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The Effectiveness of Magnesium Sulphate Intravenous Bolus or Added as an Adjunct to Ropivacaine for Brachial Plexus Block in Upper Limb Orthopaedic Surgeries

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Abstract:-
Background and Objectives: Brachial plexus block is often used for the surgery of the upper extremity. Magnesium Sulphate can be administered with multiple routes for analgesia. We have compared the duration of the postoperative analgesic effect of MgSO4 intravenous bolus or as an adjunct to ropivacaine for brachial plexus block.

Materials and Methods: Seventy-five patients posted for upper limb orthopaedic surgeries under supraclavicular brachial plexus block were divided into three equal groups (Groups A, B, and C) in a randomized, double-blind fashion. Group A received 20ml of 0.5%Ropivacaine + 2ml NS; total volume 22ml for Brachial plexus block plus 100ml NS i.v over 15 minutes. Group B received 20ml of 0.5%Ropivacaine + 2ml of 50%MgSO4; total volume 22ml for Brachial plexus block plus 100ml NS i.v over 15 minutes. Group C received 20ml of 0.5%Ropivacaine + 2ml NS; total volume 22ml for Brachial plexus block plus 100ml MgSO4(50mg/kg) i.v over 15 minutes. Sensory and motor block onset times, Ramsay sedation scale, time to first analgesic use, total analgesic need, postoperative Numeric Rating Scale, hemodynamic variables, and side effects were recorded for each patient.Findings: Sensory and motor onset time (P=0.017), and time to first analgesic use (P=0.00) were significantly longer and the total need for rescue analgesics was lower in group B than group C followed by group A. Postoperative NRS at the time of request of rescue analgesic was significantly lower in group B (P = 0.013).Conclusion: USG-guided Brachial Plexus block with MgSO4 as an adjuvant to ropivacaine as a bolus or intravenous prolongs the duration of postoperative analgesia and decreases the requirement of rescue analgesics with no side effects.

Keywords:- *Adjuvant analgesic, Brachial plexus block, Magnesium Sulphate, Postoperative pain, Ropivacaine*.

I. INTRODUCTION

Brachial plexus block is a regional anaesthesia technique that is often used either as an adjuvant to general anesthesia or as a sole anesthesia modality for the surgery of the upper extremity. It has also evolved as an important tool as a safe alternative to general anaesthesia for surgeries and relief of perioperative pain. Furthermore, the use of ultrasound for performing brachial plexus block has made the procedure safe and effective[1][2].Local anaesthetic like 2% lidocaine, 0.5% bupivacaine, and 0.5% ropivacaine have been used in brachial plexus block of which bupivacaine and ropivacaine are long-acting and thus preferred. Ropivacaine is an aminoamide local anesthetic that blocks the peripheral afferents acting on voltage-dependent sodium channels and is less CNS and cardiac toxic than other long-acting anesthetics like bupivacaine[3].

Post-operative pain is one of the most important issues faced by patients undergoing surgical procedures. Improving pain management and associated physiological responses can enhance patient satisfaction, elevate the post-operative quality of life, and effectively decrease costs for both patients and healthcare institutions[4]. Different adjuvants have been used in the past to prolong the effect of local anaesthetics. Magnesium sulfate is one adjuvant that could be used with multiple routes.

Magnesium sulfate reinforces local anesthetic action on peripheral nerves. By acting as a calcium antagonist, magnesium permits the entry of calcium into cells, ultimately inhibiting the transmission of pain impulses[4].NMDA glutamate receptors play a vital role in

pain sensation and postoperative pain, and magnesium acts as a non-competitive antagonist to these receptors [5].

These drugs have been used for pain management quite frequently and have been associated with fewer complications, so were considered in our study to seek effective analgesia and for better pain management for the patients. The purpose of our study was to compare the intraoperative and postoperative analgesia among 3 groups of patients receiving ropivacaine alone, in combination with magnesium sulphate perineurally or intravenously in supraclavicular brachial plexus block in patients undergoing upper extremity surgeries.

