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ORIGINAL ARTICLE

Preoperative $MgSO_4$ treatment's effect on depth of anesthesia during general anesthesia for cesarean section evaluated by bispectral index monitoring

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ABSTRACT

Objective: The depth of anesthesia is adjusted by the dosage of anesthetic agents used. During cesarean section, parenteral opioid analgesics can cause side effects for both the pregnant individual and the fetus. Because of these risks, using lower doses of medication is preferred; however, this comes with a significant challenge, such as keeping the patient awake. Adjuvant substances that reduce the required dosage and increase the effectiveness of anesthetic agents are therefore needed. Magnesium sulfate ($MgSO_4$) is one of the most commonly used minerals as an adjuvant in anesthesia. The efficiency of perioperative $MgSO_4$ use on the depth of anesthesia and hemodynamic changes in patients undergoing general anesthesia during cesarean surgeries was investigated using Bispectral Index Monitoring.

Material and Methods: Thirty-six patients who received $MgSO_4$ intravenous treatment before the cesarean section (Group 1) and 36 patients who did not receive $MgSO_4$ treatment as controls (Group 2) were evaluated. For both groups, blood pressure, heart rate, and oxygen saturation parameters (SBP, DBP, MBP, HR, SpO_2) were collected for hemodynamic comparison, and BIS values were collected for the evaluation of anesthesia depth. BIS measurements were grouped into two categories for statistical analysis regarding anesthesia depth levels: values of 0–60 were accepted as hypnosis, and 60–80 were accepted as sedation.

Results: There was no statistically significant difference between Group 1 and Group 2 in terms of demographic data, ASA, SBP, DBP, MBP, HR, and SpO_2 values. However, there were statistically significant differences between the BIS and anesthesia depth levels of Group 1 and Group 2 at the 5^{th}, 10^{th}, 14^{th}, 18^{th}, 22^{nd}, 26^{th}, and 30^{th} minutes of the operation. For intragroup time interval comparisons, the changes in SBP and HR values at the 26^{th} and 30^{th} minutes were found to be significantly lower than the baseline values in Group 1.

Conclusion: This study showed that the administration of $MgSO_4$ in the preoperative period of cesarean sections could provide a stable and deep level of anesthesia using the same doses of anesthetic substances in pregnant individuals.

Keywords: Awakeness, BIS, cesarean, depth of anesthesia, magnesium, $MgSO_4$.

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INTRODUCTION

Depth of anesthesia is achieved by the combination of two drug effects that are essential to clinical anesthesia.[1] One of the drug's effects is hypnosis, which induces unconsciousness. Analgesics, which lessen the body's reactive response to painful stimuli, have the second effect. Therefore, depth of anesthesia is adjusted by the amount of anesthetic agents used. During cesarean section, the second effect, which is achieved by parenteral opioid analgesics, suppresses maternal respiration and can also cause nausea, vomiting, and a delay in gastric emptying. Additionally, they can easily cross the placenta and affect the fetüs.[2] Because of these factors, it is preferred to use lower doses of medication during anesthesia induction. Using low doses of anesthetic agents poses an important problem, such as keeping the mother awake.

To determine anesthesia depth, electroencephalography (EEG) is the verifiable evaluation method, and the bispectral index (BIS) is a processed EEG parameter that measures the hypnotic effects of anesthesia. Monitoring patients with BIS during anesthesia ensures that patients are not awake by monitoring their anesthesia depth level and helps to adjust the dose of anesthetic agents.[3,4] On the BIS monitor, the awakeness level is represented by a value between 0 and 100. A value of 100 reflects the state of wakefulness, 80 reflects light sedation, 60 reflects the medium hypnotic level, and 40 reflects the deep hypnotic level.[3,4]

The monitoring of the anesthetic agent is important to minimize side effects and guarantee a sufficient degree of unconsciousness during a cesarean section. Moreover, using high doses of anesthetic agents to keep the depth of anesthesia at the preferred level can cause unwanted side effects in a pregnant woman.[5] All these factors show that there is a necessity to use adjuvant substances to reduce the doses of the anesthetic agents.[6]

