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Original Article

Comparative Evaluation of Dexmedetomidine and Dexamethasone as Adjuvants to Ropivacaine in Supraclavicular Brachial Plexus Block: A Prospective Randomized Study

Corresponding Author:
Dr Shazia Banoo

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Dr Mushtaq Ahmad Rather[1], Dr Syed Faisal Andrabi[2], Dr Shazia Banoo[3]

[1]Assistant Professor, Department of Anesthesia Critical Care Pain and Palliative Medicine, Government Medical College Srinagar, Jammu and Kashmir, India

[2]Assistant Professor, Department of Anesthesia Critical Care Pain and Palliative Medicine, Government Medical College Srinagar, Jammu and Kashmir, India

[3]Senior Resident, Department of Anesthesia and critical care, Government Medical College Doda, Jammu and Kashmir, India.

ABSTRACT

Background: Supraclavicular brachial plexus block is widely used for upper limb surgeries. Adjuvants such as dexmedetomidine and dexamethasone are commonly added to local anesthetics to enhance block characteristics and prolong postoperative analgesia. **Aim**: This study was conducted to compare the efficacy and safety of dexmedetomidine and dexamethasone as adjuvants to ropivacaine in supraclavicular brachial plexus block. **Methods**: This prospective observational study was conducted in the Department of Anaesthesiology, Government Medical College, Srinagar. A total of 120 patients undergoing elective upper limb surgeries were randomly allocated into two equal groups (n=60 each). Group DEX received ropivacaine with dexmedetomidine, while Group DXM received ropivacaine with dexamethasone. Onset and duration of sensory and motor block, duration of postoperative analgesia, hemodynamic parameters, sedation score, rescue analgesic requirement, and adverse effects were recorded and analyzed. Results: The onset of sensory block was significantly faster in Group DEX (8.2 ± 1.4 min) compared to Group DXM (10.1 ± 1.8 min) ($p<0.001$). Similarly, onset of motor block was earlier in Group DEX (12.4 ± 2.1 min vs 14.6 ± 2.3 min; $p<0.001$). However, the duration of sensory block was significantly longer in Group DXM (912.6 ± 102.4 min) compared to Group DEX (742.5 ± 85.3 min) ($p<0.001$). The duration of postoperative analgesia was also prolonged in Group DXM (1085.4 ± 120.7 min vs 820.6 ± 96.3 min; $p<0.001$). Sedation scores were higher in the dexmedetomidine group (3.2 ± 0.5 vs 2.1 ± 0.4; $p<0.001$). Bradycardia was more frequent in Group DEX (10% vs 1.7%; $p=0.04$). Hemodynamic parameters showed greater reductions in heart rate and mean arterial pressure in the dexmedetomidine group. **Conclusion**: Dexmedetomidine provides a faster onset of sensory and motor blockade with better intraoperative sedation, whereas dexamethasone significantly prolongs the duration of sensory block and postoperative analgesia with greater hemodynamic stability. Dexamethasone may be preferred when prolonged postoperative analgesia is desired, while dexmedetomidine offers advantages in rapid onset and intraoperative sedation.

Keywords: Supraclavicular brachial plexus block; Dexmedetomidine; Dexamethasone; Ropivacaine; Postoperative analgesia; Regional anesthesia; Adjuvants.

INTRODUCTION

Regional anesthesia has emerged as an essential component of modern anesthetic practice due to its ability to provide effective intraoperative anesthesia and prolonged postoperative analgesia while minimizing systemic drug exposure. Compared with general anesthesia, regional techniques offer several advantages including attenuation of surgical stress response, reduced opioid consumption, improved hemodynamic stability, early mobilization, and enhanced patient satisfaction [1]. Peripheral nerve blocks, in particular, provide site-specific anesthesia with minimal physiological disturbance and are widely used for surgical procedures involving the extremities.

