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Original Research Article

Evaluation of Ropivacaine (0.75%) Combined with Dexmedetomidine Versus Fentanyl for Supraclavicular Brachial Plexus Block: A Comparative Study

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Abstract:

Background: Supraclavicular brachial plexus block is an effective regional anesthesia technique for upper limb surgeries. The addition of adjuvants to local anesthetics like ropivacaine aims to enhance the quality and duration of analgesia. Dexmedetomidine and fentanyl are widely studied adjuvants with distinct pharmacological profiles.

Objectives:

- To compare the onset and duration of sensory and motor blockade achieved with ropivacaine (0.75%) combined with dexmedetomidine versus fentanyl.
- To assess postoperative analgesia quality, duration, and side effect profiles in both groups.

Methods: A prospective randomized comparative study was conducted in the Department of Anesthesiology, NMCH, Patna, Bihar, India from September 2020 to July 2023. A total of 90 adult patients scheduled for upper limb surgeries under supraclavicular brachial plexus block were randomized into two groups: Group D (ropivacaine + dexmedetomidine) and Group F (ropivacaine + fentanyl). Parameters assessed included onset and duration of sensory and motor blocks, duration of analgesia, hemodynamic variables, and incidence of complications.

Results: Group D exhibited a significantly faster onset of sensory and motor blocks, prolonged duration of both blocks, and extended postoperative analgesia compared to Group F. Hemodynamic stability was maintained in both groups, with mild sedation more commonly observed in Group D. No major complications were recorded.

Conclusion: Dexmedetomidine as an adjuvant to ropivacaine in supraclavicular brachial plexus block provides superior block characteristics and prolonged postoperative analgesia compared to fentanyl, with a favorable safety profile.

Keywords: Supraclavicular Brachial Plexus Block, Ropivacaine, Dexmedetomidine, Fentanyl, Regional Anesthesia, Postoperative Analgesia.

Introduction

Regional anesthesia techniques, particularly peripheral nerve blocks, have become an integral part of anesthetic practice for surgical procedures involving the upper limbs [1]. Among these, the supraclavicular brachial plexus block is considered one of the most effective approaches due to its reliability, rapid onset, and dense anesthesia suitable for surgeries below the mid-humerus level. Enhancing the quality, onset, and duration of blocks remains a prime focus to improve patient comfort and extend postoperative analgesia [2].

Ropivacaine, a long-acting amide local anesthetic with less cardiotoxicity compared to bupivacaine, has gained popularity for peripheral nerve blocks. However, the sole use of local anesthetics may not always provide prolonged postoperative analgesia. Consequently, various adjuvants are being explored to augment block characteristics, improve analgesic duration, and reduce the requirement for systemic analgesics [3].

Dexmedetomidine, a highly selective alpha-2 adrenergic agonist, has demonstrated promising results as an adjuvant in regional anesthesia. It provides sedation, anxiolysis, analgesia, and sympatholysis without significant respiratory depression. Its ability to enhance the quality of nerve blocks, accelerate onset, and prolong sensory and motor blockade duration has been well documented in several studies [4].

Fentanyl, a potent opioid agonist, is another widely used adjuvant that, when added to local anesthetics, provides improved analgesia. Fentanyl acts by binding to opioid receptors and modulating nociceptive transmission, although concerns regarding opioid-related side effects such as nausea, vomiting, and pruritus exist [5].

Comparative studies evaluating dexmedetomidine and fentanyl as adjuvants to ropivacaine specifically for supraclavicular brachial plexus block are relatively limited. Understanding the differential effects of these adjuvants on onset time, block duration, quality of postoperative analgesia, hemodynamic parameters, and side effect profiles is crucial to optimizing anesthesia techniques for upper limb surgeries [6,7].

Recognizing this clinical need, the present prospective randomized comparative study was conducted in the Department of Anesthesiology, NMCH, Patna, Bihar, India from September 2020 to July 2023. The primary objective was to compare the efficacy of dexmedetomidine versus fentanyl as adjuvants to 0.75% ropivacaine in supraclavicular brachial plexus block in terms of block characteristics, postoperative analgesia, and adverse effects.

Methodology

This prospective, randomized, comparative study was conducted in the Department of Anesthesiology at NMCH, Patna, Bihar, India from September 2020 to July 2023, with the objective of evaluating and comparing the efficacy of dexmedetomidine and fentanyl as adjuvants to 0.75% ropivacaine in supraclavicular brachial plexus block.

Study Population: The study population comprised adult patients aged between 18 and 60 years scheduled for elective upper limb surgeries below the mid-humerus under supraclavicular brachial plexus block. Only American Society of Anesthesiologists (ASA) physical status I and II patients were included to maintain homogeneity.

