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Evaluation of varying doses of magnesium as an adjuvant to ropivacaine in supraclavicular brachial plexus block

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ABSTRACT

Background: Peripheral nerve blockade is a crucial component of comprehensive anesthetic care, providing effective analgesia with fewer side effects than opioids and other oral analgesics. **Aims and Objectives:** This study investigated the effectiveness of a magnesium adjuvant in an ultrasound-guided supraclavicular brachial plexus block to determine the minimum dose required for the desired effects. **Materials and Methods:** This prospective, double-blind, and randomized controlled study included 90 patients scheduled for elective upper limb orthosurgery at GTMCH. The 90 patients were divided into three groups: A, B, and C. Each group received 21.5 mL of the test drug, with A receiving ropivacaine and normal saline, B receiving ropivacaine and magnesium, and C receiving ropivacaine and magnesium. **Results:** There was a significant difference in Group A between the onset of sensory and motor blockade in Groups B and C. There was a significant difference in Group A between the duration of sensory and motor blockade in Groups B and C, but no significant difference was observed between Groups B and C. The visual analog scale score varied from 0 to 6 in Group A and from 0 to 5 in Groups B and C. It was found to be significant only from the 7th to 10th h. There was a significant difference in Group A between Groups B and C in 1st rescue analgesia post-operatively and the number of rescue injections in the first 24 h, but no significant differences was observed between Groups B and C. **Conclusion:** Both 100 and 150 mg magnesium sulfate with 0.5% ropivacaine in supraclavicular blocks prolonged the blockade duration and reduced analgesic needs.

Key words: Magnesium adjuvant; Ultrasound-guided; Supraclavicular brachial plexus block; Peripheral nerve blockade; Ropivacaine; Rescue analgesic

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INTRODUCTION

Peripheral nerve blockade is a crucial component of comprehensive anesthetic care because of its advantages over central neuraxial blockade and general anesthesia. It offers more effective analgesia with fewer side effects than opioids and other oral analgesics and can be used in all age groups. Its role has expanded from the operating room to post-operative and chronic pain management. Peripheral nerve blockade blocks sympathetic nerves in the anesthetized limb, leading to vasodilation, improving blood flow, and facilitating microvascular surgery. This allows for extensive surgical exploration and repair, unlike locally injected local anesthetic drugs, which numb only superficial structures close to the injection site. Blockade of the brachial plexus provides superior pain control and excellent intraoperative and post-operative analgesia, eliminating the need for intraoperative opioids and minimizing post-operative opioid use. This results in quicker recovery, shortened hospital stays, increased patient and surgeon satisfaction, and a decrease in the financial burden for patients compared to general anesthesia.

Peripheral nerve blockade of the upper limb includes various methods of brachial plexus block, where the

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brachial plexus is blocked at different levels, including interscalene, supraclavicular, infraclavicular, and axillary blocks. Supraclavicular block, once described as the "spinal of the arm", offers dense anesthesia of the brachial plexus for surgical procedures at or distal to the elbow.[1] At this point, the brachial plexus is compact, and a small volume of solution produces a rapid onset of reliable blockade of the brachial plexus.[2] Historically, the supraclavicular block fell out of favor due to the high incidence of complications (pneumothorax, accidental intravascular injection) that occurred with paraesthesia and nerve stimulator techniques. It has seen a resurgence in recent years as the use of ultrasound guidance has improved safety. Ropivacaine is a long-acting regional anesthetic that is structurally related to bupivacaine. It was developed to reduce systemic toxicity and improve relative sensory-motor block profiles.

Local anesthetics alone for supraclavicular brachial plexus block provide good operative conditions but have a shorter duration of post-operative analgesia.[3] Local anesthetic adjuvants have been studied previously in an attempt to prolong the duration of analgesia after peripheral nerve blockade. Hence, various adjuvants such as opioids, clonidine, neostigmine, dexamethasone, and midazolam have been added to local anesthetics in brachial plexus block to achieve quick, dense, and prolonged block, but the results are either inconclusive or associated with side effects. Magnesium has been used in the intravenous, intrathecal, and epidural/caudal routes to improve analgesia. There is limited literature on its role in peripheral nerve blocks, and the available literature has shown mixed results. Hence, this study was designed to evaluate the efficacy of magnesium when added to ropivacaine in supraclavicular brachial plexus blocks.

Aim

To assess the impact of adding varying doses of magnesium to ropivacaine in supraclavicular brachial plexus block.

