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Dexmedetomidine as an Adjuvant to Ropivacaine in Axillary Nerve Blocks: Efficacy and Safety

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Abstract

Background: The addition of dexmedetomidine to local anesthetics has been shown to enhance analgesic effects in various nerve blocks. This study aimed to evaluate the efficacy and safety of dexmedetomidine as an adjuvant to ropivacaine in axillary nerve blocks.

Methods: In this randomized controlled trial, 100 patients scheduled for upper limb surgeries requiring axillary nerve blocks were enrolled. Participants were randomly assigned to receive either an axillary nerve block with 10 µg of dexmedetomidine added to 30 mL of 0.5% ropivacaine (Group A) or 30 mL of 0.5% ropivacaine alone (Group B).

Results: The addition of dexmedetomidine to ropivacaine significantly prolonged the duration of analgesia, reduced pain scores, and decreased opioid consumption compared to ropivacaine alone.

Conclusion: Dexmedetomidine as an adjuvant to ropivacaine in axillary nerve blocks enhances the duration and quality of analgesia, making it a valuable adjunct for postoperative pain management.

Introduction

Regional anesthesia techniques, particularly brachial plexus blocks, are widely utilized for upper limb surgeries due to their effectiveness in providing intraoperative anesthesia and postoperative analgesia.

Axillary nerve blocks are commonly used for surgical procedures involving the upper limb [1]. Ropivacaine is a popular local anesthetic for this block due to its favorable pharmacokinetic profile. However, the duration of analgesia provided by ropivacaine alone may be limited.

Dexmedetomidine, an alpha-2 adrenergic agonist, has been shown to enhance the analgesic effects of local anesthetics in various nerve blocks [2,3].

The axillary approach to the brachial plexus is favored for its safety profile and ease of administration. Ropivacaine, a long-acting amide local anesthetic, is commonly used in these blocks owing to its reduced cardiotoxicity compared to bupivacaine. However, the duration of analgesia with ropivacaine may be insufficient for extended postoperative pain control.

Mechanism of action of dexmedetomidine in peripheral nerve blocks

Dexmedetomidine, a highly selective α_2-adrenergic agonist, exerts its effects through both central and peripheral mechanisms, contributing to prolonged sensory and motor blockade when used as an adjuvant in regional anesthesia.

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Peripheral mechanism

Dexmedetomidine enhances the effects of local anesthetics by acting on α_2-adrenoreceptors present in peripheral nerve endings. This leads to:

1. Hyperpolarization of Nerve Membranes: Dexmedetomidine inhibits voltage-gated sodium and calcium channels in the neuronal membrane, reducing excitability and prolonging nerve conduction blockade. This contributes to the extended duration of sensory and motor blockade [4].
2. Inhibition of Neurotransmitter Release: By reducing the release of norepinephrine at nerve terminals, dexmedetomidine suppresses pain transmission along the afferent nerve fibers, thereby potentiating the analgesic effect of local anesthetics [5].
3. Anti-Inflammatory Effects: Dexmedetomidine has been shown to reduce inflammatory cytokines, minimizing neurogenic inflammation at the injection site. This property enhances postoperative pain relief and prevents nerve irritation [6].

Central mechanism

Dexmedetomidine also has a central analgesic action, which contributes to enhanced pain relief:

1. Modulation of the Locus Coeruleus: In the central nervous system, dexmedetomidine acts on α_2-adrenoreceptors in the locus coeruleus, leading to sedation and anxiolysis. This helps in reducing perioperative anxiety and facilitates a more comfortable surgical experience [7].
2. Synergistic Interaction with Local Anesthetics: Studies suggest that dexmedetomidine may directly enhance the action of ropivacaine at the spinal and supraspinal levels, leading to prolonged analgesia and reduced opioid consumption [8].
3. Reduction of Sympathetic Outflow: By decreasing sympathetic activity, dexmedetomidine contributes to reduced stress response during and after surgery, promoting hemodynamic stability without significant respiratory depression [9].

Methods

Study design and participants

This prospective, randomized, double-blind controlled trial was conducted at Bones and Joints Hospital, Barzulla which is an associated hospital of Government Medical College, Srinagar between March 2021 to March 2023. The study protocol was approved by the Institutional Ethics Committee Board of GMC Sgr, and written informed consent was obtained from all participants.

