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ORIGINAL RESEARCH

A Comparative Study of Dexmedetomidine and Fentanyl as Adjuvants to Ropivacaine in Ultrasound-Guided Supraclavicular Brachial Plexus Block: A Prospective Observational Study

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ABSTRACT

Background: Due to the anatomical convenience of blocking nerve roots at this level, supraclavicular brachial plexus block is commonly employed for upper limb surgeries. The present study was conducted to compare dexmedetomidine and fentanyl as an adjuvant to Ropivacaine in ultrasound guided supraclavicular brachial plexus block.

Materials & Methods: 100 patients selected for upper limb surgery of both genders were divided into 2 groups of 50 each. Group I patients received ropivacaine 0.5% (20 mL) + dexmedetomidine 1 mcg/kg and group II received ropivacaine 0.5% (20 mL) + Fentanyl 1 mcg/kg. Parameters such as onset, time to complete sensory and motor block, duration of sensory and motor block, duration of analgesia, adverse effects and haemodynamic status were monitored.

Results: Group I had 24 males and 26 females and group II had 28 males and 22 females.

The onset of sensory block was 3.2±1.1 and 3.0±0.4, total duration of sensory block was 630.2±211.5 and 547.2±110.6, onset of motor block was 4.5±2.3 and 4.3±2.0, total duration of motor block was 612.4±42.6 and 520.4±23.6 and duration of analgesia was 720.4±26.4 and 424.6±110.6 in group I and II respectively. The difference was significant (P< 0.05). Side effects were bradycardia in 1 in group I, hypotension 1 in group II, nausea and vomiting 1 each in both groups, pneumothorax 1 in group II and respiratory depression 2 in group I and 1 in group II. The difference was non- significant (P> 0.05).

Conclusion: For upper limb anaesthesia, the supraclavicular block is a dependable method of brachial plexus block with quick onset. In Ultrasound-guided supraclavicular brachial plexus block, the use of dexmedetomidine at a dose of 1 mcg/kg as an adjunct to 0.5% ropivacaine 20 mL provides superior sensory and motor block durations as well as analgesia when compared to fentanyl.

Keywords: Dexmedetomidine, Ropivacaine, Supraclavicular block

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INTRODUCTION

Due to the anatomical convenience of blocking nerve roots at this level, supraclavicular brachial plexus block is commonly employed for upper limb surgeries. Brachial plexus block offers several benefits compared to general anaesthesia, such as the preservation of overall body physiology, reduced postoperative pain, shorter duration in the postoperative care unit, and a lower occurrence of postoperative nausea and vomiting.[1]The approach to brachial plexus block has advanced from the traditional blind paresthesia technique to the ultrasound-guided supraclavicular brachial plexus block. The classical approach was linked to a higher incidence of failure and injuries to the nerves and nearby structures.[2]

The use of ultrasound for guidance in blocking provides enhanced safety and precision in locating the nerve that requires blocking. The need for a smaller total volume of local anaesthetic to achieve an effective block may decrease the likelihood of systemic toxicity from the local anaesthetic. Ropivacaine, an amide, is a long-acting local anaesthetic with the highest safety margin of all such agents. Ropivacaine has a lower risk of cardiotoxicity than bupivacaine. However, if the local anesthetics employed have a limited duration of action, the advantages of a brachial plexus block may not endure. Because the local anaesthetics used for brachial plexus block have a short duration, there may be a need for general anaesthesia.[3]

Dexmedetomidine is a potent α2 agonist and is now emerging as an adjuvant to regional anesthesia and analgesia. It can prolong the duration of the nerve block anesthesia when used with a local anesthetic and only has a few side effects.[4]Dexmedetomidine prolong the duration of local anesthetics are not completely understood and may arise from various factors. Dexmedetomidine can reduce local inflammation and prolong the duration of nerve block through vasoconstriction by maintaining the local concentration of the local anesthetic.[5,6]

AIM AND OBJECTIVES

The present study was conducted to compare dexmedetomidine and fentanyl as an adjuvant to Ropivacaine in ultrasound guided supraclavicular brachial plexus block.

