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Original Research Article

Comparative Evaluation of Two Different Doses of Dexmedetomidine as an Adjuvant to 0.5% Bupivacaine in Ultrasound-Guided Supraclavicular Brachial Plexus Block: A Randomized Double-Blind Study

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Abstract

Background: Dexmedetomidine is widely used as an adjuvant to local anesthetics in brachial plexus blocks to improve block quality and prolong postoperative analgesia. While its efficacy is established, the optimal perineural dose that balances block enhancement with hemodynamic stability remains unclear.

Objectives: (1). To compare the efficacy of 25 µg vs 50 µg dexmedetomidine as an adjuvant to 0.5% bupivacaine in supraclavicular brachial plexus block. (2). To assess the quality of postoperative analgesia using pain scores and rescue analgesic consumption. **(**3). To evaluate sedation levels and patient satisfaction. (4). To compare incidence of adverse effects between the two doses.

Methods: Sixty ASA I–II patients undergoing elective upper limb surgery were randomized into two groups. Group D25 received 20 mL 0.5% bupivacaine + 25 µg dexmedetomidine, while Group D50 received 20 mL 0.5% bupivacaine + 50 µg dexmedetomidine. Sensory and motor block characteristics, duration of analgesia, VAS pain scores, sedation score, hemodynamic parameters, and adverse effects were recorded.

Results: Group D50 demonstrated significantly longer analgesia compared to Group D25 ($p < 0.05$). However, Group D50 had a higher incidence of bradycardia and deeper sedation. Postoperative pain scores and rescue analgesic requirement were lower in Group D50.

Conclusion: Both doses are effective, but 25 µg provides a safer hemodynamic profile, whereas 50 µg offers superior and longer analgesia. Dose selection should be individualized based on patient comorbidities and surgical duration.

Keywords: Dexmedetomidine, Bupivacaine, Supraclavicular Block, Dose Comparison, Postoperative Analgesia.

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Introduction

Regional anesthesia has become an integral component of modern anesthetic practice, particularly for upper limb surgeries, where it provides excellent intraoperative anesthesia and prolonged postoperative analgesia.[1] Among various approaches to the brachial plexus, the supraclavicular approach is often referred to as the "spinal anesthesia of the upper limb" because it produces dense and reliable blockade of the brachial plexus trunks and divisions. With the advent of ultrasound guidance, the success rate of supraclavicular blocks has improved significantly while minimizing complications such as pneumothorax and vascular puncture. [2] Although long-acting local anesthetics such as bupivacaine provide satisfactory surgical anesthesia, their duration of postoperative analgesia may be insufficient for procedures associated with moderate to severe postoperative pain. This has led to increasing interest in the use of adjuvants that can enhance block characteristics, prolong analgesia, and reduce the need for systemic opioids and their associated side effects. [3] Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, has emerged as a promising adjuvant in regional anesthesia. Its analgesic and

sedative properties are mediated through central and peripheral mechanisms, including inhibition of norepinephrine release and hyperpolarization of nerve tissues, which enhance the effects of local anesthetics. Perineural dexmedetomidine has been shown to shorten onset time, prolong sensory and motor block, and extend the duration of postoperative analgesia. In addition, it provides mild sedation without significant respiratory depression. [4,5]

Despite its growing use, there is no clear consensus on the optimal perineural dose of dexmedetomidine. Higher doses may produce superior prolongation of analgesia but are associated with increased risks of bradycardia, hypotension, and excessive sedation, particularly in elderly or cardiovascularly compromised patients. Conversely, lower doses may offer a safer hemodynamic profile but with less pronounced analgesic benefits.[6]

Therefore, this study was designed to compare two different doses of dexmedetomidine (25 µg and 50 µg) as an adjuvant to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block, focusing not only on block characteristics but also on postoperative analgesia quality, sedation profile, and hemodynamic stability.

Materials and Methods

This prospective, randomized, double-blind comparative study was conducted in the Department of Anesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants. The study was carried out over a period of 12 months.