Brachial plexus block is commonly employed for upper limb surgeries as it provides reliable anesthesia and effective postoperative analgesia for procedures involving the arm, forearm, and hand [1]. Various approaches to brachial plexus blockade have been described, including interscalene, supraclavicular, infraclavicular, and axillary approaches. Among these, the supraclavicular approach is considered one of the most effective techniques for anesthesia of the upper extremity distal to the shoulder because the brachial plexus trunks are compactly arranged at this level, resulting in rapid onset, dense blockade, and high success rates [1,2]. Because of these advantages, supraclavicular brachial plexus block has become a preferred technique for upper limb orthopedic and soft tissue surgeries.

Local anesthetic agents form the cornerstone of peripheral nerve blockade. Ropivacaine, a long-acting amide local anesthetic, is widely used in regional anesthesia because of its favorable pharmacological profile, including lower cardiotoxicity and neurotoxicity compared with bupivacaine, along with a greater degree of sensory–motor differentiation [3]. Despite these advantages, single-shot peripheral nerve blocks using local anesthetics alone may provide limited duration of postoperative analgesia, leading to early onset of postoperative pain and increased requirement for rescue analgesics. Therefore, various pharmacological adjuvants have been investigated to enhance block characteristics, improve analgesic efficacy, and prolong duration of action of local anesthetics [4].

Several agents including opioids, epinephrine, corticosteroids, and α2-adrenergic agonists have been evaluated as adjuvants in peripheral nerve blocks. These agents act through different mechanisms such as vasoconstriction, anti-inflammatory effects, and modulation of nociceptive transmission to enhance block quality, shorten onset time, and prolong duration of sensory and motor blockade [4]. Among these adjuvants, dexmedetomidine and dexamethasone have gained considerable clinical interest because of their effectiveness in prolonging analgesia and improving block characteristics.

Dexmedetomidine is a highly selective α2-adrenergic receptor agonist that produces sedation, analgesia, and sympatholysis without significant respiratory depression [5]. When used as an adjuvant to local anesthetics in peripheral nerve blocks, dexmedetomidine enhances block characteristics by inhibiting norepinephrine release, causing hyperpolarization of nerve membranes, and suppressing propagation of action potentials along nerve fibers [6]. Experimental and clinical studies have demonstrated that perineural administration of dexmedetomidine significantly prolongs the duration of sensory and motor blockade and enhances postoperative analgesia when combined with local anesthetics [6,7]. However, due to its sympatholytic properties, dexmedetomidine may also be associated with hemodynamic effects such as bradycardia and hypotension [5].

Dexamethasone, a long-acting synthetic glucocorticoid, is another widely used adjuvant in peripheral nerve blocks. Its mechanism of action involves suppression of inflammatory mediators, reduction of perineural edema, inhibition of ectopic neuronal discharge, and modulation of nociceptive transmission [8]. Clinical studies have demonstrated that dexamethasone significantly prolongs the duration of sensory and motor blockade and improves postoperative analgesia when added to local anesthetics in brachial plexus block [8,9]. Furthermore, systematic reviews and meta-analyses have confirmed that dexamethasone effectively prolongs analgesic duration in peripheral nerve blocks without significant adverse effects [10].

Although both dexmedetomidine and dexamethasone have individually demonstrated beneficial effects as adjuvants in regional anesthesia, their comparative efficacy in supraclavicular brachial plexus block remains an area of ongoing research. Previous studies have shown variable findings regarding onset of blockade, duration of analgesia, sedation profile, and hemodynamic effects associated with these agents [4–10]. A direct comparison of these adjuvants is therefore necessary to determine the optimal agent for improving block characteristics, prolonging postoperative analgesia, and minimizing adverse effects.

In view of the increasing use of adjuvants in regional anesthesia and the need to identify the most effective agent for improving clinical outcomes, the present study was undertaken to compare dexmedetomidine and dexamethasone as adjuvants to ropivacaine in supraclavicular brachial plexus block with respect to onset and duration of sensory and motor block, duration of postoperative analgesia, hemodynamic changes, sedation profile, and adverse effects.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anaesthesiology, Government Medical College, Srinagar, after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. The study included 120 patients of either gender, aged between 18 and 60 years, belonging to American Society of Anesthesiologists (ASA) physical status I and II, who were scheduled to undergo elective upper limb surgeries under supraclavicular brachial plexus block.

