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Comparison of intravenous dexmedetomidine and intravenous dexamethasone for prolongation of analgesia in supraclavicular brachial plexus block: A prospective comparative study

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Abstract
Background: Supraclavicular brachial plexus block provides effective anesthesia and postoperative analgesia for upper limb surgeries. Various intravenous adjuvants have been evaluated to enhance the quality and duration of analgesia. Dexmedetomidine and dexamethasone, when administered intravenously, have shown promising analgesic effects; however, comparative evidence remains limited.
Methods: This prospective comparative study was conducted on 80 patients (ASA physical status I-II), aged 18-60 years, undergoing elective unilateral upper limb surgeries under ultrasound-guided supraclavicular brachial plexus block. Patients were randomized into two equal groups (n = 40 each). Group DEXA received intravenous dexamethasone 0.1 mg/kg, Group DEXMED received intravenous dexmedetomidine 1 µg/kg. All patients received 20 mL of 0.5% ropivacaine for the block. The primary outcome was time to first rescue analgesia. Secondary outcomes included onset and duration of sensory and motor block, postoperative VAS scores, intra-operative hemodynamic parameters, and adverse effects.
Results: Demographic variables and baseline characteristics were comparable between groups.
The onset of sensory block was 10.02±1.16 minutes in Group DEXA and 10.45±1.26 minutes in Group DEXMED (p = 0.121), while onset of motor block was 15.35±1.21 minutes and 15.40±1.24 minutes, respectively (p = 0.855).
The duration of sensory block was 443.12±53.73 minutes in Group DEXA and 433.62±51.09 minutes in Group DEXMED (p = 0.422). Motor block duration was 392.25±57.45 minutes and 378.62±52.99 minutes, respectively (p = 0.274). The time to first rescue analgesia was significantly longer in Group DEXA (504.12±55.81 minutes) compared to Group DEXMED (496.25±47.78 minutes, p = 0.046).
Postoperative VAS scores were comparable between groups, with no pain reported up to 4 hours, mild pain at 6 hours in all patients, and severe pain at 12 hours in 10.0% (DEXA) and 12.5% (DEXMED) of patients. Intra-operative heart rate showed a statistically significant reduction in the DEXMED group at 5, 15, and 20 minutes; however, systolic blood pressure, diastolic blood pressure, and SpO2 remained comparable between groups. Adverse effects were minimal, with bradycardia and hypotension observed only in the DEXMED group, without statistical significance.
Conclusion: Both intravenous dexamethasone and dexmedetomidine are effective adjuvants for supraclavicular brachial plexus block. Intravenous dexamethasone provided a significantly longer duration of postoperative analgesia, while dexmedetomidine was associated with greater intra-operative heart rate reduction but maintained overall hemodynamic stability.

Keywords: Supraclavicular brachial plexus block, dexmedetomidine, dexamethasone, postoperative analgesia, ropivacaine, regional anesthesia

Introduction
Regional anaesthesia has become an integral component of modern anaesthetic practice for upper limb surgeries. Among the various regional techniques, brachial plexus block is frequently employed either as an alternative or as an adjunct to general anaesthesia, offering excellent intraoperative anaesthesia along with prolonged postoperative analgesia. By depositing local anaesthetic agents in close proximity to the brachial plexus, effective sensory and motor blockade of the upper extremity can be achieved, thereby reducing perioperative opioid consumption and avoiding complications associated with general anaesthesia [1, 2].
Several approaches to the brachial plexus have been described based on the anatomical level of injection, including interscalene, supraclavicular, infraclavicular, and axillary techniques.

The supraclavicular brachial plexus block targets the compact arrangement of nerve trunks at the level of the clavicle, providing rapid onset, dense anaesthesia, and a high success rate for surgical procedures involving the arm, forearm, and hand, excluding the shoulder [3-5]. Since its first percutaneous description by Kulenkampff in 1911, the supraclavicular approach has evolved significantly, and with the advent of ultrasound guidance, its safety and efficacy have further improved [6, 7].

Despite these advantages, the duration of analgesia following a single-shot supraclavicular brachial plexus block remains limited by the pharmacological characteristics of the local anaesthetic used. To enhance block quality and prolong postoperative analgesia, various adjuvants have been administered either perineurally or systemically [8-12]. Among these, dexmedetomidine and dexamethasone have gained considerable attention due to their analgesic-enhancing properties and favorable clinical profiles.

