Original Article

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Comparison of Dexmedetomidine and Fentanyl as an Adjuvant to Ropivacaine in Ultrasound-guided Supraclavicular Brachial Plexus Block: A Prospective Observational Study

Anaesthesia Section

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ABSTRACT

Introduction: Upper limb surgeries are mostly performed under supraclavicular brachial plexus blocks which provide intraoperative and postoperative analgesia. Ultrasound provides clinicians with real-time images which are useful for better identification of the anatomical structures, safe needle placement, and adequate local anaesthetic spread. Adding adjuvants to local anaesthetic drugs prolong the duration of anaesthesia without concomitantly increasing the risk of complication.

Aim: To compare fentanyl and dexmedetomidine when added as an adjuvant to ropivacaine for Ultrasound-guided supraclavicular brachial plexus block.

Materials and Methods: A prospective observational, double-blinded study was conducted in the Department of Anaesthesia, at Government Medical College, Kottayam, Kerala, India, on 52 patients undergoing orthopaedic upper limb surgeries over a period of one year from April 2019-March 2020. 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. Onset, time to complete sensory and motor block, duration of sensory and motor block, duration of analgesia, adverse effects and haemodynamic status were monitored. Statistical analysis was done using t-test and Chi-square test.

Results: 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.

Conclusion: Dexmedetomidine was a better adjuvant to 0.5% ropivacaine as compared to fentanyl in Ultrasound-guided supraclavicular brachial plexus block in terms of duration of sensory block, motor block and analgesia.

Keywords: Local anaesthetics, Peripheral nerve block, Upper limb

INTRODUCTION

Supraclavicular brachial plexus block is widely used for upper limb surgeries because of the anatomical ease of blocking nerve roots at this level. Brachial plexus block provides distinct advantages over general anaesthesia like maintenance of general body physiology, decreases postoperative pain, shorter stay in postoperative care unit, and decreased incidence of postoperative nausea and vomiting [1]. The technique of brachial plexus block has evolved from the classical blind paresthesia technique to the Ultrasound-guided supraclavicular brachial plexus block. The classical approach was associated with a higher failure rate and injury to the nerves and surrounding structures. Ultrasound-guided block offers improved safety and accuracy in identifying the position of nerve to be blocked. Since less total volume of local anaesthetic may be required to produce an effective block, this could reduce the risk of local anaesthetic systemic toxicity [2].

Ropivacaine is a long acting amide with the greatest margin of safety among all local anaesthetics [3]. Compared to bupivacaine, ropivacaine is less cardiotoxic. However, the benefits of a brachial plexus block may not persist, if the local anaesthetics used have a limited duration of action. The limited duration of the local anaesthetics used for brachial plexus block may lead to the need for general anaesthesia. This can present difficulties during the surgical procedure, especially, when the patient is positioned laterally. Continuous catheter based nerve blocks provide very good postoperative analgesia, but their placement requires additional time, cost and skill. Drugs like dexmedetomidine and fentanyl were employed as adjuvants for faster onset, denser block and for prolonging peripheral nerve blockade. Dexmedetomidine, a selective centrally acting alpha 2 agonist results in profound prolongation of duration of peripheral nerve blockade [4]. Opioids were widely known to have an analgesic effect at the central and spinal cord level. Studies conducted by Rajkhowa T et al., and Magistris L et al., have shown that, the addition of fentanyl can extend the duration of a brachial plexus block [5,6]. There are limited studies comparing the use of fentanyl and dexmedetomidine with ropivacaine. Considering the minimal side-effects and excellent postoperative analgesia of two drugs, it is essential to carry out a comparative evaluation of these drugs as an adjuvant to Ultrasound-guided supraclavicular brachial plexus block. The main objective of the present study was, to compare these drugs in terms of onset time, duration of sensory block, motor block and analgesia, adverse effects and haemodynamic stability.

MATERIALS AND METHODS

A prospective observational, double-blinded study was conducted at Government Medical College, Kottayam, Kerala, India, for a period of one year, from April 2019 to March 2020, after obtaining approval from the Institutional Review Board with IRB No: 42/2019.