Patients with known hypersensitivity to study drugs, bleeding disorders, infection at the injection site, significant cardiovascular, hepatic or renal disease, uncontrolled diabetes mellitus, chronic opioid use, pregnancy, or those refusing regional anesthesia were excluded from the study.

The selected patients were randomly allocated into two equal groups of 60 patients each using a computer-generated randomization method. Group DEX received ropivacaine with dexmedetomidine, while Group DXM received ropivacaine with dexamethasone. The study drug solution was prepared under aseptic precautions.

On arrival in the operating room, standard monitoring including electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and heart rate monitoring was instituted. Baseline hemodynamic parameters were recorded before administration of the block.

Under strict aseptic precautions, supraclavicular brachial plexus block was performed using the standard landmark-based technique with the patient in supine position and head turned to the opposite side. After negative aspiration for blood and air, the study drug solution was administered slowly. All patients received the same concentration and volume of ropivacaine, with the respective adjuvant added according to group allocation.

Following administration of the block, sensory block was assessed using pinprick method in the dermatomal distribution of the radial, ulnar, median, and musculocutaneous nerves at regular intervals. Onset of sensory block was defined as the time from completion of injection to complete loss of pinprick sensation. Duration of sensory block was defined as the time from onset to return of normal sensation.

Motor block was assessed using Modified Bromage Scale for upper limb. Onset of motor block was defined as the time from injection to complete motor paralysis, and duration of motor block was defined as the time from onset to complete recovery of motor function.

Hemodynamic parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were recorded at baseline, 3, 5, 10, 15, 30, and 45 minutes after block administration and thereafter at regular intervals until completion of surgery.

Sedation was assessed using the Ramsay Sedation Scale at predetermined intervals. Postoperative pain was assessed using the Visual Analogue Scale (VAS). Duration of postoperative analgesia was defined as the time interval between administration of the block and the first request for rescue analgesia. Rescue analgesia was administered when VAS score was ≥ 4. The number of patients requiring rescue analgesia and total number of doses were recorded.

Adverse effects such as bradycardia, hypotension, nausea, vomiting, hypoxia, or any other complications were noted. Bradycardia was defined as heart rate less than 60 beats per minute and was treated with intravenous atropine. Hypotension was defined as a decrease in mean arterial pressure more than 20% from baseline and was treated with intravenous fluids and vasopressors as required.

All collected data were compiled and statistically analyzed. Continuous variables were expressed as mean ± standard deviation and compared using Student's unpaired t-test. Categorical variables were expressed as numbers and percentages and analyzed using Chi-square test. A p-value less than 0.05 were considered statistically significant.

RESULTS

Demographic variables were compared to ensure baseline comparability between groups.

There was no statistically significant difference between groups in demographic variables ($p>0.05$), indicating comparable baseline characteristics.

Table 1: Demographic Profile

Parameter	Group DEX (n=60)	Group DXM (n=60)	p-value
Patients enrolled	60	60	—
Completed study	60	60	—

Excluded	0	0	—
Age (years)	38.4 ± 10.2	39.1 ± 9.8	0.72
Gender (M/F)	36/24	34/26	0.71
Weight (kg)	66.8 ± 8.3	67.5 ± 7.9	0.63
Height (cm)	165.4 ± 7.2	166.1 ± 6.8	0.58
BMI (kg/m²)	24.4 ± 2.5	24.6 ± 2.7	0.69
ASA Grade (I/II)	38/22	40/20	0.70

Surgical characteristics were comparable between groups.