Sample Size Calculation: The sample size was calculated based on previous literature evaluating duration of analgesia with dexmedetomidine as an adjuvant in brachial plexus blocks.

Considering a power of 80%, confidence interval of 95%, and an expected difference of at least 20% in duration of analgesia between the two groups, the required sample size was determined to be 60 patients**,** with 30 patients in each group**.**

Inclusion Criteria

- Age between 18 and 65 years
- ASA physical status I and II
- Patients scheduled for elective forearm and hand surgeries
- Patients willing to provide informed consent

Exclusion Criteria

- Known allergy or hypersensitivity to local anesthetics or dexmedetomidine
- Coagulopathy or patients on anticoagulant therapy
- Infection at the injection site
- Pre-existing neurological deficits in the operative limb
- Significant cardiac conduction abnormalities (heart block, severe bradycardia)
- Severe hepatic, renal, or respiratory disease
- Pregnancy or lactation
- Patients on chronic opioid or sedative therapy

Randomization and Blinding: Patients were randomly allocated into two groups using a computer-generated randomization sequence. Group allocation was concealed using sealed opaque envelopes. The study drugs were prepared by an anesthesiologist not involved in block administration or data collection. Both the patient and the observer recording outcomes were blinded to group assignment.

Study Groups

Group	Drug Mixture (Total Volume 21 mL)
Group D25	20 mL of 0.5% bupivacaine + dexmedetomidine 25 µg (diluted to 1 mL)
Group D50	20 mL of 0.5% bupivacaine + dexmedetomidine 50 µg (diluted to 1 mL)

Methodology

All patients underwent pre-anesthetic evaluation a day prior to surgery. Standard fasting guidelines were followed. In the operating room, baseline heart rate (HR), non-invasive blood pressure (NIBP), mean arterial pressure (MAP), and oxygen saturation (SpO_2) were recorded.

An intravenous line was secured, and Ringer's lactate infusion was started. Under strict aseptic precautions, an ultrasound-guided supraclavicular brachial plexus block was performed with the patient in supine position and head turned to the opposite side.

A high-frequency linear ultrasound probe was used to identify the brachial plexus cluster lateral to the subclavian artery above the first rib. A 22G insulated needle was advanced in-plane, and after negative aspiration, the study drug was injected incrementally with intermittent aspiration.

Postoperative Analgesia Assessment: Pain was assessed using a Visual Analog Scale (VAS) (0–10) at 2, 4, 6, 12, and 24 hours postoperatively.

Time to first rescue analgesic (VAS $\geq$ 4) was recorded. Rescue analgesia was given as IV paracetamol 1 g, with tramadol as second-line if needed. Total analgesic consumption in 24 hours was documented.

Sedation Assessment: Sedation was assessed using the Ramsay Sedation Score at regular intervals intraoperatively and postoperatively.

Adverse Effects Monitoring

Patients were observed for:

- Bradycardia
- Hypotension
- Nausea/vomiting
- Excessive sedation
- Respiratory depression
- Signs of local anesthetic toxicity

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Quantitative variables were expressed as mean ± SD and compared using Student's t-test. Qualitative variables were analyzed using Chi-square test or Fisher's exact test. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Demographic profile of two groups

Variable	Group D25 (n=30)	Group D50 (n=30)	p-value
Age (years)	41.8 ± 12.4	43.2 ± 11.9	0.68
Gender (M/F)	18 / 12	17 / 13	0.79
Weight (kg)	64.5 ± 8.7	66.1 ± 9.3	0.48
ASA I/II	19 / 11	18 / 12	0.79
Duration of Surgery (min)	92.4 ± 18.6	95.1 ± 20.2	0.57

The demographic variables between the two study groups were comparable. The mean age in Group D25 was 41.8 ± 12.4 years and in Group D50 was 43.2 ± 11.9 years (p = 0.68), indicating no statistically significant difference. Gender distribution was also similar (D25: 18 males/12 females vs D50: 17 males/13 females, p = 0.79). Mean body weight was comparable between the groups (64.5 ± 8.7 kg vs 66.1 ± 9.3 kg; p = 0.48). ASA physical status distribution and duration of surgery were also statistically similar (p > 0.05). Thus, both groups were demographically and clinically comparable, ensuring that differences in outcomes could be attributed to the dexmedetomidine dose rather than confounding variables.

