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COMPARISON BETWEEN DEXMEDETOMIDINE AND FENTANYL AS ADJUVANTS TO 0.5% ROPIVACAINE IN ULTRASOUND-GUIDED INFRACLAVICULAR BRACHIAL PLEXUS BLOCK

Anaesthesiology

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ABSTRACT

Background: Ultrasound-guided infraclavicular brachial plexus block is an effective technique for upper limb surgeries, offering anaesthesia and postoperative analgesia. The addition of adjuvants like dexmedetomidine and fentanyl to local anaesthetics such as ropivacaine can improve the quality of these blocks. This study aims to compare the efficacy and safety of dexmedetomidine and fentanyl as adjuvants to 0.5% ropivacaine. **Objective:** To evaluate and compare the onset and duration of sensory and motor blocks, intraoperative hemodynamic changes, and adverse effects between dexmedetomidine and fentanyl as adjuvants in ultrasound-guided infraclavicular brachial plexus blocks. **Methods:** A randomized, controlled study was conducted with 32 patients undergoing elective upper limb surgeries. Patients were divided into two groups: Group D (n=16) received 1 µg/kg dexmedetomidine with 30 mL of 0.5% ropivacaine, and Group F (n=16) received 1 µg/kg fentanyl with 30 mL of 0.5% ropivacaine. The onset and duration of sensory and motor blocks, hemodynamic parameters and adverse effects were recorded and analysed. **Results:** Group D had a significantly faster onset of sensory (12.5 ± 2.3 mins) and motor blocks (15.0 ± 2.5 mins) compared to Group F (15.2 ± 3.1 and 18.0 ± 3.0 mins, respectively). Sensory (810.5 ± 50.3 mins) and motor block durations (780.0 ± 48.0 mins) were longer in Group D than in Group F (650.4 ± 45.8 and 620.0 ± 42.0 mins). Both groups showed stable hemodynamic profiles, though transient bradycardia was more frequent in Group D. Adverse effects, including hypotension and nausea, were minimal and comparable between groups. **Conclusion:** Dexmedetomidine as an adjuvant to ropivacaine provides a faster onset and significantly longer duration of sensory and motor blocks compared to fentanyl in infraclavicular brachial plexus blocks. Both drugs showed minimal adverse effects, with dexmedetomidine proving to be a more effective option for regional anaesthesia.

KEYWORDS

Dexmedetomidine, Fentanyl, Ropivacaine, Infraclavicular brachial plexus block, Regional anaesthesia

INTRODUCTION

Advancements in regional anaesthesia have significantly transformed upper limb surgeries, particularly through the use of ultrasound-guided brachial plexus blocks.[1] Regional anaesthesia provides various benefits, including better perioperative pain management, reduced opioid consumption, and avoidance of complications related to general anaesthesia.[2] Among the available techniques, the infraclavicular approach is favoured due to its comprehensive coverage of the brachial plexus, which includes the cords necessary to block innervation of the entire upper limb.[3]

Ropivacaine, a long-acting amide-type local anaesthetic, has gained popularity due to its relatively favourable safety profile, especially when compared to bupivacaine, another potent local anaesthetic.[4] Ropivacaine is associated with less cardiovascular and central nervous system toxicity, making it ideal for prolonged surgeries or situations requiring extended postoperative analgesia.[5] However, in order to further enhance its effects, adjuvants like dexmedetomidine and fentanyl are commonly added to prolong block duration, improve analgesia, and reduce the need for systemic analgesics.[6]

Dexmedetomidine, an alpha-2 adrenergic receptor agonist[7], has been shown to prolong both sensory and motor block durations by inhibiting the release of norepinephrine and hyperpolarizing neurons.[8]

On the other hand, fentanyl, a synthetic µ-opioid receptor agonist, is widely recognized for its potent analgesic properties, which not only help improve the duration of the sensory block but also contribute to enhanced patient comfort during and after surgery.[9] Its ability to modulate pain perception makes it a valuable adjuvant in regional anaesthesia, providing effective pain relief and reducing the need for additional analgesics postoperatively.[5]

This study aims to evaluate and compare dexmedetomidine and fentanyl as adjuvants to ropivacaine in ultrasound-guided infraclavicular brachial plexus blocks, with a focus on onset and duration of sensory and motor blocks, intraoperative hemodynamic changes, and potential adverse effects.

