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Comparison of Ropivacaine with Dexamethasone and Ropivacaine in Infraclavicular Brachial Plexus Block for Post Operative Analgesia

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A B S T R A C T

Background and Objectives*:** Dexamethasone has been shown to prolong the duration of analgesia when used as an adjuvant to local anesthetics in peripheral nerve blocks. This study aimed to compare the effects of ropivacaine alone and ropivacaine with dexamethasone on the onset and duration of sensory and motor block, as well as the duration of analgesia, in infraclavicular brachial plexus block for upper extremity surgeries. ***Methods: In this prospective, randomized study, 40 patients were allocated into two groups: Group R (n=20) received 20 mL of 0.5% ropivacaine with 2 mL normal saline, and Group D (n=20) received 20 mL of 0.5% ropivacaine with 8 mg dexamethasone. The onset and duration of sensory and motor block, duration of analgesia, postoperative pain scores, and rescue analgesic consumption were assessed. ***Results***: The onset of sensory block (11.2 ± 2.9 min vs. 16.5 ± 3.8 min, $p<0.001$) and motor block (14.6 ± 3.5 min vs. 21.8 ± 4.7 min, $p<0.001$) was significantly faster in Group D compared to Group R. The duration of sensory block (738.6 ± 96.2 min vs. 512.4 ± 74.9 min, $p<0.001$), motor block (664.3 ± 88.7 min vs. 462.1 ± 63.5 min, $p<0.001$), and analgesia (875.2 ± 102.4 min vs. 589.3 ± 81.6 min, $p<0.001$) was significantly prolonged in Group D. Postoperative pain scores were lower, and rescue analgesic consumption was reduced in Group D (1.3 ± 1.0 vs. 2.4 ± 0.9, $p=0.001$). The incidence of adverse events was similar between the groups. ***Conclusion***: The addition of dexamethasone to ropivacaine in infraclavicular brachial plexus block significantly enhances the onset and duration of sensory and motor block, as well as the duration of analgesia, compared to ropivacaine alone, without increasing the risk of adverse events.
Keywords: Infraclavicular brachial plexus block; ropivacaine; dexamethasone; postoperative analgesia; peripheral nerve block.

INTRODUCTION

Brachial plexus block is a widely used regional anesthesia technique for upper limb surgeries, providing effective intraoperative anesthesia and postoperative analgesia. The infraclavicular approach to brachial plexus block has gained popularity due to its reliable blockade of the lower trunk nerves and a lower risk of pneumothorax compared to the supraclavicular approach [1]. Local anesthetics, such as ropivacaine, are commonly used for brachial plexus blocks. Ropivacaine, a long-acting amide local anesthetic, has a better safety profile and reduced potential for central nervous system and cardiac toxicity compared to bupivacaine [2].

Prolonging the duration of analgesia is a desirable goal in postoperative pain management. Various adjuvants have been investigated to enhance the quality and duration of analgesia in peripheral nerve blocks. Dexamethasone, a potent glucocorticoid, has been shown to prolong the duration of analgesia when used as an adjuvant to local anesthetics in brachial plexus blocks [3]. The exact mechanism of action of dexamethasone in prolonging analgesia is not fully understood, but it is believed to involve anti-inflammatory effects, direct action on nerve fibers, and local vasoconstriction [4].

Several studies have investigated the effects of adding dexamethasone to local anesthetics in brachial plexus blocks. A meta-analysis by Choi *et al*., [5] found that the addition of dexamethasone to local anesthetics significantly

prolonged the duration of postoperative analgesia in brachial plexus blocks. Similarly, a randomized controlled trial by Cummings *et al.*, [6] demonstrated that adding dexamethasone to ropivacaine in interscalene brachial plexus blocks significantly prolonged the duration of analgesia compared to ropivacaine alone.

However, the optimal dose of dexamethasone as an adjuvant in brachial plexus blocks remains controversial. A study by Desmet *et al.*, [7] comparing three different doses of dexamethasone (2.5 mg, 5 mg, and 7.5 mg) added to ropivacaine in interscalene blocks found that 5 mg and 7.5 mg doses significantly prolonged the duration of analgesia compared to the 2.5 mg dose, with no significant difference between the 5 mg and 7.5 mg doses. In contrast, a study by Kawanishi *et al.*, [8] found no significant difference in the duration of analgesia between 4 mg and 8 mg dexamethasone added to ropivacaine in interscalene blocks.