Magnesium sulfate ($MgSO_4$) is one of the most common minerals used as an adjuvant in anesthesia.[7,8] By decreasing the release of acetylcholine and blocking calcium channels, $MgSO_4$ magnifies the effectiveness of anesthetics and achieves suitable anesthetic depth at lower doses of the anesthetic agents.[9–11] Due to the vasodilatory effect of $MgSO_4$ and its outcomes on heart rate, $MgSO_4$ may help to sustain cardiovascular stability. Adjunctive use of $MgSO_4$ may diminish some dose-related adverse effects of anesthetics, such as hemodynamic instability, respiratory depression, or delayed recovery from anesthesia, by resulting in a dose reduction of the main anesthetics.[12–14]

The influence of magnesium on the depth of anesthesia is still controversial, and limited studies are available in the current literature. Therefore, the efficiency of perioperative $MgSO_4$ use on depth of anesthesia and hemodynamic changes in patients who undergo general anesthesia during cesarean section surgeries was investigated in this study.

MATERIAL AND METHODS

Patient Selection

From February 2010 through March 2010, the medical data of all pregnant patients who underwent cesarean section under general anesthesia were reviewed retrospectively. The patients were identified by a computerized search of the medical records of our hospital. The study was approved by the ethics committee of our hospital (89536203-903.05.02) and performed in accordance with the guidelines of the Helsinki II Declaration.

Table 1: Demographic data and characteristics of groups

	Group 1 (n=36)	Group 2 (n=36)	p
Age (year)	28.9±5.3	29±4.6	0.90
Height (cm)	162.5±5.3	164±6	0.29
Weight (kg)	77.6±10	80.1±10.6	0.30
ASA	34/2	35/1	1
Anesthesia time (min)	52.9±10.9	50.9±12.6	0.37
Operation time (min)	47.9±10.9	45.9±12.6	0.38

cm: Centimeter; kg: Kilograms; ASA: American Society of Anesthesiologists.

ASA 2 and 3 patients and/or preeclamptic patients who received intravenous $MgSO_4$ infusion treatment before cesarean section were included in the study. Hypertensive patients who took medication but still had BP >140/80 mmHg, patients with coronary artery disease, heart valve disease, arrhythmia, severe eclampsia and HELLP syndrome, and patients under 18 years of age were excluded. In total, 36 consecutive patients who received $MgSO_4$ were identified. After the constitution of Group 1 (patients who received $MgSO_4$), the control group (Group 2) parturients who did not receive $MgSO_4$ were selected according to similar demographic findings by a computerized search. To prevent selection bias, BIS and hemodynamic values in both groups were collected after selection.

Anesthesia induction of parturients was performed with 1.5 mg/kg propofol and 0.6 mg/kg rocuronium, and sevoflurane inhaler gas at 3 L/min of 50% O_2 and 50% N_2O was used for maintenance. After birth, 1 mcg/kg of IV fentanyl was applied while keeping the patient's minimum alveolar concentration constant.

The standard protocol of $MgSO_4$ is a loading dose of 4.5 g $MgSO_4$ in 150 ml 5% dextrose as a slow IV infusion, and the maintenance dose is a continuous infusion of 20 g $MgSO_4$ (1.5–2 grams/hour).

For both groups, blood pressure, heart rate, and oxygen saturation parameters (SBP, DBP, OBP, HR, SpO_2) were collected for hemodynamic comparison, and BIS values were collected for the evaluation of anesthesia depth. In our clinic, the anesthesia depth of parturients is routinely evaluated with BIS during cesarean section surgeries. All data were recorded at baseline, induction, 1st minute, 3rd minute, 5th minute, 10th minute, 14th minute, 18th minute, 22nd minute, 26th minute, 30th minute, and the end of anesthesia. Finally, 36 patients (age 18–42, term gestational weeks) in Group 1 and 36 patients (age 18–42, term gestational weeks) in Group 2 were included in the study.

