Comparative Study of Ropivacaine Alone Versus Combination of Ropivacaine with Either Dexmedetomidine or Dexamethasone for Ultrasound Guided Supraclavicular Brachial Plexus Block

Kumud Pyakurel, Kanak Khanal, Sonia Dahal

[1]Anesthesiology and Critical care, [2]Department of Pediatrics; Birat Medical College Teaching Hospital, Morang, Nepal

Corresponding author:
Dr. Kumud Pyakurel; Email: kumudpyakurel.kp@gmail.com; ORCiD: 0000-0002-0888-3691

ABSTRACT

Background: Ropivacaine is a common choice for supraclavicular brachial plexus block. Dexmedetomidine and Dexamethasone are frequently added to local anesthetics for improved effects. With limited comparative evidence, this study aimed to assess Dexmedetomidine and Dexamethasone as adjuvants to Ropivacaine in ultrasound-guided supraclavicular brachial plexus block.

Materials and Methods: This prospective double-blind study enrolled patients aged 18-60, scheduled for elective upper limb surgery below mid-humeral level. They were randomly assigned into three groups: Ropivacaine alone, Ropivacaine with Dexmedetomidine (1 mcg/kg), or Ropivacaine with Dexamethasone (8 mg). The study aimed to compare sensory and motor blockade onset and duration, postoperative analgesia duration, and adverse event occurrence among the groups.

Results: Ninety-eight patients participated in the study. All three groups showed similar characteristics in terms of age, weight, gender, ASA grade, and surgery duration. The onset and duration of sensory and motor block were comparable between the Dexamethasone and Dexmedetomidine groups. A significant difference was observed when comparing the Ropivacaine only group to either of the other two groups or when comparing all three groups. Similarly, postoperative analgesia duration was comparable between the Dexamethasone and Dexmedetomidine groups while it differed significantly when comparing all three groups or when comparing the Ropivacaine only group to either of the other groups. Ropivacaine with Dexmedetomidine group experienced notable occurrence of bradycardia.

Conclusion: Dexamethasone and Dexmedetomidine as adjuvants to 0.5% Ropivacaine for ultrasound-guided supraclavicular brachial plexus blockade have comparable effects on sensory and motor blockade onset and duration, along with postoperative analgesia duration. Dexmedetomidine, however, is linked to more bradycardia compared to Dexamethasone.

Keywords: Dexamethasone, Dexmedetomidine, Ropivacaine, Ultrasound, Supraclavicular brachial plexus block

INTRODUCTION

Brachial plexus block is an excellent alternative to general anesthesia for upper limb surgeries. By curtailing the stress response and using minimal anaesthetic drugs it provides intraoperative analgesia along with prolonged postoperative pain-relief.[1] Ultrasound facilitates the deposition of drugs at the apt place and augments block success. The brachial plexus at supraclavicular regions is compact and shallow (20-30 mm deep) and the nerve visibility is remarkable.[2,3] Single injection peripheral nerve blockade is commonly used for perioperative analgesia and anesthesia.[4] It provides good analgesia in the early postoperative period but is often insufficient especially after first few hours. So, the idea of prolonging the duration of peripheral nerve blockade to treat postoperative pain is very relevant.

Adjuvants that are frequently added to local anesthetics to prolong analgesia following single injection peripheral nerve block include epinephrine, opioids, tramadol, ketamine, midazolam, magnesium, clonidine,

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Dexmedetomidine and Dexamethasone, but often with limited success and unproven safety.[5-7] Studies of perineural buprenorphine, Dexamethasone and Dexmedetomidine have most consistently demonstrated prolongation of peripheral nerve blockade.[6] Dexamethasone is a potent long-acting steroid that has shown efficacy as an adjuvant to local anesthetics in various studies.[8,9] Dexmedetomidine enhances peripheral nerve blockade when added to local anesthetics, providing better quality of anesthesia as well as postoperative analgesia.[10,11]

There are very few published studies comparing Dexmedetomidine and Dexamethasone as an adjuvant to Ropivacaine for brachial plexus block. Thus, the present study was designed to evaluate the effects Ropivacaine alone compared to Dexmedetomidine or Dexamethasone when added to Ropivacaine during ultrasound guided supraclavicular brachial plexus block.

