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Magnesium Sulphate as an Adjuvant to Ropivacaine in Ultrasound Guided Supraclavicular Brachial Plexus Block: A Comparative Prospective Randomized Controlled Study

Karthik G.S.[1], Sudheer R.[2], S. Rangalakshmi[3], Priyanka N.P.[4], Prajwal B.V.[5]

[1,2]Associate Professor [3]Professor [4,5]Postgraduate, Department of Anesthesiology, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka 560074, India.

Abstract

Background: Ropivacaine has been chosen for supraclavicular brachial plexus blockfor its safety profile. Magnesium Sulphate is used as an adjuvant to local anaesthetics as it is known to potentiate sensory and motor blockade. *Aims:* Our aim was to assess and compare the effectiveness of adding Magnesium Sulphate to Ropivacaine for supraclavicular brachial plexus block.The variables compared included onset, duration of sensory and motor blockade and duration of analgesia. Any adverse effects were also documented. *Methods:* A prospective randomized double blinded controlled study was conducted involving 50 adult patients between the ages of 20 and 50 years belonging to American Society of Anaesthesiologists (ASA) grade 1 and 2 who underwent upper limb orthopaedic surgeries. Patients were randomly assigned into two groups of 25 each. Group R was administered 0.75% Ropivacaine while Group RM received 0.75% of Ropivacaine along with 250 mg Magnesium Sulphate. Sensory and motor blockade characteristics along with analgesic efficiency was determined. *Statistical analysis:* The collected data was entered and tabulated in Microsoft excel and were subjected to analysis using SPSS version 16.0. Student t test was used for analysis of the demographic and hemodynamic data. Unpaired t test was used for statistical evaluation of the data which comprised of onset, duration of both sensory and motor blockade as well as duration of analgesia. The results were statistically significant if p value obtained was <0.05. P value < 0.001 was considered as highly significant statistically. *Results:* Patients in group RM had rapid onset of sensory and motor blockade (7.8±1.24min v/s 9.6±1.76min and 10.36±1.22min v/s 12.24±2.26min). There was also prolongation of sensory and motor blockade along with reduced analgesic requirements in the post operative period. *Conclusion:* Adding Magnesium Sulphate to 0.75% Ropivacaine provided faster onset and longer duration of sensory and motor blockade along with superior post operative analgesia without any adverse effects.

Keywords: Ropivacaine; Magnesium Sulphate; Supraclavicular Brachial Plexus Block; Upper Limb Orthopaedic Surgeries.

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Introduction

Brachial plexus block is used for the surgeries of the upper limb. It provides a dense and most reliable anaesthesia and analgesia.The unwanted effects of general anaesthesia can be prevented with the use of this technique [1].

There are a lot of benefits with the advent of ultrasoundfor regional anaesthesia when compared to use of other techniques. With the use of ultrasound probe, the block can be performed very quickly and the onset time is also very fast [2].

Ropivacaine is a long-acting localanaesthetic agent. It was first synthesized as a pure enantiomer.

Corresponding Author: Sudheer R., Associate Professor, Department of Anesthesiology, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka 560074, India.
E-mail address: sudheer_mys@yahoo.co.in

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It mediates its effects via the blockade of sodium channels.Because it is less lipophilic, the cardiovascular and the central nervous system are minimal [3].

Lot of adjuvants have been combined with local anaesthetics for supraclavicular brachial plexus block to provide satisfactory anaesthetic outcomes. Magnesium Sulphate is one among them. It has been postulated that Magnesium mediates anti hypertensive and analgesic effects. It also blocks the conduction of nerve impulses when used in higher doses [4,5].

Methods

A prospective randomized double blinded comparative study was planned after discussing and taking approval from the ethical committee at our medical college and hospital. This study involved 50 patients belonging to ASA physical status Grade 1 and 2. Patients who were posted for surgeries involving the forearm, elbow and wrist were selected. Their age group was between 20 -50 years. Ultrasound guided supraclavicular brachial plexus block was performed. Pre anesthetic work up was done for all the 50 patients. All relevant investigations and workup were done keeping in view about the patient's co morbid conditions.Patients were told about the interpretation of Visual Analogue Scale (VAS) score during pre anaesthetic evaluation. Consent was obtained for the procedure after explaining to the patients in their own language.

