

Efficacy of Potassium Chloride 0.2 mmol as Adjuvant to 0.5% Ropivacaine versus Plain Ropivacaine 0.5% in Supraclavicular Brachial Plexus Block

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Abstract

Background: Brachial plexus block is one of the most common regional anesthetic techniques used for upper limb surgeries. Various adjuvants have been tried for prolonging the duration of post-operative analgesia and also to enhance the quality of block. We aimed to study the effects of the addition of potassium chloride to ropivacaine in supraclavicular brachial plexus block compared to plain ropivacaine.

Materials and Methods: This prospective, randomized, double-blind, and controlled study includes 80 adult patients aged between 20 and 60 years with ASA Grade I and II scheduled for upper limb surgeries. These patients were randomly allocated into two groups of 40 each. The patients in the group I/non-KCL group received 30 ml of 0.5 % ropivacaine along with 1 ml normal saline (control group). Group II/KCL group received 30 ml of 0.5% ropivacaine along with 0.2 mmol (0.1 ml) of potassium chloride (prepared by adding 0.1 ml of potassium chloride diluted with normal saline to make a volume of 1 ml) (study group). The onset, duration of sensory and motor blockade, quality of sensory and motor blockade, and the duration of post-operative analgesia were compared between both the groups.

Results: The onset of sensory and motor blockade was earlier in Group II/ study group when compared to plain ropivacaine group/Group I and was statistically significant with a $P < 0.05$. The mean duration of sensory and motor blockade was prolonged in Group II with enhanced quality of analgesia compared to Group I.

Conclusion: In our study, it concludes that the addition of potassium chloride as an adjuvant to ropivacaine had a significant clinical advantage over plain ropivacaine on the onset, duration, quality of sensory and motor blockade, and post-operative analgesia in supraclavicular brachial plexus block.

Key words: Adjuvants, Potassium chloride, Ropivacaine, Supraclavicular brachial plexus block

INTRODUCTION

Peripheral nerve blocks have become a well-accepted component of regional anesthetic techniques, especially for upper limb surgeries over the past decade to abolish

pain which is an unpleasant sensory and emotional impact that leads to actual or potential tissue damage.^[1,2] The gate theory of pain was invented by Melzack and Wall in 1965.^[3] Halsted, first performed the brachial plexus nerve block using a cocaine solution.^[4] It has its potential advantages over general anesthesia with rare complications when correct technique and reasonable precautions like the use of ultrasound are exercised.^[5,6] Previously used amino-ester local anesthetics lost their importance because of their short duration of action in addition to associated allergic reactions and systemic toxicity. There are continuous efforts to prolong the duration of brachial plexus blockade beyond

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the duration of local anesthetics and to overcome these drawbacks. These strategies include placement of indwelling perineural catheters to allow prolonged continuous infusion (or) the co-administration of adjuvants such as sodium bicarbonate,^[7] potassium chloride,^[7] vasoconstrictors,^[8] opioids, the addition of enzymes,^[9] enhancing blockade by pain and muscular exercise,^[10] warming up of local anesthetic solutions,^[11] α -2 agonists like clonidine,^[12] dexmedetomidine,^[13] midazolam, and dexamethasone^[14] with varying degree of success. It is widely believed that the addition of potassium chloride improves the quality and duration of peripheral nerve block over when the local anesthetic was used alone. Various studies were done using potassium chloride as an adjuvant with 0.5% bupivacaine. Ropivacaine a commonly used amide local anesthetic is a first single enantiomer specific compound with reduced cardiotoxicity and neurotoxicity. However, post-operative pain relief and delayed onset of action is an issue. Hence, we aimed to compare the effects of adding potassium chloride to 0.5% ropivacaine to accentuate early-onset and prolong the duration of sensory and motor blockade following supraclavicular brachial plexus block in a group of patients undergoing upper limb surgeries.

MATERIALS AND METHODS

This prospective randomized and double-blind study was conducted in the orthopedic operation theater, Govt. General Hospital, Kakinada attached to Rangaraya Medical College between January 2019 and September 2019. After obtaining Institutional Ethical Committee approval and informed written consent. Eighty adult patients belonging to ASA Grade I and II, of both sexes, aged between 20 years and 60 years were taken up for the study.

Inclusion Criteria

The following criteria were included in the study.

1. Adult patients between 20 and 60 years of age
2. Patients belonging to ASA Grade I and II
3. Elective surgeries on the upper limb.

Exclusion Criteria

The following criteria were excluded from the study.