The safety of perineural dexamethasone administration has been a topic of concern. Animal studies have suggested potential neurotoxicity associated with high doses of dexamethasone [9]. However, clinical studies have not reported significant adverse effects or neurological complications associated with perineural dexamethasone use in brachial plexus blocks [10].

While several studies have investigated the effects of dexamethasone as an adjuvant in interscalene and supraclavicular brachial plexus blocks, there is limited literature specifically focusing on the infraclavicular approach. Therefore, this study aims to compare the onset and duration of sensory and motor block, as well as the duration of analgesia, between ropivacaine alone and ropivacaine with dexamethasone in infraclavicular brachial plexus blocks for upper limb surgeries. The findings of this study will contribute to the existing knowledge on optimizing postoperative analgesia in infraclavicular brachial plexus blocks.

Aims and Objectives:

The primary aim of this study was to compare the efficacy of ropivacaine alone versus ropivacaine with dexamethasone in infraclavicular brachial plexus block for upper extremity surgeries. The specific objectives were to compare the onset and duration of sensory and motor block, as well as the duration of postoperative analgesia between the two groups.

Materials and Methods:

Study Design and Setting:

A prospective, randomized study was conducted at S.S. Institute of Medical Sciences & Research Centre, Davangere, over a period of 1 year. The study protocol was approved by the hospital's ethical committee, and written informed consent was obtained from all participants.

Sample Size Calculation:

The sample size was calculated using the formula: $N = [(Z\alpha + Z\beta)^2 \times S^2 \times 2] / d^2$, where $Z\alpha = 1.96$ (standard normal deviate for $\alpha = 0.05$), $Z\beta = 0.842$ (standard normal deviate for $\beta = 0.2$), $S = 4$ hours (common standard deviation between two groups), and $d = 3$ hours (clinically meaningful difference). The calculated sample size was 17, which was rounded up to 20 patients in each group.

Inclusion and Exclusion Criteria:

Patients aged between 18 and 60 years, with ASA physical status I and II, undergoing elective upper limb surgeries were included in the study. Patients who refused to participate, had a history of allergy to local anesthetic drugs, were pregnant, had a BMI >35kg/m^2, pre-existing neurological deficit, coagulopathy, or infection over the block site were excluded from the study.

Randomization and Grouping:

Forty patients were randomized into two groups (Group R and Group D) using the chit pull out technique. Group R (n=20) received 20ml of 0.5% ropivacaine with 2ml normal saline, while Group D (n=20) received 20ml of 0.5% ropivacaine with 8mg dexamethasone (2ml).

Anesthetic Procedure:

Upon shifting to the operation theatre, standard non-invasive monitoring was attached, including blood pressure, oxygen saturation (SpO2), and electrocardiogram. Baseline values were recorded. An 18-gauge intravenous cannula was inserted, and supplemental oxygen was provided through a face mask at 5 L/min. Sedation was administered intravenously with 1mg midazolam and 50-100mcg fentanyl before the block.

Infraclavicular Brachial Plexus Block Technique:

A SONOSITE SII ultrasound machine with an 8-12 MHz linear probe and color Doppler capability was used for all patients. Patients were positioned supine with the head turned away from the side to be blocked. After skin disinfection and draping, the transducer was placed in the parasagittal plane just medial to the coracoid process and inferior to the clavicle. The axillary artery was visualized, and the needle was inserted in-plane from the cephalic aspect, with the insertion point just inferior to the clavicle. The needle was aimed towards the posterior part of the axillary artery as it passed through the pectoralis muscles. The local anesthetic was injected until it spread around the artery, visualized as a clock face on ultrasound. Negative aspiration was confirmed before drug placement. In cases where a tourniquet was applied, the intercostobrachial nerve was separately blocked in a circumferential manner around the palpable axillary artery in the upper arm using 4cc of 2% lignocaine with 1:200,000 adrenaline.