II. METHODOLOGY

A single-centered prospective randomized double-blind comparative study involving 75 patients aged 18-65yrs, ASA PS I and II admitted for upper limb orthopaedic surgery was conducted in BPKIHS hospital over a period of one year. Approval of this study was obtained from the BPKIHS Institutional Review Committee and informed written consent for the procedure was obtained from all the eligible patients. Every patient had the right to withdraw from the study at any time. A total of 75 patients were assigned randomly in a double-blinded fashion into three equal groups of 25 each. A total of 75 envelopes were made with numbers indicating the sequence of the patient on the outside of the envelope and the allocated group inside. The drug was prepared and injected by an anaesthesiologist not involved in the assessment of the outcome. The patients of different 3 groups (n =25) received the study drugs as given below:

- Group A received 20ml of 0.5% ropivacaine + 2ml NS; total volume 22ml for brachial plexus block plus 100ml NS i.v over 15 minutes.
- Group B received 20ml of 0.5% ropivacaine + 2ml of 50% magnesium sulphate; total volume 22ml for brachial plexus block plus 100ml NS i.v over 15 minutes.
- Group C received 20ml of 0.5% ropivacaine + 2ml NS; total volume 22ml for brachial plexus block plus 100ml MgSO4 (50mg/kg) i.v over 15 minutes.

Routine pre-anesthetic checkup was done for all the patients and all were orally premedicated with tablet lorazepam 1mg for patients less than 50 kg and 2mg for those greater than 50 kg the night before and in the morning of surgery. On the day of surgery after all the preparations were carried out; patients received 100ml of NS or magnesium sulphate (50mg/kg) in 100ml NS according to the group over a duration of 15 minutes. Patients were kept in the supine position and the head turned 45 degrees to the non-operative side. Skin preparation with povidone-iodine and spirit was done. By employing ultrasound in a coronal-oblique plane, the subclavian artery, exhibiting pulsation and a hypoechoic nature, was successfully visualized positioned above the hyperechoic first rib. The nerve structures (trunks or divisions) displaying a characteristic 'honeycomb' appearance were observed posterolateral to the artery. To initiate the procedure, a 2% lignocaine solution was administered at the puncture site on the skin, followed by the insertion of a 22-gauge, 50-mm insulated block needle from a lateral to medial direction. The needle's tip was guided toward the nerve bundle once it was clearly visible. Multiple separate injections were administered at different locations within the bundle, with a tendency to begin deeper and gradually progress toward more superficial areas.

Sensory and motor block of all four nerve territories i.e., radial, ulnar, median, and musculocutaneous were assessed.

- *Sensory block was tested by Pin Prick Test/ Spirit swab*
  0 = no perception, 1 = decreased sensation, 2 = normal sensation

- *Motor block was evaluated by using a Modified Bromage Scale[6]*
  2 = complete motor block with an inability to move elbow, wrist, and fingers
  1 = finger movement only
  0 = normal motor function with full extension and flexion of elbow, wrist, and fingers

All the patients were evaluated for pain relief and related side-effect in the postoperative period at 5-minute intervals for the first 30 minutes and at 10-minute intervals for the next 30minutes. Then patients were followed up at 6hr, 12hr, and 24hr. Assessment of pain was done using Numeric Rating Scale (NRS) and if NRS was 3-5, inj. diclofenac sodium 75mg i.m was given and for NRS 6-10 inj. tramadol 100mg i.v was given. The time of the first perception of pain in the postoperative period was noted. Duration of analgesia was defined as the time from the onset of analgesia to the first pain perception by the patient.

The primary outcome was the duration of complete analgesia in the postoperative period. Secondary outcomes were the total dose of rescue analgesics required in the postoperative period, numeric rating scale (NRS) for pain, Ramsay Sedation scale, and the onset of sensory and motor block.

Data were entered in Microsoft Excel 2016 and exported into a statistical package for social sciences (SPSS 11.5) for statistical analysis. One-way ANOVA test for normally distributed continuous variables between the three groups, Kruskal Wallis for not normally distributed or ordinal data, and chi-square test to compare qualitative data was used. Sample size calculation was based upon the study done by Akhondzade R et al.[7], with 95% power at a 5% level of significance.