Inclusion criteria:

- Patients scheduled for orthopaedic forearm surgeries
- Age 18-60 years
- American Society of Anaesthesiologists (ASA) physical status I and II
- Patient with informed written consent.

Exclusion criteria:

- Patients with hypersensitivity to local anaesthetics
- Pre-existing peripheral neuropathy
- On adrenoreceptor agonist/antagonist therapy;
- Bleeding disorders.

Sample size calculation: By considering alpha error of 0.05 and power of study >80%, the sample size was calculated based on the mean and standard deviation of the parent study by Cham SC et al., using the formula [7]:

$$N=\frac{2\sigma^2(Z\alpha+Z\beta)}{(\mu1-\mu2)^2}$$

$$\text{Pooled variance } (\sigma2)=\frac{S1^2(n1-1)+S2^2(n2-1)}{n1+n2-2}$$

$Z\alpha$=Value of Z at 5% α error=1.96

$Z\beta$=Value of Z at 20% β error=0.84

Sample size,

$$N=\frac{2\times(0.13)^2\times(1.96+0.84)^2}{58}$$

=50.96

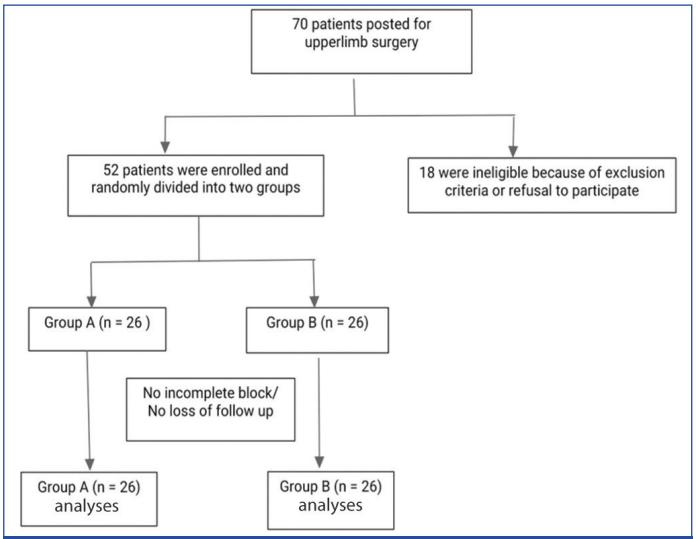
Study Procedure

The patients were randomly allocated into two groups of 26 each based on computer generated random number slips. Group A received injection ropivacaine 0.5% (20 mL)+Dexmedetomidine 1 mcg/kg (maximum 50 mcg) and group B received ropivacaine 0.5% (20 mL)+Fentanyl 1 mcg/kg (maximum 50 mcg). Total volume of drug was kept constant (20.5 mL) [8] in both the groups to achieve blinding. The drug solution was prepared by an anaesthesiologist, who was not involved in the conduct of the case and recording the observations. Both the primary assessor and the patient were blinded to the study drug used. During the preanaesthetic check-up, the patients were provided with a detailed explanation of the procedure and the Visual Analogue Scale (VAS) for pain was explained to them in their local language. The patients were instructed to maintain a six hour fast prior to the surgery and premedicated with midazolam 0.02 mg/per/kg intravenously one hour before the commencement of surgery.

On arrival to the operation theatre, baseline pulse rate, blood pressure, peripheral oxygen saturation were recorded, an 18 G canula was inserted and normal saline was started as intravenous (i.v.) fluid. Patient was positioned and brachial plexus identified. Under all aseptic precautions, the injection site was infiltrated with 1 mL of 2% lignocaine intradermally and subcutaneously. Brachial plexus was approached using 22 G stimuplex ultra 55 mm long needle (in plane needle approach) through the lignocaine infiltrated skin. A 20.5 mL drug solution was given according to the group assigned and negative aspiration was performed before every 3 mL to avoid intravascular injection. All patients were supplemented with oxygen at 4 litre/minute via simple face mask throughout the procedure. Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and oxygen saturation (SpO_2) was monitored every 15 minutes in the first hour and then every 30 minutes upto four hours. Bradycardia is defined as HR below 50 beats/min and was managed with atropine 0.6 mg. Hypotension is defined as lowering of mean Blood Pressure (BP) below 20% of initial base line value. Respiratory depression was defined as respiratory rate <8 breaths/min.