MATERIALS AND METHODS

Study Design and Population

This prospective, randomized, comparative study was conducted at Vydehi Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka from September 2022 to June 2023. After obtaining ethical approval from the Institutional Review Committee, thirty-two patients undergoing elective upper limb surgeries were enrolled, with informed consent obtained from all participants. The patients were randomly divided into two groups: Group D (Dexmedetomidine, n=16) and Group F (Fentanyl, n=16). Each group received 30 mL of 0.5% ropivacaine in combination with either 1 µg/kg of dexmedetomidine (Group D) or 1 µg/kg of fentanyl (Group F).[10]

Inclusion And Exclusion Criteria

Inclusion criteria consisted of patients aged between 21-60 years, of either gender, belonging to ASA physical status I or II, and with a body weight between 50-80 kg with normal BMI.[11]

Patients with a refusal for the block, coagulopathy, pre-existing neuropathy involving the brachial plexus, localized skin infections at the block site, or hypersensitivity to local anaesthetics were excluded from the study.[12]

Procedure

All patients were pre-operatively assessed, and standard investigations were conducted. After confirming a 6-hour nil per oral (NPO) status, intravenous access was secured with an 18G cannula, and standard monitoring (non-invasive blood pressure, heart rate, respiratory rate, and oxygen saturation) was initiated.

Patients were positioned in the supine position with their arms abducted. After sterile preparation, an ultrasound-guided infraclavicular block was performed using an in-plane lateral-to-medial approach. The ultrasound probe was placed over the middle third of the clavicle to visualize the axillary artery and the three brachial plexus cords. Using a 22G needle, the study drugs were injected around the three cords.[13]

Statistical Analysis

The study utilized a two-tailed t-test to compare means between the two groups. A significance level of $p < 0.05$ was applied to demographic characteristics and block onset/duration parameters to determine statistical significance. The sample size of 32 patients (16

per group) was selected to ensure sufficient power to detect meaningful differences in these outcomes.

The sample size was calculated using the following formula for comparing two independent means:

$$n = \frac{[(Z(\frac{\alpha}{2}) + Z(\beta))^2 \times \sigma^2]}{\Delta^2}$$

Where:

- **n** is the sample size
- **Z(α/2)** is the Z-value corresponding to the level of significance (α)
- **Z(β)** is the Z-value corresponding to the power of the study (1 - β)
- **σ^2** is the variance (or standard deviation squared)
- **Δ** is the minimum clinically significant difference or effect size you are trying to detect

The variance was estimated from preliminary data, assuming a standard deviation (σ) of 3.0 minutes for the onset of sensory and motor blocks. To detect a minimum clinically significant difference (Δ) of 3 minutes between groups, the calculated sample size was 15.5 patients per group. This was rounded up to 16 to accommodate possible data variability. Thus, a total sample size of 32 (16 per group) was deemed appropriate to achieve 80% power, ensuring the study was adequately powered to detect statistically significant differences in block characteristics.

RESULTS

Demographic Characteristics

The demographic characteristics between the two groups were compared and no significant differences were observed ($p > 0.05$).

Table 1: Demographic Characteristics

Variable	Group D (n=16)	Group F (n=16)	p-value
Age (years)	35.5 ± 8.2	36.1 ± 7.9	0.85
Gender			1.00
Male	10	10	
Female	6	6	
Weight (kg)	60.2 ± 5.5	61.0 ± 6.1	0.78
ASA Physical Status			
I	12	10	0.63
II	4	6	
Duration of Surgery (min)	90.5 ± 15.2	88.8 ± 14.6	0.82

Group D had a mean age of 35.5 ± 8.2 years, while Group F had a mean age of 36.1 ± 7.9 years. Both groups had an equal distribution of males and females, with 10 males and 6 females in each. The mean weight of patients was 60.2 ± 5.5 kg in Group D and 61.0 ± 6.1 kg in Group F. The ASA physical status distribution between the two groups was also similar, with the majority of patients being classified as ASA I (Table 1).