Dexmedetomidine is a highly selective α2-adrenergic receptor agonist with sedative, anxiolytic, and analgesic properties, notable for the absence of significant respiratory depression [13-16]. Its analgesic effects are mediated through central and spinal mechanisms, including inhibition of norepinephrine release in the locus ceruleus and suppression of nociceptive transmission at the dorsal horn of the spinal cord [17-20]. Intravenous dexmedetomidine has been shown to prolong the duration of peripheral nerve blocks and improve postoperative analgesia, although its use may be associated with dose-dependent bradycardia and hypotension [14, 15].

Dexamethasone, a potent long-acting glucocorticoid with minimal mineralocorticoid activity, has also been demonstrated to prolong peripheral nerve blockade and enhance postoperative analgesia [21-26]. The proposed mechanisms include suppression of nociceptive C-fiber activity, modulation of potassium channels, local vasoconstriction leading to reduced systemic absorption of local anaesthetics, and systemic anti-inflammatory effects [27-32]. Dexamethasone is widely available, cost-effective, and generally well tolerated when used as a single perioperative dose [33-35].

Ropivacaine, an S-enantiomer amide local anaesthetic, is commonly used for brachial plexus blocks due to its reduced cardiotoxicity, lower central nervous system toxicity, and preferential sensory blockade compared to motor blockade [17, 18]. However, despite its favorable safety profile and relatively long duration of action, postoperative analgesia following a single-shot block remains finite, necessitating the use of adjuvants to further prolong analgesic duration.

Although both intravenous dexmedetomidine and dexamethasone have individually been shown to enhance analgesia in regional anaesthesia, direct comparative studies evaluating their effects on block characteristics, duration of postoperative analgesia, hemodynamic stability, and adverse effects in supraclavicular brachial plexus block are limited. Therefore, the present prospective comparative study was undertaken to evaluate and compare the efficacy of intravenous dexmedetomidine and intravenous dexamethasone in prolonging postoperative analgesia following ultrasound-guided supraclavicular brachial plexus block in patients undergoing upper limb surgeries.

Materials and methods

Study Design and Setting: This prospective comparative study was conducted in the Department of Anaesthesiology, Sher-I-Kashmir Institute of Medical Sciences (SKIMS), Srinagar, over a period of two years. The study was initiated after obtaining approval from the Institutional Ethics Committee, and written informed consent was obtained from all participants prior to enrolment.

Study Population and Sample Size

A total of 80 patients were enrolled in the study. Sample size calculation was performed using Open Epi version 3, assuming a confidence interval of 95%, power of 80%, and a group allocation ratio of 1:1. Based on these parameters, a minimum of 40 patients per group was required.

Patients were randomly allocated into two equal groups of 40 each using simple randomization:

- **Group DEXA:** Received intravenous dexamethasone
- **Group DEXMED:** Received intravenous dexmedetomidine

Inclusion Criteria

- Age between 18 and 60 years
- Either gender
- Weight between 40 and 80 kg
- American Society of Anesthesiologists (ASA) physical status I or II
- Patients scheduled for unilateral elective upper limb surgery under supraclavicular brachial plexus block

Exclusion Criteria

- ASA physical status III or IV
- Refusal or withdrawal of informed consent
- Pre-existing peripheral neuropathy
- Local infection at the site of block
- History of coagulopathy
- Diabetes mellitus
- Hypersensitivity to any study drug
- Inadequate block requiring conversion to general anesthesia
- Systemic corticosteroid use within six months prior to surgery
- Chronic opioid use
- Pregnancy
- Patients with dementia, movement disorders, delayed developmental milestones, or previous nerve injury

Pre-anaesthetic Assessment

All patients underwent a detailed pre-anaesthetic evaluation one day prior to surgery, including medical history, physical examination, and routine laboratory investigations. Patients were educated regarding the Visual Analogue Scale (VAS) for pain assessment. Standard fasting guidelines were followed, with patients kept nil per oral for eight hours for solids and two hours for clear liquids.

Randomization and Interventions

Upon arrival in the operating room, an intravenous line was secured, and baseline vital parameters were recorded, including heart rate, non-invasive blood pressure, electrocardiography, and oxygen saturation.

All patients received an ultrasound-guided supraclavicular brachial plexus block using a high-frequency linear array transducer (13-6 MHz). Under strict aseptic precautions, 20 mL of 0.5% ropivacaine was injected after confirming correct needle placement.