III. RESULTS

The mean duration of analgesia was longest in group B (478.8±89.87 min) followed by group C (388±58.73 min) and shortest in group A (341.04±32.35 min). It suggests a significantly prolonged duration of analgesia in group B in comparison with group A (P=0.001) & C (P=0.001). It also suggests a prolonged duration of analgesia in group C in comparison to group A (P=0.033). The duration of analgesia for all three groups is shown in table-1(Fig 1).

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Table 1: Mean duration of Analgesia

Characteristics	Groups (mean± SD)			P-Value			
	Group A (n=25)	Group B (n=25)	Group C (n=25)	Overall	A&B	B&C	A&C
Duration of analgesia (mins)	341.04±32.35	478.8±89.87	388±58.73	0.001*	0.001*	0.001*	0.033*

Value expressed as Mean ± Standard Deviation; *P value <0.05=significant

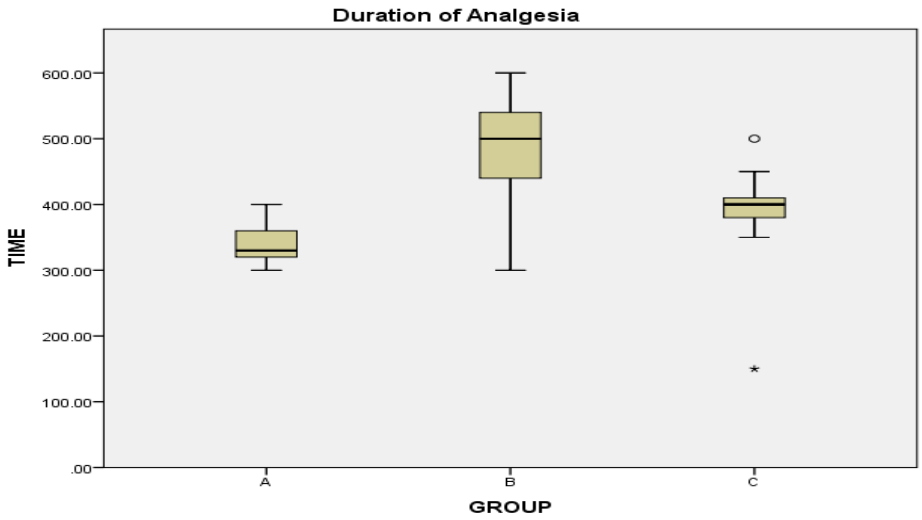

Fig. 1: Duration of Analgesia

After the brachial plexus block, time to onset of sensory blockade was noted as the time taken to achieve loss of sensation to pinprick test. The time of onset of motor blockade was noted as the time taken to achieve no movement i.e., Modified Bromage Scale of2. There was a significant difference between Group A and B (P=0.018) as Group B patients showed delayed sensory onset time and no statistical difference between Group B with respect to C and Group A with respect to C. Onset of motor block was prolonged in Group B and C compared to group A. There was statistical difference between the three groups. However, there was no statistical difference between Group A and B, Group B, and C, and Groups A and C. Mean time for onset of sensory and motor blockade is given in Table 2 and Figures 2&3.

Table 2: Mean time for onset of sensory blockade, motor blockade

Characteristics	Groups (mean± SD)			P-value			
	Group A (n=25)	Group B (n=25)	Group C (n=25)	Overall	A&B	B&C	A&C
Sensory block time (min)	14.24±2.3	16.24±2.7	14.68±2.4	0.017*	0.018*	0.081	0.812
Motor block time (min)	19.12±3.7	21.40±3.5	21.08±3.0	0.047*	0.058	0.943	0.119