Objectives

Primary: Evaluate onset and duration of sensory and motor blockade, duration of postoperative analgesia.
Secondary: Assess rescue analgesic use, pain intensity (VAS scores), and monitor side effects.

MATERIALS AND METHODS

This prospective, double-blind, randomized controlled study was conducted on 90 patients scheduled for elective upper limb orthosurgery at GTMCH. Written informed consent was obtained from all study participants after obtaining permission from our institutional ethics committee.

Inclusion criteria

Both sexes, aged 18–60 years, belonging to American Society of **A**nesthesiologists (ASA) I and II, who were scheduled for elective upper limb surgeries in GTMCH (surgeries of the distal humerus, elbow, forearm, and hand), were included in the study.

Exclusion criteria

Patients who refused to participate, pregnant and lactating mothers, ASA III and IV, known allergy or contraindication to local anesthetic, patients with peripheral neuropathy and pre-existing neurological defects in the upper limbs, known cases of seizure disorder, patients with coagulopathies and patients on chronic anticoagulation therapy, patients with psychiatric illnesses, and local skin infections were excluded from the study.

Ninety patients were randomly divided into three groups: A, B, and C. Group A (30 patients): ropivacaine and normal saline + 20 mL of 0.5% ropivacaine plus 1.5 mL of NS. Group B (30 patients): ropivacaine and magnesium (100 mg) + 20 mL 0.5% ropivacaine plus 100 mg $MgSO_4$ (diluted in 1.5 mL NS). Group C (30 patients): ropivacaine and magnesium (150 mg) + 20 mL 0.5% ropivacaine plus 150 mg $MgSO_4$ (diluted in 1.5 mL NS). All three groups of patients received a total of 21.5 mL of the test drug.

The visual analog scale (VAS) score (0, no pain, and 10, worst pain imaginable) was also explained during the pre-operative visit. Patients were kept on nil per oral for 8 h before surgery. Patients were pre-medicated with intravenous ranitidine 50 mg and intramuscular metoclopramide 10 mg 45 min before surgery. An intravenous line was secured on the limb opposite the surgery. An intravenous infusion of Ringer's lactate was started, and oxygen was administered at 4 L/min via a face mask. All patients received injection midazolam 0.03 mg/kg IV before the procedure. Blocks were performed under standard monitoring with pulse oximetry, non-invasive blood pressure measurement, and electrocardiography.

An 18-gauge Venflon needle was used using the in-plane technique. After careful aspiration of non-appearing blood, the drug was injected into each group. Local anesthetic spread was observed around the plexus. Surgery was started after confirming the adequacy of sensory and motor blockade. Sensory and motor blockades were assessed every 3 min after the completion of the injection until the start of surgery and then every 1 h after the end of surgery until the first 12 h, or until the block had completely worn off, whichever was earlier.

After the surgery was completed, 100 mg of tramadol hydrochloride (rescue analgesia) was administered

intramuscularly when the VAS score was ≥3. The number of tramadol injections administered to each patient during the first 24 h of the post-operative period was recorded (a maximum of two IM injections were administered in 24 h). The onset of sensory block was assessed, which is the time from the removal of the block needle to the time when the patient says he or she has reduced sensation when compared to the opposite limb was taken as the time of onset of sensory block. The sensory block was assessed and confirmed by a pinprick every 3 min until the onset of sensory block.

The onset of motor block was assessed from the time of removal of block needle to the time when the patient had weakness of any of the three joints, that is, shoulder, elbow, or wrist, on trying to perform active movements was taken as the time of onset of motor block. The motor block was assessed every 3 min. The duration of the sensory block was assessed, as the time interval between the onset of the sensory block and the first post-operative pain. The duration of the motor block was assessed which is the time interval between the onset of the motor block and the complete recovery of motor functions.

Statistical analysis

The information collected regarding all selected cases was recorded in a master chart. Data analysis was done with the help of a computer using SPSS 16 software. Using this software, "P" values were calculated using the student's t-test for a two-group comparison, a one-way analysis of variance test for three groups, and a Chi-square test for consolidated data to test the significance of differences between variables. A "P"<0.05 is taken to denote a significant relationship.

RESULTS

The age distribution in Group A varied from 19 to 60 years, with a mean age of 37.2±13.553. Group B varied from 18 to 60 years, with a mean age of 33.3±11.189. Group C varied from 20 to 60 years, with a mean age of 32.8±10.029. The age, sex, weight, and ASA physical status distribution in all groups were comparable and statistically insignificant (P>0.05) (Table 1).

