

Efficacy of Magnesium Sulfate as Adjuvant to Ropivacaine 0.4% for Supraclavicular Brachial Plexus Block in Patients undergoing Upper Limb Surgery: A Randomized Controlled Trial

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ABSTRACT

Objectives: To prolong the duration of brachial plexus block, different adjuvants have been used. We evaluated the effect of adding magnesium sulfate to local anesthetic ropivacaine 0.4% for institution of supraclavicular brachia plexus block. Onset of sensory and motor block, duration of motor block, and rescue analgesia were observed.

Materials and methods: Total 120 patients (20–50 years) scheduled for elective surgeries of upper limb under supraclavicular brachial plexus block were randomized into two groups. Group I received 24 mL 0.5% ropivacaine (120 mg) + 6.0 mL normal saline (NS) to make total volume of 30 mL. Group II received 24 mL 0.5% ropivacaine (120 mg) + 150 mg magnesium sulfate + 5.5 mL NS to make total volume of 30 mL.

Results: Onset of sensory block in group I was 16.63 ± 2.79 min and in group II was 17.33 ± 2.25 min (statistically not significant, $p > 0.05$). Onset of motor block in group I was 18.63 ± 2.79 min and in group II was 19.76 ± 2.18 min (statistically significant, $p < 0.05$). The duration of motor block was significantly longer in group II; 322.00 ± 81.35 min than group I; 260.25 ± 66.79 min ($p < 0.05$). Similarly, time of rescue analgesia was significantly prolonged in group II; 491 ± 100.22 min than group I; 377.67 ± 73.31 min ($p < 0.05$).

Conclusion: From our study, we concluded that the addition of 150 mg magnesium sulfate as adjuvant to 30 mL of 0.4% ropivacaine in comparison to 30 mL of 0.4% ropivacaine provides longer duration of analgesia. Although the onset of sensory block is not affected, onset of motor block is delayed. Motor block lasts for longer duration.

Keywords: Magnesium, Ropivacaine, Supraclavicular block.

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INTRODUCTION

Effective management of postoperative pain relieves suffering and leads to earlier mobilization, fewer pulmonary and cardiac complications, a reduced risk of deep vein thrombosis, faster recovery with less likelihood of the development of neuropathic pain, reduced cost of care, and increased patient satisfaction.¹ In modern anesthesia practice, peripheral nerve block has a significant contributory role to avail these benefits. Upper limb surgeries are mostly performed under the brachial plexus block. Peripheral nerve blocks not only provide intraoperative anesthesia but also extended analgesia into the postoperative period without any systemic adverse effects using minimal anesthetic drugs.² The supraclavicular brachial plexus block is commonly used as the plexus is most compactly arranged here.

Ropivacaine in comparison to other aminoamides like bupivacaine is less cardiotoxic and less neurotoxic.³ As compared with bupivacaine, ropivacaine produces less intense motor block, and of shorter duration, permitting earlier mobilization and discharge.

Local anesthetics have a limited duration of action. For denser blocks, faster onset, and prolonging the duration of analgesia, various adjuvants have been added to local anesthetic solution while minimizing systemic adverse effects along with a reduction in total dose of local anesthetic used.

Magnesium is a naturally present cation in the body; it is the second most plentiful intracellular cation after potassium. It is necessary for the presynaptic release of acetylcholine from nerve endings and may produce effects similar to calcium entry blocking drugs.⁴ Magnesium exerts antinociceptive effects by regulation of calcium influx into the cell and antagonism of the N-methyl-D-aspartate receptors.⁵ Many clinical investigations have demonstrated that magnesium administration during general anesthesia has reduced anesthetic requirement and postoperative analgesic consumption.^{6,7} Magnesium has long been used for its antihypertensive, anesthetic sparing effects and its property to enhance the effects of analgesics.^{8,9} Magnesium, after administration through epidural route, decreased postoperative opioid

consumption.⁶ Magnesium as adjuvant enhances the analgesic properties of established analgesics; it needs to be evaluated further when used as an adjuvant in perineural injection with local anesthetic in supraclavicular block.