Onset And Duration Of Sensory And Motor Blocks

Table 2: Onset And Duration Of Blocks

Parameter	Group D (Mean ± SD)	Group F (Mean ± SD)	p-value
Onset of Sensory Block (min)	12.5 ± 2.3	15.2 ± 3.1	0.049
Onset of Motor Block (min)	15.0 ± 2.5	18.0 ± 3.0	0.037
Duration of Sensory Block (min)	810.5 ± 50.3	650.4 ± 45.8	<0.001
Duration of Motor Block (min)	780.0 ± 48.0	620.0 ± 42.0	<0.001

There were significant differences between Group D and Group F with regard to the onset of sensory and motor blocks. Group D demonstrated a faster onset of sensory block (12.5 ± 2.3 minutes) compared to Group F (15.2 ± 3.1 minutes, $p = 0.049$). Similarly, the onset of motor block was faster in Group D (15.0 ± 2.5 minutes) compared to Group F (18.0 ± 3.0 minutes, $p = 0.037$).

The duration of sensory and motor blocks was also significantly longer in Group D. The sensory block lasted 810.5 ± 50.3 minutes in Group D, compared to 650.4 ± 45.8 minutes in Group F ($p < 0.001$). Similarly, the motor block duration was 780.0 ± 48.0 minutes in Group D, significantly longer than the 620.0 ± 42.0 minutes observed in Group F ($p < 0.001$).

Hemodynamic Variables

Hemodynamic stability was assessed by monitoring heart rate and mean arterial pressure (MAP) at regular intervals both intraoperatively and postoperatively. Although the heart rate in Group D was consistently lower compared to Group F, the differences were not statistically significant at any of the measured time points. Group D also experienced more frequent episodes of bradycardia; however, these were transient and self-limiting, requiring no intervention.

Table 3: Hemodynamic Parameters

Time (Hours)	Parameter	Group D (Dexmedetomidine)	Group F (Fentanyl)	p-value
Baseline	Heart Rate (bpm)	78.5 ± 6.2	79.0 ± 5.8	0.85
	MAP (mmHg)	93.5 ± 4.0	93.5 ± 4.5	0.90
1 Hour	Heart Rate (bpm)	74.0 ± 6.0	78.0 ± 5.5	0.20
	MAP (mmHg)	89.0 ± 3.5	89.0 ± 3.5	0.95
2 Hours	Heart Rate (bpm)	73.0 ± 5.8	77.5 ± 5.2	0.18
	MAP (mmHg)	87.5 ± 3.0	87.0 ± 3.0	0.85
4 Hours	Heart Rate (bpm)	72.0 ± 5.5	77.0 ± 5.0	0.12
	MAP (mmHg)	87.0 ± 3.5	87.0 ± 3.5	0.90
6 Hours	Heart Rate (bpm)	73.0 ± 5.2	77.0 ± 4.8	0.15
	MAP (mmHg)	87.5 ± 3.0	88.0 ± 3.5	0.75
8 Hours	Heart Rate (bpm)	74.0 ± 5.5	77.5 ± 5.0	0.20
	MAP (mmHg)	88.0 ± 3.0	88.0 ± 3.5	0.90
12 Hours	Heart Rate (bpm)	75.0 ± 5.8	78.0 ± 5.2	0.25
	MAP (mmHg)	89.0 ± 3.5	90.0 ± 3.5	0.80
24 Hours	Heart Rate (bpm)	77.0 ± 6.0	79.0 ± 5.5	0.40
	MAP (mmHg)	90.0 ± 3.0	90.5 ± 3.0	0.85

Mean arterial pressure remained stable across both groups throughout the study period, with no significant differences observed in blood pressure readings This suggests that both adjuvants provided good hemodynamic stability.