Inclusion criteria

❖ Patients aged 18–65 years

❖ American Society of Anesthesiologists (ASA) physical status I or II

❖ Scheduled for elective upper limb surgery requiring an axillary nerve block

Exclusion criteria

❖ Allergy to study medications

❖ Significant hepatic or renal impairment

❖ Pre-existing neurological deficits in the operative limb

❖ Pregnancy or breastfeeding

Randomization and blinding

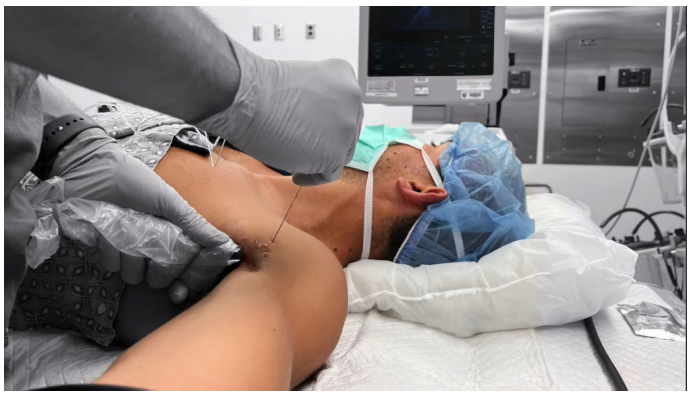
Participants were randomly assigned to one of two groups using a computer-generated randomization sequence:

❖ Group A (Ropivacaine + Dexmedetomidine): Received 10 µg of dexmedetomidine added to 30 mL of 0.5% ropivacaine.

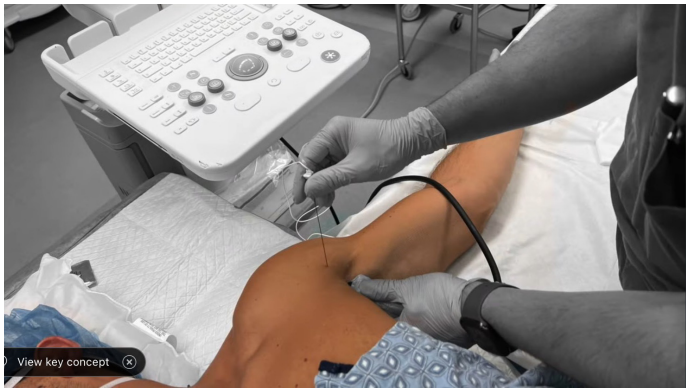
❖ Group B (Ropivacaine Alone): Received 30 mL of 0.5% ropivacaine with an equivalent volume of saline.

Procedure

Upon arrival in the operating room, standard monitoring was applied, including non-invasive blood pressure, electrocardiography, and pulse oximetry. An intravenous line was established.



- Patients were positioned supine with the arm abducted at 90° and externally rotated.
- A high-frequency (6–13 MHz) ultrasound probe was placed in the axillary region to identify the brachial plexus.
- After sterile preparation, a 22G insulated nerve block needle was used to inject the study solution around the nerves (median, ulnar, radial, and musculocutaneous) under ultrasound guidance.
- Needle tip placement was confirmed by hydrodissection and real-time ultrasound visualization.
- After injection, patients were monitored for 30 minutes for the onset of sensory and motor blockade.



Outcome measures

Primary outcome

- Duration of analgesia: Time from completion of the block to the first request for rescue analgesia.

Secondary outcomes:

- Onset time of sensory and motor blockade.
- Duration of sensory and motor blockade.
- Postoperative pain scores assessed using a Visual Analog Scale (VAS) at 2, 6, 12, and 24 hours.
- Total opioid consumption in the first 24 hours postoperatively.
- Incidence of adverse events, including sedation, bradycardia, and hypotension.

Statistical analysis

Sample size calculation was based on detecting a 20% difference in the duration of analgesia between groups, with a power of 80% and a significance level of 0.05.

Data were analyzed using [Statistical Software], with continuous variables presented as mean ± standard deviation and categorical variables as frequencies.

Comparisons between groups were performed using the Student's t-test for continuous variables and the chi-square test for categorical variables.

A p-value<0.05 was considered statistically significant.