MATERIALS AND METHODS

Study Design

This was a prospective, randomized, double-blind, comparative clinical study conducted to evaluate the efficacy of dexmedetomidine and fentanyl as adjuvants to ropivacaine in ultrasound-guided supraclavicular brachial plexus block.

Study Population

The study included 100 patients of either gender, aged between 18 and 60 years, who were scheduled to undergo elective upper limb surgery under supraclavicular brachial plexus block.

Study Place

The study was conducted in the Department of Anaesthesia, Nalanda Medical College and Hospital, Patna, Bihar, India in collaboration with Department of Anaesthesia, Lord Buddha Koshi Medical College & Hospital, Saharsa, Bihar, India.

Study Duration

The study was conducted over a period of one year and eight months from March 2023 to October 2024.

Inclusion Criteria

- Patients aged 18–60 years.ASA physical status I or II. Scheduled for elective upper limb surgery requiring a supraclavicular block.
- Willing to provide written informed consent.

Exclusion Criteria

- Known allergy or hypersensitivity to local anaesthetics or study drugs.
- Coagulopathy or patients on anticoagulant therapy.
- Local infection at the site of injection.
- Neurological deficits in the upper limb.
- Severe cardiovascular, hepatic, or renal disease.
- Pregnant or lactating women.
- BMI >35 kg/m².

Ethical Considerations

The study was approved by the Institutional Ethics Committee (IEC). Written informed consent was obtained from all participants after explaining the study's purpose, procedures, risks, and benefits in their native language. The study adhered to the principles outlined in the Declaration of Helsinki.

Study Procedure

A total of 100 patients were randomly allocated into two groups of 50 each using computer-generated random numbers and sealed envelope technique:

- Group I (R+D): Received 20 mL of 0.5% ropivacaine + dexmedetomidine 1 mcg/kg.
- Group II (R+F): Received 20 mL of 0.5% ropivacaine + fentanyl 1 mcg/kg.

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Standard monitoring (ECG, NIBP, SpO_2) was applied. Intravenous access was established. The supraclavicular block was performed under ultrasound guidance using a high-frequency linear probe (6–13 MHz) and a 22G needle with aseptic precautions.

After confirming negative aspiration, the drug solution was injected incrementally. An independent observer, blinded to the group allocation, recorded all parameters.

Surgical Technique

All patients underwent standard upper limb surgeries (e.g., fracture fixation, tendon repair, debridement) under the supraclavicular brachial plexus block. Surgeons were blinded to the drug administered.

Outcome Measures

1. Primary Outcomes:
   - Onset time of sensory and motor block (time from drug injection to complete loss of sensation and motor movement).
   - Duration of sensory and motor block (time from onset to return of sensation and motor power).
   - Duration of analgesia (time from onset of sensory block to the first request for analgesia).
2. **Secondary Outcomes:**
   - Haemodynamic changes (heart rate, blood pressure).
   - Adverse effects (nausea, vomiting, bradycardia, hypotension, respiratory depression).

Statistical Analysis

Data were compiled in Microsoft Excel and analyzed using SPSS software version [insert version]. Continuous variables were presented as mean ± standard deviation (SD) and compared using the Student's t-test. Categorical variables were analyzed using the Chi-square test. A *p*-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Gender wise distribution of Patients

Parameters	Group I (R+D), n=50	Group II (R+F), n=50
Drug	Ropivacaine 0.5% (20 mL) + Dexmedetomidine 1 mcg/kg	Ropivacaine 0.5% (20 mL) + Fentanyl 1 mcg/kg
M:F	24:26	28:22

Table 1show that group I had 24 males and 26 females and group II had 28 males and 22 females. Both groups were comparable in terms of gender distribution, with no significant imbalance between the number of male and female patients, suggesting that gender was not a confounding factor in the evaluation of block characteristics or analgesic outcomes.