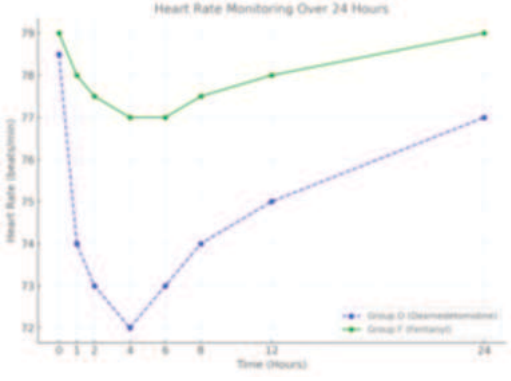

Figure 1: *Hemodynamic Variables- Heart rate(bpm)*

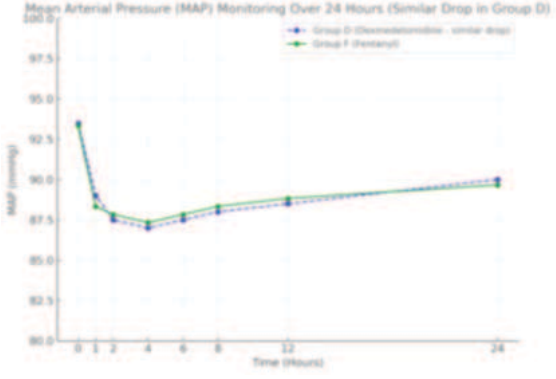

Figure 2: *Hemodynamic Variables- MAP*

Adverse Effects

Both groups had similar profiles in terms of adverse effects. One case of bradycardia (12.5%) was observed in Group D, while Group F reported one case of nausea and vomiting (12.5%). Both groups reported one case of hypotension (12.5%), though it was mild and statistically insignificant. No cases of respiratory depression or excessive sedation were reported in either group.

Table 4: Adverse Effects

Adverse Effect	Group D	Group F	p-value
Nausea	0 (0%)	1 (12.5%)	0.30
Vomiting	0 (0%)	1 (12.5%)	0.30
Bradycardia	1 (12.5%)	0 (0%)	0.30
Hypotension	1 (12.5%)	1 (12.5%)	1.00
Respiratory Depression	0 (0%)	0 (0%)	-
Sedation	0 (0%)	0 (0%)	-

DISCUSSION

This study aimed to compare the onset time and duration of both sensory and motor blocks between two groups: one receiving dexmedetomidine (Group D) and the other receiving fentanyl (Group F) as adjuvants to 0.5% ropivacaine in an ultrasound-guided infraclavicular brachial plexus block. Both groups had identical demographic characteristics, which ensured that the results were not influenced by any demographic variations such as age, gender, or ASA physical status.

The key findings of the study indicate that Group D, which received dexmedetomidine, exhibited a significantly faster onset of both sensory and motor blocks when compared to Group F, which received fentanyl. Furthermore, the duration of the blocks was significantly longer in Group D. This suggests that dexmedetomidine may be a more effective adjuvant in enhancing the action of ropivacaine, particularly in terms of achieving faster anaesthesia onset and prolonging its effects for better postoperative analgesia.

In line with the results of this study, Kathuria et al. (2015) also compared dexmedetomidine and fentanyl as adjuvants to ropivacaine in a supraclavicular brachial plexus block. Their findings supported the superiority of dexmedetomidine in providing faster onset and a prolonged block duration compared to fentanyl. Additionally, they observed better postoperative analgesia in patients who received dexmedetomidine. There were no significant side effects that were noted in the study.[9]

The current study also found no significant differences between the two groups in terms of hemodynamic parameters such as heart rate and blood pressure, or in the occurrence of adverse effects like bradycardia, hypotension, nausea, and vomiting. Both groups were hemodynamically stable, and the adverse effects observed were minor and well-tolerated. This demonstrates that dexmedetomidine not only offers superior efficacy but also maintains a safety profile comparable to fentanyl in this setting.

CONCLUSION

In conclusion, this study demonstrates that dexmedetomidine, when used as an adjuvant to 0.5% ropivacaine, provides a faster onset and significantly longer duration of both sensory and motor blocks compared to fentanyl in ultrasound-guided infraclavicular brachial plexus blocks. The rapid onset observed with dexmedetomidine allows for quicker surgical readiness, making it a more efficient choice in procedures where time is a critical factor. Additionally, the prolonged duration of sensory and motor blocks enhances postoperative analgesia, reducing the need for additional pain management interventions and improving overall patient comfort during recovery.

While both dexmedetomidine and fentanyl demonstrated minimal adverse effects, dexmedetomidine proved to be more effective overall. Both groups showed stable hemodynamic parameters throughout the procedure, with no significant differences in adverse effects such as bradycardia, hypotension, nausea, or vomiting. This indicates that dexmedetomidine is not only a more effective option in terms of onset and duration of block but also maintains a safety profile comparable to that of fentanyl.

Thus, dexmedetomidine emerges as a superior adjuvant to ropivacaine in regional anaesthesia for upper limb surgeries, particularly when prolonged postoperative analgesia and enhanced patient recovery are priorities. Its efficacy and safety make it a valuable option in the practice of regional anaesthesia.

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