MATERIALS AND METHODS

After approval from institutional review committee, this prospective comparative study was conducted on patients posted for various elective surgery of upper limb below mid humerus level at Birat medical college teaching hospital. Written and informed consent was taken for each participant in the study. Patients allergic to either drug, refusal to regional anesthesia, pre-existing peripheral neuropathy of upper limb, infection at injection site, bleeding disorders, obesity (BMI>30), pregnant or lactating mothers, patients on adrenoreceptor agonist or antagonist therapy and history of severe cardiac, respiratory, hepatic or renal disease were excluded from the study. The estimated sample size on the basis of previous study by Verma et al.[12], keeping the confidence interval at 95% and power of study at 90% was 28 in each group. Assuming dropout rate of 10%, at total of 31 patients in each group was deemed necessary.

After preparation, patients meeting inclusion criteria were randomized into three groups A, B and C, using block randomization to receive either 0.5% Ropivacaine (30 ml) only in group A, 0.5% Ropivacaine with 1 mcg/kg Dexmedetomidine (30 ml) in group B and 0.5% Ropivacaine with 8 mg Dexamethasone (30 ml) in group C. Anesthetist involved in drug administration and observation of the patient were blinded to the coded drugs prepared by another anesthetist not involved further in the study. Onset time for sensory or motor block was noted as the time interval between the end of total local anesthetic administration and complete sensory or motor block. Complete sensory block was defined by anesthetic block (score 2) on all nerve territories. Three-point scale was used to assess the sensory blockade (Grade 0: Sharp prick felt, Grade 1: Analgesia, dull sensation felt, Grade 2: Anaesthesia, no sensation felt). Motor blockade was assessed using a motor block scale (Grade 1- Able to raise the extended arm to 90 degrees for a full two seconds, Grade 2- Able to flex the elbow and move the fingers but unable to raise the extended arm, Grade 3- Unable to flex the elbow but able to move the fingers, Grade 4- Unable to move the arm, elbow or the fingers). Grade 2 was considered for onset of motor blockade and Grade 3 onwards was defined as complete blockade. Duration of sensory block was noted as the time interval between the end of study drug administration and complete resolution of sensation on all nerves. Duration of motor block was noted as the time interval between the end of study drug administration and the recovery of complete motor power of the hand and forearm. Sensory blockade of less than grade 2, for 30 minutes following administration of study drug was considered as inadequate blockade and those