- Group DEXA received intravenous dexamethasone 0.1 mg/kg
- Group DEXMED received intravenous dexmedetomidine 1 µg/kg, administered slowly over 10 minutes

Assessment of Block Characteristics

Sensory and motor block onset was assessed at 5-minute intervals for 15 minutes after block administration.

Sensory block was assessed using a pinprick test along the distribution of the radial, median, ulnar, and musculocutaneous nerves and graded as:

- **0:** Normal sensation
- **1:** Decreased sensation
- **2:** Complete loss of sensation

Motor block was assessed using the Modified Bromage Scale for upper extremities

- **0:** Full motor power
- **1:** Reduced motor power with finger movement
- **2:** Complete motor block

Intra-operative Monitoring

Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were recorded at baseline and at 0, 5, 15, 20, and 30 minutes intra-operatively.

Sedation was assessed using the four-point sedation scale described by Filos *et al.*:

1. Awake and alert
2. Drowsy, responsive to verbal stimuli
3. Drowsy, responsive to physical stimuli
4. Unarousable

Postoperative Assessment

Postoperative pain was assessed using the Visual Analogue Scale (VAS) at 1, 2, 4, 6, and 12 hours postoperatively.

The primary endpoint was time to first request for rescue analgesia, defined as a VAS score ≥ 4.

Duration of sensory and motor block was recorded as the time from block administration to complete recovery of sensation and motor function, respectively.

Adverse Effects

Patients were monitored for adverse effects such as bradycardia, hypotension, nausea, vomiting, and excessive sedation.

- Bradycardia was defined as heart rate < 50 beats/min or a decrease of more than 20% from baseline and was treated with intravenous atropine (0.6 mg).
- Hypotension was defined as a fall in systolic blood pressure > 20% from baseline or mean arterial pressure < 60 mmHg and was managed with intravenous fluids and vasopressors if required.

Results and observations

The demographic parameters, ASA physical status, duration of surgery, and baseline vital parameters were comparable between the two groups, indicating homogeneity of the study population. However, statistically significant differences were observed in weight and gender distribution [Table 1].

Table 1: Demographic and Baseline Characteristics

Parameter	DEXA (n=40)	DEXMED (n=40)	p value
Age (years)	39.62±9.78	40.88±8.01	0.588
Weight (kg)	64.42±11.37	73.62±13.21	**0.010**
Gender (Male/Female)	32 / 8	22 / 18	**0.015**
ASA I / II	21 / 19	22 / 18	0.823
Duration of surgery (hours)	2.18±0.56	2.40±0.50	0.069
Pre-operative HR (beats/min)	89.78±9.40	90.75±10.86	0.669
Pre-operative SBP (mmHg)	129.62±5.32	129.65±5.15	0.983
Pre-operative DBP (mmHg)	78.35±3.18	76.85±5.02	0.115
Pre-operative SpO_2 (%)	97.40±1.03	97.08±1.23	0.204

Values expressed as Mean ±SD or number of patients. $p<0.05$ considered statistically significant.

The onset of sensory and motor block was comparable between the two groups, with no statistically significant difference observed [Table 2].

Table 2: Onset of Sensory and Motor Block

Parameter	DEXA (Mean ±SD)	DEXMED (Mean ±SD)	p value
Onset of sensory block (minutes)	10.02±1.16	10.45±1.26	0.121
Onset of motor block (minutes)	15.35±1.21	15.40±1.24	0.855

The duration of sensory and motor block was slightly longer in the DEXA group; however, the difference between the two groups was not statistically significant [Table 3].

Table 3: Duration of Sensory and Motor Block

Parameter	DEXA (Mean ±SD)	DEXMED (Mean ±SD)	p value
Duration of sensory block (minutes)	443.12±53.73	433.62±51.09	0.422
Duration of motor block (minutes)	392.25±57.45	378.62±52.99	0.274

Postoperative Pain Assessment (VAS Scores)

Postoperative pain was assessed using the Visual Analogue Scale (VAS) at predefined intervals. All patients in both groups reported no pain up to 4 hours postoperatively. At 6 hours, all patients experienced mild pain. At 12 hours, a small proportion of patients in both groups reported severe pain.