1. Refusal by patient
2. History of bleeding disorders or patients on anticoagulant therapy
3. History of active neurological, cardiac, respiratory, and renal diseases
4. Burns/local infection
5. Hyperkalemia, severe kidney or liver dysfunction, and respiratory disease
6. Known allergy to local anesthetic drugs
7. Pregnancy
8. Nerve injury

9. Peripheral neuropathy
10. Patient with ASA Grade III and IV
11. Weight <50 kg or >100 kg.

The patients satisfying the above criteria are subjected to the study and are randomly assigned into two groups of 40 each by computer-generated random numbers.

Group I/non-KCL group	Patients received 30 ml of 0.5 % ropivacaine along with 1 ml of normal saline (control group)
Group II/KCL group	Patients received 30 ml of 0.5% ropivacaine along with 1 ml of 0.2 mmol (0.1ml) of potassium chloride (prepared by adding 0.1 ml of potassium chloride diluted with normal saline to make a volume of 1 ml) (study group)

The study drug was prepared by an anesthetist who is not involved in the study. Being a double-blinded study, the anesthesiologist performing the procedure and the observer collecting the data were blinded to the drug administered. A pre-anesthetic evaluation was done for every patient and the procedure was explained along with visual analog scale (VAS) 0–10 and informed written consent was obtained preoperatively. All the necessary investigations were done.

Patients were shifted to the operation theatre and all the standard monitors such as non-invasive blood pressure, pulse oximeter, and electrocardiography monitors were connected. Baseline parameters such as oxygen saturation (SpO₂), heart rate, and non-invasive blood pressure were recorded. Intravenous line secured limb and intravenous fluid started. All the patients were premedicated with injection midazolam 1 mg intravenously. After placing the patient in the supine position with face turned toward the contralateral shoulder, under aseptic precautions and the ultrasound guidance, using a high-frequency linear probe in optimum short-axis view, brachial plexus is identified, as round or oval hypoechoic structures (a bunch of grapes) lying posterolateral to the subclavian artery. Brachial plexus block was given by the supraclavicular approach. Neural localization was achieved by a nerve stimulator (with a current of 0.5 mA and a frequency of 2 Hz) connected to 22 G, 50 mm insulated short bevel needle (Stimuplex[®] HNSII, B Braun) after local infiltration with lignocaine 2%. The endpoint taken is the hand twitches elicited at the current of 0.5 mA. After negative aspiration, 31 ml of the drug with and without adjuvants was injected. Patients were monitored closely after completion of the local anesthetic injections. The onset, duration of sensory and motor blockade, quality of sensory and motor blockade, and the duration of post-operative analgesia were noted. Block is considered to have failed if sensory anesthesia was not achieved within 30 min, general anesthesia is given subsequently to those patients, and those patients are excluded from the study.

Vital parameters such as non-invasive blood pressure, pulse rate, and oxygen saturation were observed every 5 min for the first 30 min and thereafter every 15 min until the completion of surgery. The duration of surgery was noted. The time of injection was considered as 0 min. In the two groups, the following parameters were noted.

The Onset and Duration of Sensory and Motor Blockade

Onset of sensory block was taken as the time from injection of a local anesthetic to time of loss of pain on pinprick duration of sensory blockade was the time from the onset of loss of pain on pinprick to the reappearance of pain to pinprick and was checked every 3 min until the onset of loss of sensation after injection and thereafter every 30 min until the regain of sensation. The onset of motor block was taken as the time from injection of a local anesthetic to time of complete loss of movement duration of motor blockade was the time from the onset of paresis to the reappearance of motor movements and was checked every 3 min until the loss of movements and thereafter every 30 min until the regain of movements.

Sensory block was assessed by (pinprick)	Motor block was graded by (limb movement)
Grade	Grade
0 - No pain	5 - Normal movement of upper limb
1 - Mild pain-grimace	4 - Movement against resistance
2 - Moderate pain-withdrawal, and	3 - Movement against gravity
3 - Severe pain-screams.	2 - Movement along with gravity but not against resistance
	1 - Flickering movement and
	0 - No movement

The quality of sensory and motor block and the consumption of supplements after the block was graded as (1) complete sensory and motor blockade where supplements were not used, (2) partial sensory and motor blockade with some sparing that required supplemental drugs like opioids to continue surgery, and (3) total failure of sensory or motor blockade wherein surgery was done under general anesthesia.

Quality of Sensory Blockade

- Grade 0 – no analgesia
- Grade 1 – analgesia with dermatomal sparing
- Grade 2 – complete analgesia.

