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Original Research Article

Comparative Study of Dexamethasone and Dexmedetomidine as Adjuvants to 0.5% Levobupivacaine in Ultrasound-Guided Axillary Brachial Plexus Block for Forearm Fractures

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Abstract

Background: Ultrasound-guided axillary brachial plexus block is an effective regional anaesthetic technique for forearm surgeries. The addition of adjuvants to local anaesthetics improves block characteristics and prolongs postoperative analgesia. Dexmedetomidine and dexamethasone are commonly used adjuvants; however, evidence comparing their efficacy in axillary brachial plexus block remains limited.

Methods: This prospective, randomized, double-blind comparative study included 100 ASA I–II patients aged 18–60 years undergoing elective forearm fracture surgeries. Patients were randomly allocated into two groups. Group A received 30 mL of 0.5% levobupivacaine with dexmedetomidine (1 µg/kg), while Group B received 30 mL of 0.5% levobupivacaine with dexamethasone (0.1 mg/kg). Sensory and motor block characteristics, duration of postoperative analgesia, haemodynamic parameters, and adverse effects were evaluated.

Results: Dexmedetomidine produced a significantly faster onset of sensory block (8.34 ± 1.24 vs. 9.55 ± 1.30 min; p=0.016) and motor block (12.50 ± 1.45 vs. 14.00 ± 1.62 min; p<0.001). Sensory block duration (850 ± 124 vs. 730 ± 130 min), motor block duration (690 ± 124 vs. 620 ± 108 min), and time to first rescue analgesia (22.75 ± 2.47 vs. 17.50 ± 2.20 h) were significantly longer in the dexmedetomidine group (p<0.001). Mild bradycardia, hypotension, and sedation occurred more frequently with dexmedetomidine but were clinically manageable.

Conclusion: Both dexmedetomidine and dexamethasone were effective adjuvants to levobupivacaine for ultrasound-guided axillary brachial plexus block. However, dexmedetomidine provided superior block characteristics and prolonged postoperative analgesia with acceptable haemodynamic safety, making it the preferred adjuvant for forearm fracture surgeries.

Keywords: Axillary Brachial Plexus Block, Dexmedetomidine, Dexamethasone, Levobupivacaine, Ultrasound-Guided Regional Anaesthesia, Postoperative Analgesia, Forearm Fractures.

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Introduction

Forearm fractures are common orthopedic injuries requiring surgical fixation and are often associated with significant postoperative pain. Inadequate pain control may delay rehabilitation, prolong hospital stay, increase opioid consumption, and reduce patient satisfaction. Therefore, effective perioperative analgesia has become an essential component of enhanced recovery protocols.[1]Since Halstead first described brachial plexus blockade in 1884, regional anesthesia has evolved considerably with the introduction of peripheral nerve stimulators and, more recently, ultrasound guidance.[2,3] Ultrasound-guided brachial plexus blocks provide excellent surgical anesthesia and prolonged postoperative analgesia while reducing opioid requirements and complications associated with general anesthesia.[4] Among the various approaches, the axillary brachial plexus block is particularly suitable for forearm and hand surgeries because it is performed away from the pleura and major central vessels, thereby minimizing the risk of pneumothorax and vascular injury. Ultrasound guidance further improves block success by allowing real-time visualization of nerves, surrounding structures, needle placement, and local anesthetic spread, resulting in greater accuracy, faster performance, and fewer

complications.[5,6]Levobupivacaine, the pure S(-)-enantiomer of bupivacaine, is a long-acting amide local anesthetic widely used for peripheral nerve blocks because of its lower cardiotoxicity and neurotoxicity compared with racemic bupivacaine.[7] Although it provides effective sensory and motor blockade, its duration of postoperative analgesia may be insufficient for prolonged pain control after orthopedic procedures, leading to increasing use of adjuvants to enhance block characteristics.[8,9]Among the available adjuvants, dexamethasone and dexmedetomidine have been extensively investigated.[10]

Dexamethasone, a long-acting corticosteroid, prolongs nerve blockade by reducing perineural inflammation, suppressing inflammatory mediators, inhibiting ectopic neuronal discharge, and decreasing vascular absorption of the local anesthetic. Clinical studies have demonstrated prolonged sensory and motor blockade and extended postoperative analgesia without increasing neurological complications.[11,12]

Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, provides analgesic, sedative, and sympatholytic effects. As a perineural adjuvant, it enhances local anesthetic action by inhibiting norepinephrine release, hyperpolarizing nerve membranes, and suppressing nerve impulse conduction. Previous studies have shown that dexmedetomidine accelerates block onset, prolongs sensory and motor blockade, extends postoperative analgesia, and reduces rescue analgesic requirements with an acceptable safety profile.[11]Despite encouraging evidence, direct comparisons between dexamethasone and dexmedetomidine as adjuvants in ultrasound-guided axillary brachial plexus block remain limited, with inconsistent findings due to variations in study design, drug dosage, and outcome measures.[11,12] Therefore, the present study was designed to compare dexamethasone and dexmedetomidine as adjuvants to 0.5% levobupivacaine in ultrasound-guided axillary brachial plexus block for forearm fracture surgery.

Materials and Methods

The present study was conducted as a prospective, randomized, double-blind, comparative interventional study to compare the efficacy of dexmedetomidine and dexamethasone as adjuvants to 0.5% levobupivacaine in ultrasound-guided axillary brachial plexus block for forearm fracture surgeries. The study was conducted in the Department of Anaesthesiology, K.H. Patil Institute of Medical Sciences and Research Centre, Gadag, over a period of 15 months from February 2024 to May 2025.

Study Population: A total of 100 patients aged 18–60 years of either sex, belonging to the American Society of Anesthesiologists (ASA) physical status I or II and scheduled for elective forearm fracture surgeries under ultrasound-guided axillary brachial plexus block, were included in the study.

Sample Size: The sample size was calculated using the formula for comparison of two means:

$$n = \frac{2\sigma^2(Z_{\alpha/2} + Z_{\beta})^2}{d^2}$$

Where n represented the sample size per group, σ represented the pooled standard deviation, d represented the expected difference between the two group means, Zα/2 was 1.96 for a 95% confidence interval, and Zβ was 0.84 for 80% study power. Based on the calculation, 100 patients were enrolled, with 50 patients allocated to each group.

Inclusion Criteria

Patients fulfilling the following criteria were included:

- Age between 18 and 60 years.
- Either gender.
- ASA physical status I or II.
- Scheduled for elective forearm fracture surgery under axillary brachial plexus block.
- Willingness to participate and provide written informed consent.

Exclusion Criteria

Patients were excluded if they:

- Refused to participate in the study.
- Had infection at the proposed block site.
- Had known allergy or hypersensitivity to levobupivacaine, dexmedetomidine, or dexamethasone.
- Had coagulation disorders or thrombocytopenia.
- Were receiving anticoagulant therapy.
- Had pre-existing neurological deficits involving the operative limb.
- Had severe hepatic, renal, or cardiac disease.

Randomization and Blinding: After obtaining informed written consent, eligible patients were randomly allocated into two equal groups of 50 patients each using a computer-generated randomization sequence. Allocation concealment was achieved using sealed opaque envelopes. The study was conducted in a double-blind manner, in which both the patients and the investigator assessing block characteristics and postoperative outcomes were unaware of the group allocation.

Study Groups

Group A (Dexmedetomidine Group): Patients received 30 mL of 0.5% levobupivacaine with dexmedetomidine 1 µg/kg.

Group B (Dexamethasone Group): Patients received 30 mL of 0.5% levobupivacaine with dexamethasone 0.1 mg/kg.

Anaesthetic Technique: All patients were kept fasting according to standard preoperative fasting guidelines. After arrival in the operating room, intravenous access was secured and routine monitoring, including electrocardiography, non-invasive blood pressure, pulse rate, and peripheral oxygen saturation (SpO_2), was instituted. Baseline haemodynamic parameters were recorded. Under strict aseptic precautions, an ultrasound-guided axillary brachial plexus block was performed using a high-frequency linear ultrasound transducer. The median, ulnar, radial, and musculocutaneous nerves were identified, and the allocated study drug was injected around the nerves after careful negative aspiration for blood.