Patients were assigned randomly into 2 groups who were categorized as group R and group RM. The sample size was calculated by using Epi Info 6 software. Based on a previous study with an á error of 0.05 and the power of study being 80% and keeping the mean time of first rescue analgesic requirement as one of the main primary variables at the p value of <0.05, we selected 25 patients in each group for our study [6]. This was done with the help of computer generated code where group R had patients who were given 25ml of Ropivacaine (0.75%) with 1 ml of normal saline. The other group (group RM) were given Ropivacaine (0.75%) 25 ml in combination with 250 mg of Magnesium Sulphate (25% w/v, Harson laboratories) 1ml prepared as an admixture.

Patients with coagulation abnormalities, infection at the site of injection, history of known psychiatric ailments, peripheral vascular insufficiency, any documentations or history regarding allergy to local anaesthetics previously were not involved in the study. Other patients who were excluded were as follows: patients with severely compromised cardio respiratory reserve, taking warfarin or any other anti-coagulants and on long term pain relieving medications (like Non-steroidal anti-inflammatory drugs). Pregnant women and post-partum lactating patients were also excluded. Patients who refused to take part in the study were also not considered.

The drugs used for the procedure were prepared and kept ready by a resident not involved in the study process. Since we planned for a double blinded study, the patients on whom the procedure was done and the anaesthesiologist who was involved in the procedure did not have any idea about the drug allocation.

Patients scheduled for surgery were kept nil per orally for a duration of 6 hours before surgery. Tablet Pantoprazole 40 mg was administered orally the previous night half an hour before food. To allay anxiety and apprehension a small dose of Alprazolam 0.25 mg was administered to the patient the previous night at 10 pm.Ringer lactate infusion was started after securing 20 gauge cannula in the limb opposite the surgical site. All baseline parameters including heart rate, blood pressure (noninvasive) and oxygen saturation were noted and recorded.

In supine position and with a small elevation under the shoulder using a wedge or a small pillow, the patients were prepared for the supraclavicular brachial plexus block. Under aseptic precautions, local anaesthetic solution (2% lignocaine)was injected over the area where the block was planned. An ultrasound probe was used to perform the block. Required anatomical landmarks including subclavian artery, first rib, pleura and brachial plexus nerve cluster were delineated. We used the in plane technique using ultrasound probe wherein a 23 Gauge (23G) spinal needle was directed in the long axis of the ultrasound beam. After attaching a ten centimeter extension to the spinal needle the prepared drug mixture which included either plain Ropivacaine or Ropivacaine with Magnesium Sulphate was injected covering all the boundaries near the vicinity of the nerve clusters trying to cover all the nerve trunks. We made sure that before injection no blood vessel was entered. Assessment of the sensory and motor blockade including their onset and duration were done every 5 minutes initiallyand there on upto the entire surgery. The above parameters were noted even after completion of surgery and until the recovery of the block. The sensory block was determined by a pin prick test which indicated a 3 point scale. This was as follows; numeral0 denoted

normal sensation 1 indicated loss of sensation of pin prick 2 denoted loss of sensation of touch.

Modified Bromage scale was used to evaluate the motor blockade which includes grade 0 to grade 2. Their description is as follows:

Grade 0 is normal motor function with full extension and flexion of the elbow, wrist and fingers,

Grade 1 is inability to move the fingers only

Grade 2 is the inability to move the fingers with complete motor blockade.

The time interval between the end of local anaesthetic injection and complete sensory blockade was taken as onset time for sensory blockade (score 2). The time which has elapsed between the complete sensory blockade and complete anaesthetic resolution was considered as duration of sensory block (score 0). The time interval between local anaesthetic injection and complete motor blockade was termed as onset time for motor blockade (Grade 2). Duration of motor blockade was also considered and it was taken from the time interval involving complete motor blockade to complete recovery of motor function of hand and forearm. Between the period of complete sensory blockade and first analgesic request, the time interval recorded was taken as the duration of analgesia.

Adverse effects if any were noted. If the blood pressure declined to 20% lesser than the baseline values, it was considered as hypotension for which fluid infusion was increased. If hypotension did not respond to fluid boluses injection Mephenteramine, 5mg was used. Bradycardia was defined in our study as heart rate less than 50 beats per min. Injection Atropine 0.6 mg was kept ready if Bradycardia persisted. Mean blood pressure and heart rate values were noted down and tabulated at the intervals of every 5 minutes till 30 minutes and then on till the end of surgery.