Quality of Motor Blockade

- Grade 0 – no movement
- Grade 1 – flickering movement of upper limbs
- Grade 2 – movement along with gravity, but not against resistance
- Grade 3 – movement against gravity.

Grades 3, 2, 1 were partial blocks, Grade 0 – no movement, i.e., complete motor paralysis.

Duration of Analgesia

The time between the brachial block and the first request for rescue analgesia is considered as duration of Analgesia. The duration of analgesia was noted according to 0–10 VAS for pain which was assessed every 1 h after shifting the patient to the post-operative ward. Rescue analgesia was given in the form of injection diclofenac sodium (1.5 mg/kg) intramuscularly when VAS >4. Patients were watched for bradycardia, convulsions, restlessness, disorientation, drowsiness, nausea, vomiting, and any other complications.

The sample size was calculated based on the primary outcome taken as the mean duration of analgesia with a mean difference of 4 h between the groups (observed from prior pilot observations) to detect a clinically significant variation of >25% between the groups using 5% alpha error (two-sided) and power of study being 80%; the sample size was calculated to be 37 per group (using power analysis and sample size software.com). Hence, 40 subjects were recruited in each group to compensate for dropouts.

Statistical Analysis

The collected data were subjected to statistical analysis using GraphPad.com software. Data were communicated as mean, standard deviation, and/or ratio or absolute numbers (%) and compared using Student’s *t*-test, Fisher’s exact test, and Chi-square test. *P* < 0.05 was considered statistically significant.

RESULTS

The present study includes 80, adult consented patients aged between 20 and 60 years, allocated into two groups of 40 each. Group I/non-KCL group received 30 ml of 0.5 % ropivacaine along with 1 ml normal saline (control group). Group II/KCL group received 30 ml of 0.5% ropivacaine along with 0.2 mmol (0.1 ml) of potassium chloride (prepared by adding 0.1 ml of potassium chloride diluted with normal saline to make a volume of 1 ml) (study

Table 1: Demographic data of the patients

Parameters	Group I	Group II	P value
	Mean±Std. deviation n=40	Mean±Std. deviation n=40	
Age in years	34.79±11.30	36.06±10.41	0.602
Weight in kg	64.71±8.48	66.15±7.97	0.436
Gender (%)			
Male	33	35	0.755*
Female	7	5	
ASA I/II	28/12	31/09	0.612*
Duration of surgery (min)	108.42±19.56	112.04±22.35	0.443

Data expressed as mean (SD) or ratio or absolute numbers, Student’s *t*-test, *Chi-square test/Fisher’s exact test

group) scheduled for elective upper limb surgeries under the supraclavicular approach of brachial plexus block. All the patients completed the study successfully.

Demographic data in terms of age, gender, body weight, ASA physical status, and duration of surgery were comparable between the two groups with no statistically significant difference between the two groups [Table 1].

The mean onset time of sensory and motor blockade was earlier in Group II/ KCL group which was 9.72 ± 2.07 min and 16.85 ± 5.91 , respectively, when compared to Group I/ non-KCL group having a mean onset time of 12.04 ± 3.92 min and 21.47 ± 6.48 which was statistically significant with a $P < 0.05$ [Table 2] [Figure 1].

The mean duration of sensory and motor blockade in Group II/ KCL group was significantly prolonged with a mean duration of 469.17 ± 28.07 min, and 421.57 ± 20.07 min, respectively, when compared to Group I/non-KCL group having a sensory duration of 216.52 ± 17.13 min and motor duration of 228.40 ± 18.61 min which was statistically highly significant with a $P < 0.001$ [Table 2] [Figure 2].

The quality of sensory and motor block was higher in Group II/KCL than Group I/non-KCL group with a statistically significant, $P < 0.05$ [Table 3, Figures 3 and 4].

The number of supplements used in Group II/KCL was less when compared to Group I/non-KCL group. Supplements were used by 04 (10%) patients in Group II, whereas 14 (35%) members used supplements in Group I/non-KCL group [Table 4].

The mean duration of analgesia was prolonged in Group II/KCL group (517.04 ± 28.80 min) when compared to Group I/non-KCL group (246.92 ± 19.14 min) which was considered as statistically highly significant with a $P < 0.001$ [Table 5 and Figure 5]. Throughout the study, no side effects were observed.