Sensory blockade was assessed by loss of sensation to pinprick over the C5-T1 dermatomes using a three-point scale (0- Normal sensation, 1- loss of sensation of pin prick/analgesia, 2- loss of sensation of touch/anaesthesia), every two minute till the onset of loss of touch and then every 30 minutes till the regain of sensation [9]. The sensory onset time refers to the duration from the cessation of local anaesthetic delivery to the point at which a score of 1 is observed on a three-point scale. Time to complete sensory blockade was the interval between local anaesthetic administration and establishment of score 2 on the three-point scale in all dermatomes. Duration of sensory blockade was defined as the time interval between the end of local anaesthetic administration and complete resolution of anaesthesia (score 0 on the three-point scale in all nerve areas) [10].

Motor blockade was assessed using Modified Bromage Scale for upper limb (0- normal motor function with full flexion and extension of elbow, wrist and finger, 1- decreased motor strength with ability to move fingers only, 2- complete motor blockade with inability to move fingers [11]. Onset of motor block was the time interval between local anaesthetic administration and establishment of score 1 on bromage scale. Time to complete motor block was defined as the absence of voluntary movements in hand and forearm (score 2 on bromage scale). The period of time between administering the local anaesthetic and recovery of complete motor function of hand and forearm was defined as the duration of the motor block (score 0 on bromage scale). Duration of analgesia was defined as the time interval between supraclavicular brachial plexus block administration and the onset of pain, VAS score >5. VAS-on a scale of 0-10, the patient was asked to quantify postoperative pain (0- no pain, 10- maximum/worst pain). Injection tramadol 50 mg intravenously was administered if VAS score reaches 5. Patients were also observed for any adverse effects, such as nausea, vomiting, hypotension, bradycardia, pruritis, Horner's syndrome, recurrent laryngeal nerve palsy, pneumothorax, and respiratory depression. However, if any patient had incomplete block (sensory anaesthesia is not achieved within 30 minutes) or complained of discomfort/pain intraoperatively, then they were converted to general anaesthesia and block was considered as inadequate block. The distribution of study participants is shown in [Table/Fig-1].



[Table/Fig-1]: Flowchart showing distribution of study participants.

STATISTICAL ANALYSIS

The data obtained were entered into a Microsoft excel datasheet and analysis done using Statistical Package for the Social Sciences, (SPSS) version 19.0. Categorical variables were represented as number and percentage and continuous variables as mean and

standard deviation. Qualitative variables were analysed using Chi-square test and quantitative variables using t-test. The p-value ≤0.05 was considered statistically significant.

RESULTS

Demographic variables like age, gender, weight, ASA were compared in both the groups. In group A, 38.46% of the individuals were females, while in group B, the proportion of females was 42.31%. ASA I patients in group A was 65.38% and group B was 61.54%. Differences in age distribution, gender, ASA physical status and weight distribution in group A and B were not statistically significant [Table/Fig-2].

Demographic variables		Group A Ropivacaine+ Dexmedetomidine		Group B Ropivacaine+Fentanyl		p-value
		Count	Percentage (%)	Count	Percentage (%)	
Age distribution (years)	<20	2	7.7	3	11.5	0.879
	20-29	6	23.1	6	23.1	
	30-39	7	26.9	8	30.8	
	40-49	4	15.4	5	19.2	
	50-59	7	26.9	4	15.4	
Sex distribution	Female	10	38.46	11	42.31	0.777
	Male	16	61.54	15	57.69	
ASA physical status	ASA I	17	65.38	16	61.54	0.773
	ASA II	9	34.62	10	38.46	
Weight (Kg)	40-49	3	11.5	3	11.5	0.985
	50-59	9	34.6	9	34.6	
	60-69	9	34.6	8	30.8	
	Above 70	5	19.2	6	23.1	