The present study was conceived to examine the effect of adding magnesium sulfate as an adjuvant to local anesthetic ropivacaine 0.4% for institution of supraclavicular brachial plexus block.

MATERIALS AND METHODS

Study Design

Hospital-based randomized comparative interventional study.

Sample Size

The sample size was calculated to be 56 subjects in each of the two groups at α error 0.05 and power of study 80%, assuming detectable difference in mean of time for request of first analgesic to be 81.92 min with standard deviation (SD) of 152.57 (as per seed article).^{6,8} Hence, for study purpose, 124 patients were recruited (62 patients in each group) including 10% attrition/dropouts/loss to follow-up.

The study was conducted in a tertiary care hospital after obtaining due permission from the institutional ethical committee. A total of 124 patients of either sex, aged between 20 and 50 years, American Society of Anesthesiologists (ASA) physical status I and II, weighing 50 to 70 kg undergoing elective upper limb surgeries of duration 1 to 4 hours were included in the study. Patients not willing to participate, uncooperative patients, pregnant patients, patients with diabetes mellitus and hypertension, and patients with inadequate block necessitating institution of general anesthesia, history of convulsion, allergy to the drug used, bleeding disorder, and severe neurological deficit were excluded from the study.

Informed written consent was obtained after explaining complete study protocol and the procedure. They were made to understand that they would feel paresthesia and should report it, to alleviate their anxiety. They were reassured that the paresthesia will be transient.

The patients were randomly allocated into one of the two groups by chit in box method (62 A chits and 62 B chits, kept in a box). By shuffling, the patient was asked to pick a chit; according to the group mentioned on the chit, the patient was assigned to either group.

Group I (n = 62) received 24 mL 0.5% ropivacaine (120 mg) + 6.0 mL normal saline (NS) to make total volume 30 mL.

Group II (n = 62) received 24 mL 0.5% ropivacaine (120 mg) + 150 mg magnesium sulfate + 5.5 mL NS to make total volume 30 mL.

On arrival in the operation theater fasting status, consent, and Pre anaesthetic checkup were checked and baseline heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure (MAP), and oxygen saturation of blood (SpO₂) were recorded using a multipara monitor of spacelabs®. An IV access was secured in the nonoperative upper limb in all the patients, and infusion of Ringer's lactate was started as per the standard calculation of perioperative fluid replacement therapy.

The patient was placed in supine position with a rolled sheet in the interscapular area. The head was turned to the opposite side and the ipsilateral arm by the side of the body. Under all aseptic precautions needle was inserted almost perpendicularly to the skin with a slight backward, inward, and downward direction just posterolateral to the point where pulsations of the subclavian artery were felt maximally. Once the desired paresthesia was obtained, local anesthetic was injected using 10 mL syringe. Injecting in the proximity of the lower trunk (paresthesia over fingers) was the most important factor in accomplishing a successful supraclavicular brachial plexus block.

After performance of nerve block, patients were evaluated for onset of sensory and motor block every 2 min after completion of injection till 30 min. The sensory block was assessed by pinprick sensations with blunt 25 gauge needle, and was defined as the loss of pain to pinprick in the dermatomes innervated by the brachial plexus (C5–T1). Motor blockade was checked by modified Bromage scale. The HR, noninvasive blood pressure, and SpO₂ were measured every 10 min intraoperatively. Postoperatively, HR, noninvasive blood pressure, and motor power were recorded at 0 min, 30 min, 1, 3, 6, 12, 18, and 24 hours. The visual analog scale (VAS) score was measured at 0 min, 30 min, 1, 3, 6, 12, 18, and 24 hours.

Rescue analgesic (Inj. Diclofenac 75 mg intramuscularly) was administered at VAS score ≥ 4 and the time was noted.

All the patients were observed for any side effects like nausea, vomiting, dryness of mouth, and complications like pneumothorax, hematoma, local anesthetic systemic toxicity, and postblock neuropathy in the intra- and 24 hours postoperative periods.

