J Anesth (1994) 8:17–20

Journal of
Anesthesia

Intravenous magnesium sulfate as a preanesthetic medication: a double-blind study on its effects on hemodynamic stabilization at the time of tracheal intubation

TETSURO KAGAWA[1], RYOKICHI GOTO[1], KATSUHIRO IIJIMA[1], YUJI KAMIKAWA[1], KEIICHI SAKAI[1], and HIDEFUMI OBARA[2]

[1] Department of Anesthesia, Hyogo Prefectural Awaji Hospital, Shimogamo 1-6-6, Sumoto, 656 Japan and [2] Department of Anesthesia, Kobe University School of Medicine, Kobe, Japan

Abstract: The effects of magnesium sulfate ($MgSO_4$) as a preanesthetic medication were studied with regard to whether it can sedate or relieve a patient who is scheduled to undergo surgery, and whether it can control the hemodynamic response to tracheal intubation. Twenty adult patients in ASA status 1–2 undergoing elective surgery were studied. Ten patients received 50 $mg \cdot g^{-1}$ $MgSO_4$ intravenously by drip infusion from 30 min before the induction of anesthesia, and another ten patients received saline as a control. The changes in mean arterial pressure (MAP) and rate pressure product (RPP) after the intubation were significantly suppressed in magnesium-treated patients, but a sedative effect was not observed. Therefore, $MgSO_4$ was useful as a preanesthetic medication in suppressing the hemodynamic response associated with tracheal intubation.

Key words: Magnesium, Preanesthetic medication, Intratracheal intubation

Introduction

$MgSO_4$ has been used for the control of convulsions in patients with toxemia of pregnancy (preeclampsia) and recently, additional physiological effects and clinical uses of this agent have been outlined [1]. The effects of magnesium on the cardiovascular system [2,3] are preferable to other preanesthetics, and at the same time, sedative effects of magnesium have been reported by several authors [4–7]. In light of these favorable reports, we investigated its effect as a preanesthetic medication.

Materials and methods

The study protocol was approved by the Human Investigation Committee of Hyogo Prefectural Awaji Hospital. Informed consent was obtained from all patients after a full explanation of the study. Twenty patients (ASA status 1–2, aged 29–64 years) were studied who were scheduled for elective surgery which required tracheal intubation. The patients were divided into two groups of ten each: (1) magnesium group, in which $MgSO_4$ was administered intravenously; and (2) control group, in which saline was administered intravenously. Both the patient and the anesthesiologist in charge were blinded to the treatment.

Blood samples were taken to measure serum electrolytes 1 h before surgery. Thirty min before the induction of anesthesia, all patients received 0.5 mg of atropine sulfate intramuscularly. At the same time, intravenous infusion of 50 $mg \cdot kg^{-1}$ $MgSO_4$ with saline was started in the magnesium group. Patients in the control group received only 100 ml saline instead. The infusion speed was controlled to take exactly 30 min.

Evaluation of the effect of magnesium as a preanesthetic sedative

In the operating room, the anesthesiologist checked the patient's response to verbal commands. If the patient was responsive, then the anesthesiologist asked about his or her feeling, sleepiness, anxiety, and other symptoms. On the 1st postoperative day, the same anesthesiologist visited the patient and asked if he or she remembered what had happened before and after surgery. The answers were rated using a semiquantitative rating scale.

Evaluation of the effects of magnesium on the cardiovascular response associated with tracheal intubation

After completion of the previous questions, heart rate (HR), blood pressure (BP), respiratory rate and lead II

Address correspondence to: T. Kagawa
Received for publication on December 11, 1992; accepted on April 8, 1993

of electrocardiogram (ECG) was recorded (Cardiocap CCI-104, DATEX Instrumentarium, Helsinki, Finland). BP was measured noninvasively and automatically by using a cuff sphygmomanometer. Patients breathed 100% oxygen via a mask for 3 min, and then anesthesia was induced with thiamylal 5 mg·kg^{-1} and vecuronium 0.1 mg·kg^{-1}. Ventilation was assisted and controlled gently, with 2% sevoflurane and 50% nitrous oxide in oxygen. Three min after the administration of thiamylal and vecuronium, direct laryngoscopy was attempted with the aid of a standard Macintosh laryngoscope blade. Intubation was finished within 20 s. HR, BP, and ECG were recorded at 1, 2, 5, and 10 min after the initiation of laryngoscopy. MAP was calculated from systolic and diastolic arterial pressure. RPP was the product of systolic arterial pressure and heart rate. Blood samples were taken for the measurement of plasma catecholamines (epinephrine and norepinephrine) at 1 min before and 2 min after intubation, and for the measurement of serum electrolytes at 2 min after intubation. Plasma catecholamines were measured by the high-performance liquid chromatography (HPLC) method, and its lower limit of sensitivity was 0.1 ng·ml^{-1}.