Outcome Measures

Primary Outcome Measures

- Onset time of sensory blockade.
- Onset time of motor blockade.
- Duration of sensory blockade.
- Duration of motor blockade.

Secondary Outcome Measures

- Duration of postoperative analgesia.
- Time to first rescue analgesic request.
- Haemodynamic parameters (heart rate and mean arterial pressure).
- Adverse effects including bradycardia, hypotension, and sedation.

Statistical Analysis: The collected data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) software 26. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Continuous variables were compared using the independent Student's t-test, whereas categorical variables were analysed using the Chi-square test or Fisher's exact test, wherever appropriate. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 100 patients were enrolled in the study and were randomly allocated into two equal groups of 50 patients each. The baseline demographic characteristics, including age, gender distribution, body mass index (BMI), and ASA physical status, were comparable between the two groups, with no statistically significant differences (Table 1).The comparison of block characteristics demonstrated that the dexmedetomidine group had a significantly faster onset of both sensory and motor blockade than the dexamethasone group. Furthermore, the duration of sensory and motor blockade was significantly prolonged in patients receiving dexmedetomidine (Table 2, Figure 1).The duration of postoperative analgesia, assessed by the time to first rescue analgesic requirement, was significantly longer in the dexmedetomidine group than in the dexamethasone group, indicating superior postoperative analgesia (Table 3, Figure 2).Heart rate and mean arterial pressure remained within acceptable clinical limits in both groups throughout the study period. However, the dexmedetomidine group exhibited a greater reduction in heart rate and mean arterial pressure at 15, 30, and 60 minutes, which was statistically significant compared with the dexamethasone group. No clinically significant haemodynamic instability requiring intervention was observed (Table 4).The incidence of adverse effects was higher in the dexmedetomidine group. Bradycardia, hypotension, and sedation occurred more frequently among patients receiving dexmedetomidine, although all events were mild and managed conservatively without serious complications (Table 5, Figure 3). Overall, dexmedetomidine demonstrated superior block characteristics, prolonged postoperative analgesia, and acceptable haemodynamic stability compared with dexamethasone. Although mild adverse effects were more common with dexmedetomidine, they were clinically manageable, suggesting that dexmedetomidine may be the preferred adjuvant when prolonged analgesia is desired (Table 6).

Table 1: Baseline Demographic Characteristics of the Study Population

Variable	Group A (Dexmedetomidine) (n=50)	Group B (Dexamethasone) (n=50)	p-value
Age (years), Mean ± SD	38.8 ± 11.4	39.6 ± 10.8	0.724
Male, n (%)	32 (64.0)	30 (60.0)	0.681
Female, n (%)	18 (36.0)	20 (40.0)	
BMI (kg/m^2), Mean ± SD	24.3 ± 2.9	24.7 ± 3.1	0.548
ASA Grade I, n (%)	28 (56.0)	26 (52.0)	0.688
ASA Grade II, n (%)	22 (44.0)	24 (48.0)	

Table 2: Comparison of Block Characteristics between the Study Groups

Parameter	Group A (Dexmedetomidine)	Group B (Dexamethasone)	p-value
Sensory block onset (min)	**8.34 ± 1.24**	**9.55 ± 1.30**	0.016*
Motor block onset (min)	**12.50 ± 1.45**	**14.00 ± 1.62**	<0.001*
Sensory block duration (min)	**850 ± 124**	**730 ± 130**	0.010*
Motor block duration (min)	**690 ± 124**	**620 ± 108**	<0.001*