Analysis of Data

Categorical data, i.e., ASA physical status and the incidence of adverse events, were presented as proportions. These data were compared in two groups and the difference in the proportion was inferred by Pearson's Chi-square test. Demographic data (age, weight), duration of

surgery, VAS score, total duration of motor block, and analgesia were expressed as mean ± SD. These data were compared in two groups and differences in means were inferred by unpaired t-test. For significance, p < 0.05 was considered as significant for both types of data.

Sensory block¹⁰ was graded as

- Grade 0: Sharp pain
- Grade I: Touch sensation only
- Grade II: Not even touch sensation

Motor block

Motor block was assessed by modified Bromage scale¹⁰ for upper extremities:

- 0 – No block: Total arm and forearm flexion
- 1 – Partial block: Total forearm and partial arm flexion
- 2 – Almost complete block: Inability to flex the arm and decreased ability to flex the forearm
- 3 – Total block: Inability to flex both the arm and forearm

Visual Analog Score¹¹

- Score 0: No pain at all
- Score 1, 2, 3: Mild pain
- Score 4, 5, 6: Moderate pain
- Score 7, 8, 9: Severe pain
- Score 10: Worst pain imaginable

DEFINITIONS

- *Onset of sensory block:* The time duration from completion of local anesthetic injection till disappearance of sharp pain by pinprick test on skin dermatome C5–T1.
- *Onset of motor block:* The time duration from completion of local anesthetic injection till motor paralysis equivalent to modified Bromage score 2/3.

- *Duration of motor block:* The time between onset of motor block to complete return of motor power (Bromage 2/3 → 0).
- *Pain:* will be assessed using VAS, where 0 represents no pain and 10 means the worst possible pain.
- *Duration of analgesia:* The time between onset of analgesia and the first request for analgesic.

RESULTS AND OBSERVATIONS

In our study, we recruited 62 patients per group. Two patients in each group were excluded from the study because of inadequate block. So the final analysis includes 60 patients in each group and following observations were made.

The observations are presented as mean ± SD or as numbers as is applicable

Table 1 shows demographic variables and baseline characteristics were comparable between the groups and no statistically significant differences were observed (p > 0.05).

Table 2 shows baseline parameters were comparable between the groups and no statistically significant difference was observed (p > 0.05).

Table 3 shows that there was no statistically significant difference between the groups (p > 0.05) regarding onset of sensory block, while onset of motor block was delayed in group II and statistically significant difference was found between the groups (p < 0.05). Duration of motor block and duration of rescue analgesia were prolonged in group II, and the difference was statistically significant (p < 0.05).

Graph 1 shows comparison of mean VAS score between the groups, which were significant at 6 and 12 hours (p < 0.0001).

DISCUSSION

Supraclavicular approach to the brachial plexus is popularly used for upper limb surgeries. The plexus is

Table 1: Demographic variables and baseline characteristics

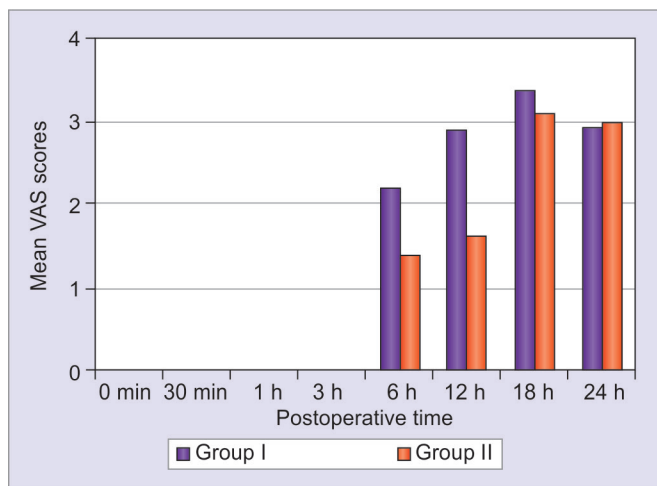
Parameters	Group I (n = 60)	Group II (n = 60)	p-value
Age (years)	32.10 ± 10.9	29.6 ± 10.21	0.205
Weight (kg)	57.78 ± 8.51	58.48 ± 7.20	0.627
Male/female	48/12	52/08	0.331
ASA – I/II	49/11	53/07	0.310
Duration of surgery (min)	80.75 ± 16.00	79.97 ± 16.86	0.794