[Table/Fig-2]: Demographic variables of group A and group B.
Chi-square test used for analysis

In the present study, it was found that, duration of sensory block motor block and analgesia was significantly higher in patients who received a combination of ropivacaine and dexmedetomidine than the combination of ropivacaine and fentanyl. Mean duration of sensory block in group A was 638.08±52.00 minutes and in group B was 568.85±36.48 minutes. The mean duration of motor block was prolonged in group A compared to group B. The mean duration of analgesia in group A was 107 minutes higher than group B. All the above differences were statistically significant with a p-value <0.001 [Table/Fig-3].

Parameters (minutes)	Mean±Standard deviation		p-value
	Group A	Group B	
Onset of sensory block	3.15±1.01	3.08±1.02	0785
Time to complete sensory block	18.85±2.78	18.54±2.75	0.690
Total duration of sensory block	638.07±52.00	568.85±36.49	0.001
Onset of motor block	4.38±1.39	4.31±1.93	0.870
Time to complete motor block	23.31±3.29	23.08±3.26	0.801
Total duration of motor block	605.77±58.80	513.46±14.98	0.001
Duration of analgesia	722.31±58.13	615.00±48.19	0.001

[Table/Fig-3]: Comparison of sensory block, motor block and analgesia among groups.
*p-value <0.001=significant, using t test

The onset of sensory block and mean time for onset of sensory block were early in group B compared with group A, but statistically not significant with p-value of 0.785 and 0.690, respectively. The mean time for onset of sensory block was seven minutes prolonged in group A compared to group B. The onset of motor block and mean time to complete motor blockade were early in group B compared with group A but statistically not significant with p-value more than 0.05 [Table/Fig-3]. The incidence of side-effects was low and compared between the groups [Table/Fig-4]. Incidence of hypotension was 3.8% (1/26) in group A and nil in group B (p-value=0.313). Bradycardia only occurred in group A (7.7%). Nausea and pruritus were seen in 1/26 (3.8%) and 2/26 (7.7%) in group B (p-value >0.05). No major complications like pneumothorax, respiratory depression and Horner's syndrome and recurrent laryngeal nerve palsy were reported.

Side-effects/ complication	Group A		Group B		p-value
	Number of patients	Percentage (%)	Number of patients	Percentage (%)	
Hypotension	1/26	3.8	0/26	0	0.313
Bradycardia	2/26	7.7	0/26	0	0.149
Nausea and vomiting	0/26	0	1/26	3.8	0.313
Pruritus	0/26	0	2/26	7.7	0.149
Respiratory depression	0/26	0	0/26	0	
Pneumothorax	0/26	0	0/26	0	
Horner's syndrome	0/26	0	0/26	0	
Recurrent laryngeal nerve palsy	0/26	0	0/26	0	

[Table/Fig-4]: Incidence of side-effects and complication between the groups.
Chi-square test used

Although, the use of dexmedetomidine as an adjuvant resulted in a greater decrease in HR and BP from baseline compared to fentanyl. By comparing heart rate between groups there was statistically significant difference (p-value ≤0.05) in HR in 30, 45, 60, 90, 120, 150, 180 and 210 minutes. At the beginning of surgery HR was comparable among groups. At 240 min, heart again becomes comparable with p-value=0.868 [Table/Fig-5].

Heart rate (minutes)	Group	Mean (per min)	Standard deviation	p-value
0	A	79.69	9.38	0.901
	B	80.12	14.46	
15	A	76.42	9.92	0.437
	B	79.04	13.83	
30	A	70.42	10.73	0.031
	B	77.38	11.85	
45	A	68.77	12.02	0.025
	B	76.46	12.03	
60	A	67.92	11.99	0.029
	B	75.50	12.38	
90	A	66.65	11.03	0.023
	B	74.08	11.81	
120	A	63.62	10.06	0.002
	B	73.27	11.14	
150	A	63.92	8.71	0.002
	B	72.58	10.58	
180	A	63.58	8.76	0.002
	B	72.15	10.57	
210	A	65.31	8.47	0.025
	B	71.15	9.76	
240	A	69.81	6.92	0.868
	B	70.19	9.47	

[Table/Fig-5]: Comparison of mean heart rate between groups.
t-test used

By comparing SBP between groups there was statistically significant difference (p-value ≤0.05) only at 210 minute. At the beginning of surgery SBP was comparable among groups. There was no

significant difference between SBP during surgery [Table/Fig-6]. During entire period of the study, DBP and oxygen saturation were comparable between groups and the difference was not statistically significant with (p-value ≤0.05).

