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The Effects of Postoperative Brachial Plexus Block Using $MgSO_4$ on the Postoperative Pain after Upper Extremity Surgery

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Background:

Although a brachial plexus block can be used to provide anesthesia and analgesia for upper extremity surgery, its effects using $MgSO_4$ on postoperative pain management have not been reported. The aim of this study was to evaluate brachial plexus block using $MgSO_4$ on postoperative analgesia.

Methods:

Thirty-eight patients who were scheduled to undergo upper extremity surgery were randomly allocated into two groups: patients receiving axillary brachial plexus block with 0.2% ropivacaine 20 ml and normal saline 2 ml (group S) or 0.2% ropivacaine 20 ml and $MgSO_4$ 200 mg (group M). Before extubation, the blocks were done and patient controlled analgesia was started, and then, the patients were transported to a postanesthetic care unit. The postoperative visual analogue scale (VAS), opioid consumption, and side effects were recorded.

Results:

The two groups were similar regarding the demographic variables and the duration of the surgery. No differences in VAS scores were observed between the two groups. There was no statistically significant difference in opioid consumption between the two groups. Nausea was observed in three patients for each group.

Conclusions:

Axillary brachial plexus block using $MgSO_4$ did not reduce the level of postoperative pain and opioid consumption. (Korean J Pain 2011; 24: 158-163)

Key Words:

analgesia, brachial plexus, magnesium sulfate, upper extremity.

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INTRODUCTION

Patients undergoing orthopedic surgery for upper extremity injuries often report postoperative pain that is intense and difficult to control. The pain itself is not only associated with a number of complications that can develop in patients but can also lead to an unintended long-term stay in the hospital after surgery [1]. Various approaches have thus been adopted to help alleviate postoperative pain, with the majority of them using high doses of opioids. Opioids, however, have side effects such as severe nausea and vomiting.

Nerve blocks, mostly using topical anesthetics, reduce the side effects of anesthesia by using large doses of opioids, which can control postoperative pain effectively. The brachial plexus block (BPB) in particular is a widely used option in upper extremity surgeries. During a BPB, various drugs are used in combination with local anesthetics to help reduce the anesthetics' time to onset of effect, to prolong the duration of action, and to increase the chance of successful blockade. Toward these ends, a number of studies have been done, with varying results [2-11].

The magnesium helps to regulate the amount of calcium inside the cells and is known to be able to control for pain. For example, magnesium sulfate ($MgSO_4$), when injected intravenously, helps reduce the consumption of anesthetics during surgeries; in addition, when administered through epidural injection, it helps to decrease the amount of opioids needed postoperatively [12]. Despite its known benefits for pain control, magnesium has never been studied extensively for its effects as an adjuvant to aesthetics during BPBs, much less for its synergistic effects during BPBs when used in combination with ropivacaine, a local anesthetic used widely in recent years.

In this study, we did axillary brachial plexus blocks (ABPBs), a popular nerve block technique, as a way to control postoperative pain in patients who underwent a surgery in their brachial regions. We examined the effects of a ropivacaine-magnesium regimen used during the ABPBs on the patients' postoperative pain, on the consumption of opioids, and on reported side effects.

MATERIALS AND METHODS

We enrolled 38 male and female patients, ages 15 to 65, who were scheduled to undergo an upper extremity surgery and who met the requirements of the American Society of Anesthesiologists (ASA) physical status classification system's Class 1 or Class 2. The exclusion criteria were a history of lung disease, obesity (body mass index $> 30\ kg/m^2$), a history of chronic pain or psychiatric disorder, drug or alcohol abuse, and hypersensitivity to local anesthetics. The prospective study design was approved by the institutional review board (IRB) at this hospital. The purpose and methods of the study were explained to the participating patients; their written consent was collected prior to the study.

The patients were randomly assigned to either group S (ropivacaine-saline injected group) or group M (ropivacaine-magnesium injected group). All patients were transported to the operating room without being administered a preoperative anesthetic or analgesic. Their ECG, blood pressure, and oxygen saturation level were monitored by means of an ECG machine, a noninvasive blood pressure (NIBP) monitor, and a pulse oximeter. To induce general anesthesia in the patients, 2% lidocaine (1 mg/kg) and 1% propofol (2-2.5 mg/kg) were injected intravenously. Upon confirming the induced unconsciousness in the patients, rocuronium (0.6 mg/kg), a nondepolarizing muscle relaxant, was injected intravenously; after 90 seconds, endotracheal intubation was done; the positioning of the tube was checked. O_2 and N_2O were each maintained at 1 L/m, while desflurane was maintained at 4-6 Vol% depending on the response of the patient's autonomic nervous system. If the systolic blood pressure of the patient increased more than 30% from his or her baseline reading that was taken in their hospital room prior to the anesthesia, 0.5 mg of nicardipine was injected intravenously.