Statistical Analysis

SPSS software (ver. 21.0 for Windows; SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Descriptive statistics are given with mean, standard deviation, median, minimum, and maximum values

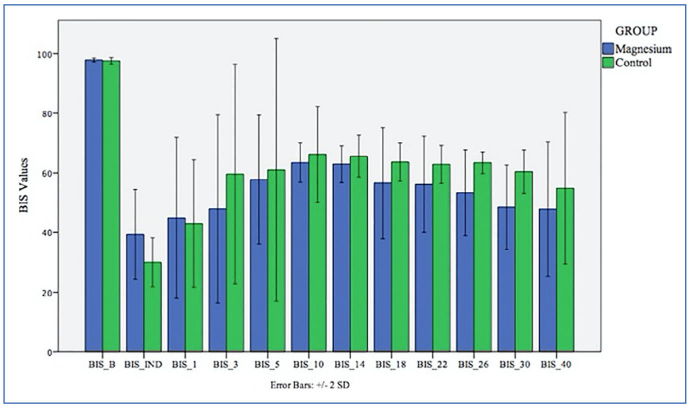

Figure 1: Graph showing the mean-BIS values of the groups by time.

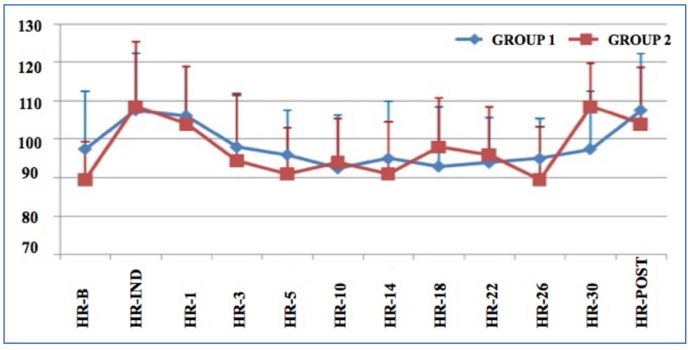

Figure 2: Graph showing the heart rate values of the groups by time.

or with frequency and percent for continuous or qualitative variables, respectively. The Shapiro-Wilk test was used for tests of normality. The independent samples t-test was used for two-group comparisons of normally distributed variables. For non-normally distributed variables, the Kruskal-Wallis test was performed for independent group comparisons. The Bonferroni-corrected Mann-Whitney U test was used for post-hoc analysis. Statistical analyses of time comparisons within the group were made using the Friedman test. For all statistical comparisons, a p value below 0.05 was assumed to be statistically significant.

RESULTS

There was no statistically significant difference between Group 1 (magnesium group) and Group 2 (control group) in terms of demographic data and ASA values ($p>0.05$) (Table 1).

The BIS values of both groups were collected and compared over anesthesia time (Table 2). The BIS values measured after 40 minutes (BIS-50, 60, and 70) were excluded from statistical analysis.

Intergroup Data Comparison

In terms of SBP, DBP, MBP, HR, and SpO_2, there was no statistically significant difference between the groups ($p>0.05$). During intubation, no increase was observed in either HR or BP in both groups, and no significant difference was found between the groups.

Statistical evaluation in terms of BIS values was made separately between groups for each measurement time (Fig. 1). Significant differences between Group 1 and Group 2 were found at the 5th, 10th, 14th, 18th, 22nd, 26th, and 30th minutes ($p<0.05$) (Table 2). No statistically significant difference was found between groups at induction, 1st, 3rd, and 40th minutes of operation.

Table 2: The mean-BIS values and the patients' numbers according to timetable

Groups	n	Mean	SD	Std. Error Mean
BIS_B				
Magnesium	36	97.89	0.398	0.066
Control	36	97.69	0.822	0.137
BIS_IND				
Magnesium	36	32.94	7.968	1.328
Control	36	31.94	6.719	1.120
BIS_1				
Magnesium	36	43.50	11.653	1.942
Control	36	42.64	11.509	1.918
BIS_3				
Magnesium	36	52.47	11.616	1.936
Control	36	55.81	13.827	2.305
BIS_5				
Magnesium	36	60.50	6.708	1.118
Control	36	63.69	9.838	1.640
BIS_10				
Magnesium	36	63.25	2.222	0.370
Control	36	65.81	6.418	1.070
BIS_14				
Magnesium	36	61.89	3.592	0.599
Control	36	66.39	5.056	0.843
BIS_18				
Magnesium	35	59.57	5.797	0.980
Control	36	64.53	5.283	0.881
BIS_22				
Magnesium	33	59.64	6.968	1.213
Control	31	62.29	6.214	1.116
BIS_26				
Magnesium	25	55.84	7.548	1.510
Control	22	59.55	6.545	1.395
BIS_30				
Magnesium	12	49.33	8.015	2.314
Control	11	58.64	4.342	1.309
BIS_40				
Magnesium	9	47.78	11.289	3.763
Control	5	54.80	12.696	5.678

BIS: Bispectral index; SD: SD: Standard deviation.