Systolic blood pressure (minutes)	Group	Mean	Standard deviation	p-value
0	A	129.62	14.04	0.984
	B	129.69	12.77	
15	A	125.62	11.51	0.508
	B	127.85	12.59	
30	A	122.15	12.15	0.343
	B	125.46	12.76	
45	A	122.08	11.93	0.982
	B	122.15	12.62	
60	A	118.92	12.73	0.824
	B	119.69	12.05	
90	A	117.46	13.13	0.860
	B	118.08	11.81	
120	A	116.08	12.79	0.727
	B	117.23	10.84	
150	A	114.62	12.08	0.596
	B	116.23	9.62	
180	A	116.92	9.75	0.498
	B	115.15	8.91	
210	A	119.38	9.58	0.044
	B	114.08	8.95	
240	A	120.69	9.73	0.005
	B	113.08	8.77	

[Table/Fig-6]: Comparison of mean systolic blood pressure (SBP) between groups. t-test used

DISCUSSION

Dexmedetomidine 1 mcg/kg, when used as an adjuvant to 0.5% ropivacaine 20 mL in an ultrasound guided supraclavicular brachial plexus block, is superior to fentanyl 1 mcg/kg in terms of sensory block duration, motor block duration, and analgesia. Both groups were similar in terms of demographic variables such as age, gender, weight, and ASA. The study found that, the use of dexmedetomidine as an adjuvant resulted in a significantly longer duration of sensory block compared to the use of fentanyl, with a p-value=0.001. This result was consistent with study by Esmaoglu A et al., [12], using 40 mL levobupivacaine 0.5% and dexmedetomidine 100 mcg compared to plain levobupivacaine in axillary brachial plexus block. Dexmedetomidine 50 mcg with 30 mL bupivacaine 0.33% also showed significantly prolonged duration of sensory block in the study by Ammar AS and Mahmoud KM [13].

A statistically significant difference was observed in the mean duration of motor block between group A and group B. This finding correlates with study done by Kathuria S et al., and Das A et al., using 0.5% ropivacaine 30 mL with or without 50 mcg dexmedetomidine [14,15]. The presence of alpha-2 receptors in the brachial plexus caused a longer duration of sensory and motor block when dexmedetomidine was administered through a block, as opposed to intravenous administration as per Kathuria S et al., [14]. Masuki S et al., suggested that dexmedetomidine induces vasoconstriction around the site of injection via alpha-2 receptors in human forearm thus, delaying the absorption of local anaesthetic and hence, prolonging the effect [16]. The study results showed similarity to the study conducted by Sahi P et al., in which the use of 30 mL ropivacaine 0.5%, and ropivacaine in combination with fentanyl and dexmedetomidine, were evaluated for their effectiveness in brachial plexus block [17]. Both, dexmedetomidine and fentanyl enhances readiness for surgery. In comparison to fentanyl, the use of dexmedetomidine resulted in a significantly longer duration of both motor and sensory block, as well as, improved postoperative analgesia. The difference was particularly noteworthy when compared to ropivacaine, where the results were highly significant. Dar FA et al., evaluated the effect of adding dexmedetomidine to ropivacaine for axillary brachial plexus blockade in 80 patients scheduled for elective forearm and hand surgeries [18]. When dexmedetomidine was added sensory and motor block onset times were shorter but sensory and motor blockade durations were longer along with duration of analgesia.