Other side effects like nausea and vomiting were treated with injection Ondansetron 8 mg intravenously. In the post-operative period, visual analogue scale (VAS score)was used to access the intensity of pain in the first 24 hours. In this scale 0 depicts no pain and a score of 10 represents worst possible pain. Rescue analgesic was given to the patients in both the groupsif VAS score was more than 3. We used injection Diclofenac 75mg as a rescue analgesic if the patients complained of pain. The amount of analgesic requirement was calculated in group R as well as in group RM postoperatively. The collected data was entered and tabulated in Microsoft excel and were subjected to analysis using SPSS version 16.0. Student t test was used for analysis of the demographic and hemodynamic data. Unpaired t test was used for statistical evaluation of the data which comprised of onset, duration of both sensory and motor blockade as well as duration of analgesia. The results were statistically significant if p value obtained was <0.05. P value < 0.001 was considered as highly significant statistically.

Results

Fifty patients were enrolled for the study as per the study protocol mentioned above. Both the groups R and RM were comparable with respect to age, weight, sex distribution, height (Table 1) and ASA grading (Table 2). Even the duration of surgery were comparable among both the groups (p=0.1314). As per the observations in Table 3, the onset time for sensory and motor blockade were significantly shorter in RM

Table 1: Comparison of demographic variables

	Group R	Group RM	P Value
Age in YRS	35.6±6.1	36.1± 7.2	0.4226
Weight (KG)	60.6 ± 4.7	61.9 ± 3.7	0.2483
Height (CM)	163.90 ± 5.92	162.2 ± 3.2	0.2127
Sex (Male/Female)	13(52%)/12(48%)	13(52%)/12(48%)	1.0
Mean Duration of Surgery (in minutes)	67 ± 4.16	68 ± 3.04	0.1314

Group R=Ropivacaine, Group RM=Ropivacaine+Magnesium Sulphate, p value-not significant (student t test)

Table 2: ASA grading in both the groups

	Group R	Group RM	P value
Grade 1	9(36%)	10(40%)	
Grade 2	16(64%)	15(60%)	0.862
Total	25(100%)	25(100%)	

Group R=Ropivacaine, Group RM=Ropivacaine+Magnesium Sulphate, p=0.862, not significant

group (7.8±1.24 minutes and 10.36±1.22 minutes respectively) when compared to R group (9.6±1.76 minutes and 12.24±2.26 minutes respectively) with p value <0.05. By adding Magnesium Sulphateto Ropivacaine in our study, we noted the occurrence of early onset of sensory and motor blockade when compared to use of Ropivacaine alone. The duration of sensory blockade was longer in RM group (526.32±10.34minutes) when compared to R group (403.78±14.62minutes) with p value of 0.0037 (statistically significant). The duration of motor blockade was also enhanced to a greater degree in RM group (428.76± 12.76minutes) when compared to R group(296.16± 16.41)(p value <0.001)(Table 4). The duration of analgesia lasted longer in RM group (634.96±18.35) when compared to group R (496.62± 13.68 minutes) (p value <0.001)(Table 4).

Haemodynamic stability was maintained in patients of both the groups. Adverse effects like nausea, vomiting, sedation and respiratory depression

Table 3: Comparison of onset time of both sensory and motor blockade among both the groups