Table 3: Comparison of anesthesia dept levels between groups

	Group 1 ($MgSO_4$)	Group 2 (Control)	p
BIS_1			1
Sedation	4 (11.1%)	4 (11.1%)	
Hypnosis	32 (88.9%)	32 (88.9%)	
BIS_3			0.35
Sedation	16 (44.4%)	21 (58.3%)	
Hypnosis	20 (55.6%)	15 (41.7%)	
BIS_5			0.735
Sedation	30 (83.3%)	32 (88.9%)	
Hypnosis	6 (16.7%)	4 (11.1%)	
BIS_10			1
Sedation	33 (91.7%)	33 (91.7%)	
Hypnosis	3 (8.3%)	3 (8.3%)	
BIS_14			0.29
Sedation	30 (83.3%)	33 (91.7%)	
Hypnosis	6 (16.7%)	3 (8.3%)	
BIS_18			0.09
Sedation	24 (68.6%)	31 (86.1%)	
Hypnosis	11 (31.4%)	5 (13.9%)	
BIS_22			0.04
Sedation	16 (48.5%)	23 (74.2%)	
Hypnosis	17 (51.5%)	8 (25.8%)	
BIS_26			0.04
Sedation	7 (28%)	13 (59.1%)	
Hypnosis	18 (72%)	9 (40.9%)	
BIS_30			0.15
Sedation	1 (8.3%)	4 (36.4%)	
Hypnosis	11 (91.7%)	7 (63.6%)	
BIS_40			0.65
Sedation	1 (11.1%)	1 (20%)	
Hypnosis	8 (88.9%)	4 (80%)	

BIS: Bispectral index.

BIS measurements were grouped into two categories regarding anesthesia depth levels for statistical analysis: 0–60 values were accepted as hypnosis, and 60–80 were accepted as sedation. Statistical evaluation in terms of anesthesia depth levels was made separately between groups for each measurement time. Statistically significant differences in anesthesia depth levels between Group 1 and Group 2 were found at the 5th, 10th, 14th, 18th, 22nd, 26th, and 30th minutes of operation ($p<0.05$) (Table 3). In terms of anesthesia depth level, there was no statistically significant difference between groups at induction, 1st, 3rd, and 40th minutes of operation.

Intragroup Time Intervals' Data Comparison

In terms of DBP and SpO_2, there was no statistically significant difference between time intervals in each group separately ($p>0.05$). In terms of SBP, no statistically significant difference was found in the intra-group evaluation for Group 2. In Group 1, the change in SBP value at the 26th minute was found to be significantly lower than the baseline value ($p<0.01$). No difference was found in terms of MBP changes between measurement times compared to the baseline value in the intra-group evaluation for Group 2. In Group 1, the 30th-minute MBP value change was found to be significantly lower than the baseline value ($p<0.05$). No statistically significant difference was found in the change in HR between measurement times compared to the baseline value in the intra-group evaluation for Group 2. In Group 1, the 30th-minute HR value change was found to be significantly lower than the baseline value ($p<0.05$) (Fig. 2). BIS values regarding time comparisons within the group were evaluated separately for each group. In Group 1, the changes in BIS values at induction, 1st minute, 3rd minute, 18th minute, 22nd minute, 26th minute, and 30th minute were found to be significantly lower than the baseline value ($p<0.05$). Similarly, in Group 2, the comparison of BIS values at induction, 1st minute, 3rd minute, 18th minute, 22nd minute, 26th minute, and 30th minute to the baseline value in the intra-group evaluation was found to be significant ($p<0.05$).