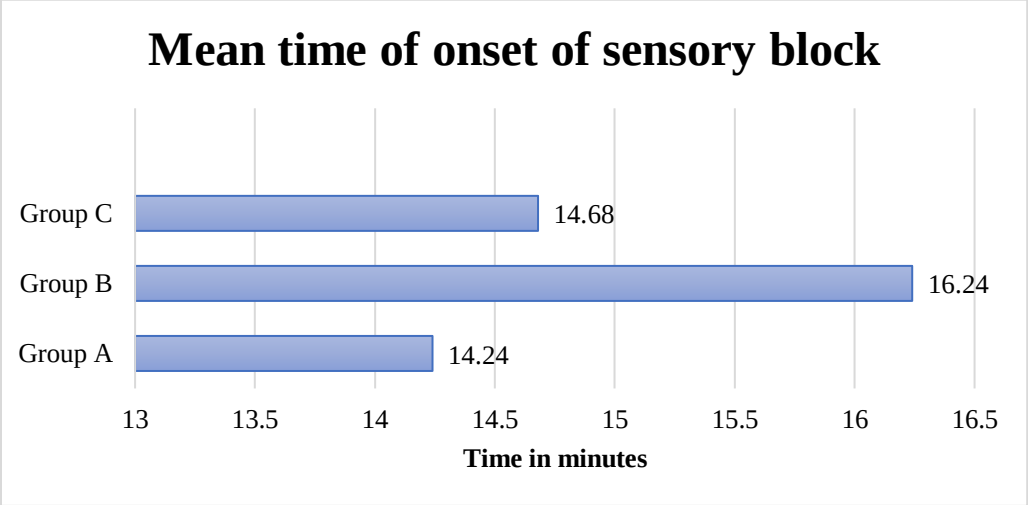

Fig. 2: Mean time of onset of sensory block

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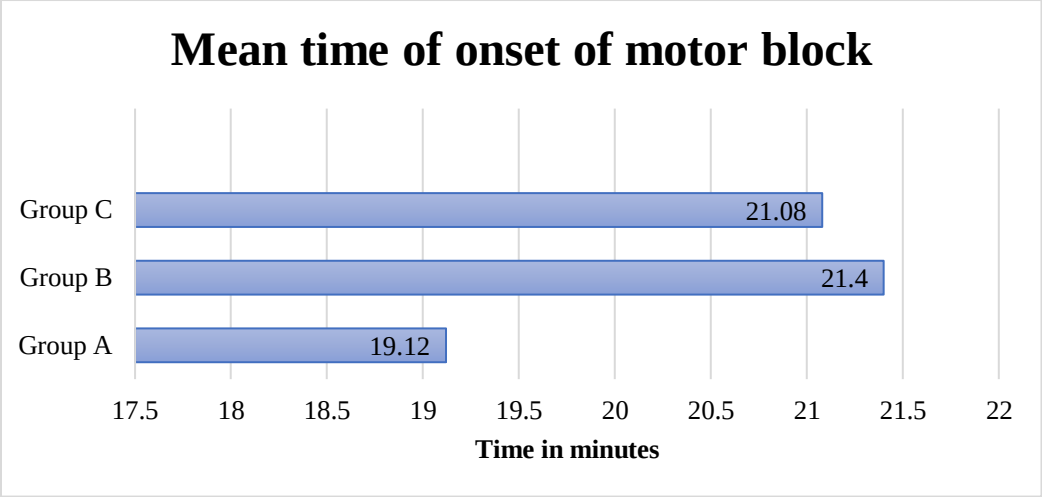

Fig. 3: Mean time of onset of motor block

The mean NRS of group B (5.28±1.33) was less in comparison to group C (5.96±1.48) and group A (6.72±1.02). The mean NRS of Group C was comparable to Group A. There was statistical difference between the three groups with respect to NRS. When we compared Group A with Group B, we found a significant statistical difference (P=0.001). However, when (group A & group C) and (group B & group C) were compared, there was no significant statistical difference (P=0.103 and P=0.160) respectively. Acomparison of NRS between all groups is given in Table 3.

