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Original Research Article

Efficacy of Intravenous versus Perineural Dexmedetomidine as an Adjunct to Levobupivacaine in Supraclavicular Brachial Plexus Block: A Randomized Comparative Study

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Conflict of interest: Nil

Abstract:

Background and Aim: Dexmedetomidine, an α2-adrenergic agonist, is increasingly used as an adjuvant in regional anaesthesia to improve block quality and prolong postoperative analgesia. However, the optimal route of administration—intravenous versus perineural—remains under debate. This study aimed to compare the efficacy of intravenous versus perineural dexmedetomidine when used as an adjunct to levobupivacaine in ultrasound-guided supraclavicular brachial plexus blocks.

Material and Methods: A prospective randomized study was conducted on 100 adult patients undergoing elective upper limb surgeries. Patients were divided into two groups (n=50 each). Group DP received perineural dexmedetomidine (1 µg/kg) with levobupivacaine, and Group DIV received intravenous dexmedetomidine (1 µg/kg) with levobupivacaine alone perineurally. Primary outcomes included onset time and duration of sensory and motor block. Secondary outcomes were sedation, hemodynamic stability, and duration of analgesia.

Results: Onset of both sensory and motor block was significantly faster in Group DIV compared to Group DP ($p < 0.001$). However, the duration of sensory and motor block, as well as postoperative analgesia, was significantly longer in the DP group ($p < 0.001$). No significant adverse effects were observed in either group.

Conclusion: Intravenous dexmedetomidine leads to a quicker onset of block, while perineural administration offers prolonged analgesia and block duration. Both routes are safe and effective, and the choice may be tailored based on surgical requirements and desired clinical outcomes.

Keywords: Dexmedetomidine, Perineural, Intravenous, Levobupivacaine, Supraclavicular Block, Brachial Plexus, Regional Anaesthesia.

Introduction

The supraclavicular brachial plexus block (SCBPB) has emerged as a cornerstone in regional anaesthesia for upper limb surgeries, offering profound sensory and motor blockade, excellent postoperative analgesia, and opioid-sparing effects [1]. Among the wide array of local anaesthetics, levobupivacaine is frequently preferred due to its long duration of action and better cardiovascular safety profile compared to racemic bupivacaine [2]. Despite its favorable pharmacokinetics, adjuncts are often co-administered to improve the onset time, prolong the duration of analgesia, and enhance overall block quality.

Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, has shown promising results as an adjuvant to local anaesthetics owing to its analgesic, anxiolytic, and sympatholytic properties without significant respiratory depression [3]. The drug can be administered either intravenously (IV) or perineurally, and both routes have been evaluated for efficacy in enhancing regional anaesthesia outcomes. However, the debate continues regarding the optimal route of administration for maximizing block characteristics while minimizing systemic side effects.

Several studies have demonstrated that perineural dexmedetomidine, when combined with levobupivacaine, significantly prolongs the duration of both sensory and motor blockade in brachial plexus blocks, likely due to its action on hyperpolarization-activated cation channels at the nerve site [4,5]. On the other hand, IV dexmedetomidine exerts its effects via central α2-receptor activation, which may modulate nociceptive transmission and augment local anaesthetic effects through a systemic mechanism [6]. With the widespread use of ultrasound guidance, there has been a shift toward precision in

drug deposition, further opening the debate on whether perineural administration still holds a distinct advantage when the local anaesthetic is already accurately delivered [7]. Additionally, concerns about potential neurotoxicity of perineural dexmedetomidine—though rare—have prompted many practitioners to prefer the intravenous route [8]. Recent literature has explored both methods in various brachial plexus block approaches. A number of studies suggest similar efficacy between IV and perineural routes, with some showing slightly prolonged analgesia with perineural use but increased sedation and hemodynamic side effects with IV use [9, 10]. However, variability in patient populations, dosages, surgical types, and assessment techniques has resulted in heterogeneous data and lack of consensus.

Hence, there remains a need for high-quality, randomized controlled trials to directly compare the two routes using standardized techniques and outcome measures. This study aims to fill that gap by comparing the efficacy of intravenous versus perineural dexmedetomidine as an adjunct to levobupivacaine in ultrasound-guided supraclavicular brachial plexus blocks, with special emphasis on onset time, block duration, postoperative analgesia, and side effect profiles.