Upon completion of the upper extremity surgery, an ABPB was done. A band was applied on the distal site of the operated area; the arm upon which the operation was performed was abducted to 100 degrees supine and was flexed at the elbow joint to 90 degrees. The axillary artery was palpated at a site situated in the armpit, about 1 cm off from the lateral edges of the pectoralis major; the site was marked for injection. Betadine (topical antiseptic) was applied to the site; a 23-gauge scalp vein needle, connected to the syringe containing the drugs, was advanced into the skin slowly. As the needle continued to infiltrate into the skin, the site of blood regurgitation was located; and the site where the needle was further advanced and the site where the needle was retrieved were each marked.

The surgical assistant did the block by injecting the sites with 20 ml of 0.2% ropivacaine (Ropiva Injection, Hanlim Pharm Co., Ltd.) combined with normal saline solution if the patient was in group S, and a mixture of 0.2% ropivacaine (20 ml) and 200 mg of $MgSO_4$ (Magnesium Daihan Injection, Daihan Pharm., Co., Ltd.) if the patient was in group M. Both drug regimens were prepared prior to the block. Upon the completion of the ABPB, the endotracheal tube was removed; a patient-controlled analgesia (PCA) device was hooked up to the patient's intravenous line; the patient was transported to his or her recovery room. The drug mixture (100 ml) used for the PCA device contained 1,000 μg of fentanyl (BC Fentanyl Citrate Injection, BC World Pharm, Co., Ltd.), 0.3 mg of ramosetron (Nasea Injection, Astellas Pharma Korea, Inc.), and normal saline solution. In all patients, the per-injection amount of fentanyl was 0.2 μg/kg; the lockout interval was set at 5 minutes.

Prior to the surgery, the patients were educated on how to use the PCA device and how to rate on the visual analogue scale (VAS), i.e., a line along which patients rate the severity of their perceived pain by marking a number (0 to 10) that best represents the pain. Before inducing anesthesia in the patients, baseline VAS scores were collected from the patients and their sensory and motor responsiveness were tested. For sensory responsiveness testing, the dermatomere of the area covering the patient's C6 through C8 was pinpricked (e.g., the radial, ulnar, and median nerves); in addition, both of the arms were stimulated using the same amount of pressure in each arm to compare their responsiveness. Three rating options were offered: '1' represents the loss of all sensory responsiveness, '2' the loss of pain sensations, and '3' the maintenance of full sensory responsiveness. For motor responsiveness testing, we checked the dorsiflexion, adduction, and abduction of the patients' fingers. The patients were offered three rating options: '1' indicates no motor responsiveness; '2' indicates weak motor responsiveness; and '3' indicates maximum motor responsiveness.

In the recovery room, an anesthesiologist, unaware of the study design (i.e., patient assignment to each of the two treatment groups), collected the patients' VAS pain score, tested their motor and sensory responsiveness, checked the amount of fentanyl administered through the PCA device postoperatively, measured their blood pressure and heart rate, and asked if the patients' experienced any adverse events, such as headache, nausea, vomiting, and dizziness. Data on each of these categories were taken immediately after the surgery, at 30 minutes after the surgery, and at 1 hour after the surgery. In addition, the data were collected at 2 hours, 3 hours, 6 hours, 12 hours, and 24 hours afterwards by visiting the patients in their room. A successful ABPB was defined as the patients' rating their sensory responsiveness as either '1' or '2' on the VAS scale. If the patient reported adverse events such as nausea or vomiting, 4 mg of ondansetron (Ondant Injection, Hanmi Pharm Co., Ltd.) was injected intravenously.

All statistical data analyses were done with SPSS version 12.0 software (SPSS, Chicago, IL, USA). Comparison between group S and group M in terms of gender, adverse events, and motor and sensory responsiveness was done by means of the chi-squared test. Comparison between the groups' age, stature, weight, duration of surgery, VAS pain score, blood pressure, heart rate, and fentanyl consumption was done with Student's t-test. Analytical results were considered statistically significant if the P value was less than 0.05.