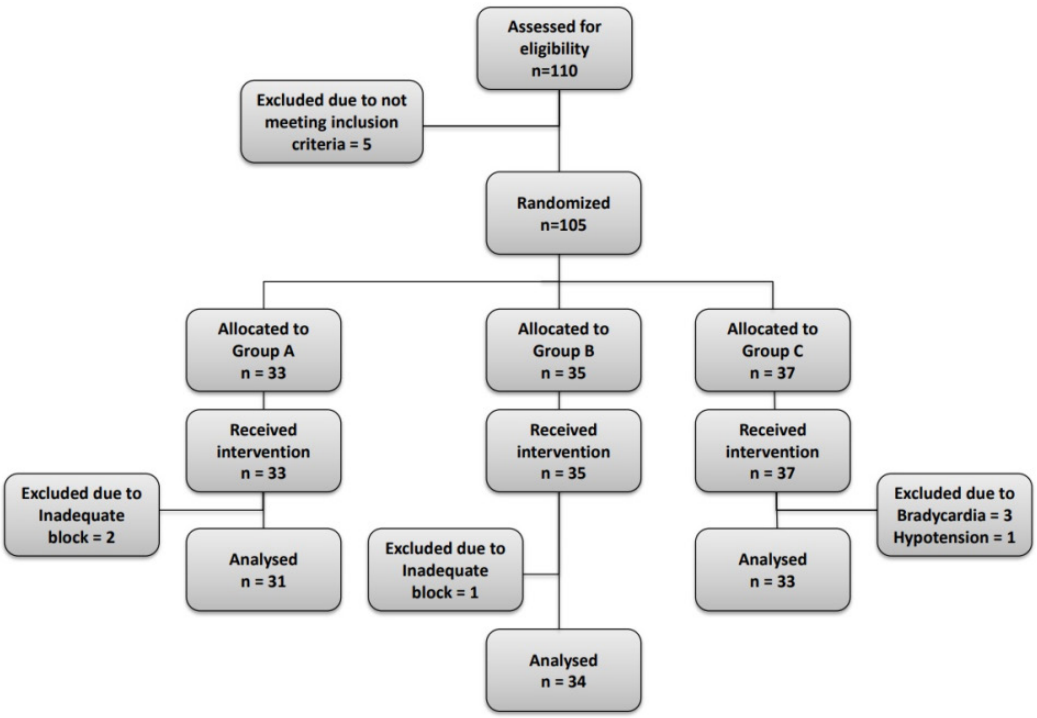

Figure 1: Consort Flow Diagram

patients were excluded from analysis. The duration of analgesia was defined as the time between the end of local anesthetic administration and first rescue analgesic administration. Clinically relevant bradycardia was defined as heart rate of less than 50 per minute and hypotension was defined as reduction in mean arterial pressure of less than 20% or more from the baseline. Participants experiencing bradycardia and hypotension were later excluded from the study.

Data were entered in SPSS version 22 which was used for analysis. Continuous data are represented as mean ± SD and categorical data as number and percentage. Chi-square test analyzed categorical data (gender, ASA grade and complications), One-way ANOVA compared continuous variables (age, weight, duration of surgery) among the three groups, and t-tests compared means for onset and duration of sensory and motor block, and postoperative analgesia duration between groups. P- value of < 0.05 was considered as significant. After conducting ANOVA to identify significant group differences, the Tukey HSD test was employed as a post hoc analysis. This method was chosen to control experiment-wise error in multiple comparisons, ensuring precision in detecting significant differences between groups while mitigating the risk of false positives. This approach enhances the overall statistical reliability of the study.

RESULTS

A total of 105 patients were randomized and 98 patients were enrolled for the study (Figure 1). Table 1 shows patient variables in between the groups. All the three groups were comparable in terms of age, weight, gender, ASA grade or duration of surgery.

Table 2 shows block characteristics in between the groups. Figure 2 shows the time of onset of sensory and motor block and Figure 3 shows the duration of sensory, motor block and postoperative analgesia among the groups.

The onset and duration of both sensory as well as motor block were comparable between Ropivacaine with Dexamethasone and Ropivacaine with Dexmedetomidine groups. Significant difference was noted when Ropivacaine only group was compared with either of the two other groups, or when all the three groups were compared. Similarly, duration of postoperative analgesia was significantly different when all the three groups were compared or when Ropivacaine only group was compared with Ropivacaine with Dexamethasone and Ropivacaine

Table 1: Patient variables (values expressed as mean ± SD and frequency)

Patient Variables		Groups			X^2 -value	p-value
		A (n=31)	B (n=34)	C (n=33)		
Age (Years)		37.29 ± 10.99	36.06 ± 12.24	39.48 ± 11.05	-	0.468
Weight (Kg)		58.9 ± 10.04	62.59 ± 12.23	59.18 ± 12.17	-	0.355
Gender (n)	Male	15	18	17	0.139	0.933
	Female	16	16	16		
ASA grade (n)	I	19	22	16	1.993	0.369
	II	12	12	17		
Duration of Surgery (minutes)		114.58 ± 32.19	117.47 ± 33.42	103.96 ± 35.86	-	0.237