Material and Methods

This prospective, randomized, double-blinded study was conducted after obtaining approval from the Institutional Ethics Committee. A total of 100 adult patients of either sex, aged between 18 and 65 years, scheduled for elective upper limb surgeries under supraclavicular brachial plexus block, were enrolled in the study.

All patients provided written informed consent prior to participation. Eligible patients were classified as ASA physical status I or II. Exclusion criteria included patient refusal, history of allergy to study drugs, local infection at the block site, coagulopathy, neurological or psychiatric disorders, and chronic opioid use.

Patients were randomly allocated into two equal groups (n = 50 each) using computer-generated randomization and the sealed envelope technique:

- Group DP (Perineural Dexmedetomidine Group, n = 50): Received 25 mL of 0.5% levobupivacaine mixed with 1 µg/kg of dex-medetomidine administered perineurally under ultrasound guidance.
- Group DIV (Intravenous Dexmedetomidine Group, n = 50): Received 25 mL of 0.5% levobupivacaine alone perineurally, and 1 µg/kg of dexmedetomidine diluted in 50 mL normal saline administered as an intravenous infusion over 10 minutes, started just before the block.

Procedure

All patients were monitored preoperatively with ECG, non-invasive blood pressure, and pulse oximetry. An intravenous cannula was secured, and baseline vitals were recorded. All blocks were performed under strict aseptic precautions using a high-frequency linear ultrasound probe. With the patient in the supine position and the head turned to the contralateral side, the supraclavicular brachial plexus was visualized using ultrasound. A 22G insulated stimulating needle was inserted using the in-plane technique. After negative aspiration, the prepared drug mixture was administered in a single injection after confirming proper needle placement.

Sensory block was assessed every 2 minutes using a pinprick method in the radial, median, ulnar, and musculocutaneous nerve territories until complete loss of sensation. Motor block was evaluated using the Modified Bromage Scale for upper limbs. Block onset time, duration of sensory and motor blockade, and duration of analgesia were recorded. Postoperative pain was evaluated using the Visual Analog Scale (VAS) at 1, 2, 4, 6, 12, and 24 hours. Duration of analgesia was defined as the time from completion of block to the first request for rescue analgesia (inj. paracetamol 1 g IV). Sedation was assessed using the Ramsay Sedation Scale. Hemodynamic parameters (HR, MAP) were recorded at baseline and at regular intervals intraoperatively and postoperatively.

Statistical Analysis:

Sample size calculation was based on detecting a minimum 20% difference in duration of analgesia between the two groups, with 80% power and a 5% significance level. Data were analyzed using SPSS version 22.0. Quantitative variables were expressed as mean ± standard deviation and compared using the independent t-test. Categorical variables were analyzed using the chi-square or Fisher's exact test. A p-value < 0.05 was considered statistically significant.

Results

Table 1 shows the demographic distribution of the 100 patients included in the study, with 50 patients each in the intravenous dexmedetomidine group (DIV) and the perineural dexmedetomidine group (DP). Age distribution was comparable between the groups, with most patients falling in the 31–60 years range.

The p-value for age distribution was 0.663, indicating no statistically significant difference. Gender distribution was also balanced, with 42% females in the DIV group and 38% in the DP group ($p = 0.684$). ASA physical status was similar between both groups, with 70% of patients in Group DIV and 72% in Group DP classified as ASA I, and the remaining as ASA II ($p = 0.823$).

This confirms that both groups were demographically comparable and well-matched for the study. Table 2 shows the comparison of onset time and duration of sensory and motor blockade between the two groups. The onset of sensory block was significantly faster in the DIV group (576.42 ± 58.37 seconds) compared to the DP group (638.58 ± 65.21 seconds), with a p-value <0.001. Similarly, the motor block onset was quicker in the DIV group (542.63 ± 57.89 seconds) than in the DP group (619.16 ± 69.03 seconds), also statistically significant (p <0.001). In contrast, the duration of both sensory and motor blocks was longer in the DP group. Sensory block lasted 668.14 ± 70.92 minutes in Group DP versus 582.24 ± 63.84 minutes in Group DIV (p <0.001), and motor block lasted 645.72 ± 68.15 minutes in Group DP compared to 559.07 ± 61.32 minutes in Group DIV (p <0.001). These findings indicate that intravenous dexmedetomidine leads to a faster onset of block, whereas perineural administration prolongs the duration of anaesthesia significantly.