The degree of neuromuscular blockade was checked by a transcutaneous electrical nerve stimulation (TENS) unit (Tristim, Model NS-3A, Life-Tech Houston, Tex.).

All data in the two groups were statistically compared using the Mann-Whitney U-test, and the degrees of sedation were evaluated with the chi-square test. A P value of less than 0.05 was considered statistically significant. Results are reported as mean ± SD.

Results

There were no significant differences between two groups in age, weight, gender, and baseline levels of serum Na^+, K^+, Ca^{2+}, and Mg^{2+}. Serum magnesium increased from 0.90 ± 0.14 mmol·l^{-1} to 1.47 ± 0.20 mmol·l^{-1} in the magnesium group. Other electrolytes were not changed by magnesium infusion. Signs of hypermagnesemia such as dyspnea, muscle weakness, loss of deep tendon reflex, and ECG abnormalities were not observed.

Effect of magnesium as a preanesthetic sedative

At the termination of magnesium or saline infusion, all patients were awake and responsive. There were no significant differences between the two groups in the degrees of feeling, sleepiness, anxiety, and amnesia. From these results, $MgSO_4$ was shown to have no sedative effects at the serum level used in this study.

Cardiovascular response associated with tracheal intubation

HR and MAP showed no significant differences between the two groups before the induction of anesthesia.

Figures 1 and 2 indicate changes in MAP and RPP, respectively. At 1 min and 2 min after intubation, the changes in MAP and RPP were significantly suppressed in the magnesium group compared with the control group ($P < 0.05$). However, HR increased equally in both groups. HR, MAP, and RPP at 5 and 10 min after intubation were not significantly different.

Plasma catecholamine concentrations were similar between the two groups before intubation. They slightly increased after intubation, but no difference between the groups was detected. The duration of skeletal muscle relaxation tended to be prolonged in the magnesium group, but the difference was not significant.

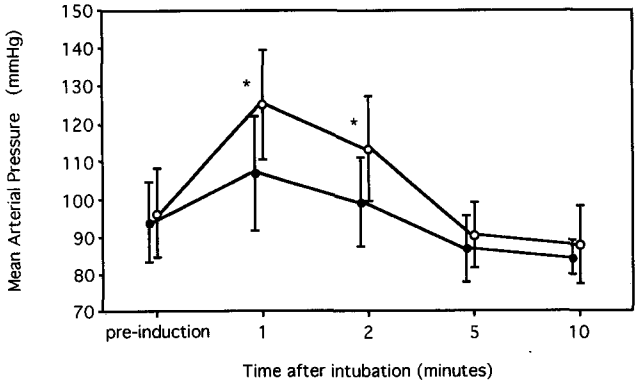

Fig. 1. Changes in mean arterial pressure (mean ± SD) before and after induction with prior magnesium or saline (control). *Closed circles*, magnesium; *open circles*, control. *$P <$ 0.05 for differences between groups

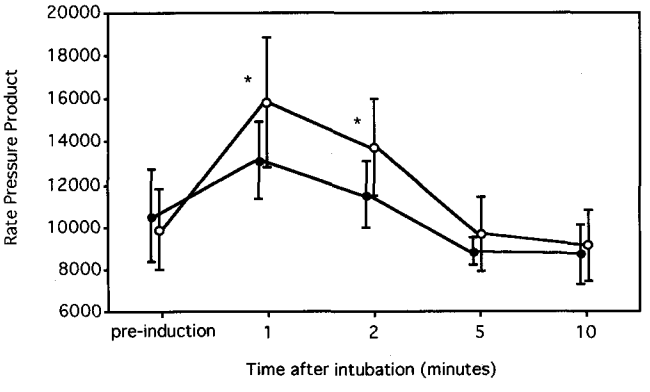

Fig. 2. Changes in rate pressure product (mean ± SD) before and after induction with prior magnesium or saline (control). *Closed circles*, magnesium; *open circles*, control. *$P < 0.05$ for differences between groups

Discussion

Method of magnesium administration

Serum concentration of magnesium in normal patients ranges from 0.75 to 1.0 mmol·l^{-1}, and 2.0–4.0 mmol·l^{-1} is necessary to control convulsion induced by pre-eclampsia. Magnesium therapy is usually initiated by a slow intravenous administration of 40–60 mg·kg^{-1} of $MgSO_4$ [8]. To achieve a therapeutic level of serum magnesium, it should be administered parenterally not only because magnesium is poorly absorbed from the gastrointestinal tract but also because renal elimination of excessive magnesium is extremely rapid [1]. Rapid intravenous injection of $MgSO_4$ to awaken patients may cause side effects such as a sensation of heat, bradycardia, hypotension, and loss of deep tendon reflex. Therefore, 50 mg·kg^{-1} $MgSO_4$ were administered by a drip infusion from 30 min before the induction of anesthesia to achieve the highest concentration of serum magnesium during the operation.

