The Effect of Magnesium Sulfate on Motor and Sensory Axillary Plexus Blockade

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Background: Magnesium is a physiologic cation that blocks neuromuscular transmission and does not allow the nerve to be stimulated.

Objectives: This study investigates the effect of adding magnesium sulfate to lidocaine to extend the duration of sensory and motor blocks of the axillary plexus in orthopedic surgeries of the upper extremities.

Patients and Methods: This controlled randomized double-blind study was performed on patients who were candidates for orthopedic surgery of the upper extremities. A total of 60 patients between 18-60 years with ASA Class 1 or 2 participated in the study. One group received lidocaine (5 mg/kg) with magnesium sulfate 20% (3 mL) as the case group, while the second group received lidocaine (5 mg/kg) with normal saline (3 mL) as a placebo to block the axillary plexus using the trans-arterial technique. The duration of the sensory and motor block of the axillary plexus was monitored and evaluated using the pinprick and modified Bromage scale.

Results: A total of 60 patients were included in the study with 30 patients having received lidocaine plus magnesium and the other 30 patients having received lidocaine plus normal saline. The mean sensory block duration in the case group was 248.83 ± 18.36 and in control group was 204.67 ± 22.62. The mean motor block duration in the case group was 207.0 ± 16.64 and in control group was 147.33 ± 21.52 (both P < 0.0001). The mean onset of sensory block in case group was 15.5 ± 3.79 and the onset block in control group was 10.33 ± 4.13 (P < 0.0001).

Conclusions: The addition of magnesium sulfate to lidocaine increased the duration of motor and sensory axillary block in the upper extremities during surgeries when compared to the use of lidocaine alone.

Keywords: Magnesium Sulfate; Lidocaine; Regional anesthesia

1. Background

Regional anesthesia has been accepted as a safe and effective method for various surgical procedures including upper limb surgery. This method can prolong analgesia during surgery and assist with postoperative pain management. An axillary plexus block is commonly used as a regional anesthesia in the hand, arm, and forearm surgeries. Several attempts have been made to prolong the effect of regional anesthetics by sensory and motor blocks of axillary plexus using various factors such as narcotics, verapamil, clonidine, and tramadol (1).

Magnesium sulfate does not let catecholamines be released from the adrenal and peripheral nerve endings. Therefore, catecholamines receptors are blocked. So Magnesium sulfate results are sympathetic blocks (2). Some studies have demonstrated that the magnesium seems to reduce the postoperative pain, moreover injecting intravenously led to a reduction of the consumption of anesthetics during surgery (3). Studies have also shown that intrathecal administration of magnesium can strengthen the analgesic properties of opioids used for pain management following knee arthroscopy and during childbirth labor (4).

2. Objectives

Magnesium may use different mechanisms to prolong the effect of regional anesthetics. Our study was done to evaluate the effect of magnesium sulfate with lidocaine when used for sensory and motor axillary-plexus blocks.

3. Patients and Methods

This randomized controlled, double blind study was done on 60 patients, who were ASA Class 1 or 2 and between the ages of 18 and 60. The patients were admitted to the trauma center of Poursina Hospital in Rasht, Iran. In addition, they were candidates for hand and forearm surgery. The duration of each surgery was less than 90
the artery. The continuous aspiration and injection was anesthetic was injected posterior and 20 ml in anterior to formed under transarterial method and 20 mL of local pian Company, Iran). The axillary plexus block was per-
ing skin was anesthetized with 1 mL of 2% lidocaine (Cas-
a site situated in the proximal of axillae and the overlay-
shaved and betadine was applied to the site as a topical 
flexed at the elbow joint to 90 degrees. The armpit was 
monitored with a Novin S 1800 machine (Pooyandegan 
test and Bromage test were explained to all patients. 
the drugs. The method of injection as well as the pinprick 
know about the pharmaceutical composition, injected 
the primary investigator prepared the pharmaceutical 
sulfate was calculated based on previous studies (5-7). 
Using randomization, 60 medical packets were pre-
pared, mixed, and then given to the nurse in the operat-
ing room. Patients eligible to participate in this study and 
who had given written informed consent were referred 
to the operating room nurse who distributed one packet 
to each patient. The patients were introduced to the doc-
tor and the nurse then discarded each packet. A total of 
30 packets, named A, consisted of lidocaine plus magne-
sium sulfate and normal saline and the other 30 packets, 
named B, consisted of lidocaine plus normal saline. The 
nurse gave one of the closed envelopes to each patient 
and referred them to the doctor. After giving one packet 
to each patient, the nurse was not allowed to use it again. 
Patients were thus randomly allocated into two groups. 
Group A received magnesium sulfate (5 mg/kg lidocaine 
plus 3 mL of 20% magnesium sulfate and diluted in 40 mL 
of normal saline solution) and group B (control) received 
normal saline instead of magnesium sulfate (5 mg/kg 
lidocaine plus 3 mL of normal saline and diluted in 40 mL 
of normal saline solution). The dose of magnesium 
sulfate was calculated based on previous studies (5-7). 
The primary investigator prepared the pharmaceutical 
components. The anesthesiology resident, who did not 
know about the pharmaceutical composition, injected 
the drugs. The method of injection as well as the pinprick 
test and Bromage test were explained to all patients. 
During surgery, ECG and oxygen saturation level were 
monitored with a Novin S 1800 machine (Pooyandegan 
Rahe Saadat). The patient’s arm on which the operation 
was performed was abducted to 90 degrees supine and 
flexed at the elbow joint to 90 degrees. The armpit was 
shaved and betadine was applied to the site as a topical 
antisepic. The patients did not receive any sedatives 
before the axillary block. The axillary artery was palpated at 
a site situated in the proximal of axillae and the overlay-
ing skin was anesthetized with 1 mL of 2% lidocaine (Cas-
pian Company, Iran). The axillary plexus block was per-
formed under transarterial method and 20 mL of local 
anesthetic was injected posterior and 20 mL in anterior to 
the artery. The continuous aspiration and injection was 
taken to avoid intravascular injection. The musculocuta-
neous nerve was blocked by 5 mL of lidocaine 2% within 
the body of coracobrachialis muscle. The musculocuta-
neous nerve that provides sensory input for the lateral 
forearm also was blocked (in two groups). Sensory block 
level was monitored at one-minute intervals, as the onset 
of the nerve block is rapid. Sensory block level was 
performed by testing dermatomes of the sensory regions 
of the radial, median, and ulnar nerves. The intensity of the 
motor block was assessed using the modified Bromage 
scale at one-minute intervals as follows: 
0) Unable to move fingers; 
1) Able to move fingers only; 
2) Able to bend wrist; and 
3) Full flexion of the elbow.