Inclusion Criteria:

- Age between 18–60 years.
- ASA physical status I and II.
- Scheduled for elective upper limb orthopedic or soft tissue surgeries.
- Willingness to provide informed written consent.

Exclusion Criteria:

- Patient refusal for regional anesthesia.
- Local infection at the block site.
- Known allergy to study drugs (ropivacaine, dexmedetomidine, fentanyl).
- History of bleeding disorders or coagulopathy.
- Severe cardiopulmonary, hepatic, or renal disease.
- Pregnancy or lactation.

Sample Size: A total of 90 patients were enrolled and randomly divided into two groups of 45 patients each:

- Group D: Received 30 mL of 0.75% ropivacaine + 1 µg/kg dexmedetomidine.
- Group F: Received 30 mL of 0.75% ropivacaine + 1 µg/kg fentanyl.

Randomization was performed using a computer-generated random number table, and group allocation was concealed using sealed opaque envelopes.

Procedure:

All patients underwent pre-anesthetic evaluation, and standard fasting guidelines were followed. In the operating room, standard monitoring (electrocardiography, non-invasive blood pressure, pulse oximetry) was instituted. Intravenous access was secured, and premedication with midazolam 1 mg IV was administered.

Supraclavicular brachial plexus block was performed under ultrasound guidance using a high-frequency linear probe and a 22G nerve-stimulating needle. After identifying the brachial plexus elements, the study drug was injected in incremental doses after negative aspiration.

Assessment Parameters:

- **Onset of Sensory Block:** Time from completion of drug injection to complete loss of pinprick sensation in the distribution of all four major nerves (median, radial, ulnar, musculocutaneous).
- **Onset of Motor Block:** Time from drug injection to complete motor block assessed by Modified Bromage Scale for upper limb.
- **Duration of Sensory and Motor Block:** Time from onset to complete recovery of sensation or motor function.
- **Duration of Analgesia:** Time from drug administration to the first request for rescue analgesia.
- **Hemodynamic Parameters:** Heart rate, blood pressure, and oxygen saturation monitored at baseline and every 5 minutes for the first 30 minutes, then every 15 minutes until the end of surgery.
- **Sedation Level:** Assessed intraoperatively using Ramsay Sedation Scale.
- **Complications:** Bradycardia, hypotension, nausea, vomiting, respiratory depression, block failure.

Postoperative Management: Patients were monitored postoperatively for duration of analgesia

and need for rescue analgesics. Any complications were noted and managed accordingly.

Outcome Measures:

Primary outcomes:

- Comparison of onset and duration of sensory and motor blockade between Group D and Group F.

Secondary outcomes:

- Duration of postoperative analgesia.
- Hemodynamic stability and incidence of complications.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 21.0. Continuous variables were expressed as mean ± standard deviation and compared using the independent t-test. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results

A total of 90 patients undergoing elective upper limb surgeries under supraclavicular brachial plexus block were included in the study and randomized equally into two groups. Both groups were comparable in demographic parameters. Group D (Dexmedetomidine) demonstrated a significantly faster onset of sensory and motor block, prolonged block duration, and extended postoperative analgesia compared to Group F (Fentanyl). Hemodynamic stability was maintained in both groups, with mild sedation more frequently observed in Group D. No major adverse events were recorded during the study.

Table 1: Demographic Characteristics of Patients

Variable	Group D (n=45)	Group F (n=45)	p-value
Age (years, mean ± SD)	36.2 ± 10.4	35.7 ± 9.8	0.78
Gender (M/F)	28/17	26/19	0.68
BMI (kg/m², mean ± SD)	24.5 ± 3.2	24.9 ± 3.0	0.52

Table 2: Onset of Sensory Block

Group	Onset Time (minutes, mean ± SD)
Group D	7.4 ± 1.2
Group F	9.6 ± 1.5
p-value	<0.001

Table 3: Onset of Motor Block

Group	Onset Time (minutes, mean ± SD)
Group D	10.2 ± 1.8
Group F	12.7 ± 2.0
p-value	<0.001

Table 4: Duration of Sensory Block

Group	Duration (minutes, mean ± SD)
Group D	485.3 ± 50.7
Group F	358.9 ± 46.2
p-value	<0.001

Table 5: Duration of Motor Block

Group	Duration (minutes, mean ± SD)
Group D	430.5 ± 45.2
Group F	310.7 ± 40.8
p-value	<0.001

Table 6: Duration of Postoperative Analgesia

Group	Duration (minutes, mean ± SD)
Group D	600.3 ± 65.5
Group F	470.1 ± 60.8
p-value	<0.001

Table 7: Sedation Scores (Ramsay Scale)