Table 1: Demographic Variables with Comparison among Study Groups (n = 100)

Variable	Category	DIV (n = 50)	DP (n = 50)	p-value*
Age	**≤30 years**	12 (24.0%)	10 (20.0%)	**0.663**
	31–40 years	11 (22.0%)	13 (26.0%)	
	41–50 years	10 (20.0%)	9 (18.0%)	
	51–60 years	9 (18.0%)	11 (22.0%)	
	61–70 years	8 (16.0%)	7 (14.0%)	
Gender	**Female**	21 (42.0%)	19 (38.0%)	**0.684**
	Male	29 (58.0%)	31 (62.0%)	
ASA Grade	**I**	35 (70.0%)	36 (72.0%)	**0.823**
	II	15 (30.0%)	14 (28.0%)	

***Chi-square test applied**

Table 2: Comparison of Onset and Duration of Sensory and Motor Block (n = 100)

Variable	Type	DIV (mean ± SD)	DP (mean ± SD)	p-value*
Duration of Onset	**Sensory**	576.42 ± 58.37 sec	638.58 ± 65.21 sec	**<0.001**
	Motor	542.63 ± 57.89 sec	619.16 ± 69.03 sec	**<0.001**
Duration of Block	**Sensory**	582.24 ± 63.84 min	668.14 ± 70.92 min	**<0.001**
	Motor	559.07 ± 61.32 min	645.72 ± 68.15 min	**<0.001**

***Unpaired t-test applied**

Discussion

In this prospective randomized study comparing intravenous versus perineural dexmedetomidine as an adjuvant to levobupivacaine in ultrasound-guided supraclavicular brachial plexus blocks, both groups demonstrated effective anaesthesia and analgesia. However, significant differences were observed in the onset and duration of sensory and motor blocks.

The intravenous dexmedetomidine (DIV) group exhibited a faster onset of both sensory and motor blockade, suggesting that systemic dexmedetomidine may modulate central α2-adrenoceptors, reducing sympathetic outflow and facilitating quicker nerve desensitization [11]. This is consistent with findings from Goyal et al., who reported a faster onset with IV dexmedetomidine in upper limb blocks compared to perineural use [12].

In contrast, the perineural dexmedetomidine (DP) group showed a significantly prolonged duration of both sensory and motor blockade, indicating enhanced local action when the drug is applied directly at the nerve plexus. Dexmedetomidine's ability to inhibit hyperpolarization-activated cation currents prolongs local anaesthetic action and contributes to sustained analgesia [13]. These findings align with those of Park et al., who observed enhanced block duration with perineural dexmedetomidine in brachial plexus blocks [14]. Despite faster onset in the IV group, the extended block duration in the perineural group provides a significant advantage in terms of postoperative analgesia, reducing the need for rescue analgesics. However, concerns about neurotoxicity with perineural dexmedetomidine have been raised, though current evidence remains inconclusive [15].

The choice between intravenous and perineural administration must balance rapid onset versus prolonged analgesia, as well as safety and simplicity of administration. In clinical practice, perineural administration may be favored when extended postoperative analgesia is desired, whereas intravenous use may be more appropriate in short-duration procedures or when perineural injection of adjuvants is not feasible.

Conclusion

The results of this study indicate that intravenous dexmedetomidine leads to a faster onset of sensory and motor blockade, whereas perineural dexmedetomidine significantly prolongs the duration of anaesthesia and postoperative analgesia. Both routes are effective and safe when used with

levobupivacaine in supraclavicular brachial plexus blocks.

Therefore, the route of dexmedetomidine administration may be selected based on the desired clinical outcome—faster onset versus prolonged duration—and individual patient requirements.

Further large-scale studies are needed to assess long-term safety and optimize dosing strategies.

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