When the sensory and motor blocks were fully estab-
lished, the surgery was started. The sensory and motor 
blocks were assessed by the pinprick test and the modi-
fied Bromage test from the initiation of the blocks until 
the end of anesthesia. Such tests are safe and cause no 
damage. The end of sensory block was defined by have 
pain sensation during the pinprick test. At the end of 
motor block, the patient had pain sensation during the 
pinprick test in all sensate areas and the patient had 
complete movement of their body. All these tests were 
assessed in the recovery room. The operating time was 90 
minutes or less and recovery time was approximately 30 
minutes. After taking the patients to the recovery room, 
questionnaires of demographic features were complet-
ed. The duration of sensory and motor blocks were fol-
lowed when the patients were in the recovery room. Sen-
sory and motor responsiveness was tested at 10-minute 
intervals.

After inducing anesthesia in the patients, hemodynamic 
monitoring was performed. The patients who had blood 
pressure or pulse rate variability were excluded from the 
study as well as any patients who were not completely 
blocked 30 minutes after performing the infusion. After 
the sensory and motor block was established, patients re-
porting pain received an injection of 25 mg of pethidine 
and were excluded from the study. Patients who received 
IV drugs to control anxiety were also excluded from the 
study. In the study, no one had complications. Analysis 
was performed by descriptive statistics, the Chi-square test, 
and the t-test. Data was analyzed by the SPSS (version 16). A 
P value < 0.05 was considered statistically significant.

4. Results

A total of 60 patients were included in the study with 
30 patients having received lidocaine plus magnesium 
and the other 30 patients having received lidocaine plus 
normal saline. Table 1 shows the demographic features 
of the patients from this study. By using the t-test, there 
were no significant differences in the demographic data 
of the patients and differences in the mean age and sex 
in the two groups were not significant. (P = 0.805 and P = 
1). All block randomization was done successfully. All the
patients were stable based on hemodynamic variables. No patients had complications such as hypotension to control and none were excluded from the study.

The mean sensory block duration in lidocaine plus magnesium group was 248.83 ± 18.36 and in lidocaine plus normal saline was 204.67 ± 22.62 (Table 2). The mean motor block duration in lidocaine plus magnesium group was 207.0 ± 16.64 and in lidocaine plus normal saline was 147.33 ± 21.52 (both P < 0.0001). The duration of the sensory and motor block was significantly longer in patients who received magnesium sulfate in lidocaine (Table 2).

The mean onset of sensory block in lidocaine plus magnesium group was 15.5 ± 3.79 and the onset block in lidocaine plus normal saline was 10.33 ± 4.13 and showed significant differences (P < 0.0001). (Table 2 and Figure 1) The mean onset of motor block in the lidocaine plus magnesium group was 20.66 ± 4.09 and the onset block in the lidocaine plus normal saline was 19.73 ± 26.18 and did not show any significant differences (P < 0.848) and (Table 2, Figures 2 and 3).

