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Original Research Article

"EFFECT OF INTRAVENOUS MAGNESIUM SULFATE ON HEMODYNAMIC RESPONSES DURING LAPAROSCOPIC CHOLECYSTECTOMY"

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Abstract

ABSTRACT

Background: During laparoscopic cholecystectomy, laryngoscopy, endotracheal intubation, and carbon dioxide pneumoperitoneum are linked to considerable sympathetic activation that causes hemodynamic oscillations. Magnesium sulfate may help reduce these reactions and enhance perioperative stability because of its sympatholytic and calcium antagonistic qualities.

Aim & Objectives: To assess how intravenous magnesium sulfate affects hemodynamic reactions in patients having laparoscopic cholecystectomy under general anesthesia during endotracheal intubation and pneumoperitoneum.

Methodology: One hundred patients undergoing elective laparoscopic cholecystectomy under general anesthesia participated in this hospital-based prospective interventional comparative study. Patients were divided into two groups of fifty at random. Prior to induction, Group A was given 30 mg/kg of magnesium sulfate intravenously, while Group B was given regular saline. Perioperative hemodynamic parameters were measured, including heart rate, mean arterial pressure, systolic and diastolic blood pressure, and SpO_2. Complications, analgesic need, and postoperative pain levels were all evaluated. SPSS version 30 was used for the statistical analysis, and $p<0.05$ was regarded as statistically significant.

Results: Magnesium sulfate-treated patients showed considerably lower mean arterial pressure and perioperative heart rate than the control group ($p<0.001$). Group A had significantly lower postoperative pain levels and a lower need for rescue analgesics. In contrast to none in Group B, 52% of patients in Group A had minimal pain levels (NRS 0–2). The magnesium sulfate group experienced fewer perioperative problems ($p=0.03$).

Conclusion: During laparoscopic cholecystectomy, intravenous magnesium sulfate improved perioperative stability with an acceptable safety profile, decreased the need for postoperative analgesics, and successfully suppressed hemodynamic responses during intubation and pneumoperitoneum.

Keywords: Magnesium sulfate, hemodynamic response, pneumoperitoneum, endotracheal intubation, laparoscopic cholecystectomy, general anaesthesia.

Introduction

Because laparoscopic cholecystectomy has several advantages over open surgery, such as decreased postoperative pain, a shorter hospital stay, early ambulation, quicker recovery, and better cosmetic results, it is currently considered the gold standard surgical procedure for the management of benign gallbladder diseases. [1, 2, 3, 4] Despite these benefits, major hemodynamic changes during crucial perioperative events like endotracheal intubation and the development of carbon dioxide pneumoperitoneum are linked to laparoscopic procedures. [5,6,7]

Because they activate somatic and visceral afferent fibers, laryngoscopy and endotracheal intubation are two of the most stimulating aspects of general anesthesia and are known to cause severe sympathetic stimulation. This leads to elevated myocardial oxygen demand, hypertension, and brief tachycardia. [5, 8, 9] These reactions are typically well tolerated in healthy people, but in patients with cardiovascular compromise, elevated intracranial pressure, or elevated intraocular pressure, they may cause major complications like myocardial ischemia, arrhythmias, left ventricular failure, or cerebrovascular events. [10]

Increased intra-abdominal pressure and carbon dioxide insufflation exacerbate the physiological stress response during laparoscopic surgery. Hypercarbia, catecholamine release, vasopressin secretion, increased systemic vascular resistance, and decreased venous return are all consequences of pneumoperitoneum that raise arterial blood pressure and heart rate. [6, 7, 11] Furthermore, by reducing venous return and cardiac output, patient posture during laparoscopic cholecystectomy—especially the reverse Trendelenburg position—may further jeopardize cardiovascular stability. [12,13,14]

To lessen these hemodynamic reactions, a variety of pharmacological agents have been used, such as opioids, beta blockers, alpha-2 agonists, vasodilators, and calcium channel blockers. Nevertheless, many of these medications have side effects, including excessive sedation, respiratory depression, bradycardia, hypotension, delayed recovery, and postoperative nausea and vomiting. [6, 7, 15, 16] As a result, the hunt for a safer and more efficient supplement that can offer hemodynamic stability with few adverse effects is still ongoing.