Table 2:Assessment of Parameters

Parameters	Group I (R+D), n=50	Group II (R+F), n=50	P value
Onset of sensory block (min)	3.2±1.1	3.0±0.4	0.12
Total duration of sensory block(min)	630.2±211.5	547.2±110.6	0.05
Onset of motor block(min)	4.5±2.3	4.3±2.0	0.94
Total duration of motor block(min)	612.4±42.6	520.4±23.6	0.04
Duration of analgesia(min)	720.4±26.4	424.6±110.6	0.02

Table 2 shows that the mean onset time for sensory block was slightly longer in Group I (3.2 ± 1.1 min) compared to Group II (3.0 ± 0.4 min), but this difference was not statistically significant (*p = 0.12*).Similarly, the onset of motor block was nearly the same in both groups (4.5 ± 2.3 minvs4.3 ± 2.0 min, *p = 0.94*), indicating that both adjuvants provided comparable block onset times.The duration of sensory block was significantly longer in Group I (630.2 ± 211.5 min) than in Group II (547.2 ± 110.6 min, *p = 0.05*), suggesting dexmedetomidine prolonged the sensory block more effectively.Likewise, the motor block duration was also longer in Group I (612.4 ± 42.6 min) versus Group II (520.4 ± 23.6 min, *p = 0.04*), which was statistically significant.Group I experienced significantly prolonged analgesia (720.4 ± 26.4 min) compared to Group II (424.6 ± 110.6 min, *p* =

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0.02), confirming that dexmedetomidine provided more sustained postoperative pain relief.

Table 3 Comparison of side effects

Parameters	Group I (R+D), n=50	Group II (R+F), n=50	P value
Bradycardia	2	0	0.81
Hypotension	0	2	
Nausea and vomiting	2	2	
Pneumothorax	0	2	
Respiratory depression	4	2	