| Table 1. Demographic Features of the Patients a |
|-----------------|-------------------|-----------------|--------|-------|
| Features        | Lidocaine + Magnesium | Lidocaine + Normal Saline | t      | P Value |
| Age, y          | 35.6 ± 11.61       | 34.93 ± 10.24   | 0.248  | 0.805  |
| Gender          |                    |                  |       |       |
| Male            | 8 (26.7)           | 8 (26.7)         | -      | 1      |
| Female          | 22 (73.3)          | 22 (73.3)        | -      | 1      |
| Weight, kg      | 65.12 ± 13         | 66.16 ± 11.65   | 0.235  | 0.786  |
| Surgical time, min | 78.65 ± 8.42         | 75.87 ± 10.45 | 0.225  | 0.682  |
| Tourniquet time, min | 67.45 ± 7.52         | 66.38 ± 7.86 | 0.218  | 0.678  |
| Site of surgery |                    |                  |       |       |
| Hand            | 7                  | 10               | -      | 1      |
| Forearm         | 23                 | 20               |        |        |

 a Data are presented as mean ± SD. or No. (%).

| Table 2. Comparison of Mean Changes in Sensory and Motor Block in the Two Study Groups a |
|-----------------|-------------------|-----------------|--------|-------|
| Variable        | Lidocaine + Magnesium | Lidocaine + Normal Saline | t      | P Value |
| Onset of sensory block, min | 15.5 ± 3.79       | 10.33 ± 4.13   | 5.04   | 0.0001 |
| Onset of motor block, min     | 20.66 ± 4.09      | 19.73 ± 26.18  | 0.193  | 0.848  |
| Sensory block duration, min   | 248.83 ± 18.36    | 204.67 ± 22.62 | 8.3    | 0.0001 |
| Motor block duration, min     | 207.0 ± 16.64     | 147.33 ± 21.52 | 12.01  | 0.0001 |

 a Data are presented as Mean ± SD.

![Figure 1. The Mean Onset and Offset of Sensory Block in the Two Groups](image1)

![Figure 2. The Mean Onset and Offset of Motor Block in the Two Groups](image2)
5. Discussion

Magnesium is a competitive NMDA-receptor antagonist and inhibits the voltage-dependent ion channels. Additionally, it seems that magnesium sulfate increases the length of block in intravenous regional anesthesia (8). Therefore, improving the quality of local anesthetics in regional and local blocks as well as the management of postoperative acute pain is important for patients who suffer from the pain after surgery such as orthopedic surgery. Various axillary block methods as well as anatomical differences in the nerves of the upper limb warrant further research. This study investigated the effects of adding magnesium sulfate with lidocaine in axillary-plexus blocks to prolong the duration of sensory and motor blockage and diminish postoperative acute pain for the patient.

In this study, the mean duration of the sensory and motor blocks in the lidocaine plus magnesium group was significantly longer than in the lidocaine plus normal saline group (control). We also assessed the onset of the sensory and motor blocks between the two groups. The onset time of sensory block, i.e., the time from when the infusion was completed and the first symptoms of anesthesia in the limb were established, was significantly longer (P < 0.0001) for the lidocaine plus magnesium group than for the control group who received lidocaine plus normal saline group. The onset of anesthesia in the motor block also required a longer time in the magnesium plus lidocaine group when compared with the control group. However, this difference was not significant (P < 0.848). (Table 2) While an axillary block using lidocaine with magnesium sulfate has a delayed onset, the overall duration of the sensory and motor blocks was longer than the controlled condition of lidocaine with normal saline.

Ozalevli et al. compared intrathecal blocks of bupivacaine with fentanyl and magnesium in combination with sodium chloride in the patients undergoing lower limb surgery (9). They concluded that magnesium delayed the onset of sensory and motor blocks, but prolonged the duration of spinal anesthesia. In another study conducted by Elsharnouby et al. in Cairo in 2008, intra-articular injections of bupivacaine with magnesium resulted in longer periods of analgesia (duration) when compared with the control group that received a placebo (10). Two similar studies conducted by Arcioni et al. and by El-Kerdawy et al. reported that the addition of magnesium increased the duration time of an epidural analgesia (11, 12). Narang et al. investigated the effect of magnesium in a Bier block and reported that the onset of sensory and motor analgesia was faster in the magnesium group than in the placebo group (13). There was also an increased incidence of transient pain on injection when magnesium sulfate was added to the block. These findings were in contrast to our study. Gunduz et al. reported that magnesium prolonged the duration of the axillary plexus block (5). Also in the study conducted by Abdelfatah et al. it was
shown that magnesium sulfate plus lidocaine in an interscalene plexus block prolongs the analgesic duration in shoulder arthroscopic surgery, which was also consistent with our study (14).

One of the limitations of our study was a lack of regional anesthesia under guidance from sonography performed on the blocks. Therefore, it is recommended to perform another study to use above the technique. In addition, we recommend studying another sample size to receive higher doses of magnesium.

In the future, we recommend studying a larger sample size and follow up with patients for the longitude duration to confirm the results of the study and to assess the long-term complications of the drugs.

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Authors’ Contributions

Study concept and design: Mohammad Haghighi; acquisition of data: Abbas Sedighinejad; analysis and interpretation of data: Mehdi Rahmati; drafting of the manuscript: Ahmadreza Mirbolook; critical revision of the manuscript for important intellectual content: Bahram Naderi Nabi; statistical analysis: Nasim Ashoori Saheli; administrative, technical, and material support: Mehran Soleymanha, study supervision: Mohammad Haghighi.

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