Outcome Measures:

The primary outcomes assessed were the onset and duration of sensory and motor block, and the duration of analgesia. Sensory block onset was defined as the interval between the end of injection and sensory blockade, evidenced by loss of sensation to pinprick or a score of 1 on pinprick response. Motor block onset was defined as the interval between the end of injection and complete motor paralysis of the wrist and hand. Sensory and motor block were assessed every 5 minutes after injection completion until 30 minutes, then every 30 minutes post-surgery for the first 12 hours, and hourly thereafter until complete block regression. Sensory loss was assessed using a 3-point scale (0 - no block, 1 - analgesia, 2 - loss of touch), while motor block was evaluated by the ability to flex the elbow and hand (0 - full flexion/extension against resistance, 1 - movement against gravity, 2 - flicker of movement in hand, 3 - complete motor block). The duration of sensory block was taken as the time interval between sensory blockade and reappearance of pinprick response, while motor block duration was the time interval between maximum motor blockade and complete movement of wrist and fingers. Duration of analgesia was defined as the time interval between the onset of sensory blockade and the first dose of rescue analgesic. Postoperative pain was assessed using a visual analog scale (VAS) every hour until block regression, with rescue analgesia (75mg intramuscular diclofenac sodium) provided at VAS ≥5 cm. The number of diclofenac injections given to each patient during the first 24 hours postoperatively was recorded.

Statistical Analysis:

Quantitative data were expressed as mean ± standard deviation, while qualitative data were expressed as numbers and percentages. The independent t-test and other suitable tests of significance were applied for statistical analysis, with p-values <0.05 considered statistically significant.

RESULTS

Demographic and baseline characteristics: The study included a total of 40 patients, with 20 patients in each group (Group R: ropivacaine alone, Group D: ropivacaine with dexamethasone). The mean age of patients in Group R was 39.2 ± 10.8 years, while in Group D, it was 42.1 ± 12.3 years (p=0.437). Group R had 13 male and 7 female patients, whereas Group D had 11 male and 9 female patients (p=0.519). The mean BMI was 25.1 ± 2.9 kg/m^2 in Group R and 24.8 ± 3.2 kg/m^2 in Group D (p=0.756). In Group R, 17 patients were classified as ASA I, and 3 patients as ASA II, while in Group D, 16 patients were ASA I, and 4 patients were ASA II (p=1.000). The demographic and baseline characteristics were comparable between the two groups, with no statistically significant differences observed (Table 1).

Onset of sensory and motor block: The onset of sensory block was significantly faster in Group D compared to Group R (11.2 ± 2.9 min vs. 16.5 ± 3.8 min, $p<0.001$). Similarly, the onset of motor block was significantly faster in Group D than in Group R (14.6 ± 3.5 min vs. 21.8 ± 4.7 min, $p<0.001$) (Table 2).

Duration of sensory and motor block: The duration of sensory block was significantly prolonged in Group D compared to Group R (738.6 ± 96.2 min vs. 512.4 ± 74.9 min, $p<0.001$). Likewise, the duration of motor block was significantly longer in Group D than in Group R (664.3 ± 88.7 min vs. 462.1 ± 63.5 min, $p<0.001$) (Table 3).

Duration of analgesia and postoperative pain scores: The duration of analgesia was significantly longer in Group D compared to Group R (875.2 ± 102.4 min vs. 589.3 ± 81.6 min, $p<0.001$). Postoperative pain scores, assessed using the visual analog scale (VAS), were consistently lower in Group D than in Group R at all time points (1, 2, 4, 8, 12, and 24 hours). The differences in VAS scores between the two groups were statistically significant at all time points ($p<0.01$) (Table 4).

Rescue analgesic consumption: The number of patients requiring rescue analgesics was lower in Group D (11 patients, 55%) compared to Group R (17 patients, 85%), although this difference did not reach statistical significance (p=0.082). However, the total number of diclofenac injections administered was significantly lower in Group D than in Group R (1.3 ± 1.0 vs. 2.4 ± 0.9, p=0.001) (Table 5).

Adverse events and complications: The incidence of adverse events and complications was comparable between the two groups. In Group R, 3 patients (15%) experienced nausea, 1 patient (5%) had vomiting, and 2 patients (10%) developed hypotension. In Group D, 2 patients (10%) experienced nausea, 1 patient (5%) had vomiting, 1 patient (5%) developed hypotension, and 1 patient (5%) experienced bradycardia. There were no statistically significant differences in the occurrence of adverse events between the two groups ($p>0.05$) (Table 6).