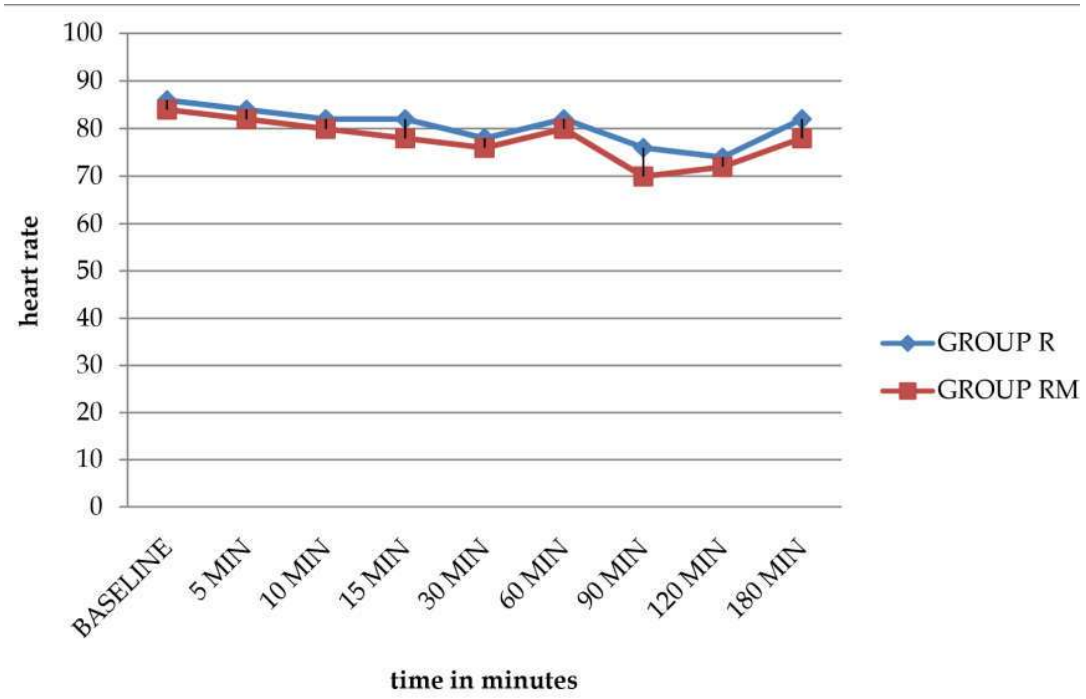
	Group R	Group RM	P value
Onset Time of Sensory Blockade (in Minutes)	9.6 ± 1.76	7.8 ± 1.24	0.0031
Onset Time of Motor Blockade (in Minutes)	12.24 ± 2.26	10.36 ± 1.22	0.0037

p value< 0.05, statistically significant and <0.001- statistically highly significant (unpaired t test). Group R=Ropivacaine, Group RM: Ropivacaine+Magnesium Sulphate

Table 4: Comparison of duration of both sensory and motor blockade among both the groups

	Group R	Group RM	P Value
Duration of Sensory Blockade (in minutes)	403.78 ± 14.62	526.32 ± 10.34	0.0037
Duration of Motor Blockade (in Minutes)	296.16 ± 16.41	428.76 ± 12.76	<0.001

p value< 0.05, statistically significant and <0.001- statistically highly significant (unpaired t test). Group R=Ropivacaine, Group RM=Ropivacaine+Magnesium Sulphate



Group R=Ropivacaine, Group RM=Ropivacaine+Magnesium Sulphate

Graph 1: Comparison of mean pulse rate in both the groups (graphical representation)

in either of the groups were not statistically significant.No any other adverse effects were noticed. VAS scores were less in patients of group RM and hence total analgesic requirement was less in group RM (67.62±11.61 minutes) when compared to group R (102.68±12.72 minutes) ($p<0.001$) (table 5).

Discussion

When general anaesthesia is used for the patients undergoing surgeries of the upper limb patients do not experience good analgesia in the perioperative period when compared to brachial plexus block. The stress response mediated by laryngoscopy and intubation causes significant hemodynamic disturbances. Other adverse effects following general anaesthesia include nausea, vomiting and respiratory depression in the post-operative period. To avoid all these adverse effects brachial plexus block is commonly administered. Brachial plexus block provides excellent analgesia in the perioperative period as the upper limb is innervated solely by the brachial plexus.