Table 3: Comparison of NRS between all groups

Characteristics	Mean±SD			P value			
	Group A (n=25)	Group B (n=25)	Group C (n=25)	Overall	A&B	A&C	B&C
NRS	6.72±1.02	5.28±1.33	5.96±1.48	0.013	0.001	0.103	0.160

We compared the mean total dose of analgesics required in the postoperative period for the first 24 hours. Patients with NRS of 3-5 were given IM 75mg diclofenac and with NRS of 6-10 were given IV 100mg tramadol. The mean dose of rescue analgesic consumed in the three groups is shown in Table-4 (Fig 4).

Table 4: Mean dose of rescue analgesics

Total dose in mg	Mean ±SD			P value			
	Group A (n=25)	Group B (n=25)	Group C (n=25)	Overall	A&B	B&C	A&C
IV Tramadol	108.00±64.03	45.83±50.89	76.00±59.72	0.002	0.001	0.176	0.137
IM Diclofenac	60.00±53.03	63.00±60.00	72.00±59.21	0.746	0.981	0.845	0.742

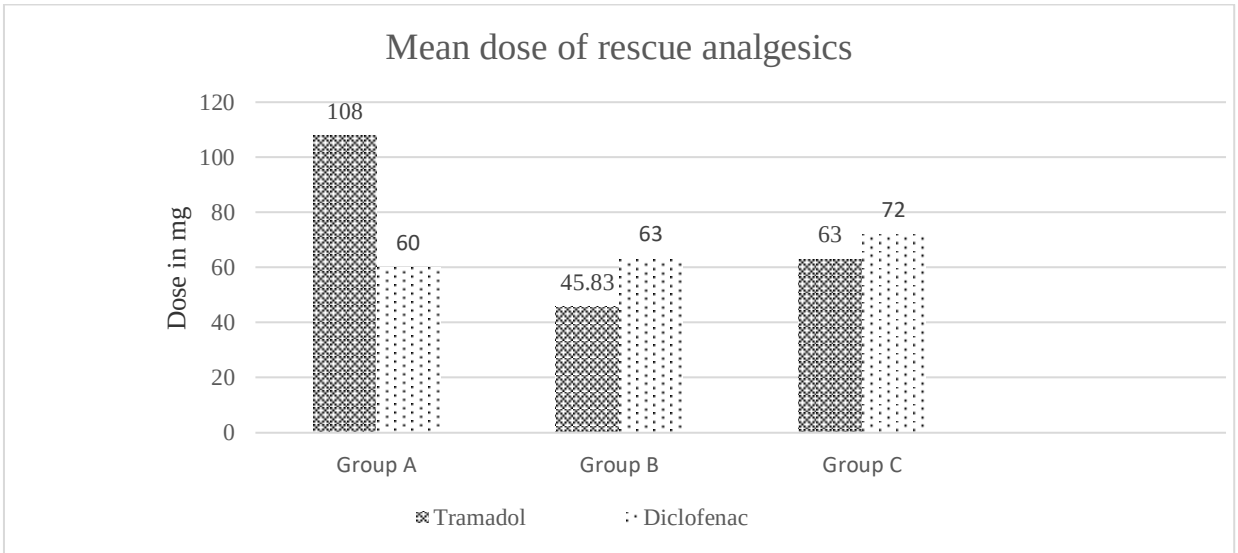

Fig. 4: Mean dose of rescue analgesics

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Patients of group B required less amount of tramadol with respect to groups A and C. There was a significant difference between the groups with respect to the consumption of tramadol (P=0.002). Patients in group A required less amount of diclofenac with respect to groups B and C. However, there was no statistical difference concerning the consumption of diclofenac in the three groups (P=0.746). There was a significant statistical difference in tramadol consumption with respect to A and B (P=0.001) but no significant difference in tramadol consumption with A & C (P=0.137) and B & C (P=0.176).

Ramsay sedation scale (RSS) was taken at a 5-minute interval for the first 30 minutes then at the interval of 15 minutes till the end of surgery intraoperatively. Patients in group C were more sedated when compared to groups A & B and illustrated in Figure 5. The difference was statistically significant (P=0.001).