Table 2: Block Characteristics among the groups (values expressed as mean ± SD)*

Block Characteristics (minutes)	Groups			P-value of pair comparisons			
	A (n=31)	B (n=34)	C (n=33)	A/B/C	A/B	A/C	B/C
Onset Sensory	20.39 ± 6.77	13.35 ± 2.87	12.36 ± 3.48	<0.01	<0.01	<0.01	0.208
Onset Motor	25.39 ± 8.29	15.97 ± 3.21	14.51 ± 3.89	<0.01	<0.01	<0.01	0.099
Duration Sensory	634.68 ± 209.95	900.55 ± 143.24	937.93 ± 178.51	<0.01	<0.01	<0.01	0.347
Duration Motor	537.19 ± 177.8	827.76 ± 129.58	878.94 ± 166.04	<0.01	<0.01	<0.01	0.164
Duration of Post operative analgesia	813.16 ± 258.18	1352.94 ± 163.61	1393.82 ± 204.78	<0.01	<0.01	<0.01	0.369

Table 3: Complications between the groups (values expressed as frequency)

Complications (n)	Groups			Fisher's Exact Test	p-value
	A (n=31)	B (n=34)	C (n=33)		
Hypotension	0	0	1	1.82	0.337
Bradycardia	0	0	3	4.143	0.065

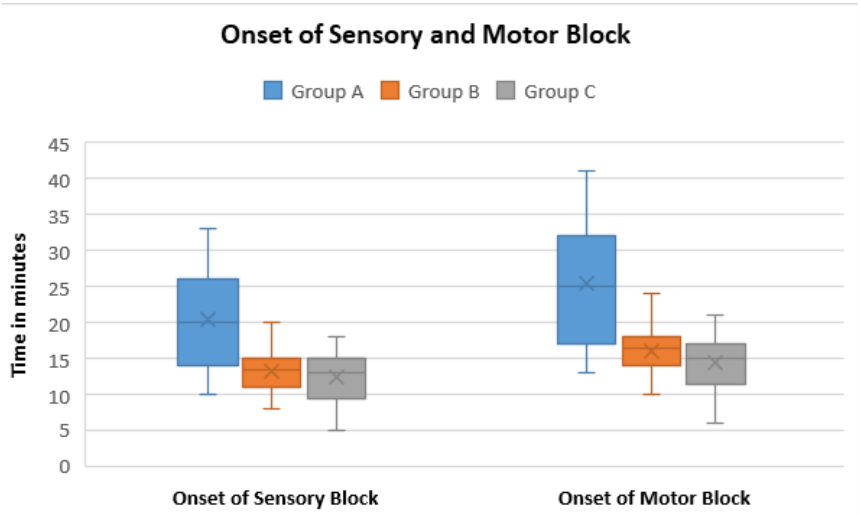

Figure 2: Box-plot illustrating the Onset times of Sensory and Motor block among the groups

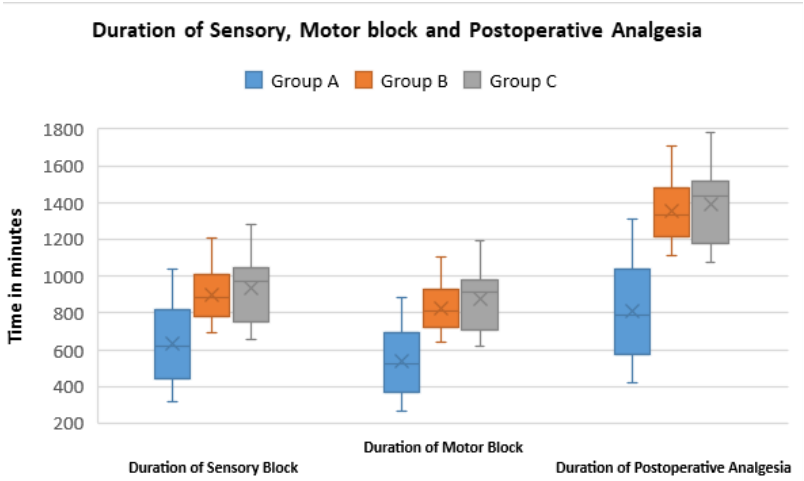

Figure 3: Box-plot illustrating the Duration of Sensory, Motor block and Postoperative analgesia among the groups

with Dexmedetomidine groups. But this was comparable for Ropivacaine with Dexamethasone and Ropivacaine with Dexmedetomidine groups.

