb surgeries, providing effective surgical anaesthesia and prolonged postoperative analgesia while reducing opioid requirements. Bupivacaine was traditionally used for brachial plexus blockade; however, concerns regarding its cardiotoxic potential have led to the increased use of newer long-acting local anaesthetics such as ropivacaine and levobupivacaine. Although ropivacaine provides a favourable safety profile with prolonged sensory blockade and less cardiotoxicity, the duration of analgesia following a single-shot block remains limited. Therefore, several pharmacological adjuvants have been investigated to improve block quality and extend postoperative pain relief.

In the present randomized comparative study, we evaluated dexmedetomidine and dexamethasone as adjuvants to ropivacaine in ultrasound-guided interscalene brachial plexus block for upper limb surgeries. Our study demonstrated that the addition of dexmedetomidine resulted in a significantly faster onset of sensory and motor blockade, prolonged duration of sensory and motor blockade, and longer duration of effective analgesia compared with dexamethasone.

Dexmedetomidine, a potent and highly selective α2-adrenergic receptor agonist, has gained popularity as an adjuvant to local anaesthetics due to its analgesic and anaesthetic-sparing properties. It has approximately eight times greater affinity for α2 receptors compared with clonidine. Its mechanism of action involves activation of peripheral α2A receptors, inhibition of hyperpolarization-activated cation currents, suppression of compound action potentials, and modulation of nociceptive signal transmission.

These effects may enhance the intensity and duration of peripheral nerve blockade when combined with local anaesthetics.[7,8]

Dexamethasone, a potent glucocorticoid, prolongs the duration of peripheral nerve blocks through several mechanisms, including inhibition of inflammatory mediator release, suppression of potassium channel-mediated discharge of nociceptive C-fibres, and reduction of ectopic neuronal activity. Although dexamethasone is an established and effective adjuvant, its influence on the onset and duration of block may differ from that of dexmedetomidine.[5]

In our study, dexmedetomidine significantly reduced the onset time of sensory and complete motor blockade compared with dexamethasone. The duration of sensory blockade, motor blockade, and effective analgesia was also significantly prolonged in the dexmedetomidine group. The prolonged analgesic effect observed with dexmedetomidine may be attributed to its direct peripheral action on nerve fibres in addition to its central analgesic effects, resulting in delayed transmission of nociceptive impulses and enhanced local anaesthetic efficacy.

Our findings are supported by the study conducted by Hengfei Luan et al.,[9] who evaluated the effect of adding dexmedetomidine to ropivacaine for ultrasound-guided interscalene brachial plexus block in patients undergoing arthroscopic shoulder surgery. They reported that dexmedetomidine (0.5 μg/kg) significantly prolonged the duration of analgesia compared with ropivacaine alone (11.55 ± 2.41 h vs. 8.25 ± 1.76 h; $P < 0.05$). Additionally, dexmedetomidine was associated with lower postoperative VAS scores, delayed requirement for patient-controlled analgesia, reduced 24-hour opioid consumption, and improved patient satisfaction. These findings support the analgesic-enhancing effect of dexmedetomidine and are consistent with our observation of prolonged sensory and motor blockade and extended duration of effective analgesia in patients receiving dexmedetomidine as an adjuvant.[10]

The haemodynamic effects observed in our study were consistent with the known pharmacological profile of dexmedetomidine. Patients receiving dexmedetomidine showed a greater reduction in heart rate and blood pressure compared with those receiving dexamethasone, likely due to the sympatholytic effect of α2-adrenergic receptor stimulation. However, these changes remained within clinically acceptable ranges, and no patient required treatment for significant bradycardia or hypotension. Dexamethasone demonstrated minimal influence on perioperative haemodynamic variables, which is consistent with its mechanism of action.

Both adjuvants were well tolerated, and no major complications such as local anaesthetic systemic toxicity, neurological deficits, or severe drug-related adverse effects were observed. Although concerns regarding the perineural administration of adjuvants remain, previous clinical studies have not demonstrated significant long-term neurological complications when dexmedetomidine or dexamethasone is used at appropriate doses.

The findings of the present study suggest that dexmedetomidine provides superior block characteristics compared with dexamethasone when used as an adjuvant to ropivacaine for ultrasound-guided interscalene brachial plexus block. The faster onset of blockade and prolonged analgesic duration make dexmedetomidine a useful option for improving postoperative analgesia in upper limb surgeries. However, appropriate patient selection and perioperative monitoring are essential due to its potential haemodynamic effects.

This study has several limitations. First, it was conducted at a single centre with a relatively small sample size, which may limit the external validity of the findings. Second, only one dose of dexmedetomidine and dexamethasone was evaluated; therefore, the optimal dose and dose-response relationship could not be established.

CONCLUSION

Dexmedetomidine as an adjuvant to ropivacaine in ultrasound-guided interscalene brachial plexus block provides superior block characteristics compared with dexamethasone, with faster onset of sensory and motor blockade and significantly prolonged duration of sensory block, motor block, and postoperative analgesia. Although dexmedetomidine was associated with a greater reduction in heart rate and blood pressure, these changes remained clinically acceptable without significant adverse events. Therefore, dexmedetomidine may be considered an effective adjuvant for enhancing the quality and duration of analgesia in patients undergoing upper limb surgeries.

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