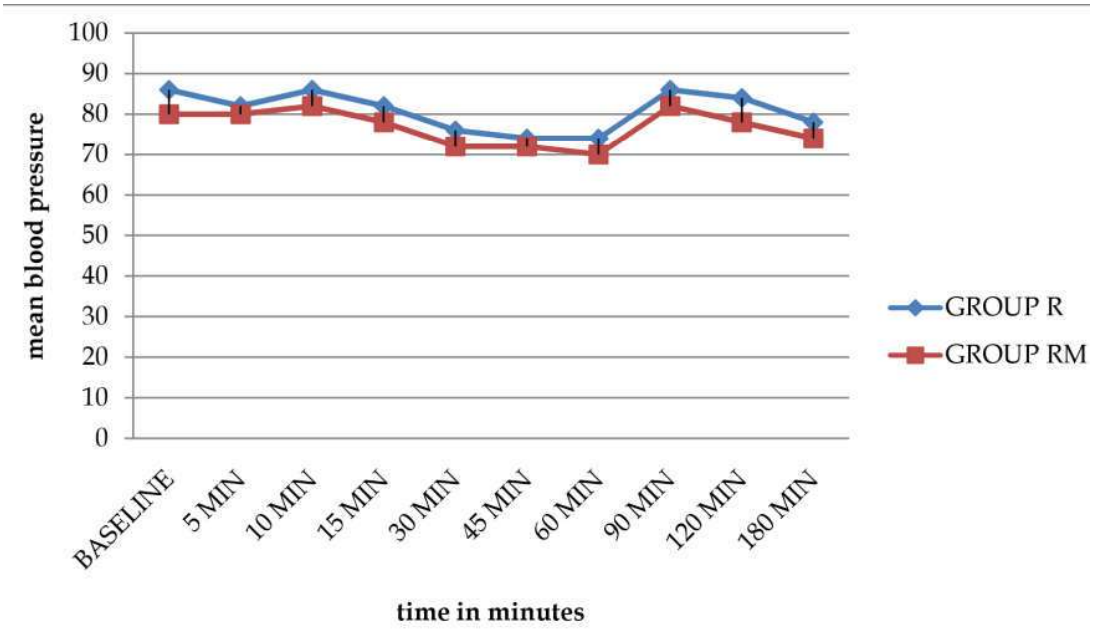
Ropivacaine is one of the recently synthesized long acting local anaesthetic which belongs to the amide group. It mediates its effects via the blockade of sodium channels. When compared to Bupivacaine it is less lipophilic and hence it is associated with minimal cardio vascular and central nervous system effects [7].

Magnesium is one of the important ion which mediates lot of physiological processes within the body system. It plays an important role in the prevention ofrelease of acetyl choline at the neuro muscular junction which is mediated by the entry of calcium thus bringing about blockade of nerve impulses. Its effects are mediated by inhibition of NMDA (N- methyl, D- aspartate) receptors. Beneficial effects of Magnesium have been found out during general anaesthesia and epidural anaesthesia. It's a known fact that Magnesium mediates anti-hypertensive effects and when used during anaesthesia it reduces the requirements of the drugs used in combination with it [8].

Table 5: Comparison of analgesic profile among both the groups

	Group R	Group RM	P value
Duration of Analgesia (in minutes)	496.62 ± 13.68	634.96 ± 18.35	<0.001
Rescue analgesia- diclofenac (mg)	102.68± 12.72	67.62± 11.61	<0.001

Group R=Ropivacaine, Group RM=Ropivacaine+Magnesium Sulphate $p<0.001$ highly significant



Group R=Ropivacaine, Group RM=Ropivacaine+Magnesium Sulphate

Graph 2: Comparison of mean arterial pressure in both the groups (graphical representation)

Brachial plexus block ensures better anaesthetic conditions when used in conjunction with ultrasound. The nerve clusters are better identified and hence the block quality is superior.The occurrence of accidental intra-arterial injection can be avoided. As the pleura is visible the chances of pneumothorax are very negligible [9].

In our study, we used 250 mg of Magnesium Sulphate as an additive to Ropivacaine and we found out that Magnesium Sulphate prolonged the duration of sensory and motor blockade. The duration of analgesia was also prolonged. The rescue analgesic medication used in the post operative period was of lesser doses in the group which received Magnesium Sulphate as adjuvant (group RM)(based on VAS score). These observations in our study correlates to a similar study which was conducted by Verma et al.[10]. They used two doses of Magnesium Sulphate(125 mg and 250 mg) which were used as adjuvants to Bupivacaine and have concluded that Magnesium Sulphate in a dose dependent fashion provided faster onset of sensory and motor blockade (5.17±2.2 min v/s 8.9±2.3 min). The duration of sensory and motor blockade was also prolonged along with very good analgesia (665.13±97.87min v/s 475.10±53.29 min). Therefore according to their study, higher doses of Magnesium Sulphate (250 mg) was very effective when compared to lower dose (125 mg). Like in our study, they also did not report any adverse effects. Even the post operative analgesic requirement was very low in the group to which Magnesium Sulphate was used as an adjuvant. They also used VAS score to evaluate the requirement of rescue analgesic.

Our study also correlates with the study conducted by Goyal et al.[11] wherein they have reported that the requirement of rescue analgesic was very less in the post operative period as they independently used Magnesium to the axillary approach of brachial plexus block. This is also in support with our observations as the total dose of rescue analgesic was less in RM group when compared to group R.