The mean time of onset of sensory blockade was 10.7±2.693 min in Group A, 13.6±3.41 min in Group B, and 14.9±3.977 min in Group C. There was a significant difference in Group A between the onset of sensory blockade in Groups B and C (P<0.001, P<0.001), but no significant difference was observed between Groups B and C (P=0.242).

The mean time of onset of motor blockade was 14.767±3.401 min in Group A, 18.1±3.478 min in Group B, and 19.4±4.709 min in Group C. There was a significant difference in Group A between the onset of motor blockade in Groups B and C (P<0.001, P<0.001), but no significant difference was observed between Groups B and C (P=0.252).

The mean duration of sensory blockade was 442±74.713 min in Group A, 566±64.359 min in Group B, and 592±84.462 min in Group C. There was a significant difference in the duration of sensory blockade in Group A between Groups B and C (P<0.001, P<0.001), but no significant difference was observed between Groups B and C (P=0.185).

The mean duration of the motor blockade was 352±76.762 min in Group A, 466±81.393 min in Group B, and 496±83.278 min in Group C. There was a significant difference in the duration of motor blockade in Group A between Groups B and C (P<0.001, P<0.001), but no significant difference was observed in Group B between Groups C (P=0.164) (Table 2).

The VAS score was obtained hourly for the first 12 h post-operatively. The VAS score varied from 0 to 6 in Group A and from 0 to 5 in Groups B and C. It was found to be significant only from the 7th to 10th h (Figure 1).

The mean time to first rescue analgesic administration was 474.6±78.3 min in Group A, 599.4±63.1 min in Group B, and 613.2±80.7 min in Group C. There was a significant difference in Group A between Groups B and C of first rescue analgesia post-operatively (P<0.001, P<0.001), but no significant difference was observed between Groups B and C (P=0.464).

The mean number of rescue analgesic injections administered in the first 24 h in Group A was 1.67±0.479, in Group B, it was 1.33±0.479 injections, and in Group C it was 1.3±0.466 injections. There was a significant difference in Group A between Groups B and C in the number of rescue injections in the first 24 h (P=0.008 and P=0.004, respectively), but no significant difference was observed between Groups B and C (P=0.807).

One patient in Group B experienced nausea, which was managed conservatively with intravenous fluids. One patient in Group C experienced vomiting, which was managed with intravenous fluids and IM metoclopramide (10 mg). None of the patients developed hypotension (Table 3).

DISCUSSION

In our study, the demographic profile of all the patients was statistically insignificant between the three groups,

Table 1: Demographic data of the three groups

Patients characteristics	Group A	Group B	Group C	P-value
Age				
<25	7	4	5	0.284
25–50	18	23	23	
>50	5	3	2	
Mean±SD	37.2±13.553	33.3±11.189	32.8±10.029	
Sex				
Male	22	19	21	0.696
Female	8	11	9	
Weight (kg)				
<55	11	12	11	0.916
55–65	12	10	14	
>65	7	8	5	
Mean±SD	58.067±7.114	58.933±9.157	58.433±7.704	
ASA risk				
I	17	16	22	0.235
II	13	14	8	

SD: Standard deviation, ASA: American society of anesthesiologists

Table 2: Onset and duration of sensory and motor blockade

Patients characteristics	Group A	Group B	Group C
Onset of sensory blockade (min)			
<10	16	4	6
10–15	10	11	11
>15	4	15	13
Mean±SD	10.7±2.693	13.6±3.41	14.9±3.977
P-value	Group A versus Group B <0.001	Group B versus Group C 0.242	Group A versus Group C <0.001
The onset of motor blockade (min)			
<10	3	1	0
10–15	18	7	9
>15	9	22	21
Mean±SD	14.767±3.401	18.1±3.478	19.4±4.709
P-value	Group A versus Group B <0.001	Group B versus Group C 0.252	Group A versus Group C <0.001
Duration of sensory blockade (min)			
<400	6	1	1
400–500	19	3	1
>500	5	26	28
Mean±SD	442±74.713	566±64.359	592±84.462
P-value	Group A versus Group B <0.001	Group B versus Group C 0.185	Group A versus Group C <0.001
Duration of motor blockade (min)			
<300	5	1	1
300–500	24	21	11
>500	1	8	18
Mean±SD	352±76.762	466±81.393	496±83.278
P-value	Group A versus Group B <0.001	Group B versus Group C 0.164	Group A versus Group C <0.001

