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Comparison of Three Different Doses of Dexmedetomidine as an Adjuvant to Bupivacaine in Supraclavicular Brachial Plexus Block for Upper Limb Orthopaedic Surgeries

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ABSTRACT

Background: Supraclavicular brachial plexus block is frequently used for upper limb orthopaedic surgeries because it provides dense intraoperative anaesthesia and useful postoperative analgesia. Dexmedetomidine, an alpha-2 adrenergic agonist, has been used as an adjuvant to local anaesthetics to improve block characteristics.
Objectives: To compare three doses of dexmedetomidine, 50 mcg, 75 mcg and 100 mcg, added to 0.25% bupivacaine for supraclavicular brachial plexus block and to identify the dose providing optimal onset and postoperative analgesia.
Methods: This randomized comparative study included 60 ASA physical status I and II patients undergoing upper limb orthopaedic surgeries under supraclavicular brachial plexus block. Patients were allocated into three equal groups. Group A received 30 mL of 0.25% bupivacaine with dexmedetomidine 50 mcg, Group B received dexmedetomidine 75 mcg, and Group C received dexmedetomidine 100 mcg. Sensory and motor block onset, sensory and motor block duration, and duration of analgesia were evaluated.
Results: Sensory block onset was shortest in Group C, followed by Group B and Group A. Motor block onset showed the same dose-related trend. Sensory block duration, motor block duration and duration of analgesia were longest in Group C. The mean duration of analgesia was 480.5 ± 81.3 minutes in Group A, 642 ± 76.5 minutes in Group B and 736 ± 67.1 minutes in Group C.
Conclusion: Dexmedetomidine 100 mcg added to 30 mL of 0.25% bupivacaine produced the most favourable block profile, with faster onset and prolonged postoperative analgesia without reported major side effects..

Keywords: *Dexmedetomidine; bupivacaine; supraclavicular brachial plexus block; upper limb surgery; postoperative analgesia; regional anaesthesia.*

INTRODUCTION

Supraclavicular brachial plexus block is a widely practiced regional anaesthetic technique for surgeries involving the upper limb below the shoulder[1]. At this level, the trunks and divisions of the brachial plexus are compactly arranged, allowing rapid and reliable anaesthetic spread when the block is performed correctly. The technique provides operative anaesthesia, reduces the need for general anaesthesia, decreases perioperative opioid exposure, and offers useful postoperative pain control[2]. For fracture fixation and other upper limb orthopaedic procedures, these advantages are clinically meaningful because early pain relief, stable intraoperative physiology and smoother recovery are essential components of perioperative care [3,4].

Bupivacaine remains a commonly used long-acting local anaesthetic in brachial plexus blockade. Although it provides a satisfactory duration of anaesthesia, the duration of postoperative analgesia after a single-shot block is limited. This limitation has encouraged the use of adjuvant drugs that intensify nerve blockade and extend analgesia without exposing patients to repeated systemic analgesics. Alpha-2 adrenergic agonists have received particular attention because of their

sedative, analgesic and sympatholytic properties. Clonidine has been studied for many years, while dexmedetomidine has emerged as a more selective alpha-2 agonist with a stronger pharmacological profile [5].

Clinical and experimental evidence suggests that dexmedetomidine can enhance the effect of local anaesthetics when used as a perineural adjuvant. Proposed mechanisms include hyperpolarisation of nerve fibres, inhibition of hyperpolarisation-activated cation currents, reduced release of norepinephrine and local vasoconstrictive effects that delay systemic absorption of local anaesthetic. Human studies have reported earlier onset, prolonged sensory and motor blockade, and longer time to rescue analgesia when dexmedetomidine is combined with bupivacaine, levobupivacaine or ropivacaine in brachial plexus blocks [5-8].