Table 2: Surgical Characteristics

Parameter	Group DEX	Group DXM	p-value
Duration of surgery (min)	92.6 ± 18.4	94.2 ± 17.8	0.64
Forearm surgeries n (%)	28 (46.7%)	30 (50%)	0.71
Hand surgeries n (%)	32 (53.3%)	30 (50%)	

The onset time of sensory and motor block was assessed in both groups following administration of supraclavicular brachial plexus block. Onset of sensory block was defined as the time interval between completion of drug injection and complete loss of pinprick sensation in the distribution of the brachial plexus, whereas onset of motor block was defined as the time from drug administration to complete motor paralysis of the limb. The onset time of both sensory and motor block was compared between the two groups. The onset of sensory block was significantly faster in Group DEX compared to Group DXM ($p<0.001$). Similarly, the onset of motor block was significantly earlier in the dexmedetomidine group than in the dexamethasone group [Table 3].

Table 3: Comparison of Onset of Sensory and Motor Block

Parameter	Group DEX (n=60) Mean ± SD (min)	Group DXM (n=60) Mean ± SD (min)	p-value
Onset of Sensory Block (min)	8.2 ± 1.4	10.1 ± 1.8	<0.001
Onset of Motor Block (min)	12.4 ± 2.1	14.6 ± 2.3	<0.001

The duration of sensory block was significantly longer in Group DXM compared to Group DEX ($p<0.001$). Similarly, the duration of motor block was significantly prolonged in the dexamethasone group compared to the dexmedetomidine group [Table4].

Table 4: Comparison of Duration of Sensory and Motor Block

Parameter	Group DEX (n=60) Mean ± SD (min)	Group DXM (n=60) Mean ± SD (min)	p-value
Duration of Sensory Block (min)	742.5 ± 85.3	912.6 ± 102.4	<0.001
Duration of Motor Block (min)	680.4 ± 76.2	810.3 ± 90.5	<0.001

Secondary outcome parameters including duration of postoperative analgesia, sedation score, and rescue analgesic requirement were compared between the two groups. Duration of postoperative analgesia was defined as the time interval between administration of the block and the first request for rescue analgesia. Sedation was assessed using the Ramsay Sedation Scale at predefined intervals. Rescue analgesic requirement was recorded as the number of patients requiring analgesia and total number of doses administered. The duration of postoperative analgesia was significantly prolonged in Group DXM compared to Group DEX ($p<0.001$). Sedation scores were significantly higher in the dexmedetomidine group ($p<0.001$). Rescue analgesic requirement was significantly lower in Group DXM in terms of both number of patients requiring analgesia and total doses administered [Table 5].

Table 5: Comparison of Secondary Outcome Parameters

Parameter	Group DEX (n=60)	Group DXM (n=60)	p-value
Duration of Postoperative Analgesia (min)	820.6 ± 96.3	1085.4 ± 120.7	<0.001
Sedation Score (Mean at 20 min)	3.2 ± 0.5	2.1 ± 0.4	<0.001
Patients requiring Rescue Analgesia [n (%)]	18 (30%)	8 (13.3%)	0.03
Total Rescue Doses (Mean ± SD)	1.4 ± 0.6	0.8 ± 0.4	0.01

Bradycardia was more common in dexmedetomidine group [Fig 1].