Duration of sensory and motor block was also prolonged in the comparative study of the efficacy of dexmedetomidine and fentanyl as adjuvants to ropivacaine in ultrasound-guided supraclavicular brachial plexus block by Shivalgond P et al., [19]. According to the statistical analysis, there was a significant difference in the duration of sensory blockade between the patients who received dexmedetomidine and those who received fentanyl with a p-value=<0.001. Specifically, the duration of sensory blockade was 801.75±46.07 minutes for the dexmedetomidine group, and 590.25±40.41 minutes for the fentanyl group. The duration of motor blockade was also highly statistically significant with 649.56±42.73 minutes in dexmedetomidine group compared to 456.75±32.93 minutes in fentanyl group. Similar results were also obtained by the study by Cham SC et al., in which 30 mL ropivacaine 0.5% alone, 50 mcg fentanyl or 50 mcg dexmedetomidine to ropivacaine were used for supraclavicular brachial plexus block [7]. The addition of adjuvant enhanced the onset of block and also increased duration of surgical anaesthesia with prolongation of postoperative analgesia. The total duration of analgesia was significantly increased in dexmedetomidine group (by 2 and half hour) compared to fentanyl group. Wang RD et al., explains the advantages of ropivacaine over bupivacaine which includes greater sensorimotor differential block, increased cardiovascular safety and shorter elimination half life with a lower potential for accumulation [20]. Kathuria S et al., found that adding dexmedetomidine to 0.5% ropivacaine in ultrasound-guided brachial plexus block had several effects [14]. Specifically, this combination shortened the onset time of both sensory and motor blocks, prolonged the duration of both sensory and motor blocks, and increased the overall duration of analgesia. Esmaoglu A et al., in their study on brachial plexus block described significant bradycardia when 100 mcg dexmedetomidine was added as adjuvant [21]. Hence, a dose of 100 mcg was not used for the study. Also, 25 mcg dexmedetomidine showed no sedative effect when used as an adjuvant in brachial plexus block as found by Sudani C et al., [22]. Since, the unwanted side-effect of dexmedetomidine (bradycardia) was not desired and also the added advantage of a conscious sedation is desirable, the authors used 1 mcg/kg of dexmeditomidine in the present study.

Farooq N et al., compared the efficacy of fentanyl and dexmedetomidine as adjuvant to ropivacaine among patient undergoing upper limb surgeries in their study [23]. Unlike the present study they stated that 3 mg/kg of 0.75% ropivacaine along with 1 µg/kg of fentanyl diluted with normal saline to make a total volume 35 mL were shown to be the most effective combination for brachial plexus block in patients having upper limb orthopaedic surgery. The results were analysed in terms of the onset time for both sensory and motor blockade, duration of sensory and motor blockade and duration of analgesia. While comparing side-effects like hypotension, bradycardia, pruritus, nausea, vomiting, respiratory depression, Horner's syndrome, pneumothorax and recurrent laryngeal nerve palsy between the groups, no statistically significant difference was there. According to Perlas A et al., ultrasound-guided supraclavicular block is associated with a high rate of successful surgical anaesthesia and low rate of complications like pneumothorax and Horner's syndrome [24].

Limitation(s)

The study did not follow-up patients with a postoperative chest radiograph to rule out asymptomatic pneumothorax. Study included patients aged 18-60 years and belonging to ASA I and II status, the efficacy of both the adjuvants are not validated in old, as well as, non ASA I and II patients. However, further research is needed to determine the optimal dosing and safety profile of dexmedetomidine for this use, as well as, to compare its efficacy to other adjuvants or local anaesthetics. Overall, dexmedetomidine has potential as a future consideration for improving the efficacy and safety of supraclavicular block in upper limb surgeries.

CONCLUSION(S)

The supraclavicular block is a reliable and rapid onset method of brachial plexus block for anaesthesia of the upper limb. Dexmedetomidine 1 mcg/kg is a better adjuvant to 0.5% ropivacaine 20 mL in Ultrasound-guided supraclavicular brachial plexus block in terms of duration of sensory block, motor block and analgesia compared to fentanyl. Dexmedetomidine appears to be a promising drug for supraclavicular block in upper limb surgeries.

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