***Significant (p <0.05)**

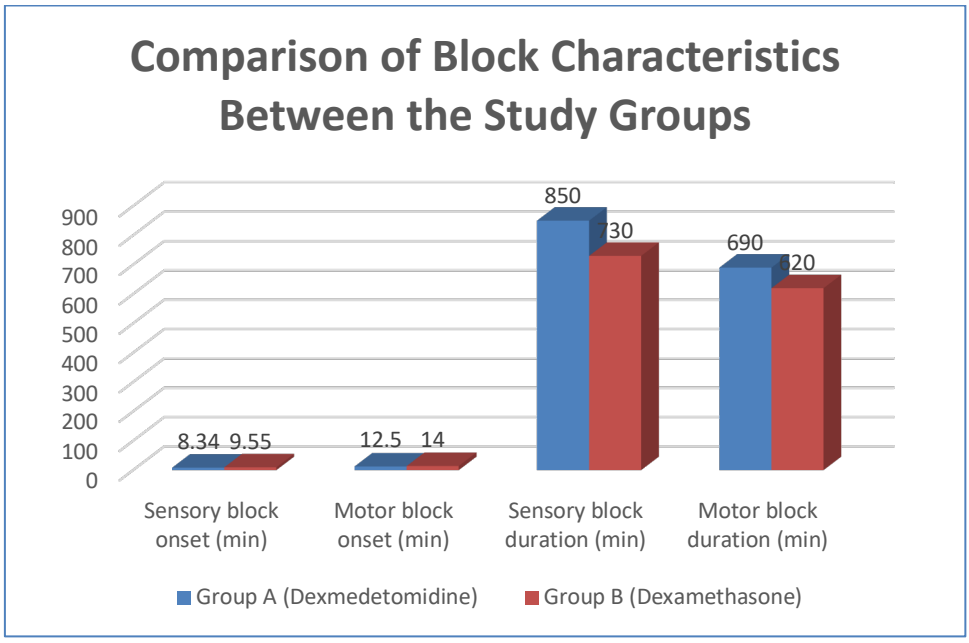

Figure 1: Comparison of Block Characteristics between the Study Groups

Table 3: Time to First Rescue Analgesia

Parameter	Group A (Dexmedetomidine)	Group B (Dexamethasone)	p-value
Rescue analgesia (minutes)	**1365 ± 148**	**1050 ± 132**	<0.001*
Rescue analgesia (hours)	**22.75 ± 2.47**	**17.50 ± 2.20**	<0.001*

***Significant (p <0.05)**

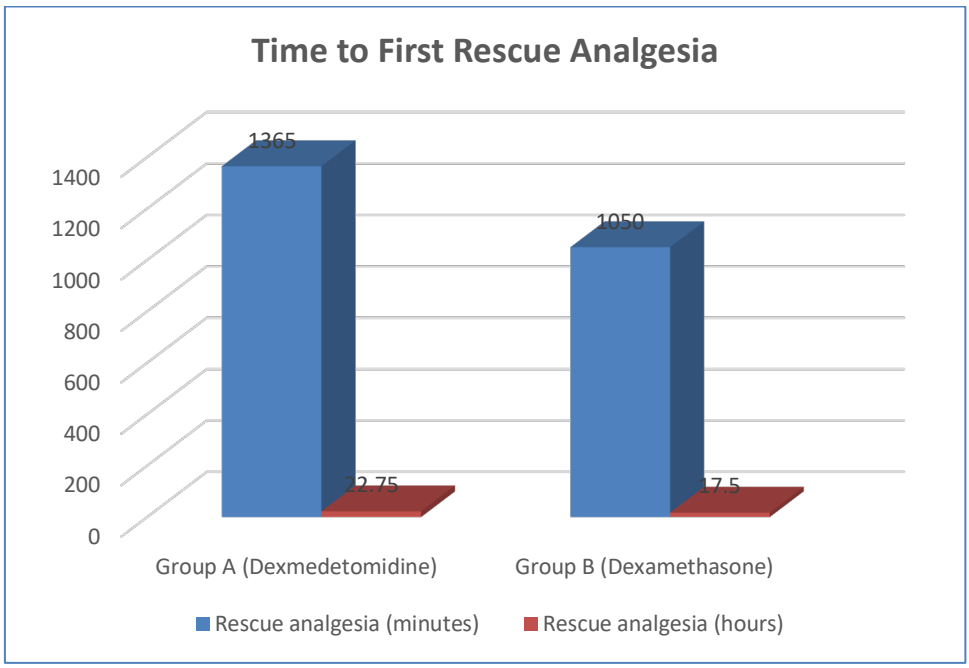

Figure 2: Time to First Rescue Analgesia

Table 4: Comparison of Hemodynamic Parameters Heart Rate (beats/min)