DISCUSSION

Brachial plexus blockade provides the ideal operating conditions for the surgeon with good analgesia and complete muscular relaxation and sympathetic block which reduces post-operative vasospasm, pain, and edema. There are continuous efforts to prolong the duration of the Brachial plexus blockade beyond the duration of local anesthetics. Different local anesthetics alone or in combination with numerous adjuvants have been tried for a long time to prolong the duration of post-operative analgesia. Bupivacaine is a widely used regional anesthetic,^[15] which, like all amide anesthetics, is well known

Table 2: Comparison of outcome parameters

Parameters	Group I	Group II	P value
	Mean±Std. deviation	Mean±Std. deviation	
	n=40	n=40	
The onset of sensory blockade (minutes)	12.04±3.92	9.72±2.07	P=0.001
The onset of motor blockade (minutes)	21.47±6.48	16.85±5.91	P=0.001
Duration sensory blockade (minutes)	216.52±17.13	469.17±28.07	P=0.0001**
Duration motor blockade (minutes)	228.40±18.61	421.57±20.07	P=0.0001**

Data expressed as mean (SD) or ratio or absolute numbers, Student's t-test, **Highly significant, P<0.001 significant

Table 3: Quality of sensory and motor blockade

Parameters	Group I	Group II	P value
	Mean±Std. deviation	Mean±Std. deviation	
	n=40	n=40	
Sensory blockade	1.871±0.338	2.00±0.00	P=0.018
Motor blockade	0.55±0.845	0.225±0.588	P=0.04

Data expressed as mean (SD) or ratio or absolute numbers, Student's t-test, P<0.05 significant

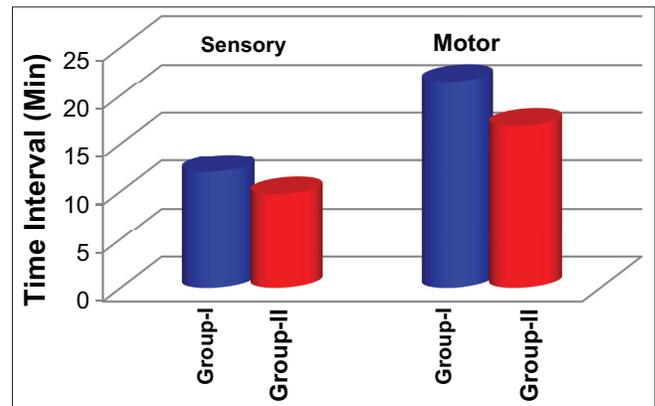


Figure 1: Onset of sensory and motor block

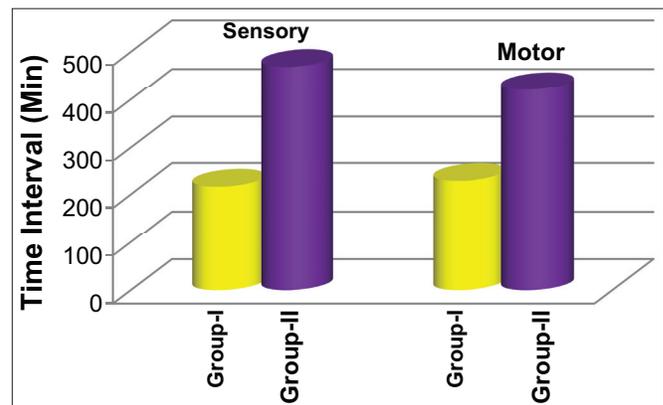


Figure 2: Duration of sensory and motor block

Table 4: Supplement used

Parameters	Group I	Group II
	Mean±Std. deviation	Mean±Std. deviation
	n=40 (%)	n=40 (%)
Not used	26 (65)	36 (90)
Used	14 (35)	4 (10)