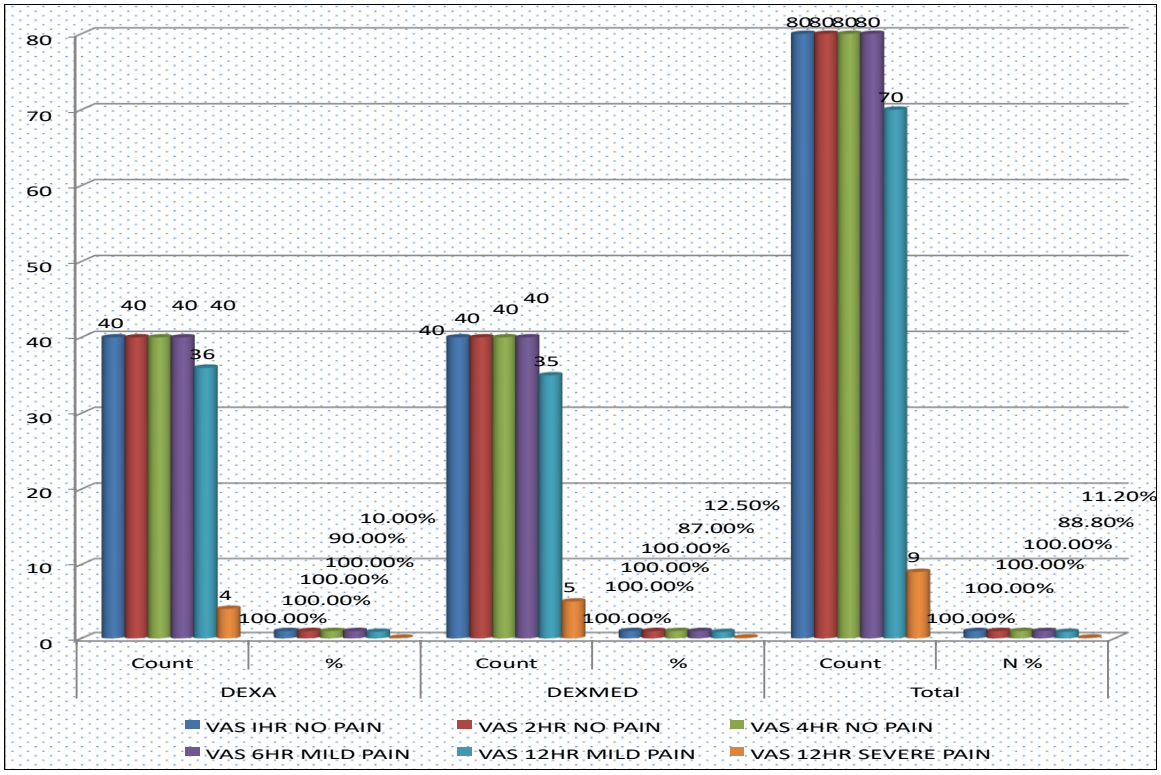

Fig 1: Postoperative VAS Score Distribution

Time to First Rescue Analgesia

The time to first request for rescue analgesia was significantly longer in the DEXA group compared to the DEXMED group [Table 4].

Table 4: Time to First Rescue Analgesia

Parameter	DEXA (Mean ±SD)	DEXMED (Mean ±SD)	p value
Time to first rescue analgesia (minutes)	504.12±55.81	496.25±47.78	**0.046***

*p<0.05 considered statistically significant.

Intra-operative Hemodynamic Parameters: Heart rate, systolic blood pressure, diastolic blood pressure, and oxygen saturation were monitored intra-operatively at predefined intervals.