Despite these benefits, the ideal perineural dose remains unsettled. Lower doses can provide moderate prolongation of analgesia with less sedation, whereas higher doses can produce longer analgesia at the cost of bradycardia, hypotension or prolonged motor block in susceptible patients. Dose-comparison studies are therefore important, especially in resource-limited practice settings where landmark or paraesthesia-guided supraclavicular blocks are still performed. The present study was conducted to compare three different doses of dexmedetomidine, 50 mcg, 75 mcg and 100 mcg, as an adjuvant to 30 mL of 0.25% bupivacaine in supraclavicular brachial plexus block for upper limb orthopaedic surgeries. The primary objective was to compare sensory and motor block onset and duration among the three groups. The secondary objective was to compare duration of postoperative analgesia and identify the dose with the most favourable clinical profile.

METHODOLOGY

Study design and setting

This randomized comparative clinical study was conducted in the Department of Anaesthesia, Kamineni Institute of Medical Sciences, Narketpally, among patients scheduled for upper limb orthopaedic surgeries. The study was designed to evaluate dose-related differences in block characteristics after adding dexmedetomidine to bupivacaine for supraclavicular brachial plexus block.

Study population

Sixty adult patients belonging to ASA physical status I and II were included. Eligible patients were those posted for elective or scheduled upper limb orthopaedic procedures, including fracture humerus and fracture radius and ulna surgeries, under supraclavicular brachial plexus block. Patients were assessed preoperatively for clinical status and anaesthetic fitness. Patients with contraindications to peripheral nerve block, local infection at the puncture site, coagulopathy, allergy to study drugs, severe systemic disease, pre-existing neurological deficit in the involved limb, pregnancy or refusal for regional anaesthesia were excluded.

Group allocation and intervention

Patients were randomly allocated into three equal groups of 20 each. Group A received 30 mL of 0.25% bupivacaine with dexmedetomidine 50 mcg. Group B received 30 mL of 0.25% bupivacaine with dexmedetomidine 75 mcg. Group C received 30 mL of 0.25% bupivacaine with dexmedetomidine 100 mcg. The total volume of local anaesthetic solution was kept uniform across groups to maintain comparability. The selected dose range was based on earlier clinical studies using dexmedetomidine as a brachial plexus block adjuvant and on the need to identify a clinically effective dose with acceptable tolerability [4,8-10].

Block technique and monitoring

After arrival in the operating room, baseline pulse rate, non-invasive blood pressure and oxygen saturation were recorded. Intravenous access was secured and standard monitoring was continued throughout the intraoperative period and postoperatively. Supraclavicular brachial plexus block was performed using the paraesthesia technique under aseptic precautions by an experienced anaesthesia provider. After negative aspiration, the prepared drug solution was injected incrementally. Patients were observed for block adequacy, haemodynamic changes, oxygen saturation, sedation and complications. Sedation score and clinical adverse events were monitored during the perioperative period.

Outcome assessment

Sensory block onset was assessed using response to pinprick in the relevant nerve distribution. Motor block onset was assessed by loss or reduction of motor power in the blocked limb. Duration of sensory block was defined as the time from completion of drug injection to recovery of normal sensation. Duration of motor block was defined as the time from completion of injection to recovery of motor function. Duration of analgesia was recorded as the interval from block administration to the first requirement of rescue analgesia or clinically relevant pain recurrence. These definitions follow common brachial plexus block assessment methods [5].

Statistical analysis and ethics

Data were summarized as frequency and percentage for categorical variables and as mean ± standard deviation for continuous variables. The three study groups were compared descriptively for onset of sensory and motor block, duration of sensory and motor block and duration of analgesia. One-way analysis of variance is appropriate for normally distributed continuous outcomes across three independent groups. Patient confidentiality was maintained and no personal identifiers were included in the analysis or manuscript.

RESULTS

A total of 60 patients undergoing upper limb orthopaedic surgeries were included and equally allocated into three study groups. Each group contained 20 patients and received 30 mL of 0.25% bupivacaine with one of the three dexmedetomidine doses. The distribution of groups and drug intervention is presented in Table 1.