SD: Standard deviation

similar to other research investigators, and thus provided us with a uniform platform to compare the results obtained. Ropivacaine was chosen for our study because it had a better sensory-to-motor block profile and lesser cardiotoxicity than bupivacaine. This was following the study done by Hofmann-Kiefer et al., and Raeder et al.[4,5]

In our study, the addition of magnesium to ropivacaine significantly delayed the onset of sensory and motor blockades. This was comparable to the study done by Mukherjee et al., whose time of onset of sensory block was 15.91±1.60 min versus 16.27±3.07 min. The time of onset of the motor block was 17.80±7.6 min, versus 19.2±6.2 min.[3] Gupta et al., whose time of onset of sensory block was 16.63±2.79 min versus 17.33±2.25 min, also had delayed onset, but in both studies, it was not of statistical significance.[6] In our study, there was no significant difference in the onset of sensory and motor blockade

Table 3: First rescue analgesic post-operative, rescue injections, and side effects between the three groups

Patients characteristics	Group A	Group B	Group C
1st rescue analgesic post-operative (min)			
Mean±SD	474.6±78.3	599.4±63.1	613.2±80.7
P-value	Group A versus Group B <0.001	Group B versus Group C 0.464	Group A versus Group C <0.001
Number of rescue injections in first 24 h			
Mean±SD	1.67±0.479	1.33±0.479	1.3±0.466
P-value	Group A versus Group B 0.008	Group B versus Group C 0.807	Group A versus Group C 0.004
Side effects			
Nausea	Nil	1	Nil
Vomiting	Nil	Nil	1
Hypotension	Nil	Nil	Nil

SD: Standard deviation

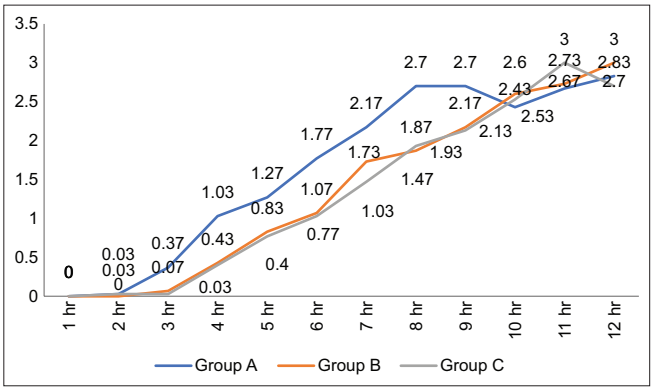

Figure 1: Visual analog scale score between the three groups

between the two groups with 100 mg and 150 mg of magnesium.

In our study, the addition of magnesium to ropivacaine significantly prolonged the duration of the sensory and motor blockade. This was comparable to the study done by Mukherjee et al., whose duration of sensory block was 289.67±62.50 min versus 456.21±97.99 min. The duration of the motor block was 242.16±23.86 min, versus 366.62±24.42 min.[3] Verma et al., whose duration of sensory and motor block was also prolonged significantly.[7] But in our study, there was no significant difference in the duration of sensory and motor blockade between the two groups with 100 mg and 150 mg of magnesium.

In our study, the VAS score was calculated for the first 12 h post-operatively. The difference was significant at 7th h (P<0.001), 8th h (P<0.001), 9th h (P=0.008), and 10th h (P=0.004). It is comparable to the study done by Gupta et al., in which the VAS score was significant at the 6th and 12th h.[6]

In our study, we strongly concluded that magnesium prolongs the duration of post-operative analgesia when added to the local anesthetic. This is similar to the studies done by Gupta et al., in which the time to first rescue analgesic was prolonged from 377.67±73.31 min to 491±100.22 min.[6] Mukherjee et al., whose post-operative analgesia increased from 379.79±145.52 min to 461.71±152.57 min and similar to the studies of Verma et al.[3,7] But the difference in post-operative analgesia between 100 mg (599.4 min) and 150 mg (613.2 min) magnesium is not significant. Therefore, 100 mg magnesium is as efficacious as 150 mg $MgSO_4$ when added to ropivacaine in the supraclavicular block.

In our study, the addition of magnesium to ropivacaine significantly reduced the number of rescue injections post-operatively, thereby minimizing the use of systemic opioids. This is following the study done by Mukherjee et al., and ELShamaa et al., also concluded that much less amount (35.6 mg vs. 113.6 mg) of diclofenac sodium was administered as a rescue analgesic in the bupivacaine plus magnesium group than in the control group.[3,8] However, in our study, the number of rescue injections did not differ much between 100 mg and 150 mg of magnesium. Therefore, 150 mg $MgSO_4$ does not have any extra benefit compared to 100 mg $MgSO_4$ in reducing post-operative opioid consumption.