Time	Group A	Group B	p-value
Baseline	84 ± 7	82 ± 8	0.248
15 min	76 ± 6	81 ± 7	0.012*
30 min	72 ± 6	80 ± 7	0.001*
60 min	70 ± 5	79 ± 7	<0.001*
120 min	79 ± 7	80 ± 6	0.542

Mean Arterial Pressure (mmHg)

Time	Group A	Group B	p-value
Baseline	95 ± 7	95 ± 8	1.000
15 min	88 ± 6	94 ± 7	0.018*
30 min	85 ± 6	93 ± 7	0.003*
60 min	83 ± 5	94 ± 7	<0.001*
120 min	86 ± 7	90 ± 6	0.002*

***Significant (p <0.05)**

Table 5: Comparison of Adverse Effects

Adverse Effect	Group A (Dexmedetomidine) n (%)	Group B (Dexamethasone) n (%)	p-value
Bradycardia	8 (16.0)	0 (0.0)	0.030*
Hypotension	6 (12.0)	2 (4.0)	0.040*
Sedation	20 (40.0)	4 (8.0)	0.010*

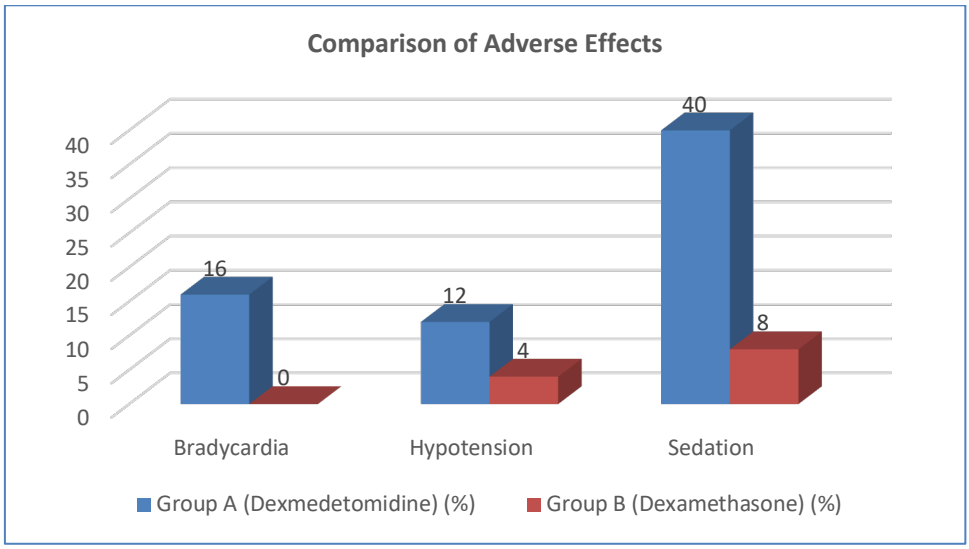

Figure 3: Comparison of Adverse Effects

Table 6: Summary of Primary and Secondary Outcomes

Outcome	Group A (Dexmedetomidine)	Group B (Dexamethasone)
Sensory onset	8.34 ± 1.24 min	9.55 ± 1.30 min
Motor onset	12.50 ± 1.45 min	14.00 ± 1.62 min
Sensory duration	850 ± 124 min	730 ± 130 min
Motor duration	690 ± 124 min	620 ± 108 min
Rescue analgesia	22.75 ± 2.47 h	17.50 ± 2.20 h

Discussion

The present study showed that both groups were comparable in baseline demographic characteristics, including age, sex, body mass index, and ASA physical status, with no statistically significant differences (Table 1). The mean age was 38.8 ± 11.4 years in the dexmedetomidine group and 39.6 ± 10.8 years in the dexamethasone group (p=0.724), confirming successful randomization and minimizing baseline confounding. Similar findings were reported by Kaygusuz et al. [13], Kaur et al. [14], and Bisui et al. [12], who also demonstrated comparable baseline characteristics between study groups.