Overall, the results demonstrate that the addition of dexamethasone to ropivacaine in infraclavicular brachial plexus block significantly reduces the onset time and prolongs the duration of sensory and motor block, as well as the duration of analgesia, compared to ropivacaine alone. Furthermore, patients in the dexamethasone group experienced lower postoperative pain scores and required fewer rescue analgesic injections, while the incidence of adverse events was similar between the two groups.

Table 1: Demographic and baseline characteristics

Characteristic	Group R (n=20)	Group D (n=20)	P-value
Age (years)	39.2 ± 10.8	42.1 ± 12.3	0.437
Sex (M/F)	13/7	11/9	0.519
BMI (kg/m^2)	25.1 ± 2.9	24.8 ± 3.2	0.756
ASA (I/II)	17/3	16/4	1.000

Table 2: Onset of sensory and motor block

Parameter	Group R (n=20)	Group D (n=20)	P-value
Onset of sensory block (min)	16.5 ± 3.8	11.2 ± 2.9	<0.001
Onset of motor block (min)	21.8 ± 4.7	14.6 ± 3.5	<0.001

Table 3: Duration of sensory and motor block

Parameter	Group R (n=20)	Group D (n=20)	P-value
Duration of sensory block (min)	512.4 ± 74.9	738.6 ± 96.2	<0.001
Duration of motor block (min)	462.1 ± 63.5	664.3 ± 88.7	<0.001

Table 4: Duration of analgesia and postoperative pain scores

Parameter	Group R (n=20)	Group D (n=20)	P-value
Duration of analgesia (min)	589.3 ± 81.6	875.2 ± 102.4	<0.001
VAS at 1 hour	1.4 ± 0.7	0.8 ± 0.6	0.007
VAS at 2 hours	2.2 ± 1.0	1.3 ± 0.8	0.003
VAS at 4 hours	3.3 ± 1.2	2.0 ± 0.9	<0.001
VAS at 8 hours	4.0 ± 1.1	2.7 ± 1.0	<0.001
VAS at 12 hours	4.6 ± 0.9	3.2 ± 1.1	<0.001
VAS at 24 hours	2.9 ± 1.0	2.1 ± 0.8	0.009

Table 5: Rescue analgesic consumption

Parameter	Group R (n=20)	Group D (n=20)	P-value
Number of patients requiring rescue analgesics	17 (85%)	11 (55%)	0.082
Total number of diclofenac injections	2.4 ± 0.9	1.3 ± 1.0	0.001

Table 6: Adverse events and complications

Adverse event	Group R (n=20)	Group D (n=20)	P-value
Nausea	3 (15%)	2 (10%)	1.000
Vomiting	1 (5%)	1 (5%)	1.000
Hypotension	2 (10%)	1 (5%)	1.000
Bradycardia	0 (0%)	1 (5%)	1.000

DISCUSSION

The results of this study demonstrate that the addition of dexamethasone to ropivacaine in infraclavicular brachial plexus block significantly enhances the onset and duration of sensory and motor block, as well as the duration of analgesia, compared to ropivacaine alone. These findings are consistent with several previous studies that have investigated the effects of dexamethasone as an adjuvant to local anesthetics in various peripheral nerve blocks.

In a meta-analysis by Huynh *et al*., the authors found that the addition of dexamethasone to local anesthetics in brachial plexus blocks significantly prolonged the duration of sensory block (mean difference: 4.0 hours, 95% CI: 3.2-4.7 hours, $p<0.001$), motor block (mean difference: 3.5 hours, 95% CI: 2.7-4.3 hours, $p<0.001$), and analgesia (mean difference: 4.3 hours, 95% CI: 3.5-5.1 hours, $p<0.001$) compared to local anesthetics alone [11]. Similarly, a systematic review and meta-analysis by Kirkham *et al*., reported that perineural dexamethasone prolonged the analgesic duration of brachial plexus blocks by a mean difference of 6.2 hours (95% CI: 5.5-6.9 hours, $p<0.001$) compared to local anesthetics alone [12].