An essential intracellular cation and physiological calcium antagonist, magnesium sulfate ($MgSO_4$) has become a viable anesthetic adjunct. [12, 17] Magnesium works by blocking the release of catecholamines from the adrenal medulla and adrenergic nerve terminals, blocking N-methyl-D-aspartate (NMDA) receptors, and controlling the flow of calcium across cell membranes. [17, 18, 12, 19] These characteristics help to reduce the need for perioperative anesthesia and analgesics, as well as attenuate sympathetic responses, vasodilation, bronchodilation, and analgesia. [18,12,20]

Intravenous magnesium sulfate has been shown in numerous trials to be effective in reducing hemodynamic reactions during laryngoscopy, endotracheal intubation, and pneumoperitoneum during laparoscopic procedures. [21] Magnesium supplementation has been shown to lower heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure. It has also been shown to improve perioperative stability and reduce the need for postoperative analgesics. [21] Nevertheless, more assessment of its effectiveness and safety in ordinary laparoscopic anesthesia practice is necessary due to differences in dosage regimens, study methodologies, and patient groups.

In order to determine how intravenous magnesium sulfate affected hemodynamic parameters during endotracheal intubation and pneumoperitoneum in patients undergoing laparoscopic cholecystectomy under general anesthesia, as well as how it affected the need for postoperative analgesics and perioperative hemodynamic stability, the current study was conducted.

Methodology:

Study Design and Setting

The present study was a hospital-based prospective interventional comparative study conducted in the Department of Anaesthesiology and Critical Care, Muzaffarnagar Medical College, Muzaffarnagar. The study was carried out over a period of 18 months after obtaining approval from the Institutional Ethics Committee.

Study Population

The study population comprised adult patients of either sex scheduled for elective laparoscopic cholecystectomy under general anaesthesia. Patients fulfilling the predefined eligibility criteria were enrolled after obtaining written informed consent.

Sample Size and Group Allocation

A total of 100 patients were included in the study and randomly allocated into two equal groups of 50 patients each using a computer-generated randomization method.

Group A (Magnesium Sulfate Group, n=50): Patients received intravenous magnesium sulfate.

Group B (Control Group, n=50): Patients received an equivalent volume of normal saline.

Pre-Anaesthetic Evaluation and Baseline Assessment

All patients underwent a detailed pre-anaesthetic evaluation one day prior to surgery. A complete history, physical examination, and routine preoperative investigations were performed. Baseline parameters including serum magnesium level, respiratory rate, oxygen saturation (SpO_2), heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure (MAP) were recorded.

Study Intervention

After randomization, patients received the assigned study intervention before induction of general anaesthesia.

Patients in Group A received intravenous magnesium sulfate 30 mg/kg, diluted in normal saline and administered over a period of 5 minutes before induction of anaesthesia.

Patients in Group B received an equivalent volume of normal saline administered over 5 minutes before induction.

Anaesthetic Technique

A standardized anaesthetic protocol was followed for all patients. Premedication was administered with intravenous midazolam and fentanyl. Induction of anaesthesia was performed using propofol, and succinylcholine was used to facilitate endotracheal intubation.

Anaesthesia was maintained with oxygen, nitrous oxide, isoflurane, and vecuronium bromide. Pneumoperitoneum was created during laparoscopic surgery, and intra-abdominal pressure was maintained between 12–14 mmHg.

Intraoperative Monitoring and Assessment

Hemodynamic parameters were monitored throughout the perioperative period. Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were recorded at predefined time points:

- Baseline (before study drug administration)
- Immediately after intubation
- At regular intraoperative intervals
- During the recovery period

Any intraoperative hemodynamic variations and adverse events were documented.

Postoperative Assessment

Postoperative pain intensity was assessed using the Numerical Rating Scale (NRS). Patients were monitored for postoperative complications and adverse effects. The requirement for rescue analgesics during the postoperative period was recorded and compared between the two groups.

Data Collection

Data were collected using a structured proforma. The collected variables included:

- Demographic characteristics
- Baseline clinical parameters
- Intraoperative hemodynamic variables
- Postoperative pain scores
- Postoperative analgesic requirement
- Perioperative adverse effects

All collected data were entered into a Microsoft Excel database for statistical analysis.