Table 1. Distribution of study groups and drug intervention

Study group	Sample size	Local anaesthetic	Dexmedetomidine dose	Block technique
Group A	20	30 mL of 0.25% bupivacaine	50 mcg	Supraclavicular brachial plexus block
Group B	20	30 mL of 0.25% bupivacaine	75 mcg	Supraclavicular brachial plexus block
Group C	20	30 mL of 0.25% bupivacaine	100 mcg	Supraclavicular brachial plexus block
Total	60	—	—	—

Sensory and motor onset times showed a clear dose-related reduction with increasing dexmedetomidine dose. Group C, which received 100 mcg dexmedetomidine, had the fastest mean sensory onset and the fastest mean motor onset. Group A, which received 50 mcg, showed the slowest onset for both sensory and motor blockade. These findings are shown in Table 2.

Table 2. Comparison of sensory and motor block onset among the three groups

Parameter	Group A, 50 mcg	Group B, 75 mcg	Group C, 100 mcg	Interpretation
Sensory block onset, minutes	16.3 ± 3.31	12.4 ± 2.5	7.35 ± 1.0	Fastest sensory onset was observed in Group C
Motor block onset, minutes	20.4 ± 2.7	16.5 ± 2.89	12.15 ± 2.81	Fastest motor onset was observed in Group C

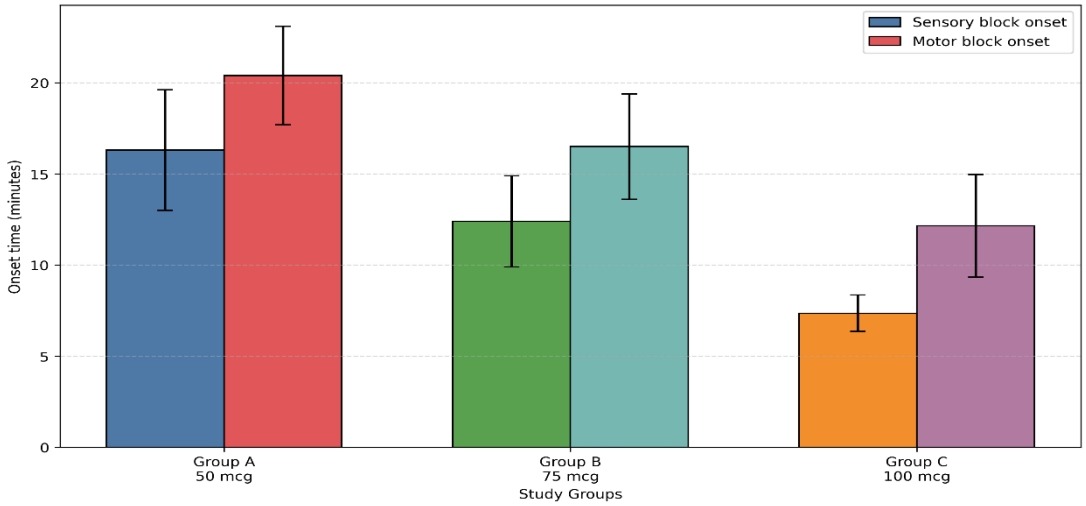

Figure 1: Comparison of sensory and motor block onset among the three groups

The duration of sensory and motor blockade increased as the dose of dexmedetomidine increased. Group C had the longest mean sensory block duration and the longest mean motor block duration, followed by Group B and Group A. The difference in duration across the three groups indicates a consistent dose-response pattern. The detailed comparison is provided in Table 3.