Preoperative profiles (pulse rate, blood pressure, respiratory rate) were comparable among the three groups. Pulse rate was comparable among the three groups during the intraoperative period as well. There was a significant difference in systolic BP between the three groups after 20mins following the blocks; Group A (SBP) > Group B (SBP) > Group C (SBP). When groups A and B were compared, mean arterial pressure was comparable during all intraoperative periods. However, when group A and group C were compared, group C showed more drop in mean arterial pressure. Group C showed the lowest MAP of all three groups at 20 min and thereafter. There was no statistical difference between the three groups in terms of intraoperative respiratory rates at any point in time.

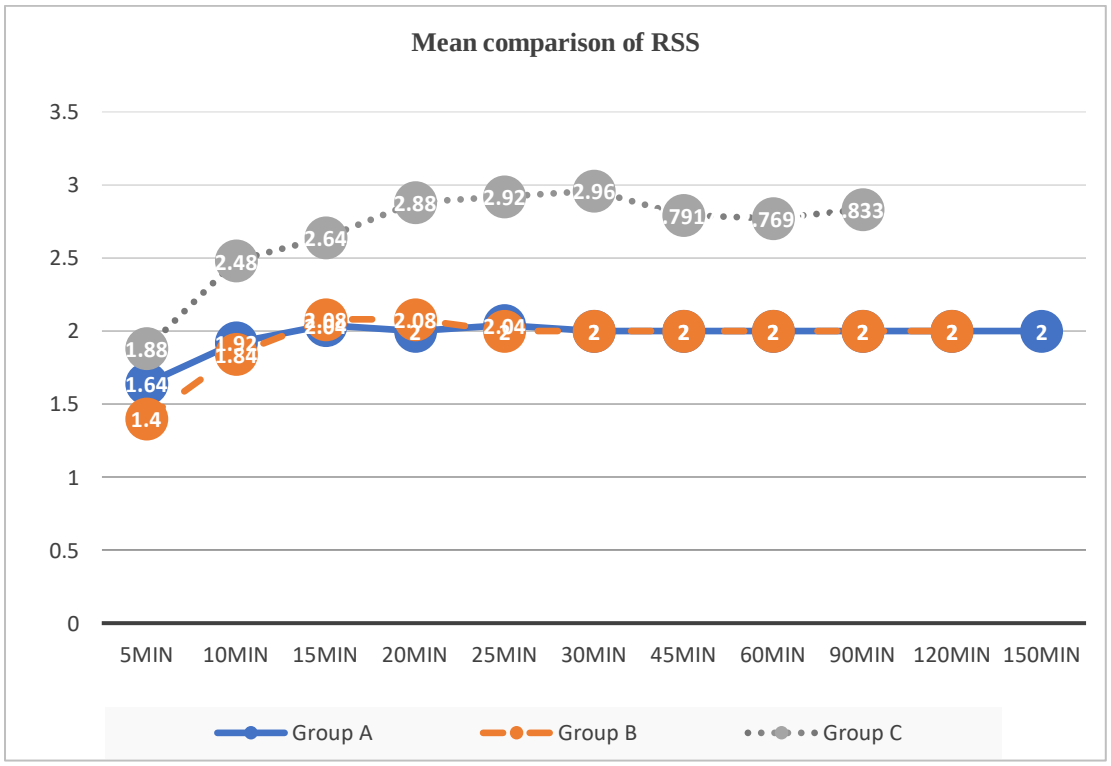

Fig. 5: Mean comparison of RSS

IV. DISCUSSION

This prospective, randomized, double-blinded, comparative study was designed to determine the effectiveness of the addition of magnesium sulphate (2ml of 50%) as an adjuvant to ropivacaine or intravenous bolus (50mg/kg) on intra-operative and postoperative analgesia. Each patient of different study groups received an equal volume of drugs through supraclavicular approach for brachial plexus block to avoid bias among the groups and to prevent alteration of concentration of local anaesthetics.