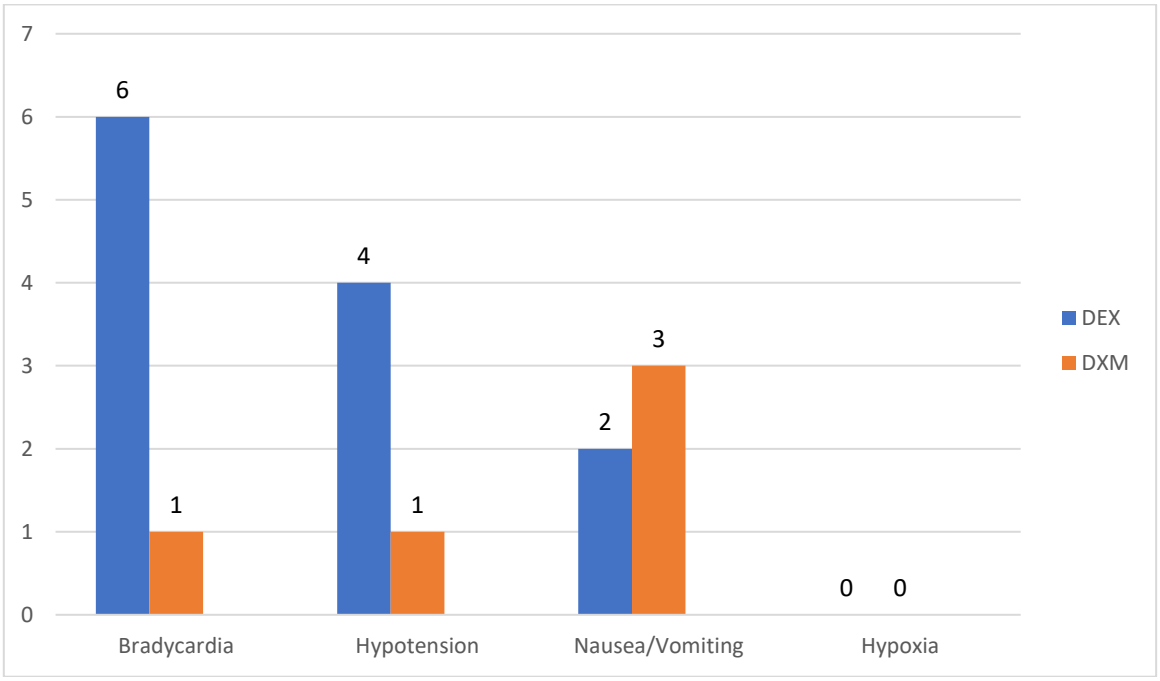
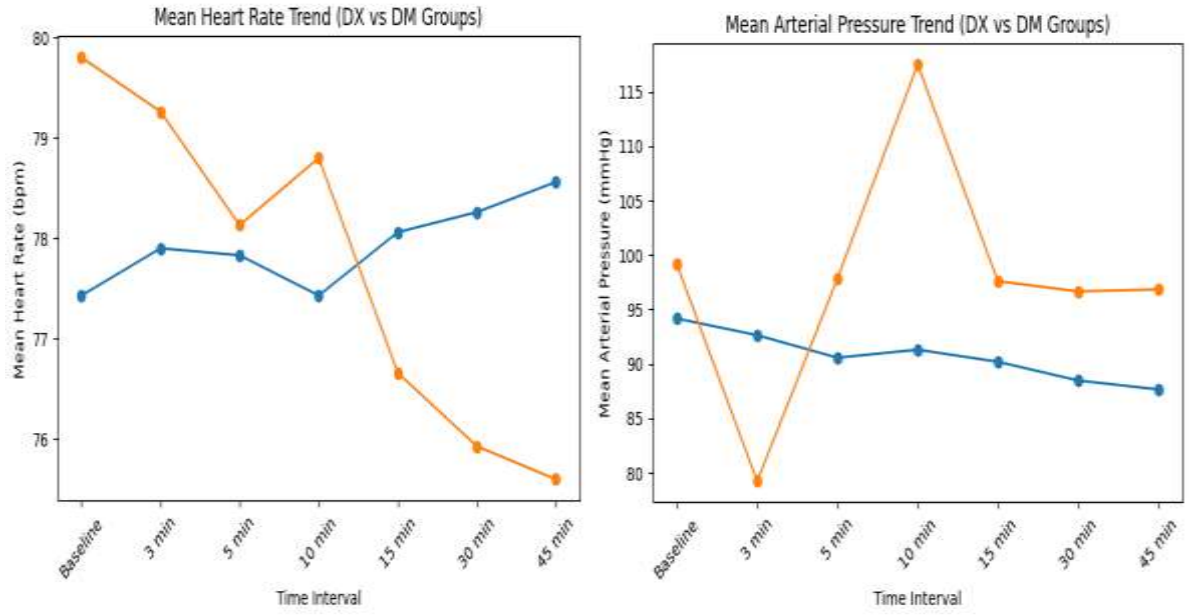


Fig 1.