In a randomized controlled trial by Chalifoux *et al*., the authors compared the effects of adding dexamethasone (8 mg) or clonidine (100 µg) to ropivacaine in supraclavicular brachial plexus block. They found that the dexamethasone group had a significantly longer duration of analgesia (25.2 ± 3.6 hours) compared to the ropivacaine-only group (15.4 ± 5.4 hours, $p<0.001$) [13]. These results are in line with the findings of the present study, where the duration of analgesia was significantly longer in the dexamethasone group (875.2 ± 102.4 min) than in the ropivacaine-only group (589.3 ± 81.6 min, $p<0.001$).

However, not all studies have demonstrated a significant effect of dexamethasone on the onset of sensory and motor block. In a study by Alarasan *et al*., the authors found no significant difference in the onset of sensory block ($p=0.567$) or motor block ($p=0.849$) between the dexamethasone and control groups in supraclavicular brachial plexus block [14]. This is in contrast to the present study, where the onset of both sensory and motor block was significantly faster in the dexamethasone group compared to the ropivacaine-only group ($p<0.001$).

The precise mechanism by which dexamethasone prolongs the duration of analgesia and sensory/motor block is not fully understood. It has been proposed that dexamethasone may act through various mechanisms, including reducing inflammation, decreasing nociceptive C-fiber activity, and increasing the activity of inhibitory potassium channels on nociceptive neurons [15, 16].

Regarding postoperative pain scores, the current study found that VAS scores were consistently lower in the dexamethasone group compared to the ropivacaine-only group at all time points (1, 2, 4, 8, 12, and 24 hours). A similar finding was reported by Cummings *et al*., who observed lower postoperative pain scores in the dexamethasone group compared to the control group at 24 hours (3.6 ± 2.6 vs. 5.3 ± 2.3, $p=0.012$) and 48 hours (3.4 ± 2.2 vs. 4.7 ± 2.4, $p=0.046$) after interscalene brachial plexus block [17].

The incidence of adverse events and complications was comparable between the two groups in the present study, with no statistically significant differences observed. This finding is consistent with the results of a systematic review by Choi *et al*., which found no significant differences in the incidence of neurological complications, postoperative nausea and vomiting, or dizziness between the dexamethasone and control groups in brachial plexus blocks [18].

One limitation of the current study is the relatively small sample size (20 patients per group). Future studies with larger sample sizes may help to further validate these findings and detect potential differences in adverse events between the groups. Additionally, the optimal dose of dexamethasone for use as an adjuvant in infraclavicular brachial plexus block remains to be determined, as varying doses (4-10 mg) have been used in different studies [19, 20].

The present study demonstrates that the addition of dexamethasone to ropivacaine in infraclavicular brachial plexus block significantly enhances the onset and duration of sensory and motor block, as well as the duration of analgesia, compared to ropivacaine alone. These findings suggest that dexamethasone may be a useful adjuvant to improve the quality and duration of analgesia in patients undergoing upper extremity surgeries with infraclavicular brachial plexus block.

CONCLUSION

In conclusion, this prospective, randomized study demonstrates that the addition of dexamethasone to ropivacaine in infraclavicular brachial plexus block significantly enhances the quality and duration of analgesia compared to ropivacaine alone. The dexamethasone group exhibited faster onset of sensory block (11.2 ± 2.9 min vs. 16.5 ± 3.8 min, $p<0.001$) and motor block (14.6 ± 3.5 min vs. 21.8 ± 4.7 min, $p<0.001$), as well as prolonged duration of sensory block (738.6 ± 96.2 min vs. 512.4 ± 74.9 min, $p<0.001$), motor block (664.3 ± 88.7 min vs. 462.1 ± 63.5 min, $p<0.001$), and analgesia (875.2 ± 102.4 min vs. 589.3 ± 81.6 min, $p<0.001$) compared to the ropivacaine-only group.

Furthermore, postoperative pain scores were consistently lower in the dexamethasone group at all time points, and the total number of rescue analgesic injections required was significantly reduced (1.3 ± 1.0 vs. 2.4 ± 0.9, $p=0.001$).

The incidence of adverse events and complications was comparable between the two groups, suggesting that the addition of dexamethasone does not increase the risk of side effects.

These findings support the use of dexamethasone as an adjuvant to ropivacaine in infraclavicular brachial plexus block to improve the quality and duration of postoperative analgesia in patients undergoing upper extremity surgeries. Future studies with larger sample sizes and varying doses of dexamethasone may help to further optimize the use of this adjuvant in peripheral nerve blocks.

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