Table 3. Comparison of sensory and motor block duration among the three groups

Parameter	Group A, 50 mcg	Group B, 75 mcg	Group C, 100 mcg	Interpretation
Sensory block duration, minutes	423 ± 69.8	625.5 ± 72.7	722.5 ± 55.1	Longest sensory block duration was observed in Group C
Motor block duration, minutes	426.5 ± 81.8	604 ± 98.6	704 ± 41.4	Longest motor block duration was observed in Group C

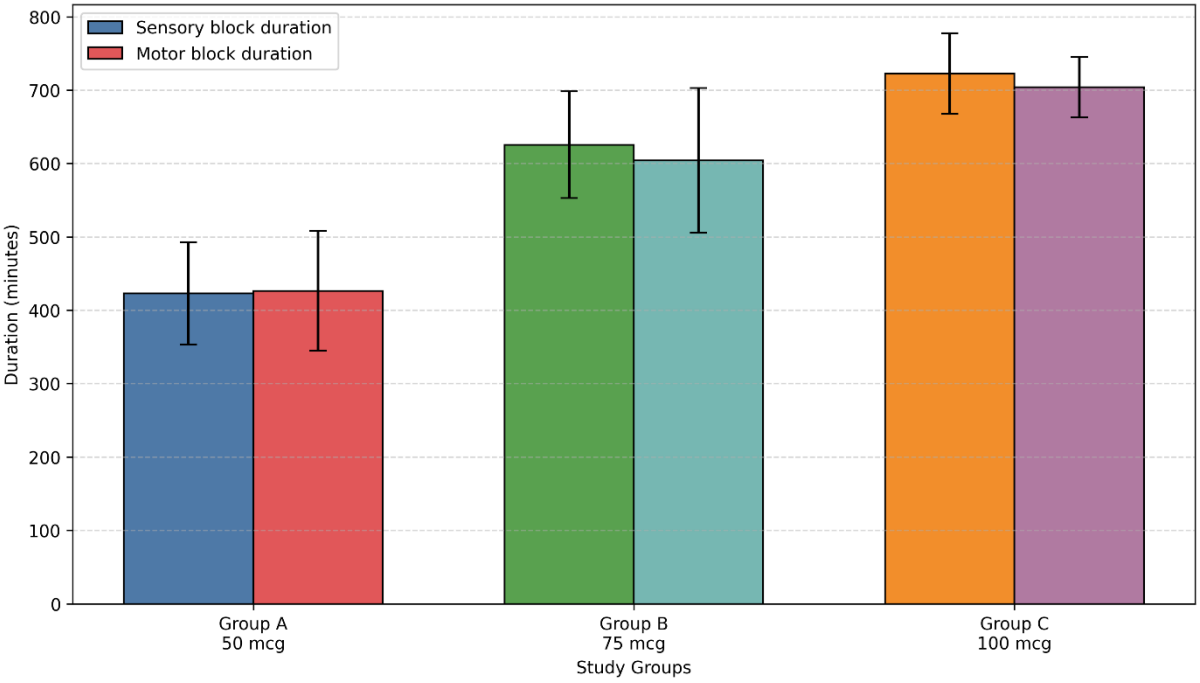

Figure 2: Comparison of sensory and motor block duration among the three groups

The duration of postoperative analgesia also followed the same ascending pattern. Analgesia was shortest in Group A, intermediate in Group B and longest in Group C. The mean duration of analgesia was 480.5 ± 81.3 minutes in Group A, 642 ± 76.5 minutes in Group B and 736 ± 67.1 minutes in Group C. The overall ranking of analgesic effect is summarized in Table 4.

Table 4. Comparison of duration of analgesia among the three groups

Parameter	Group A, 50 mcg	Group B, 75 mcg	Group C, 100 mcg	Dose-response pattern
Duration of analgesia, minutes	480.5 ± 81.3	642 ± 76.5	736 ± 67.1	Analgesia duration increased with increasing dexmedetomidine dose
Overall ranking	Shortest	Intermediate	Longest	Group C showed the most prolonged postoperative analgesia

Overall, dexmedetomidine 100 mcg produced the most favourable clinical profile among the three tested doses. This group achieved the fastest sensory and motor onset, the longest sensory and motor block duration and the most prolonged postoperative analgesia. No major side effects were reported in the available dataset.