Hemodynamic Parameters —



DISCUSSION

The present prospective Observational study was undertaken to evaluate and compare dexmedetomidine and dexamethasone as adjuvants to ropivacaine in supraclavicular brachial plexus block with respect to onset and duration of sensory and motor block, duration of postoperative analgesia, hemodynamic changes, sedation profile, and adverse effects. The findings of the present study were compared with previously published literature.

The demographic profile including age, gender distribution, body weight, BMI, and ASA physical status was comparable between the two groups in the present study, indicating uniformity of the study population and minimizing confounding variables affecting block characteristics. Similar demographic comparability was reported by Nagaraju et al. (2023) [11], Kaur et al. (2018) [12], and Swaminathan et al. (2019) [13], who also observed no statistically significant difference in baseline characteristics between study groups.

In the present study, the onset of sensory and motor block was significantly faster in the dexmedetomidine group compared to the dexamethasone group. The faster onset observed with dexmedetomidine may be attributed to its action on presynaptic α2-adrenergic receptors, which inhibit norepinephrine release, produce hyperpolarization of nerve tissues, and enhance local anesthetic action. Similar findings were reported by Singh et al. (2020) [14], who demonstrated significantly faster onset of sensory and motor block with dexmedetomidine when used as an adjuvant to ropivacaine in supraclavicular brachial plexus block. Nagaraju et al. (2023) [11] also observed earlier onset of sensory and motor blockade in the dexmedetomidine group compared to dexamethasone. Praneetha and Rao (2020) [15] further supported these findings by reporting that dexmedetomidine significantly hastened onset of sensory analgesia compared to dexamethasone. The faster onset associated with dexmedetomidine is attributed to enhanced nerve conduction blockade and peripheral vasoconstriction, which prolongs local anesthetic action at the site of injection.

In contrast, the present study demonstrated that dexamethasone significantly prolonged the duration of sensory and motor blockade compared to dexmedetomidine. The prolonged duration of block with dexamethasone may be due to its anti-inflammatory properties, reduction of perineural edema, and inhibition of nociceptive transmission along nerve fibers.

These findings are consistent with the observations of Ali et al. (2020) [16], who reported significantly prolonged duration of sensory and motor block in the dexamethasone group compared to dexmedetomidine when used with bupivacaine. Swaminathan et al. (2019) [13] also demonstrated longer duration of blockade with dexamethasone due to suppression of inflammatory mediators and decreased ectopic neuronal discharge. Similarly, Khaleeq et al. (2020) [17] reported that dexamethasone significantly prolonged the duration of both sensory and motor block and improved block quality compared to dexmedetomidine. Nagaraju et al. (2023) [11] reported comparable findings, further supporting the superior block prolongation effect of dexamethasone.

The duration of postoperative analgesia in the present study was significantly prolonged in the dexamethasone group compared to the dexmedetomidine group, and the requirement for rescue analgesics was significantly lower. The prolonged analgesic effect of dexamethasone is attributed to inhibition of phospholipase activity, reduction in inflammatory response, and suppression of transmission in nociceptive C fibers. Similar results were reported by Kaur et al. (2018) [12], who observed significantly prolonged postoperative analgesia and reduced analgesic consumption in patients receiving dexamethasone. Singh et al. (2020) [14] also demonstrated prolonged duration of analgesia with dexamethasone compared to dexmedetomidine in ultrasound-guided supraclavicular block. Ali et al. (2020) [16] further supported these findings by reporting decreased rescue analgesic requirement and better postoperative pain control in the dexamethasone group. The findings of Nagaraju et al. (2023) [11] also corroborate the superior analgesic efficacy of dexamethasone.