Table 2: Baseline clinical variables

Variables	Group I (mean ± SD)	Group II (mean ± SD)	p-value
Heart rate	72.73 ± 6.66	72.72 ± 6.20	0.988
SBP	119.37 ± 8.20	118.53 ± 7.17	0.554
DBP	79.00 ± 5.32	78.03 ± 5.47	0.328
MAP	92.46 ± 5.65	91.53 ± 5.18	0.353
SpO ₂	99.47 ± 0.50	99.55 ± 0.57	0.395

Table 3: Onset of sensory and motor block, duration of motor block, and duration of analgesia

Parameters	Group I (mean ± SD)	Group II (mean ± SD)	p-value
Onset of sensory block (min)	16.63 ± 2.79	17.33 ± 2.25	>0.05
Onset of motor block (min)	18.63 ± 2.79	19.76 ± 2.18	<0.05
Duration of motor block (min)	260.25 ± 66.79	322 ± 81.35	<0.05
Duration of rescue analgesia (min)	377.67 ± 73.31	491 ± 100.22	<0.05



Graph 1: Mean VAS scores at various time intervals

compactly arranged here, thus providing more complete and consistent block. To prolong the duration of analgesia in order to avail maximum benefit of single shot blocks, various adjuvants have been added to local anesthetics. Magnesium sulfate is a promising adjuvant administered perineurally.

The demographic profile and duration of surgery were comparable between the groups.

In our study, onset of sensory block was earlier in group I (16.63 ± 2.79 min) than group II (17.33 ± 2.25 min), which was statistically not significant ($p > 0.05$).

Our findings were similar with the study of Rao et al¹² who investigated the effect of adding magnesium sulfate to 0.5% bupivacaine to extend the duration of sensory and motor blocks of the supraclavicular brachial plexus. Similar results were found by Haghighi et al¹³ and Mukherjee et al.¹⁴ Our findings were different from the results of the study conducted by Hamed et al¹⁵ who compared the effect of adding dexamethasone and magnesium sulfate to bupivacaine in ultrasound-guided supraclavicular brachial plexus block. They noted that sensory block onset was earlier (12.70 ± 2.92 min) in magnesium sulfate group than control group (16 ± 3.48 min). Their results differed from ours probably because they used 200 mg magnesium sulfate, which was statistically significant ($p < 0.05$).

In our study, we observed that onset of motor block was earlier in group I (18.63 ± 2.79 min) than in group II (19.76 ± 2.18 min), which was statistically significant between the groups ($p < 0.05$). This observation was similar with the study conducted by Mukherjee et al¹⁴ and Haghighi et al.¹³ Our observations are not similar with Li et al.¹⁶ In their meta-analysis of efficacy and safety of magnesium sulfate as an adjuvant to local anesthetics perineurally in nerve blocks, onset of motor block was faster in magnesium sulfate group.

In our study, duration of motor block was more in group II (322.00 ± 81.35 min) than in group I (260.25 ± 66.79 min), which was statistically significant between the groups ($p < 0.05$). Similar findings were found by Li et al¹⁶ (meta-analysis), Hamed et al,¹⁵ Rao et al,¹² Haghighi et al,¹³ and Mukherjee et al.¹⁴

In our study, we observed that duration of analgesia was more in group II (377.67 ± 73.31 min) than in group I (491 ± 100.22 min), which was statistically significant between the groups ($p < 0.05$).

Similar findings were made by Li et al¹⁶ in their meta-analysis; Hamed et al¹⁵ where duration of analgesia was significantly longer in magnesium sulfate group (558.00 ± 48.08 min) than control group (313.50 ± 103.68 min), which was statistically significant ($p < 0.05$); Reddy et al (855.8 ± 73.66 min; magnesium sulfate group) vs (676 ± 89.55 min; control group), which was statistically highly significant ($p < 0.0001$).

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