DISCUSSION

The present study demonstrated a dose-related improvement in supraclavicular brachial plexus block characteristics when dexmedetomidine was added to 30 mL of 0.25% bupivacaine. Patients receiving 100 mcg dexmedetomidine had the fastest onset of sensory and motor blockade and the longest duration of postoperative analgesia. The 75 mcg dose produced intermediate results, while the 50 mcg dose showed the least prolongation of block characteristics. These findings suggest that the 100 mcg dose provided the most effective balance between rapid onset and sustained analgesia in this study population.

The observed shortening of onset time is consistent with earlier supraclavicular block studies. Agarwal et al. reported that dexmedetomidine added to bupivacaine significantly reduced sensory and motor onset time and prolonged block duration [9]. Similarly, Sane et al. found that dexmedetomidine with bupivacaine reduced sensory and motor onset and improved postoperative pain scores after upper extremity surgery [5]. The present data follow the same direction, with mean sensory onset decreasing from 16.3 minutes in the 50 mcg group to 7.35 minutes in the 100 mcg group, and motor onset decreasing from 20.4 minutes to 12.15 minutes.

Prolongation of sensory and motor block is one of the most reproducible benefits of dexmedetomidine as a local anaesthetic adjuvant. Swami et al. and Tripathi et al. showed that dexmedetomidine prolonged block duration and time to rescue

analgesia when compared with clonidine [2,3]. Nallam et al. specifically compared 50 mcg and 100 mcg doses with levobupivacaine and reported longer analgesia with 100 mcg [4]. The current study adds a 75 mcg middle-dose arm and demonstrates a graded response across 50, 75 and 100 mcg, supporting a biologically plausible dose-response relationship. The mechanism of this effect is probably multifactorial. Experimental work indicates that dexmedetomidine enhances local anaesthetic action by direct peripheral nerve effects, including hyperpolarisation-activated cation current blockade and suppression of compound action potentials [12-14]. Systematic reviews and meta-analyses have also concluded that perineural dexmedetomidine prolongs sensory block, motor block and analgesia in brachial plexus and other peripheral nerve blocks [7-11]. These effects are clinically useful after orthopaedic surgery because prolonged analgesia reduces early postoperative pain and delays rescue analgesic requirement.

Safety remains an important consideration. Larger reviews have reported increased risks of bradycardia and hypotension with dexmedetomidine, particularly at higher doses or with systemic absorption [10,11]. The present dataset did not show major side effects, but monitoring of pulse rate, blood pressure, oxygen saturation and sedation is essential whenever dexmedetomidine is used. Prolonged motor block should also be considered when early limb mobilisation or neurological assessment is required. Within the limits of the present data, 100 mcg dexmedetomidine appeared to be the optimal tested dose for prolonging postoperative analgesia in supraclavicular brachial plexus block.

Limitations

This study had a modest sample size and was conducted at a single centre. The available dataset did not include detailed demographic comparability, p values, sedation scores or complete adverse-event frequencies. Block was performed using the paraesthesia technique rather than ultrasound guidance. Long-term neurological follow-up, patient satisfaction scores and rescue analgesic consumption were not available for expanded safety assessment and external validity.

CONCLUSION

Dexmedetomidine used as an adjuvant to 30 mL of 0.25% bupivacaine improved supraclavicular brachial plexus block characteristics in a dose-related manner. Among the three tested doses, 100 mcg produced the fastest sensory and motor onset, the longest sensory and motor block duration, and the most prolonged postoperative analgesia. The 75 mcg dose showed intermediate efficacy, while 50 mcg produced the shortest analgesic duration. Based on the available results, dexmedetomidine 100 mcg appears to be the optimal tested dose for upper limb orthopaedic surgeries under supraclavicular block, provided haemodynamic and sedation monitoring are performed carefully during the perioperative period in routine clinical practice for every patient consistently in anaesthesia practice.

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