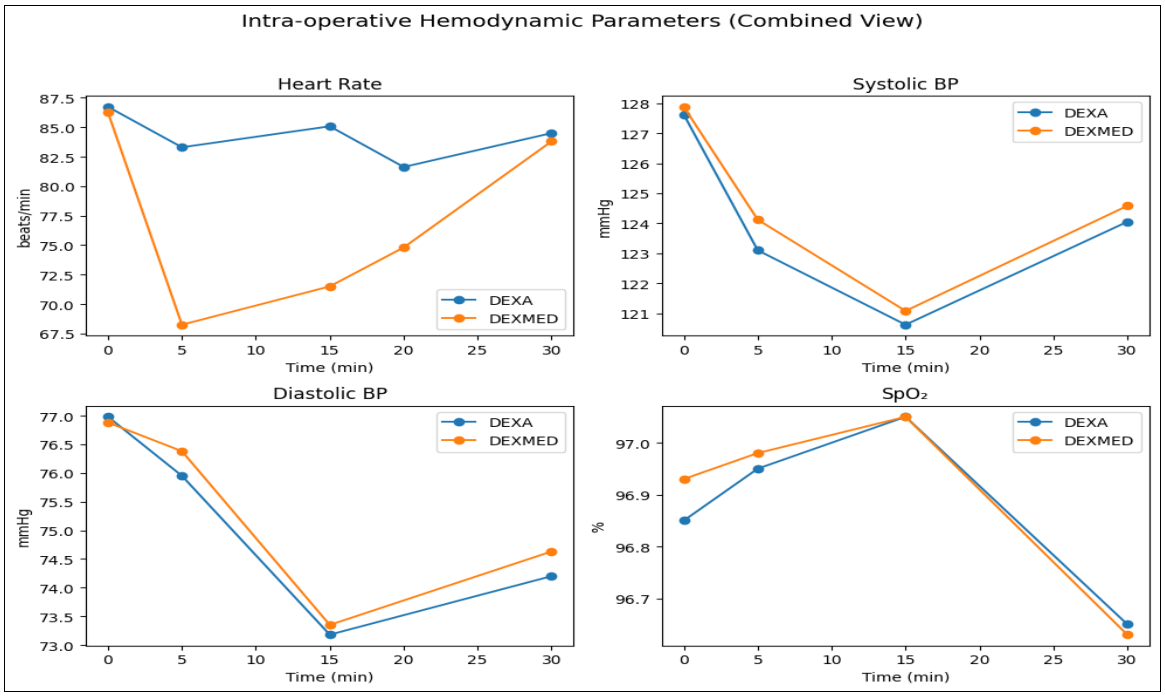

Fig 2: Intra-operative Hemodynamic Parameters

Adverse Effects

Adverse effects were minimal in both groups. Bradycardia and hypotension were observed only in the DEXMED group; however, the overall incidence was not statistically significant [Table 5].

Table 5: Adverse Effects

Adverse Effect	DEXA (n=40)	DEXMED (n=40)	Total (n=80)	p value
Bradycardia	0 (0.0%)	3 (7.5%)	3 (3.75%)	0.079
Hypotension	0 (0.0%)	2 (5.0%)	2 (2.5%)	
Nil	40 (100%)	35 (87.5%)	75 (93.8%)	
Total	40 (100%)	40 (100%)	80 (100%)	

Discussion

Peripheral nerve blocks, particularly the supraclavicular brachial plexus block, are widely utilized for upper limb surgeries due to their ability to provide excellent intraoperative anaesthesia and prolonged postoperative analgesia. The ongoing search for ideal adjuvants aims to enhance analgesic duration and block quality without compromising safety. Dexmedetomidine and dexamethasone are among the most frequently used intravenous adjuvants, and their comparative efficacy continues to be evaluated. The present prospective comparative study was undertaken to assess and compare the effects of intravenous dexmedetomidine and intravenous dexamethasone on block characteristics, duration of postoperative analgesia, pain scores, hemodynamic stability, and adverse effects in patients undergoing supraclavicular brachial plexus block.

In the present study, demographic variables such as age and weight were comparable between the two groups, ensuring homogeneity of the study population. The mean age of patients in the dexamethasone and dexmedetomidine groups was similar, minimizing the influence of age-related pharmacodynamic and pharmacokinetic variations on study outcomes. Comparable age distribution has also been reported by Parveen S *et al.* [36] and AbdElwahed WI *et al.* [39], supporting the internal validity of such comparative studies. Abdallah FW *et al.* similarly reported balanced demographic characteristics when comparing intravenous dexamethasone in supraclavicular block [37].

Although a statistically significant male predominance was observed in the dexamethasone group, previous literature suggests that such gender imbalance is unlikely to substantially influence block characteristics or analgesic outcomes when other demographic variables are comparable. Sinha C *et al.* also reported male predominance in their study population without clinically significant impact on outcomes [38].

The onset of sensory block in the present study was marginally faster in the dexamethasone group, though the difference was not statistically significant. Similar observations were reported by Adinarayanan S *et al.* [41], whereas Sehmbi H *et al.* demonstrated a faster onset of sensory blockade with dexmedetomidine [40]. These inconsistent findings suggest that sensory onset may be influenced by multiple factors, including drug dose, route of administration, and the local anaesthetic used, rather than the adjuvant alone.