DISCUSSION

During endotracheal intubation, the management of tachycardia and blood pressure is one of the essential challenges, especially during cesarean section and pheochromocytoma surgery. $MgSO_4$ has attracted attention in recent years for its use in anesthesia and intensive care due to its vasodilatory and antiarrhythmic properties, which may help maintain cardiovascular stability and control hypertension. These effects also lead to a decrease in the use of anesthetic and analgesic drugs.[6,15]

Several studies have demonstrated the effectiveness of $MgSO_4$ in stabilizing BP and HR changes associated with intubation.[7,8,14,16] Conversely, our study showed that $MgSO_4$ infusion did not have any superiority as an adjuvant agent regarding BP and HR during general anesthesia and intubation. Similarly, James et al.[17] compared 60 mg/kg $MgSO_4$ administered after thiopental with a control group in terms of catecholamine release and cardiovascular response due to tracheal intubation. They found that after intubation, there were no HR changes in the magnesium group, whereas in the control group, HR increased. Although they reported that SBP increased in both groups, it was statistically less in the magnesium group compared to the control group.

In the study by Amer et al.,[18] the effect of $MgSO_4$ on SBP, DBP, MBP, and HR values was not found to be statistically significant between the groups. Similarly, our study did not show any statistically significant changes in terms of HR and SBP after intubation in both groups. Nevertheless, we observed that between 25 and 30 minutes of the operation, the hemodynamic values of the patients who received $MgSO_4$ were more stable than those of the control group.

BIS is the most valuable method to evaluate anesthesia depth. Our study showed that both groups had similar BIS values and anesthesia depth levels during the first 5 minutes of induction. This situation is likely related to the adrenergic stimulation caused by intubation, and these findings are similar to the study of Lee et al.[6] Similarly, in our study, after the elimination of adrenergic stimulation, Group 1 had lower BIS values than Group 2. This result is likely associated with the NMDA receptor antagonist effect of $MgSO_4$ on the central nervous system.

One of the functions of NMDA receptors is the transmission of pain signals. These receptors are inhibited by magnesium, which may decrease the perception of pain and modulate pain pathways. The interaction of magnesium with calcium causes inhibition of calcium channels, which may impact the release of pain-signaling neurotransmitters, potentially reducing the intensity of pain.[19–21] However, the effects of $MgSO_4$ on the central and peripheral nervous systems have been studied, and controversial results have been published, especially regarding its neuroprotective effects on the CNS. We believe that the NMDA receptor antagonist effect of $MgSO_4$ is a key factor influencing anesthesia depth levels.[5]

Furthermore, this study reported that sufficient anesthesia depth was achieved in only 40.9% of patients without $MgSO_4$ and 72% of patients with $MgSO_4$ at the 26th minute of induction. The anesthesia depth levels in both groups demonstrated that most parturients undergoing cesarean section did not reach the level of hypnosis. This finding underscores the necessity of using an adjuvant agent to achieve a deeper level of anesthesia with the same dose of anesthetic agent or, if possible, to reduce the amount of anesthetic agent during cesarean sections in routine practice. Ultimately, this result supports that $MgSO_4$ is an effective and safe adjuvant agent in anesthesia.

This study has several limitations. The first limitation is the small sample size from a single center, which could lead to selection bias. To minimize this bias, we attempted to include all patients who met the inclusion criteria. Another limitation is the small number of patients observed after 30 minutes of induction, which is related to the duration of cesarean sections. Additionally, the blood magnesium levels in patients receiving $MgSO_4$ therapy are unknown, though a standard magnesium therapy protocol was applied to all patients. It is also worth noting that the elimination time of magnesium from the blood is 24 hours, and it is almost exclusively excreted in the urine.[22]

CONCLUSION

This study revealed that the administration of $MgSO_4$ in the preoperative period of cesarean sections could provide a stable and deep level of anesthesia using the same doses of anesthetic substances in pregnant women. Therefore, further research is needed to standardize the loading and maintenance doses and the preoperative administration time of $MgSO_4$ for its most effective use as an adjuvant substance.

Statement

Conflict of Interest: The author have no conflict of interest to declare.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Use of AI for Writing Assistance: Not declared.

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