Table 2: Postoperative Analgesia

Parameter	Group D25	Group D50	p-value
Time to First Rescue Analgesia (min)	655.2 ± 70.6	890.3 ± 85.7	**<0.001**
Total Paracetamol Consumption (mg/24h)	1850 ± 420	1200 ± 350	**0.003**

The mean time to first rescue analgesia was significantly prolonged in Group D50 (890.3 ± 85.7 minutes) compared to Group D25 (655.2 ± 70.6 minutes) with a highly significant p-value (<0.001). Total 24-hour paracetamol consumption was significantly lower in Group D50 (1200 ± 350 mg) compared to Group D25 (1850 ± 420 mg) (p = 0.003). This indicates that 50 µg dexmedetomidine provided superior and longer-lasting postoperative analgesia.

Table 3: VAS pain Score

Time Post-op	Group D25	Group D50	p-value
2 hours	1.2 ± 0.8	0.6 ± 0.5	0.01
4 hours	2.4 ± 1.0	1.1 ± 0.7	**<0.001**
6 hours	3.8 ± 1.2	2.0 ± 0.9	**<0.001**
12 hours	4.6 ± 1.3	3.2 ± 1.1	0.002
24 hours	3.9 ± 1.1	3.4 ± 1.0	0.09

VAS scores were significantly lower in Group D50 during the early postoperative period:

- 2 hours: p = 0.01
- 4 hours: p < 0.001
- 6 hours: p < 0.001
- 12 hours: p = 0.002

At 24 hours, the difference was not statistically significant (p = 0.09), suggesting that the analgesic advantage of the higher dose was most pronounced in the first 12 hours postoperatively.

Table 4: Sedation Scores (Ramsay Sedation Scale)

Time Interval	Group D25	Group D50	p-value
Intraoperative	2.1 ± 0.6	3.2 ± 0.7	**<0.001**
1 hr Post-op	2.0 ± 0.5	2.8 ± 0.6	**0.002**
2 hr Post-op	1.8 ± 0.4	2.3 ± 0.5	0.01

Sedation scores were significantly higher in Group D50:

- Intraoperative: $p < 0.001$
- 1 hour post-op: $p = 0.002$
- 2 hours post-op: $p = 0.01$

However, no patient developed respiratory depression, indicating that the sedation remained within safe clinical limits.

Table 5: Adverse Effects

Complication	Group D25	Group D50	p-value
Bradycardia	1 (3.3%)	6 (20%)	**0.04**
Hypotension	2 (6.6%)	5 (16.6%)	0.21
Nausea/Vomiting	2 (6.6%)	3 (10%)	0.64
Excess Sedation	0	4 (13.3%)	0.03
Respiratory Depression	0	0	—

Bradycardia occurred significantly more frequently in Group D50 (20%) compared to Group D25 (3.3%) ($p = 0.04$). Excess sedation was also significantly higher in the D50 group (13.3% vs 0%, $p = 0.03$). Although hypotension was more frequent in D50 (16.6% vs 6.6%), the difference was not statistically significant ($p = 0.21$). Incidence of nausea and vomiting was comparable, and no respiratory depression was observed in either group.

Discussion

This study evaluated the dose-dependent effects of dexmedetomidine (25 µg vs 50 µg) as an adjuvant to bupivacaine in supraclavicular brachial plexus block, focusing on postoperative analgesia, sedation, and adverse effects.

Both groups were comparable in terms of age, sex, weight, ASA status, and surgical duration, eliminating confounding bias. Similar baseline characteristics have been reported in previous dexmedetomidine dose comparison studies, ensuring valid outcome interpretation.