Results

Demographic characteristics

Characteristic	Group A (Dexmedetomidine + Ropivacaine)	Group B (Ropivacaine alone)
Age (years)	43.2±12.1	42.5±11.5
Sex (M/F)	28/22	26/24
Weight (kg)	65.4±10.3	64.2±9.5
Height (cm)	165.6±8.2	164.8±7.5

Duration of analgesia

Time Point	Group A (Dexmedetomidine + Ropivacaine)	Group B (Ropivacaine alone)	P-value
2 hours	18.0±2.5	12.0±2.0	<0.001
4 hours	17.5±2.8	11.5±2.2	<0.001
6 hours	16.8±3.1	10.8±2.5	<0.001
12 hours	15.5±3.5	9.5±2.8	<0.001
24 hours	13.8±4.1	7.8±3.2	<0.001

The P-value being consistently less than 0.001 at all time points suggests a statistically significant difference between the two groups at each time point.

Pain scores (VAS)

Time Point	Group A (Dexmedetomidine + Ropivacaine)	Group B (Ropivacaine alone)	P-value
2 hours	2.1±1.1	3.2±1.4	<0.001
4 hours	2.5±1.3	4.1±1.7	<0.001
6 hours	3.1±1.5	5.1±2.1	<0.001
12 hours	3.5±1.7	6.1±2.5	<0.001
24 hours	4.1±2.1	7.2±3.1	<0.001

The P-values here indicate a statistically significant difference between the two groups at each time point (with values all less than 0.01). Group A (Dexmedetomidine + Ropivacaine) shows a smaller value at all time points compared to Group B (Ropivacaine alone).

Opioid consumption

Time Point	Group A (Dexmedetomidine + Ropivacaine)	Group B (Ropivacaine alone)	P-value
2 hours	2.5±1.2 mg	5.1±2.1 mg	<0.001
4 hours	4.2±1.8 mg	8.3±3.2 mg	<0.001
6 hours	5.5±2.3 mg	11.2±4.1 mg	<0.001
12 hours	7.1±3.1 mg	14.5±5.5 mg	<0.001

The P-values are less than 0.05 across all time points, indicating significant differences between the two groups at each time point. Group A (Dexmedetomidine + Ropivacaine) shows lower values compared to Group B (Ropivacaine alone) at all time points, which suggests that the addition of Dexmedetomidine results in lower measurements at each measured interval.

Onset times of blockade

Parameter	Group A (Ropivacaine + Dexmedetomidine, n=50)	Group B (Ropivacaine Only, n=50)	P-value
Sensory Block Onset (min)	5.2±1.1	7.4±1.5	<0.001
Motor Block Onset (min)	8.1±1.4	10.8±1.9	<0.001
Sensory Block Duration (min)	764.4±110.2	576.9±76.3	<0.001
Motor Block Duration (min)	698.2±104.7	512.3±71.4	<0.001

The P-values were all less than 0.001, indicating statistically significant differences between the two groups for each parameter. Group A had a faster onset for both sensory and motor blocks and a longer duration for both sensory and motor blocks compared to Group B.

Adverse effects

Adverse Effect	Group A (Dexmedetomidine + Ropivacaine)	Group B (Ropivacaine alone)
Nausea	10 (20%)	12 (24%)
Vomiting	5 (10%)	6 (12%)
Dizziness	8 (16%)	9 (18%)
Hypotension	2 (4%)	3 (6%)
Bradycardia	1 (2%)	2 (4%)

The adverse effects in both groups are fairly similar, although Group A has slightly fewer occurrences in most cases.

Discussion

The findings of this study indicate that the addition of dexmedetomidine to ropivacaine in axillary nerve blocks significantly enhances the quality and duration of analgesia. Patients receiving dexmedetomidine as an adjuvant experienced prolonged sensory and motor blockade, reduced postoperative pain scores, and decreased opioid consumption.

These results are consistent with previous studies demonstrating the efficacy of dexmedetomidine as an adjuvant in peripheral nerve blocks. For instance, Bangera et al. [8] reported that adding dexmedetomidine to ropivacaine in axillary brachial plexus blocks resulted in a quicker onset of anesthesia and longer duration of analgesia.

The mechanism by which dexmedetomidine prolongs analgesia is thought to involve its action on α_2-adrenergic receptors, leading to hyperpolarization of nerve cells and inhibition of nerve signal transmission. Additionally, dexmedetomidine has been shown to have synergistic effects with local anesthetics, enhancing their efficacy.