Table 3 shows complications in between the groups. One episode of hypotension and three episodes of bradycardia were noted in the Ropivacaine with Dexmedetomidine group. The occurrence of bradycardia though higher but was not significant for this group.

DISCUSSION

Both Dexamethasone and Dexmedetomidine have been successfully used as adjuvants with local anesthetics in brachial plexus blockade for desirable effects such as faster onset and longer duration of action of both sensory and motor blockade, as well as prolonged duration of analgesia in the postoperative period. This study was conducted to compare the effects of Ropivacaine alone with Ropivacaine with Dexamethasone and Ropivacaine with Dexmedetomidine for supraclavicular brachial plexus block for upper limb surgeries.

The results of our study show compared to Ropivacaine alone, the usage of either of Dexamethasone or Dexmedetomidine with Ropivacaine fastens the time of onset, lengthens the duration of action of both sensory and motor blockade and also prolongs the duration of postoperative analgesia, while neither of Dexamethasone and Dexmedetomidine being superior compared to each other.

Dexamethasone as an adjuvant to Ropivacaine for supraclavicular blocks have consistently produced significantly prolonged duration of sensory and motor block as well as post operative analgesia which is similar to our findings.[13] But the superiority for onset of sensory and motor block compared to Ropivacaine alone or with other local anesthetics is not well established.[10,14] We have observed a significantly faster onset of sensory and motor block with Dexamethasone as adjuvant to Ropivacaine. Similar observations have been made by other studies though peripheral nerve stimulation or landmark guided blocks were given.[14,15]

Studies with similar methodology as ours have results similar to our findings. Kumar S et al. used peripheral nerve stimulation and observed perineural Ropivacaine with Dexamethasone prolonged duration of sensory and motor block and postoperative analgesia but did not fasten the onset of sensory and motor block compared to Ropivacaine alone.[14] Similarly, Pani N et al. concluded that the addition of Dexamethasone to Levobupivacaine in supraclavicular brachial plexus blockade prolonged time for first rescue analgesia and reduced the requirement of rescue analgesics with faster onset and prolonged duration of sensory and motor block.[16]

The dose of 8 mg has consistently produced similar effects across different studies hence was used for this study as well. It is unclear how corticosteroids cause prolonged regional anesthesia and analgesia. The block effect may be due to its local action and not a systemic one.[17] Steroids induce vasoconstriction reducing local anesthetic absorption[18], increased activity of inhibitory potassium channels on nociceptive C-fiber[19,20] and inhibition of synthesis and/or release of various inflammatory mediators are the proposed mechanisms.[21]

On the basis of the above observations, it can be agreed that Dexamethasone added to Ropivacaine prolongs the duration of sensory and motor block but the onset time of sensory and motor block is not consistently similar. Multiple attributable factors could be use of ultrasonography, Ropivacaine in different concentrations and volume as well as the dose Dexamethasone used.

Dexmedetomidine is another adjuvant used commonly for desirable effects along with local anesthetics for different nerve blocks. Dexmedetomidine with Ropivacaine when used for supraclavicular brachial plexus block produces faster onset and longer duration of sensory and motor block and prolongs the post operative analgesia compared to Ropivacaine alone as observed in multiple studies.[22] This is similar to our observation.