RESULTS

There were no significant differences in the patients' gender, age, height, weight, duration of surgery, or type of surgery between group S and group M (Tables 1 and 2). In terms of time-specific VAS pain scores collected postoperatively (Fig. 1), fentanyl consumption (Table 3), and changes in blood pressure and heart rate, no significant differences were observed between the groups. The pinprick test done on the patients' dermatomere 30 minutes

Table 1. Patients' Demographic Characteristics and Surgical Characteristics

	Group S (n = 20)	Group M (n = 18)
Age (yr)	49.6 ± 15.4	48.2 ± 13.4
Gender (M/F)	5/15	10/8
Height (cm)	160.9 ± 8.4	163.6 ± 7.7
Weight (kg)	64.3 ± 8.6	65.7 ± 11.3
Duration of surgery (min)	75.5 ± 36.3	77.8 ± 32.9

Data are expressed as mean ± SD or number of patients. Group S: BPB with 0.2% ropivacaine 20 ml + normal saline 2 ml. Group M: BPB with 0.2% ropivacaine 20 ml + $MgSO_4$ 200 mg. There were no significant differences between the two groups. BPB: brachial plexus block.

Table 2. Surgical Types

Surgical types	Group S (n = 20)	Group M (n = 18)
Open reduction & internal fixation	18	16
Closed reduction & pinning	1	1
Tenorrhaphy	1	1

Group S: BPB with 0.2% ropivacaine 20 ml + normal saline 2 ml. Group M: BPB with 0.2% ropivacaine 20 ml + $MgSO_4$ 200 mg. There were no significant differences between the two groups. BPB: brachial plexus block.

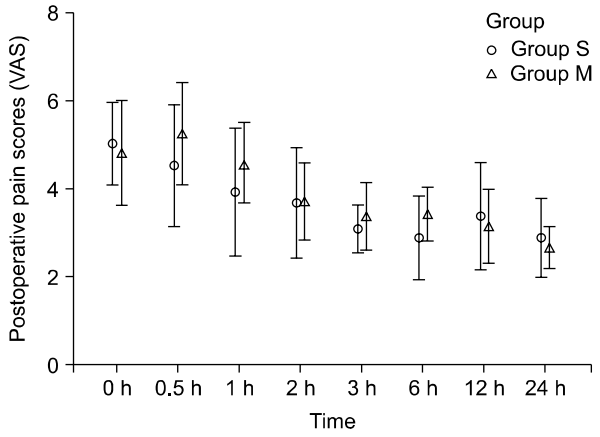

Fig. 1. Postoperative pain scores on a visual analogue scale (VAS). Brachial plexus block was performed using 20 ml of 0.2% ropivacaine, added normal saline 2 ml in group S, $MgSO_4$ 200 mg in group M. There were no significant difference between the two groups. Data are expressed as mean ± SD.

after the surgery found that 80% of group S marked either '1' (loss of all sensory responsiveness) or '2' (loss of pain sensations) on the VAS scale, while the corresponding number in group M was 72%. The same test done 12 hours after the surgery, however, showed that all patients recovered their sensory responsiveness. Regarding the patients' motor responsiveness, the results of the pressure test done 30 minutes after the surgery showed that 68% of group S marked either '1' (no motor responsiveness) or '2' (weak motor responsiveness) on the VAS scale, while the corresponding figure in group M was 60%. The same test done 12 hours after the surgery, however, showed that all patients recovered their motor responsiveness. Nausea was reported in 3 patients in group S and group M, respectively. Vomiting was observed in 1 patient in group S; the inter-group difference, however, was not significant (Table 4).

Table 3. Postop Opioid Consumption

	Group S (n = 20)	Group M (n = 18)
0 h	0	0
0.5 h	1.6 ± 1.3	1.7 ± 1.7
1 h	3.9 ± 2.3	4.0 ± 3.1
2 h	7.5 ± 4.2	9.1 ± 6.7
3 h	10.6 ± 6.8	12.2 ± 10.1
6 h	17.1 ± 11.2	17.4 ± 14.3
12 h	27.7 ± 16.1	26.2 ± 21.2
24 h	37.4 ± 24.0	28.6 ± 21.0

Data are expressed as mean ± SD. Group S: BPB with 0.2% ropivacaine 20 ml + normal saline 2 ml. Group M: BPB with 0.2% ropivacaine 20 ml + $MgSO_4$ 200 mg. There were no significant differences between the two groups. BPB: brachial plexus block.

Table 4. Side Effects

Side effects	Group S (n = 20)	Group M (n = 18)
Headache	0	1
Nausea	3	3
Vomiting	1	0
Dizziness	2	0

Group S: BPB with 0.2% ropivacaine 20 ml + normal saline 2 ml. Group M: BPB with 0.2% ropivacaine 20 ml + $MgSO_4$ 200 mg. There were no significant differences between the two groups. BPB: brachial plexus block.