In our study, one patient in Group B experienced nausea, which was managed conservatively with intravenous fluids. One patient in Group C experienced vomiting, which was managed with intravenous fluids and IM metoclopramide (10 mg). None of the patients developed hypotension. Choi et al., also found similar side effects (nausea, vomiting, and dizziness), but the difference between the magnesium and normal saline groups was also not significant.[9]

Limitations of the study

The relatively small sample size, specific patient selection criteria, single location of the study, defined timeframe, and potential for bias due to blinding could all limit the generalizability of the results to other populations and treatment settings.

CONCLUSION

We concluded that the addition of both 100 mg and 150 mg magnesium sulfate to 0.5% ropivacaine in the supraclavicular brachial plexus block significantly prolonged the duration of sensory and motor blockade and significantly reduced the requirement for rescue analgesics in the post-operative period but delayed the onset time of sensory and motor blockade. However, both 100 mg and 150 mg of magnesium had similar efficacy in post-operative analgesia. Thus, it is inferred that 100 mg of magnesium is sufficient for the supraclavicular block to achieve the desired effects.

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REFERENCES

1. Koyyalamudi VB, Arulkumar S, Yost BR, Fox CJ, Urman RD and Kaye AD. Supraclavicular and paravertebral blocks: Are we underutilizing these regional techniques in perioperative analgesia? Best Pract Res Clin Anaesthesiol. 2014;28(2):127-138. https://doi.org/10.1016/j.bpa.2014.04.003
2. Raghove P, Singh K, Taxak S, Ahlawat M and Hooda S. Comparison of ultrasound guided technique with conventional landmark technique for supraclavicular brachial plexus nerve block in patients undergoing upper limb surgery. Int J Pharmacol Clin Sci. 2016;5(2):1-4. https://doi.org/10.5530/ijpcs.5.1.1
3. Mukherjee K, Das A, Basunia SR, Dutta S, Mandal P and Mukherjee A. Evaluation of magnesium as an adjuvant in ropivacaine-induced supraclavicular brachial plexus block: A prospective, double-blinded randomized controlled study. J Res Pharm Pract. 2014;3(4):123-129. https://doi.org/10.4103/2279-042x.145387
4. Hofmann-Kiefer K, Herbrich C, Seebauer A, Schwender D and Peter K. Ropivacaine 7.5 mg/ml versus bupivacaine 5 mg/ml for interscalene brachial plexus block--a comparative study. Anaesth Intensive Care. 2002;30(3):331-337. https://doi.org/10.1177/0310057x0203000311
5. Raeder JC, Drøsdahl S, Klaastad Ø, Kvalsvik O, Isaksen B, Strømskag KE, et al. Axillary brachial plexus block with ropivacaine 7.5 mg/ml: A comparative study with bupivacaine 5 mg/ml. Acta Anaesthesiol Scand. 1999;43(8):794-798. https://doi.org/10.1034/j.1399-6576.1999.430802.x
6. Gupta D, Mangal V, Kulshestha A and Kalra P. 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. J Recent Adv Pain. 2017;3(2):85-89. https://doi.org/10.5005/jp-journals-10046-0075
7. Verma V, Rana S, Chaudhary SK, Singh J, Verma R and Sood S. A dose-finding randomised controlled trial of magnesium sulphate as an adjuvant in ultrasound-guided supraclavicular brachial plexus block. Indian J Anaesth. 2017;61(1):250. https://doi.org/10.4103/ija.ija_466_16
8. EL Shamaa HA, Ibrahim M and Eldesuky H. Magnesium sulfate in femoral nerve block, does postoperative analgesia differ? A comparative study. Egypt J Anaesth. 2014;30(2):169-173. https://doi.org/10.1016/j.egja.2013.10.005
9. Choi IG, Choi YS, Kim YH, Min JH, Chae YK, Lee YK, et al. The effects of postoperative brachial plexus block using MgSO(4) on the postoperative pain after upper extremity surgery. Korean J Pain. 2011;24(3):158-163. https://doi.org/10.3344/kjp.2011.24.3.158

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SG- Manuscript preparation, literature review, data collection, data analysis; **KRA-** Study design, review manuscript.

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