With respect to hemodynamic parameters, the present study demonstrated greater reductions in heart rate and mean arterial pressure in the dexmedetomidine group compared to dexamethasone, with a higher incidence of bradycardia. These effects are consistent with the sympatholytic action of dexmedetomidine, which decreases sympathetic outflow and enhances vagal activity. Comparable findings were reported by Swaminathan et al. (2019) [13], who observed significant reductions in heart rate and blood pressure in patients receiving dexmedetomidine. Khaleeq et al. (2020) [17] also reported greater hemodynamic depression with dexmedetomidine compared to dexamethasone, whereas dexamethasone demonstrated better cardiovascular stability. Nagaraju et al. (2023) [11] similarly reported significant decreases in heart rate and blood pressure in the dexmedetomidine group.

Sedation scores were significantly higher in the dexmedetomidine group in the present study. This is attributed to central α2-receptor activation producing dose-dependent sedation and anxiolysis. Singh et al. (2020) [14] and Praneetha and Rao (2020) [15] also reported significantly higher sedation scores with dexmedetomidine compared to dexamethasone. The sedative property of dexmedetomidine may be beneficial in improving patient comfort during regional anesthesia without causing respiratory depression.

Regarding adverse effects, a higher incidence of bradycardia was observed in the dexmedetomidine group in the present study, whereas hypotension, nausea, and vomiting were comparable between groups. Similar observations were reported by Ali et al. (2020) [16] and Nagaraju et al. (2023) [11], who also noted higher incidence of bradycardia with dexmedetomidine but no major complications associated with either adjuvant. The absence of serious adverse effects in both groups indicates that both dexmedetomidine and dexamethasone are relatively safe when used as adjuvants in peripheral nerve blocks.

Overall, the findings of the present study are consistent with previously published literature demonstrating that dexmedetomidine provides faster onset of sensory and motor blockade and superior intraoperative sedation, whereas dexamethasone significantly prolongs the duration of sensory and motor block and provides superior postoperative analgesia with greater hemodynamic stability. The present study therefore supports the use of dexamethasone when

prolonged postoperative analgesia is desired and dexmedetomidine when rapid onset and intraoperative sedation are preferred.

CONCLUSION

The present prospective randomized comparative study was conducted to evaluate and compare the efficacy of dexmedetomidine and dexamethasone as adjuvants to ropivacaine in supraclavicular brachial plexus block for upper limb surgeries. Based on the findings of the study, both dexmedetomidine and dexamethasone were found to be effective adjuvants in enhancing the quality and duration of brachial plexus blockade; however, each drug demonstrated distinct advantages with respect to block characteristics, postoperative analgesia, and hemodynamic effects.

Dexmedetomidine as an adjuvant to ropivacaine produced a significantly faster onset of sensory and motor blockade compared to dexamethasone. It also provided superior intraoperative sedation and improved block quality. However, dexmedetomidine was associated with greater reductions in heart rate and mean arterial pressure and a higher incidence of bradycardia, reflecting its sympatholytic effects.

In contrast, dexamethasone significantly prolonged the duration of sensory and motor blockade and provided a longer duration of postoperative analgesia compared to dexmedetomidine. Patients receiving dexamethasone required fewer rescue analgesics in the postoperative period, indicating better and sustained analgesic efficacy. Furthermore, dexamethasone demonstrated greater hemodynamic stability and a lower incidence of adverse effects.

Thus, while dexmedetomidine offers the advantage of rapid onset of blockade and better intraoperative sedation, dexamethasone provides prolonged postoperative analgesia and superior duration of block with better hemodynamic stability. The choice of adjuvant may therefore be guided by the clinical requirement—dexmedetomidine may be preferred when rapid onset and intraoperative sedation are desired, whereas dexamethasone may be more beneficial when prolonged postoperative analgesia is the primary objective.

Overall, the findings of this study suggest that dexamethasone may be considered a more suitable adjuvant to ropivacaine for supraclavicular brachial plexus block when extended duration of analgesia and improved postoperative pain control are desired, while dexmedetomidine remains a useful alternative for rapid onset and enhanced intraoperative conditions.

Further large-scale randomized controlled studies with longer follow-up are recommended to confirm these findings and to evaluate the long-term safety and optimal dosing of these adjuvants in regional anesthesia practice.

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