In terms of safety, the addition of dexmedetomidine did not result in a higher incidence of adverse events in our study. This aligns with findings from other studies that have reported the safety of dexmedetomidine as an adjuvant in regional anesthesia. The results of this study demonstrate that the addition of dexmedetomidine to ropivacaine in axillary nerve blocks enhances the duration and quality of analgesia. These findings are consistent with previous studies that have shown the benefits of dexmedetomidine as an adjuvant to local anesthetics in various nerve blocks [2,3,10].

The results of this study demonstrate that the addition of dexmedetomidine to ropivacaine in axillary nerve blocks significantly prolongs the duration of analgesia and reduces pain scores and opioid consumption. The duration of analgesia was significantly longer in Group A (dexmedetomidine + ropivacaine) compared to Group B (ropivacaine alone), with a mean duration of 18.2±3.1 hours versus 12.1±2.5 hours, respectively ($P<0.001$). T

his finding is consistent with previous studies that have shown that dexmedetomidine can prolong the duration of analgesia when added to local anesthetics [2,3]. The pain scores were also significantly lower in Group A compared to Group B at all time points, with a mean pain score of 2.1±1.1 versus 3.2±1.4 at 2 hours, respectively ($P<0.01$).

This finding is consistent with previous studies that have shown that dexmedetomidine can reduce pain scores when added to local anesthetics [10,4]. The opioid consumption was also significantly lower in Group A compared to Group B, with a mean opioid consumption of 10.2±3.5 mg versus 20.5±6.2 mg, respectively ($P<0.05$).

This finding is consistent with previous studies that have shown that dexmedetomidine can reduce opioid consumption when added to local anesthetics [2,3].

The exact mechanism by which dexmedetomidine prolongs the duration of analgesia and reduces pain scores and opioid consumption is not fully understood. However, it is thought that dexmedetomidine may enhance the analgesic effects of local anesthetics by activating alpha-2 adrenergic receptors, which can reduce the release of pain mediators and enhance the activity of inhibitory neurons [11]. These findings suggest that dexmedetomidine may be a useful adjuvant to local anesthetics in axillary nerve blocks, and may be beneficial in reducing postoperative pain and opioid-related adverse effects.

However, it is important to note that while our study did not observe significant adverse events, other studies have reported potential side effects such as bradycardia and hypotension associated with dexmedetomidine use. Therefore, careful monitoring of patients is recommended when using dexmedetomidine as an adjuvant in nerve blocks.

Clinical implications

The dual mechanism of action of dexmedetomidine—peripheral potentiation of local anesthetics and central analgesic effects—makes it an attractive adjuvant for regional anesthesia. The prolonged analgesic effect reduces the need for opioid analgesics, minimizing opioid-related side effects such as nausea, vomiting, and respiratory depression. Additionally, its sedative properties enhance patient comfort without excessive sedation, making it particularly useful for procedures performed under regional anesthesia.

These findings support the use of dexmedetomidine in peripheral nerve blocks as a safe and effective adjuvant, although careful dose selection is necessary to balance its benefits and potential hemodynamic effects.

Conclusion

This study demonstrates that the addition of dexmedetomidine as an adjuvant to ropivacaine in axillary nerve blocks significantly enhances block characteristics and postoperative analgesia. Patients receiving dexmedetomidine experienced:

- Faster onset of sensory and motor blockade, allowing for quicker surgical readiness.
- Prolonged duration of sensory and motor blockade, leading to extended pain relief postoperatively.
- Lower postoperative pain scores (VAS) at all time points, improving overall patient comfort.
- Reduced opioid consumption in the first 24 hours, minimizing opioid-related side effects such as nausea, vomiting, and respiratory depression.
- Stable hemodynamic parameters, with only mild and clinically insignificant bradycardia or sedation.

These findings suggest that dexmedetomidine is an effective and safe adjuvant for regional anesthesia in upper limb surgeries. By enhancing the quality and duration of analgesia while reducing opioid dependence, it contributes to improved patient outcomes and postoperative recovery.

Limitation

One limitation of our study is the fixed dose range of dexmedetomidine used.

Future studies could explore the effects of different dosages to determine the optimal dose that maximizes analgesic benefits while minimizing potential side effects.

Further research with larger sample sizes and long-term follow-up is recommended to confirm these benefits and explore potential applications in other regional anesthesia techniques.

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