Inclusion Criteria

1. Patients fulfilling the following criteria were included in the study:
2. Age between 20–60 years
3. Patients of either sex
4. American Society of Anesthesiologists (ASA) physical status I and II
5. Patients scheduled for elective laparoscopic cholecystectomy under general anaesthesia
6. Patients willing to participate and providing written informed consent

Exclusion Criteria

Patients with any of the following conditions were excluded:

1. ASA physical status III and IV
2. Pre-existing hypertension
3. Hypomagnesemia or hypermagnesemia
4. Known allergy to study drugs
5. Uncontrolled diabetes mellitus
6. Ischaemic heart disease
7. Severe hepatic, endocrine, renal, or cardiac dysfunction
8. Gallstone pancreatitis
9. Alcohol abuse
10. Bleeding disorders
11. Patients receiving calcium channel blockers
12. Conversion of laparoscopic surgery to open surgery

Statistical Analysis

The collected data were analyzed using Statistical Package for Social Sciences (SPSS) version 30. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.

For comparison between the two groups, the independent Student's t-test was applied for continuous variables, while the paired t-test was used for intragroup comparisons. Categorical variables were analyzed using the Chi-square test.

A p-value <0.05 was considered statistically significant.

Results:

In terms of age, gender distribution, weight, and ASA physical state (p>0.05), Table 1 shows that both groups were equivalent. However, the control group's baseline heart rate and mean arterial pressure were considerably higher than those of the magnesium sulfate group (p<0.0001). Group A had a considerably higher baseline oxygen saturation than Group B (p<0.0001).

Following endotracheal intubation, individuals receiving intravenous magnesium sulfate had significantly lower heart rate responses than the control group at all observed time intervals (p<0.0001), as shown in Table 2. Group A's heart rate gradually decreased after intubation, while Group B's tachycardic reactions persisted. This suggests that magnesium sulfate successfully reduced the sympathetic hemodynamic reaction linked to endotracheal intubation and laryngoscopy.

When compared to the control group, intravenous magnesium sulfate significantly improved hemodynamic stability during pneumoperitoneum (Table 3). When compared to Group B, patients in Group A maintained considerably lower heart rates during the pneumoperitoneum period and the postoperative phase ($p<0.0001$). These results imply that during laparoscopic cholecystectomy, magnesium sulfate successfully reduced the sympathetic cardiovascular response linked to carbon dioxide pneumoperitoneum.

In comparison to the control group, patients receiving intravenous magnesium sulfate showed significantly lower postoperative pain levels and less need for analgesics (Table 4). While a higher percentage of patients in Group B reported moderate-to-severe pain scores, over half of the patients in Group A reported mild pain scores (NRS 0–2). The control group had a considerably higher need for rescue analgesia and harsher analgesics such tramadol ($p<0.001$), indicating that magnesium sulfate provided better postoperative analgesia.

The magnesium sulfate group experienced considerably fewer perioperative problems than the control group ($p=0.03$). While Group B showed a higher prevalence of cardiovascular problems, such as arrhythmia, hypotension, and bradycardia, the majority of patients in Group A remained complication-free. These results suggest that intravenous magnesium sulfate treatment improves perioperative hemodynamic stability and safety (Table 5).

Figure 1 shows that during the perioperative phase, patients receiving intravenous magnesium sulfate (Group A) consistently had lower heart rates than the control group. Better hemodynamic stability was shown by Group A's greater attenuation of the tachycardic response during pneumoperitoneum and after endotracheal intubation.

Figure 2 shows that at all observed perioperative time intervals, the magnesium sulfate group's mean arterial pressure was consistently lower and more stable than that of the control group. These results imply that during laparoscopic cholecystectomy, intravenous magnesium sulfate successfully reduced the pressor response related to intubation and pneumoperitoneum.