We noted certain differences in our study from a study conducted by Mukherjee et al. [12]. In their study protocol, they have come to a conclusion that addition of 150 mg of Magnesium Sulphate to 0.5% Ropivacaine prolonged the duration of sensory and motor blockade. Here the onset time of sensory and motor blockade(as per the bromage scale) was delayed, whereas in our study we have derived that Magnesium Sulphate when added to Ropivacaine resulted in an immediate onset of both sensory and motor blockade. This might be because we used increased dose of Magnesium Sulphate (250mg).

In one of the other studies conducted by Gupta et al. [13], Magnesium Sulphate was used as an adjuvant to Ropivacaine (0.5%). They opined that addition of 150 mg of Magnesium Sulphate to Ropivacaine speeds the onset of sensory blockade but delays the onset of motor blockade. However the duration of motor blockade lasted for a longer time. But we noted that addition of Magnesium Sulphate to Ropivacaine hastened the onset of both motor and sensory blockade. This could also be attributed to the use of 250 mg of Magnesium Sulphate.

Studies involving the use of Magnesium Sulphate as an additive to 0.5% bupivacaine were conducted by Rao et al.[14] and Lee et al.[15] wherein they have also proved that Magnesium Sulphate is a superior adjunct to 0.5% bupivacaine when added to supraclavicular brachial plexus block in terms of onset, duration and analgesic potentiation. Though the observations made by Rao et al had a weak statistical significance, clinically the addition of Magnesium Sulphate had a good impact in increasing the duration of motor and sensory blockade.

Studies using Magnesium Sulphate in intravenous regional anaesthesia has also been reported by Bansal et al. [16] and Narang et al. [17]. As per their observations the onset of sensory and motor blockade was very quick in their study group which used Magnesium Sulphate as an adjuvant.

There are reports of Magnesium being used as an adjuvant to other local anaesthetics like prilocaine by Gunduz et al. [18]. They have concluded that, Magnesium Sulphate when added to prilocaine in supraclavicular brachial plexus block prolonged the duration of sensory and motor blockade. Our study is also supported by a study conducted by El Shamaa et al. [19] wherein the post operative rescue analgesia required was significantly less in their group of patients who received Magnesium Sulphate for femoral nerve block.

Dogru K et al. [20] in their study concluded that addition of Magnesium Sulphate to bupivacaine for arteriovenous fistula surgeries prolonged the duration of both sensory and motor blockade. Similar observations were noted by Haghighi M et al. [21] wherein Magnesium Sulphate (20%) was used as an adjuvant to Lignocaine in axillary brachial plexus block.They also noted that the duration of sensory and motor blockade was prolonged in the group which received magnesium sulphate.

Choi IG et al. [22] in their study used 200 mg of Magnesium Sulphate as adjuvant to 0.2% Ropivacaine in axillary brachial plexus block. But they did not note significant potentiation of

analgesic effects of Ropivacaine along with Magnesium Sulphate. This could be because of using either only 20 ml of 0.2% Ropivacaine or 200 mg of Magnesium Sulphate which might not have been sufficient to enhance analgesic potency.

Our study has provided superior block characteristics along with prolonged post operative analgesia with the addition of Magnesium Sulphate as an adjuvant to 0.75% Ropivacaine when compared to Ropivacaine alone in supraclavicular brachial plexus block. Thus it can be emphasized that Magnesium Sulphate can be a good adjuvant to Ropivacaine in supraclavicular brachial plexus block. There are few limitations in our study as further studies have to be carried out to conclude the optimal and safe dose of Magnesium Sulphate to be used in clinical practice as adjuvants to local anaesthetic medications. Large sample size may have to be used to obtain clinically and statistically valid observations to prove our findings.

Conclusion

Our conclusion from the present study is that addition of 250 mg of Magnesium Sulphateto 0.75% of Ropivacaine speeds up the onset of both sensory and motor blockade when added to Ropivacaine in ultrasound guided supraclavicular brachial plexus block for upper limb orthopaedic surgeries. It also lengthens the duration of sensory and motor blockade. The quality of block was enhanced as the duration of analgesia was significantly prolonged and thus it is one of the potential adjuvant for local anaesthetics in peripheral nerve blocks.

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