DISCUSSION

Previous studies have reported the use of adjuvant drugs during BPBs. Kim [6] and Singelyn et al. [13] observed that clonidine (α_2-receptor agonist) used during BPB prolonged the duration of the anesthetic action and pain control; they noted the benefits were the topical effects of the clonidine, not general ones. Other drugs used during BPBs included tramadol, an opioid, and an α_2 receptor agonist. When used in combination with local anesthetics during a BPB, tramadol helped prolong the blocking of sensory and motor nerve transmissions to the brain [14].

Other studies have reported the use of narcotic drugs such as fentanyl and alfentanil, administered in combination with local anesthetics during BPBs. The drugs were found to help block sensory and motor nerve transmissions [2,5].

Magnesium, a cation existing inside the cell whose quantities are second only to potassium, plays a crucial role in activating enzymes in the cardiovascular system. In addition, magnesium acts as a physiological calcium antagonist. It is used to treat arrhythmia, myocardial or nerve ischemia, and gestational toxicosis, and to inhibit uterine contraction [15,16]. More recently, magnesium's effects of N-methyl-D-aspartate (NMDA) receptor antagonism and sympathetic blocking have been noted, and magnesium is now used to help reduce the consumption of anesthetics and pain medications [12,17]. Magnesium blocks the effects of excitatory amino acids (e.g., glutamate, aspartate) on NMDA receptors and contribute to central sensitization [18,19].

Studies on the pain control effects of magnesium have shown conflicting results. Lee et al. [20] reported that the preoperative intravenous injection of magnesium was effective in controlling postoperative pain. On the contrary, Ko et al. [21] reported that the same approach was not effective.

There are only a small number of studies that have used $MgSO_4$ during BPBs. Gunduz et al. [22] used prilocaine, a local anesthetic, during a BPB and observed that the drug, when used in combination with magnesium, prolonged the duration of the sensory and motor nerve block without causing adverse events. Goyal et al. [23] reported that the injection of $MgSO_4$ into the axillary sheath, without adding a topical anesthetic, reduced postoperative pain. In this study, we used ropivacaine in combination with magnesium during ABPBs. The use of magnesium, however, did not result in significant differences in postoperative VAS pain scores or fentanyl consumption between the two groups. Differences between this study and the study by Gunduz et al. [22] were the use of ropivacaine and the adoption of a different dose (20 ml) during the block. We used ropivacaine because it has a higher threshold value than lidocaine and offers a longer duration of action, and because it has less cardiovascular toxicity than bupivacaine. However, we note the combination of prilocaine and magnesium (the study by Gunduz et al.) and the combination of ropivacaine and magnesium (this study) might have resulted in different pain control effects of magnesium. As for our use of a smaller dose, we used 20 ml of ropivacaine because our aim was at reducing postoperative pain resulting from general anesthesia during ABPBs and not to provide an adjuvant drug for the anesthesia during a block, which was the case in the study by Gunduz et al. [22]. Another reason why we considered our selected dose to be sufficient enough to control postoperative pain was due to the study by Goyal et al. [23] that used the same dose (i.e., 20 ml) of magnesium without any other anesthetics during a BPB in order to control postoperative pain.

In this study, we did not use a control group, whereas some of the previous studies have used a control group that was administered non-steroidal anti-inflammatory drugs (NSAIDs) via intravenous injection. Technically speaking, however, a group injected with NSAIDs does not constitute a control group due to the anti-inflammatory effects of the drugs. In addition, we suspect that the use of a control group injected with normal saline solution might even lead to distinct effects of its own; moreover, the patients might experience pain or discomfort when injected with 20 ml of normal saline solution. Thus, we excluded the use of control group on ethical grounds and as a result do not know what kinds of effects a ropivacaine-only regimen would have had on postoperative pain control had it been used during ABPBs. Note that with the generally same category of upper extremity surgery, patients undergoing one may feel different postoperative pain depending on the site and type of the surgery. Although we specified what was involved in the surgery (e.g., open reduction, closed reduction, tenorrhaphy), we see the need to further specify upper extremity surgery according to its site and type. In addition, we recommend a larger sample size for future studies, considering ours was relatively small.

In this study, no serious adverse events were reported in either group. There were no significant differences between the groups in terms of occurrence of adverse events such as headaches, nausea, vomiting, and dizziness. We attribute the finding to the fact that both groups underwent general anesthesia; however, we note the fact that only one dose of magnesium was used. Future studies may need to investigate the possibilities of adverse events resulting from different doses of magnesium.

In summary, the postoperative pain control effects of 0.2% ropivacaine (20 ml) combined with magnesium used during ABPBs were compared with the effects of 0.2% ropivacaine (20 ml) combined with normal saline solution. The results show that there were no statistically significant differences between the groups in terms of their VAS pain

score, sensory and motor responsiveness, and fentanyl consumption.

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