Table 1: Demographic and Baseline Characteristics of Study Participants

Parameters	Group A ($MgSO_4$) (n=50)	Group B (Control) (n=50)	p-value
Age (years)	42.94 ± 11.10	47.82 ± 14.27	0.06
Gender (M/F)	25/25	23/27	0.84
Weight (kg)	72.5 ± 10.93	68.12 ± 12.26	0.06
ASA Grade (I/II)	25/25	24/26	1.00
Baseline Heart Rate (beats/min)	85.48 ± 6.24	98.20 ± 5.86	**<0.0001**
Baseline MAP (mmHg)	85.34 ± 5.34	104.08 ± 5.79	**<0.0001**
Baseline SpO_2 (%)	98.82 ± 0.77	96.39 ± 1.08	**<0.0001**

Table 2: Comparison of Hemodynamic Parameters During Endotracheal Intubation Between the Two Groups

Time Interval	Heart Rate (beats/min) Group A	Heart Rate (beats/min) Group B	p-value	MAP (mmHg) Group A	MAP (mmHg) Group B	p-value
Baseline	85.48 ± 6.24	98.20 ± 5.86	**<0.0001**	85.34 ± 5.34	104.08 ± 5.79	**<0.0001**
Immediately after intubation (0 min)	83.36 ± 5.14	100.22 ± 9.64	**<0.0001**	—	—	—
1 minute	80.96 ± 5.01	99.54 ± 11.46	**<0.0001**	—	—	—
3 minutes	79.06 ± 4.50	96.82 ± 10.09	**<0.0001**	—	—	—
5 minutes	79.12 ± 3.96	100.06 ± 10.43	**<0.0001**	—	—	—

Table 3: Comparison of Hemodynamic Parameters During Pneumoperitoneum Between the Two Groups

Time Interval	Heart Rate (beats/min) Group A	Heart Rate (beats/min) Group B	p-value
10 minutes	79.60 ± 4.44	98.46 ± 12.70	**<0.0001**
15 minutes	79.28 ± 4.24	97.30 ± 9.86	**<0.0001**
20 minutes	78.52 ± 4.65	97.38 ± 9.19	**<0.0001**
25 minutes	78.20 ± 4.37	96.69 ± 9.68	**<0.0001**
30 minutes	77.48 ± 4.06	98.76 ± 12.14	**<0.0001**
Post-operative	77.26 ± 4.24	96.74 ± 10.30	**<0.0001**

Table 4: Comparison of Postoperative Outcomes Between the Two Groups

Parameters	Group A ($MgSO_4$) (n=50)	Group B (Control) (n=50)	p-value
Duration of surgery (60–120 min)	50 (100%)	36 (72%)	<0.001
Duration of surgery (120–180 min)	0 (0%)	14 (28%)	
NRS 0–2	26 (52%)	0 (0%)	<0.001
NRS 2–4	13 (26%)	15 (30%)	
NRS 4–6	11 (22%)	15 (30%)	
NRS 6–8	0 (0%)	15 (30%)	
NRS 8–10	0 (0%)	5 (10%)	
Postoperative analgesic requirement – Yes	15 (30%)	32 (64%)	0.001
Postoperative analgesic requirement – No	35 (70%)	18 (36%)	
Paracetamol requirement	7 (14%)	6 (12%)	<0.001
Diclofenac requirement	8 (16%)	16 (32%)	
Tramadol requirement	0 (0%)	10 (20%)	
No analgesic required	35 (70%)	18 (36%)	

Table 5: Comparison of Perioperative Adverse Effects Between the Two Groups

Complications	Group A ($MgSO_4$) (n=50)	Group B (Control) (n=50)	p-value
Arrhythmia	1 (2%)	5 (10%)	
Hypotension	2 (4%)	6 (12%)	
Bradycardia	2 (4%)	4 (8%)	
No complications	45 (90%)	35 (70%)	0.03

Figure 1: Comparison of mean heart rate between the two groups at different perioperative time intervals