The duration of sensory block was longer in the dexamethasone group in the present study, although the difference was not statistically significant. Sinha C *et al.* and Sehmbi H *et al.* reported a longer sensory block duration with dexmedetomidine [38, 40]. In contrast, a network meta-analysis by Sane S *et al.* concluded that dexamethasone, particularly when administered intravenously, was associated with a prolonged sensory blockade compared to dexmedetomidine [42]. These findings indicate that intravenous dexamethasone may provide sensory block duration comparable to dexmedetomidine.

Time to first rescue analgesia was significantly prolonged in the dexamethasone group in the present study, indicating superior postoperative analgesia. While Hamada MH *et al.* and Sinha C *et al.* reported longer analgesic duration with dexmedetomidine [43, 38], a systematic review and meta-analysis by Albrecht E *et al.* demonstrated that dexamethasone provided longer-lasting analgesia compared to dexmedetomidine, with no additional benefit when both agents were combined [44]. These contrasting results highlight the influence of route, dosage, and study design on analgesic outcomes.

The onset of motor block was slightly faster in the dexamethasone group in the present study, although not statistically significant. Sehmbi H *et al.* and Kang R *et al.* observed a trend toward faster motor block onset with dexmedetomidine [40, 45]. These findings suggest that dexmedetomidine may have a modest advantage in facilitating motor block onset, though the clinical relevance appears limited.

The duration of motor block was marginally longer in the dexamethasone group, with no statistically significant difference. Comparable motor block durations between dexamethasone and dexmedetomidine have been reported by Dhanger S *et al.* and Kang R *et al.* [46, 45]. However, Sane S *et al.* reported a longer motor block duration with dexmedetomidine [42], again emphasizing variability among studies.

Postoperative pain scores in the present study were slightly lower in the dexamethasone group, though the difference was not statistically significant. Kang R *et al.* and Hamada MH *et al.* reported significantly lower VAS scores with dexmedetomidine [43, 45], whereas Adinarayanan S *et al.* found dexamethasone to be equally effective [41]. These observations suggest that both agents provide effective postoperative analgesia without consistent superiority of one over the other.

Hemodynamic parameters remained largely stable in both groups, although heart rate was significantly lower at certain intraoperative intervals in the dexmedetomidine group. Similar findings were reported by Hamada MH *et al.* and Abdallah FW *et al.*, who observed bradycardia and hypotension associated with dexmedetomidine due to its sympatholytic properties [43, 47]. Hong B *et al.* also highlighted greater hemodynamic variability with dexmedetomidine [48]. These findings underscore the importance of vigilant monitoring when using dexmedetomidine as an adjuvant.

Overall, the findings of the present study indicate that both intravenous dexamethasone and dexmedetomidine are effective and safe adjuvants for supraclavicular brachial plexus block. Intravenous dexamethasone provided a longer duration of postoperative analgesia with stable hemodynamics, whereas dexmedetomidine was associated with greater heart rate reduction, warranting closer hemodynamic monitoring.

Conclusions

The present prospective comparative study demonstrates that both intravenous dexamethasone and intravenous dexmedetomidine are effective adjuvants to ultrasound-guided

supraclavicular brachial plexus block using ropivacaine for upper limb surgeries. Both agents enhanced the quality of the block and provided satisfactory intraoperative anaesthesia with prolonged postoperative analgesia.

Intravenous dexamethasone was associated with a significantly longer duration of postoperative analgesia, as evidenced by a prolonged time to first rescue analgesic requirement, along with stable intraoperative and postoperative hemodynamic parameters. The onset and duration of sensory and motor blockade were comparable between the two groups, and postoperative pain scores did not show clinically meaningful differences.

Intravenous dexmedetomidine, while providing effective analgesia and block characteristics comparable to dexamethasone, was associated with a greater reduction in heart rate during the intraoperative period, reflecting its sympatholytic properties. Although these changes were clinically manageable, they underscore the need for vigilant hemodynamic monitoring when dexmedetomidine is used as an intravenous adjuvant.

Overall, intravenous dexamethasone appears to be a preferable adjuvant for prolongation of postoperative analgesia in supraclavicular brachial plexus block due to its longer analgesic duration, ease of administration, cost-effectiveness, and favorable hemodynamic profile. However, intravenous dexmedetomidine remains a valuable alternative, particularly when its sedative and analgesic properties are desired, provided appropriate monitoring is ensured.

Further large-scale, multicentric studies are recommended to establish optimal dosing regimens and to explore long-term outcomes associated with these intravenous adjuvants in regional anaesthesia.

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