Chinappa et al.[23], Kathuria S et al.[22] and N Singh et al.[24] have reported that Dexmedetomidine (1 µg/kg) when used as an adjuvant to 30 ml of 0.5% Ropivacaine, quickens the onset of sensory and motor block, prolongs supraclavicular brachial plexus block duration and offers a prolonged duration of postoperative analgesia. Similarly when Dexmedetomidine (1 mcg/kg) was added to Levobupivacaine (0.325%) for ultrasound-guided supraclavicular brachial plexus block, onset of block was quickened and duration of sensory/motor block along with the duration of analgesia was significantly extended.[25] These finding also corroborate with other studies.[26,27]

Thus it is clear that Dexmedetomidine as an adjuvant to Ropivacaine provides desirable clinical effects. The analgesic properties of Dexmedetomidine has been described by a) local vasoconstriction led delayed absorption of local anesthetics and/or direct inhibition of nerve conduction by α_2 agonists[28] b) blockade of the hyperpolarization-activated cation current[29] or reduction in Cationic action potential amplitudes similar to local anesthetics[30].

Our study suggests the effects of both Dexamethasone and Dexmedetomidine as adjuvants to Ropivacaine are statistically similar in terms of onset and duration of sensory and motor blockade as well as duration of postoperative analgesia. Similar observation of non-inferiority of either adjuvant was made by Nidhi S et al. having similar methodology as ours.[29] M J Lee et al. observed equal effectiveness of both agents in extending duration of Ropivacaine while not having significant effects on onset time.[31] NK Verma et al.[12] however, have contrasting results to ours as Dexmedetomidine was statistically better than Dexamethasone as adjuvant to Ropivacaine in terms of onset and duration of block and postoperative analgesia. Interestingly a meta-analysis that included individual studies of Dexmedetomidine and Dexamethasone with different local anesthetics concluded Dexamethasone to be better adjuvant to local anesthetics owing to longer analgesia duration and lesser risk of adverse events compared to Dexmedetomidine.[32]

We observed 1 episode of hypotension and 3 episodes of bradycardia in the Dexmedetomidine group. Esmaoglu et al.[33] observed significant bradycardia and Srinivasa Rao Nallam et al.[34] observed significant bradycardia and hypotension with Dexmedetomidine 100mcg as adjuvant to 0.5% Levobupivacaine. Usage of lower doses of Dexmedetomidine in other studies had no hypotension, bradycardia or sedation.

The study's findings demonstrate that both Dexamethasone and Dexmedetomidine as adjuvants to Ropivacaine can enhance block characteristics and prolong postoperative analgesia. Therefore, anesthesia practitioners can choose either of these adjuvants based on availability, cost, and individual patient factors. This flexibility in choosing adjuvants can provide anesthesia providers with options to tailor the anesthesia regimen based on patient-specific needs and preferences. Moreover, this study also highlights the importance of cautious use of Dexmedetomidine as an adjuvant, especially in patients with cardiovascular comorbidities or those at increased risk of bradycardia.

Limitations: Limited numbers of participants were taken for the study though guided by the sample size. Additionally, we utilized a simple randomization technique, which may lead to potential imbalances in participant characteristics between the treatment groups, and can introduce bias and impact the validity of study results. Moreover, since few patients developed bradycardia and hypotension, it would be noteworthy that fixed dose of adjuvants as taken for our study cannot answer the ideal agent characteristics unless different doses are searched for ideal effects. Hence, different doses should be tried in order to guide optimal combination especially for significant cardiovascular diseases.

CONCLUSION

Both Dexamethasone and Dexmedetomidine as adjuvants to 0.5 % Ropivacaine for ultrasound guided supraclavicular brachial plexus blockade have similar effects in terms of onset and duration of sensory and motor blockade as well as duration of postoperative analgesia. Dexmedetomidine as adjuvant is associated with bradycardia compared to Dexamethasone.

Further researches should study different doses of Dexmedetomidine and Dexamethasone to guide the ideal combination dose with Ropivacaine. To address potential imbalances and biases introduced by simple randomization, future studies could consider implementing block randomization technique to ensure a more even distribution of important participant characteristics across treatment groups, improving the robustness of the study findings.

Availability of data and materials: The raw data supporting the research findings can be made available by corresponding author upon request.

Author's contribution: KP and KK conceptualized the study. All authors designed the study. KP conducted literature search, data collection and analysis. KP and KK prepared and edited the manuscript. All authors reviewed, read and approved the final manuscript.

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Conflict of Interest: None declared.

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