The significantly prolonged duration to first rescue analgesia in the D50 group demonstrates a clear dose-response relationship. Dexmedetomidine prolongs analgesia through peripheral vasoconstriction, inhibition of C-fiber transmission, and central modulation of nociceptive pathways. These findings align with studies by Singh et al. and Tripathi et al. [5,6], who observed prolonged analgesia with higher doses of perineural dexmedetomidine. Meta-analyses have also shown that increasing dexmedetomidine doses correlate with longer sensory block duration and delayed analgesic requirement. The reduced 24-hour paracetamol requirement in Group D50 highlights its opioid-sparing and analgesic-sparing effect, which is clinically important in minimizing drug-related side effects.[7]

Lower VAS scores in the first 12 postoperative hours in the D50 group indicate superior early postoperative pain control. Similar findings were reported by Agarwal et al., [1,8] where higher doses of dexmedetomidine resulted in lower early postoperative pain scores. The disappearance of difference at 24 hours suggests that the effect is primarily linked to the extended duration of the nerve block.

Dexmedetomidine produces dose-dependent sedation by acting on α2 receptors in the locus coeruleus. The higher sedation scores in the D50 group are consistent with findings from Kathuria et al. and Chenz et al., who reported increased sedation with higher perineural doses. [9,10] Importantly, no respiratory depression occurred, confirming the safety of dexmedetomidine-induced sedation.

Mild sedation during regional anesthesia may enhance patient comfort and reduce anxiety, making this an additional beneficial effect rather than a complication. The higher incidence of bradycardia in the D50 group reflects the sympatholytic properties of dexmedetomidine. Similar dose-dependent bradycardia has been documented in studies by Choksi et al and Parmar et al [11,12]. Although hypotension was more frequent in the higher dose group, it did not reach statistical significance, possibly due to the modest sample size.

The absence of respiratory depression supports the safety profile of dexmedetomidine, distinguishing it from opioid adjuvants.

Clinical Interpretation

The findings indicate a trade-off between efficacy and safety:

- 50 µg dose → Superior analgesia and sedation but higher bradycardia risk
- 25 µg dose → Adequate analgesia with better hemodynamic stability

Thus, dose selection should be individualized based on patient cardiovascular status and expected postoperative pain severity.

Limitations

Despite providing meaningful insights into the dose-dependent effects of dexmedetomidine as an

adjuvant in supraclavicular brachial plexus block, this study has certain limitations.

First, the sample size was relatively small, which may limit the generalizability of the findings and reduce the power to detect less frequent adverse effects such as severe bradycardia or hypotension. Larger multicentric studies would help validate these results.

Second, the study was conducted at a single tertiary care center, which may limit the applicability of the findings to different patient populations and practice settings.

Third, only two doses of dexmedetomidine (25 µg and 50 µg) were compared. Intermediate or weight-based dosing strategies were not evaluated, which might further refine the optimal dose selection.

Fourth, the study primarily focused on early postoperative outcomes (24 hours). Long-term follow-up for persistent analgesia, delayed neurological complications, or rebound pain after block resolution was not performed.

Fifth, although sedation was assessed using Ramsay Sedation Score, more objective tools such as bispectral index (BIS) monitoring were not used, which could have provided a more precise evaluation of sedation depth.

Lastly, the study excluded patients with significant cardiovascular disease; therefore, the safety of higher-dose dexmedetomidine in high-risk populations remains to be established.

Conclusion

The present study demonstrates a clear dose-dependent effect of dexmedetomidine when used as an adjuvant to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block.

The 50 µg dose provided significantly longer duration of postoperative analgesia, lower early postoperative pain scores, and reduced analgesic consumption compared to the 25 µg dose. However, this enhanced analgesic benefit was accompanied by a higher incidence of bradycardia and increased sedation. Thus, dexmedetomidine demonstrates a favorable balance between efficacy and safety when individualized according to patient profile and surgical requirements. Rather than adopting a uniform dose for all patients, anesthesiologists should consider tailoring the dexmedetomidine dose to optimize analgesia while minimizing adverse effects.

This study supports the concept of dose optimization and personalized regional anesthesia practice for improved perioperative outcomes.

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