Data expressed as a ratio or absolute numbers

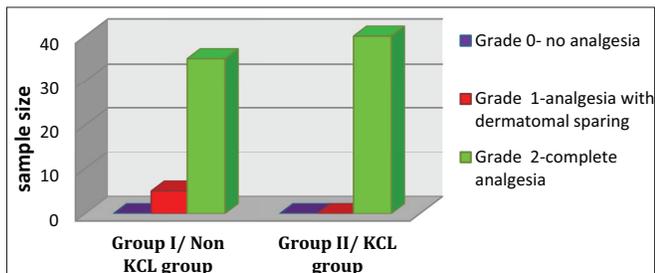


Figure 3: Quality of sensory block

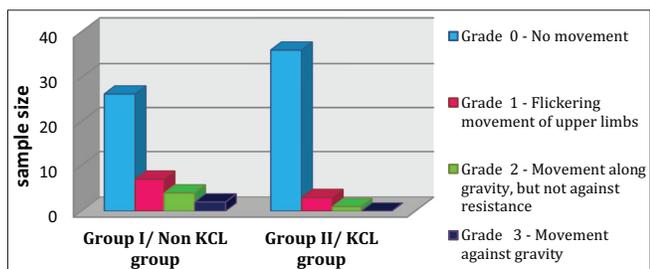


Figure 4: Quality of motor block

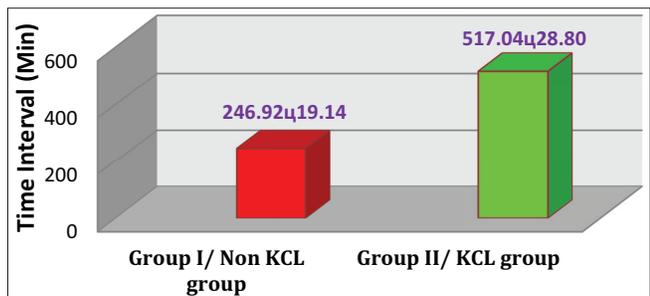


Figure 5: Mean duration of analgesia

for its cardiotoxicity when used in high concentration or with accidental intravascular administration. Ropivacaine, a local amide anesthetic is a first single enantiomer specific compound with reduced cardiotoxicity and neurotoxicity with a rapid recovery of motor function.

Potassium salt, as an adjuvant to local anesthetic, has been gaining popularity recently. Movement of ions through the nerve membrane is considered as one of the main steps in the process of excitation and propagation of nerve stimuli. A nerve impulse can be effectively blocked by the accumulation of ions outside the neuron. Thus, the administration of exogenous potassium chloride will

reinforce and prolong the blockade produced by ropivacaine. It is widely believed that potassium chloride improves the quality and duration of peripheral nerve block over local anesthetic when used alone. It also improves the quality of recovery after surgery by providing an extended period of analgesia when compared with local anesthetic alone.

Ropivacaine is a long-acting local anesthetic structurally related to bupivacaine with all the assets of bupivacaine and without cardiotoxicity.^[16] Hence, ropivacaine has been selected as the regional anesthetic of choice in our study for its improved quality of block and reduced potential toxicity wide margin of safety.^[17]

Yasuda *et al.*^[18] used a nerve stimulator and an insulated needle for supraclavicular brachial plexus block with a success rate of 98% of patients. For a similar reason, we used peripheral nerve stimulators through a supraclavicular approach to brachial plexus block in our study.

In our study, the mean onset time of sensory and motor blockade was earlier in Group II/KCL group when compared to Group I/non-KCL group with a statistically highly significant, $P < 0.001$. Our findings are inconsistent with the findings of Shivani *et al.*,^[19] except that they used 0.375% bupivacaine instead of ropivacaine in their study.

Shobana and Chandrasekaran^[7] study showed the addition of potassium chloride as an adjuvant to bupivacaine shortens the onset time of sensory block significantly. The result of our study is similar to their study which showed the addition of potassium chloride as an adjuvant to local anesthetic ropivacaine hastens the onset time of sensory block significantly.

Kumar *et al.*,^[20] in his comparative study between bupivacaine and bupivacaine plus potassium chloride for brachial plexus block, demonstrated that 0.2 mmol of potassium chloride used as adjuvant prolonged the mean duration of sensory and motor blockade significantly. Our study also the mean duration of sensory and motor blockade was increased with 0.2 mmol of potassium chloride used as an adjuvant.

The quality of sensory and motor blockade was significantly improved in the potassium chloride group in our study. Shreedhar *et al.*^[21] in their study on the effect of potassium chloride as a local anesthetic adjuvant for supraclavicular brachial plexus block for upper limb surgeries also proclaimed the addition of potassium chloride as an adjuvant improves operating quality.

The mean duration of analgesia was significantly prolonged in our study by the addition of 0.2 mmol of potassium

Table 5: Comparison of outcome parameters

Parameters	Group I	Group II	P value
	Mean±Std. deviation	Mean±Std. deviation	
	n=50	n=50	
Postoperative analgesia (minutes)	246.92±19.14	517.04±28.80	P=0.0001**

Data expressed as mean (SD) or ratio or absolute numbers, Student's t-test, **Highly significant, P<0.001 significant

chloride to the local anesthetic. Our result is similar to the study of Solanki *et al.*,^[22] wherein the duration of post-operative analgesia is significantly prolonged by the addition of 0.2 mmol of potassium chloride.

CONCLUSION

In our study, it concludes that the addition of potassium chloride to ropivacaine quickened the onset time, prolonged the duration, and enhanced the quality of sensory and motor block compared to plain ropivacaine in supraclavicular brachial plexus block for upper limb surgeries.

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