The supraclavicular brachial plexus block has demonstrated rapid onset and effective anesthesia, instilling a sense of confidence[8]. The utilization of ultrasound guidance enables real-time needle localization, visualization of drug distribution, and reduces the risk of failed blocks and vascular injuries. The administration of local anesthetic alone ensures favorable surgical conditions and provides some degree of postoperative pain relief. Magnesium sulfate, known for its analgesic, antihypertensive, and anesthetic-sparing properties across various administration routes[9],is now being incorporated as an adjuvant to local anesthetic drugs, reflecting recent practices[10]. Our study, therefore, attempted to find out the effect of magnesium sulphate as an additive to local anaesthetic for brachial plexus block or i.v to supplement analgesia. In our study, the demographic characteristics between the three groups were comparable, reflecting proper randomization (p=0.228 for age and p=0.94 for gender). There was no difference in ASA-PS distribution between the three groups (p=0.29). Our study has shown prolonged postoperative analgesia in patients receiving magnesium sulphate perineurally as an adjuvant to ropivacaine followed by patients receiving intravenous magnesium sulphate. The mean total duration of

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analgesia produced by ropivacaine with magnesium sulphate as an adjunct was 478.8±89.87 minutes compared to ropivacaine with intravenous magnesium sulphate which was 388±58.73 minutes followed by 341.04±32.35 minutes in ropivacaine alone (P=0.001).

Although the precise mechanism through which magnesium produces analgesia is not yet fully comprehended, the surface charge theory stands as the primary hypothesis. This theory suggests that by modifying the external concentration of magnesium surrounding a nerve bundle, the blockade induced by local anesthetics can be augmented. Mert et al.[11] conducted a study indicating that the presence of high levels of divalent ions (such as magnesium and calcium) attracted by the negative charges on the outer surface of the nerve membrane can impact the gating of sodium channels and potentially induce hyperpolarization. Hyperpolarization of the nerve fiber increases the difficulty of reaching the threshold level, consequently resulting in a blockage of nerve conduction.

The onset of sensory block was longer in patients receiving magnesium sulphate perineurally with ropivacaine (16.24±2.72 min) than those receiving ropivacaine & intravenous magnesium sulphate (14.68±2.44 min) and those receiving ropivacaine alone (14.24±2.38 min). There was a statistical difference between groups A and B only. It is possible that the solution made when MgSO4 was added had a different pH, which might explain our findings. However, we cannot offer a satisfactory explanation for this delay, and further studies are needed. Similarly, the onset of motor block was longer in patients receiving magnesium sulphate with ropivacaine (21.40±3.51) for brachial plexus block compared to the other remaining groups. However, the difference was not statistically significant. In our study, we found significantly reduced tramadol consumption in the postoperative period in the first 24 hours in patients who received magnesium sulphate perineurally when added to ropivacaine for brachial plexus block compared to the other two groups (p=0.001). Total Tramadol requirement in the 24-hour postoperative period was less in the intravenous magnesium sulphate group as compared to the control group but not to the extent of statistical significance (p=0.137). Sedation score was higher in patients receiving intravenous magnesium sulphate which is one of the known adverse effects of magnesium sulphate. Hypotension, bradycardia, and respiratory depression are other potential side effects of magnesium sulphate. However, no such adverse effects were seen in our study. Nausea, vomiting, neurological deficit, or any local formation of hematoma or pneumothorax were not seen in our study.

One limitation of our study was that we did not measure the serum level of magnesium sulphate. Therefore, we did not know the plasma concentration of MgSO4 via different routes; such as local deposition and intravenous injection. Follow-up for neurological deficit after 24hr postoperative period was not done. Follow-up at later days could have appropriately shown whether perineural deposition of MgSO4 could have caused any neurological deficit.

V. CONCLUSION

Addition of magnesium sulphate to ropivacaine as an adjunct either perineurally or intravenously results in a longer duration of analgesia in the postoperative period. Perineural injection of magnesium sulphate resulted in more effective analgesia as compared to intravenous magnesium sulphate. So, we conclude that magnesium sulphate when added to ropivacaine as an adjunct either perineurally or intravenously prolongs the duration of analgesia and decreased postoperative rescue analgesic requirement without any serious adverse effects.

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