Effect of magnesium as a preanesthetic medication

The sedative effect of magnesium was first described by several authors in the early 1900s [4–6], and in 1988, Thompson et al. [7] reported that the alveolar halothane MAC could be reduced by 20% at plasma magnesium concentrations of 2.9–4.5 mmol·l^{-1} achieved in pregnant rats. This suggests that the administration of $MgSO_4$ before the induction of anesthesia may cause sedation. However, contrary to our expectations, no such effect was observed, although this may be due to the lower serum concentration of magnesium used in the present study compared to that used in Thompson's study. If sedation with magnesium is possible, it may be that a massive injection is required, and this may provoke an unpleasant feeling. As a result, $MgSO_4$ does not seem to be a viable candidate as a preanesthetic sedative.

Second, magnesium has many beneficial effects on the human cardiovascular system. Altura et al. [2] reported that magnesium acts as a "natural calcium antagonist" because it blocks Ca^{2+} ion channels in vascular membranes, and it can lower cerebral, coronary, and peripheral vascular resistance and relieve vasospasm. Magnesium is also effective in the treatment of several types of arrhythmia [9]. James [10] described that magnesium inhibited the release of catecholamines and acted as a catecholamine receptor antagonist. He also said the pretreatment with 60 mg·kg^{-1} intravenous $MgSO_4$ could suppress increases in plasma norepinephrine and epinephrine, and in HR 2 min after tracheal intubation [11]. However, he administered $MgSO_4$ as a single rapid intravenous injection after loss of consciousness.

In our study, magnesium showed desirable effects on BP and RPP change associated with tracheal intubation. How did magnesium affect the cardiovascular system? There were no differences in HR, MAP, and RPP just after the administration of magnesium or saline alone. In other words, magnesium itself did not change hemodynamics. The changes in MAP and RPP were suppressed after intubation in the magnesium group, but plasma catecholamines were not different between the two groups. These results indicate that lower BP after intubation in magnesium-treated patients was: (1) not caused by magnesium-induced vasodilation, and (2) not caused by inhibition of plasma catecholamine release. From these findings, the cardiovascular-suppressive effect of magnesium is thought to be mediated by blunting the contractile response of vascular tissue to catecholamines, including blocking catecholamine receptors [12,13].

Plasma magnesium concentration was 2.95 ± 0.56 mmol·l^{-1} in the study of James et al. [11], but our study proved that hemodynamic control could be achieved with a lower concentration. Considering that magnesium reduces myocardial oxygen demand [3] and improves uterine blood flow [14], judicious use may be advantageous in patients with ischemic cardiac disease or gestational proteinuric hypertension, and further study on these patients is required.

References

1. James MFM (1992) Clinical use of magnesium infusions in anesthesia. Anesth Analg 74:129–136
2. Altura BM, Altura BT, Carella A, et al. (1987) Mg^{2+}-Ca^{2+} interaction in contractility of vascular smooth muscle: Mg^{2+} versus organic calcium channel blockers on myogenic tone and agonist-induced responsiveness of blood vessels. Can J Physiol Pharmacol 65:729–745
3. Altura BM (1988) Ischemic heart disease and magnesium. Magnesium 7:57–67
4. Meltzer SJ, Auer J (1906) Physiological and pharmacological studies of magnesium salts. Am J Physiol 15:387–405
5. Peck CH, Meltzer SJ (1916) Anesthesia in human beings by intravenous injection of magnesium sulphate. JAMA 67:1131–1133
6. Moore RM, Wingo WJ (1942) Blood level of magnesium ion in relation to lethal, anesthetic, analgesic and antitetanic effects. Am J Physiol 135:492–495
7. Thompson SW, Moscicki JC, DiFazio CA (1988) The anesthetic contribution of magnesium sulfate and ritodrine hydrochloride in rats. Anesth Analg 67:31–34
8. Gutsche BB, Cheek TG (1987) Anesthetic considerations in preeclampsia-eclampsia. In: Shnider SM (ed) Anesthesia for Obstetrics. Williams and Wilkins, Baltimore, p 230
9. Iseri LT, Allen BJ, Brodsky MA (1989) Magnesium therapy of cardiac arrhythmias in critical care medicine. Magnesium 8:299–306

10. James MFM (1985) The use of magnesium sulfate in the anesthetic management of pheochromocytoma. Anesthesiology 62:188–190
11. James MFM, Beer RE, Esser JD (1989) Intravenous magnesium sulfate inhibits catecholamine release associated with tracheal intubation. Anesth Analg 68:772–776
12. Zaloga G, Eisenach JC (1991) Magnesium, anesthesia, and hemodynamic control. Anesthesiology 74:1–2
13. Cohen L, Kitzes R (1984) Magnesium sulfate in the treatment of variant angina. Magnesium 3:46–49
14. Aldrete JA (1987) Magnesium physiology and pharmacology in anesthesia. Anesthesiol Rev 14:33–39