Dexmedetomidine significantly improved block characteristics compared with dexamethasone (Table 2). Sensory block onset was faster (8.34 ± 1.24 vs. 9.55 ± 1.30 min; p=0.016), motor block

onset occurred earlier (12.50 ± 1.45 vs. 14.00 ± 1.62 min; p<0.001), and both sensory (850 ± 124 vs. 730 ± 130 min) and motor block durations (690 ± 124 vs. 620 ± 108 min) were significantly prolonged.

These findings agree with Das et al. [15], who demonstrated faster onset and prolonged sensory and motor blockade with dexmedetomidine added to levobupivacaine. Likewise, Narasimhan et al. [16] reported a faster sensory block onset (3.9 vs. 7.8 min) and longer analgesia (892 vs. 538 min) with dexmedetomidine than dexamethasone during ultrasound-guided supraclavicular brachial plexus block. In contrast, Lee et al. [17] found that although both dexmedetomidine and dexamethasone prolonged sensory blockade, no significant difference was observed in block onset. Postoperative analgesia was significantly longer with dexmedetomidine (Table 3).

The mean time to first rescue analgesia was 1365 ± 148 minutes (22.75 ± 2.47 h) compared with 1050 ± 132 minutes (17.50 ± 2.20 h) in the dexamethasone group (p<0.001). This finding is consistent with Narasimhan et al. [16], who also demonstrated prolonged analgesia with dexmedetomidine. However, a systematic review and meta-analysis by Li et al. [18], including seven randomized controlled trials and 465 patients, concluded that dexamethasone provided a longer duration of analgesia than dexmedetomidine. The discrepancy may be attributed to differences in brachial plexus block approaches, local anaesthetic agents, adjuvant doses, and study populations. Hemodynamic parameters remained clinically stable in both groups (Table 4).

Nevertheless, dexmedetomidine was associated with significantly lower heart rate and mean arterial pressure at 15, 30, and 60 minutes after block administration, without requiring pharmacological intervention. Similar observations were reported by Kaygusuz et al. [13] and by the study Comparative Evaluation of Dexmedetomidine and Dexamethasone as Adjuvants in Supraclavicular Brachial Plexus Block, both of which attributed these modest reductions to the sympatholytic effect of dexmedetomidine while maintaining overall cardiovascular stability.

Adverse effects were more frequent with dexmedetomidine (Table 5). Bradycardia (16%), hypotension (12%), and sedation (40%) occurred more often than with dexamethasone (0%, 4%, and 8%, respectively), although all events were mild and managed conservatively. These findings are comparable with those of Kaygusuz et al. [13] and Narasimhan et al. [16], who similarly reported a higher incidence of bradycardia and sedation with dexmedetomidine because of its α_2-adrenergic agonist properties. The present study demonstrates that dexmedetomidine is a superior adjuvant to 0.5% levobupivacaine for ultrasound-guided axillary brachial plexus block, providing faster onset, prolonged sensory and motor blockade, and longer postoperative analgesia than dexamethasone. Although mild bradycardia, hypotension, and sedation were more common with dexmedetomidine, these effects were clinically manageable. The findings are supported by several randomized clinical trials, while differing from the meta-analysis by Li et al. [18], highlighting the need for larger multicentre studies to establish the optimal adjuvant.

Conclusion

The present study demonstrated that both dexmedetomidine and dexamethasone are effective adjuvants to 0.5% levobupivacaine for ultrasound-guided axillary brachial plexus block in forearm fracture surgeries. However, dexmedetomidine provided a significantly faster onset of sensory and motor blockade, prolonged the duration of blockade, and offered longer postoperative analgesia than dexamethasone.

Although dexmedetomidine was associated with a higher incidence of mild bradycardia, hypotension, and sedation, these adverse effects were transient and clinically manageable. Therefore, dexmedetomidine may be considered the preferred adjuvant when prolonged postoperative analgesia and improved block characteristics are desired.

Limitations

The present study was conducted at a single tertiary care centre with a relatively small sample size, which may limit the generalizability of the findings. Long-term postoperative outcomes and patient satisfaction were not evaluated. In addition, only one dose of dexmedetomidine and dexamethasone was studied; therefore, the optimal dose and long-term safety of these adjuvants require further investigation through larger multicentric trials.

Ethical clearance: done at KHPIMS- Gadag Instutional committee

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