Figure I: Comparison of side effects

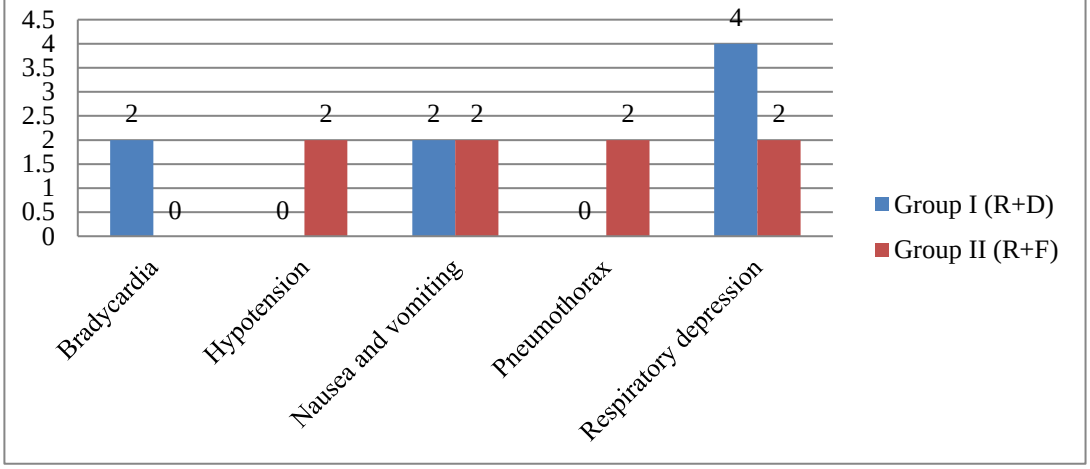

Table 3, figure I shows that side effects were bradycardia was seen in 2 patients in the dexmedetomidine group (Group I) and in none in the fentanyl group (Group II), though the difference was not statistically significant (p = 0.81). This side effect may be attributed to the known bradycardic effects of dexmedetomidine due to its sympatholytic activity.Hypotension occurred only in Group II (fentanyl group) in 2 patients. Fentanyl, though less commonly associated with hypotension, can cause vasodilation and histamine release in some individuals, which might explain this finding.Nausea and vomiting occurred in both groups equally (2 patients each), indicating no significant difference between dexmedetomidine and fentanyl in causing this common opioid-related side effect.Pneumothorax was reported in 2 patients from the fentanyl group and none from the dexmedetomidine group. However, this complication is likely related to the block technique (needle insertion) rather than the drugs used, and may be incidental.Respiratory depression was more frequent in Group I (4 patients) than in Group II (2 patients), but the difference is not statistically significant. Dexmedetomidine is generally associated with minimal respiratory depression, so this finding may need further investigation to rule out other contributory factors (e.g., co-administered sedatives or pre-existing conditions).

DISCUSSION

Vasoconstriction also inhibits the nociceptive impulse transmission along myelinated C fibers. Possible mechanisms of dexmedetomidine in prolonging the duration of nerve blocks may also include the inhibition of the hyperpolarization-activated cation current (Ih current).[7,8]

Some research suggests that dexmedetomidine may provide local anesthetic action that blocks the conduction of nerve signals through C and A fibers, not through α_2 action, and may stimulate the release of enkephalin-like substances at peripheral sites.[9]

The present study was conducted to compare dexmedetomidine and fentanyl as an adjuvant to Ropivacaine in ultrasound guided supraclavicular brachial plexus block.

In present study, group I had 24 males and 26 females and group II had 28 males and 22 females. Previous research suggests that gender may influence pain threshold, response to anaesthetic agents, and analgesic requirements due to hormonal and physiological differences.

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Studies have shown that females may experience higher sensitivity to pain and may metabolize certain drugs differently than males, potentially affecting the onset or duration of local anaesthetic action (Fillingim et al., 2009; Gear et al., 1996).[10,11] However, in present study, the near-equal male-to-female ratio in both groups ensures that any gender-based variability in drug response was evenly distributed, thus preserving the internal validity of the comparative findings.

We found that onset of sensory block was 3.2±1.1 and 3.0±0.4, total duration of sensory block was 630.2±211.5 and 547.2±110.6, onset of motor block was 4.5±2.3 and 4.3±2.0, total duration of motor block was 612.4±42.6 and 520.4±23.6 and duration of analgesia was 720.4±26.4 and 424.6±110.6 in group I and II respectively.Sanjeevenet al.[12] compared fentanyl and dexmedetomidine when added as an adjuvant to ropivacaine for Ultrasound-guided supraclavicular brachial plexus block. Patients were divided into two groups of 26 subjects each. Group A received ropivacaine 0.5% (20 mL)+dexmedetomidine 1 mcg/kg and group B received ropivacaine 0.5% (20 mL)+Fentanyl 1 mcg/kg. The demographic variables, onset of sensory and motor block were comparable in both the groups. Mean duration of sensory block in group A and B were 638.08±52.001 minutes and 568.85±36.478 minutes, respectively. The mean duration of motor block in group A was 605.77±58.8 minutes and group B was 513.46±14.982 minutes. The mean duration of analgesia in group A and B were 722.3±58.13 and 615.00±48.19 minutes, respectively. Mean duration of sensory block, motor block and analgesia were found more in group A which was statistically significant with p-value ≤0.05. There was no significant difference in haemodynamic parameters. Karl Nicholas et al.[13] evaluated the effects of adding Dexmedetomidine to Ropivacaine regarding the onset of sensory and motor blockade in ultrasound guided axillary brachial plexus block. Fifty-four ASA physical status I-II patients undergoing elective forearm and hand surgery under ultrasound-guided axillary brachial plexus block were allocated into two groups. Group A (n=27) received 20ml 0.5% Ropivacaine + Normal saline (1ml) and Group B (n=27) received 20 ml 0.5% Ropivacaine + 0.5µg/kg Dexmedetomidine. Onset time of sensory and motor block and haemodynamic changes were assessed. Onset time of sensory block for ulnar (6.48 minutes), radial (6.51 minutes), median (6.59minutes), musculocutaneous (6.66 minutes) was significantly faster in group B.