Group	Sedation Score (median, range)
Group D	2 (1–3)
Group F	1 (1–2)
p-value	<0.01

Table 8: Intraoperative Hemodynamic Parameters

Parameter	Group D (mean ± SD)	Group F (mean ± SD)	p-value
Heart Rate (beats/min)	74.5 ± 7.2	76.2 ± 7.4	0.28
Systolic BP (mmHg)	122.4 ± 8.6	124.1 ± 9.1	0.32
Diastolic BP (mmHg)	76.8 ± 6.5	78.2 ± 6.8	0.29

Table 9: Requirement for Rescue Analgesia

Group	Patients Requiring Rescue Analgesia (n)	Percentage (%)	p-value
Group D	8	17.8%	<0.01
Group F	19	42.2%	

Table 10: Incidence of Minor Complications

Complication	Group D (n=45)	Group F (n=45)	p-value
Nausea/Vomiting	4 (8.9%)	8 (17.8%)	0.21
Bradycardia	2 (4.4%)	1 (2.2%)	0.55
Hypotension	1 (2.2%)	2 (4.4%)	0.55

Table 11: Respiratory Depression Incidence

Group	Cases (n)	Percentage (%)
Group D	0	0%
Group F	0	0%

Table 12: Patient Satisfaction Scores

Group	Mean Satisfaction Score (out of 10) ± SD
Group D	9.2 ± 0.6
Group F	8.3 ± 0.8
p-value	<0.001

A total of 90 patients were studied with demographic comparisons outlined in Table 1. Onset and duration of sensory and motor blocks are detailed in Tables 2 to 5. Postoperative analgesia duration is shown in Table 6. Sedation profiles (Table 7), hemodynamic stability (Table 8), rescue analgesia requirement (Table 9), and minor complications (Table 10) were evaluated. No respiratory depression occurred (Table 11), and patient satisfaction scores were assessed (Table 12), favoring Group D significantly.

Discussion

Peripheral nerve blocks, particularly the supraclavicular brachial plexus block, offer a highly effective means of anesthesia and postoperative analgesia for upper limb surgeries. Optimizing block characteristics by adding adjuvants to local anesthetics has been a major focus of recent anesthetic practice [8]. This study compared the efficacy of dexmedetomidine versus fentanyl as adjuvants to 0.75% ropivacaine and provided important insights into their differential effects on block parameters, analgesia, and safety profiles [9].

The demographic distribution between the two groups was comparable, eliminating confounding influences related to age, gender, or body mass index. The findings of this study revealed that the addition of dexmedetomidine significantly accelerated the onset of both sensory and motor blocks compared to fentanyl. This rapid onset can be attributed to the local vasoconstrictive and direct action of dexmedetomidine on nerve fibers, enhancing the penetration and efficacy of ropivacaine [10,11].

The duration of both sensory and motor blockade was significantly prolonged in the dexmedetomidine group. This prolongation is consistent with the pharmacological profile of dexmedetomidine, which, through alpha-2 receptor agonism, reduces the transmission of nociceptive signals and hyperpolarizes neuronal membranes, thereby extending block effects [12].

Importantly, the duration of postoperative analgesia was also significantly longer in Group D compared to Group F. Patients in Group D required fewer rescue analgesics within the first 24 postoperative hours, indicating superior analgesic efficacy.

Enhanced patient satisfaction scores further reflected the clinical benefits of prolonged analgesia and stable anesthesia [13].

Hemodynamic parameters remained stable in both groups, with no significant differences in heart rate or blood pressure trends. Although mild sedation was more frequent in the dexmedetomidine group, it did not translate into respiratory depression or require any intervention. This mild sedation was considered advantageous for patient comfort during the surgical procedure [14].

The incidence of minor complications such as nausea and vomiting was slightly higher in the fentanyl group, consistent with known opioid-related side effects. No major adverse events, including respiratory depression or block failures, were recorded in either group, demonstrating that both adjuvants, when used judiciously, are safe adjuncts [15,16].

Overall, dexmedetomidine emerged as a superior adjuvant compared to fentanyl when combined with ropivacaine for supraclavicular brachial plexus block, offering faster onset, longer duration of blockade, prolonged postoperative analgesia, and higher patient satisfaction without compromising safety.

Conclusion

Dexmedetomidine, when used as an adjuvant to 0.75% ropivacaine in supraclavicular brachial plexus block, provides a faster onset, prolonged sensory and motor blockade, extended duration of postoperative analgesia, and higher patient satisfaction compared to fentanyl. Both adjuvants demonstrated stable hemodynamic profiles and minimal side effects. Dexmedetomidine offers a superior alternative to fentanyl in optimizing the quality and efficacy of supraclavicular brachial plexus block for upper limb surgeries.

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