We found that side effects were bradycardia was observed in 2 patients in the dexmedetomidine group and none in the fentanyl group. This aligns with previous literature, as **dexmedetomidine**, a selective α2-adrenergic agonist, is known to cause dose-dependent bradycardia and hypotension due to central sympatholysis and enhanced vagal activity.[14,15]

Hypotension was reported in 2 patients from the fentanyl group and none in the dexmedetomidine group. While fentanyl can occasionally cause hypotension due to vasodilation or histamine release, it is relatively uncommon.[16]The absence of hypotension in the dexmedetomidine group may be due to the careful titration of dosage and patient selection, although hypotension is a known adverse effect of dexmedetomidine in higher doses or in volume-depleted individuals.[14]

Nausea and vomiting were equally reported in both groups (2 patients each), which is consistent with the emetogenic potential of **opioids like fentanyl**, and possibly related to patient factors such as anxiety or fasting status. Previous studies have documented a mild incidence of nausea and vomiting with both drugs used in peripheral nerve blocks.[17]

Pneumothorax, though observed in 2 patients of the fentanyl group, is more likely to be a **technique-related complication** of supraclavicular block rather than drug-related. Ultrasound guidance significantly reduces this risk but does not eliminate it entirely.[18] Proper needle visualization and technique are crucial in avoiding such complications.

Respiratory depression was more common in the dexmedetomidine group (4 patients) than in the fentanyl group (2 patients), although this was not statistically significant. Interestingly, dexmedetomidine is usually associated with minimal respiratory depression when compared to opioids.[19]The slightly higher incidence in our study may reflect either mild sedation mistaken for hypoventilation or co-administered sedatives. Fentanyl, being a potent opioid, also has the potential for respiratory depression, especially in higher doses or when combined with other sedatives.[16]

Abdallah FW et al.[14] in their study a total of 516 patients were analysed from nine RCTs. Five trials investigated dexmedetomidine as part of spinal anaesthesia and four as part of a brachial plexus (BP) block. Sensory block duration was prolonged by 150 min [95% confidence interval

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(CI): 96, 205, P<0.00001] with intrathecal dexmedetomidine. Perineural dexmedetomidine used in BP block may prolong the mean duration of sensory block by 284 min (95% CI: 1, 566, P=0.05), but this difference did not reach statistical significance. Motor block duration and time to first analgesic request were prolonged for both intrathecal and BP block. Dexmedetomidine produced reversible bradycardia in 7% of BP block patients, but no effect on the incidence of hypotension. No patients experienced respiratory depression. Dexmedetomidine is a potential LA adjuvant that can exhibit a facilitatory effect when administered intrathecally as part of spinal anaesthesia or peripherally as part of a BP block.

LIMITATIONS OF THE STUDY

- Small sample size, which may limit the generalizability of the results.
- Short follow-up period; long-term adverse effects were not assessed.
- Single-centre study design.
- Variability in surgical procedures may have influenced analgesic requirements.
- Sedation scores and patient satisfaction were not evaluated.

CONCLUSION

Authors found that for upper limb anaesthesia, the supraclavicular block is a dependable method of brachial plexus block with quick onset. In Ultrasound-guided supraclavicular brachial plexus block, the use of dexmedetomidine at a dose of 1 mcg/kg as an adjunct to 0.5% ropivacaine 20 mL provides superior sensory and motor block durations as well as analgesia when compared to fentanyl. Dexmedetomidine, as an adjuvant to ropivacaine in ultrasound-guided supraclavicular brachial plexus block, provides longer sensory and motor block duration and extended postoperative analgesia compared to fentanyl, with minimal and manageable side effects. It is a more effective adjuvant for upper limb surgeries.

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