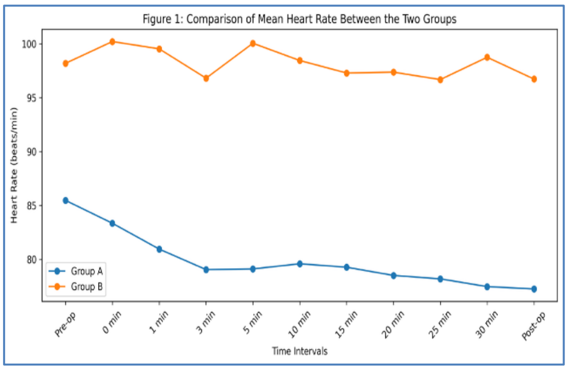
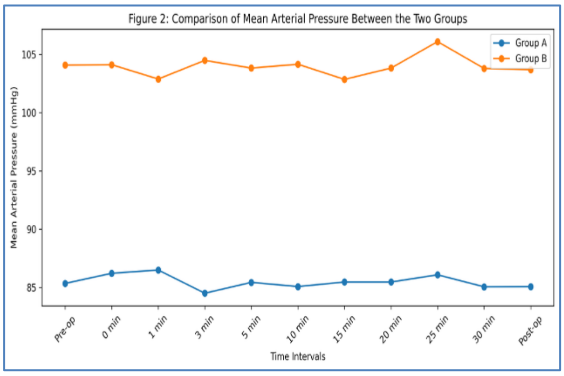


Figure 2: Comparison of mean arterial pressure between the two groups at different perioperative time intervals



Discussion

The current prospective interventional study assessed the impact of intravenous magnesium sulfate on hemodynamic reactions related to pneumoperitoneum and endotracheal intubation during laparoscopic cholecystectomy under general anesthesia. The study's results showed that, in comparison to the control group, patients receiving magnesium sulfate had improved perioperative hemodynamic stability, lower postoperative pain levels, less need for analgesics, and fewer perioperative problems.

In terms of age, gender distribution, weight, and ASA physical status, the patient demographics in both groups were similar, suggesting sufficient baseline matching between the study groups. Previous research by Paul S et al., Desai DJ et al., and Gautam B et al. have revealed similar results. [21,22,23]

Throughout the perioperative period, patients receiving intravenous magnesium sulfate in the current study showed considerably lower mean arterial pressure and heart rate than the control group. Following laryngoscopy, endotracheal intubation, and pneumoperitoneum, tachycardic and pressor responses were shown to be attenuated. These results are in line with research by Jee D et al., Kalra NK et al., and Zareen A et al., who also found that administering magnesium sulfate during laparoscopic procedures enhanced hemodynamic stability. [24, 25, 26] Magnesium sulfate's vasodilatory qualities, calcium channel antagonism, and inhibition of catecholamine release could all be part of the likely mechanism. [18]

Patients in the magnesium sulfate group maintained generally lower and more consistent blood pressure readings compared to the control group, despite brief variations in systolic and diastolic blood pressure during the intraoperative period. Similar findings indicating the importance of magnesium sulfate in attenuating sympathetic cardiovascular responses during laparoscopic procedures were reported by Das S et al., Desai DJ et al., and Ramya N et al. [27,22,28]

Patients in the magnesium sulfate group maintained generally lower and more consistent blood pressure readings compared to the control group, despite brief variations in systolic and diastolic blood pressure during the intraoperative period. Similar findings indicating the importance of magnesium sulfate in attenuating sympathetic cardiovascular responses during laparoscopic procedures were reported by Das S et al., Desai DJ et al., and Ramya N et al. [17]

In terms of perioperative safety, the magnesium sulfate group experienced fewer problems, including bradycardia, hypotension, and arrhythmia. Most patients receiving magnesium sulfate remained complication-free, indicating an acceptable safety profile when used in appropriate doses. Studies by Paul S. et al., Das S. et al., and Gautam B. et al. have reported similar results. [21,27,23]

Overall, the results of this study indicate that intravenous magnesium sulfate is a useful supplement for reducing hemodynamic reactions related to pneumoperitoneum and endotracheal intubation during laparoscopic cholecystectomy. In addition to improved perioperative cardiovascular stability, magnesium sulfate also contributed to better postoperative analgesia with minimal adverse effects.

Conclusion

During laparoscopic cholecystectomy under general anesthesia, intravenous magnesium sulfate was found to be beneficial in reducing the hemodynamic reactions linked to endotracheal intubation and pneumoperitoneum. In comparison to the control group, patients who received magnesium sulfate showed improved perioperative hemodynamic stability, lower postoperative pain levels, less need for analgesics, and fewer perioperative problems. Magnesium sulfate may therefore be regarded as a helpful and secure adjuvant in laparoscopic procedures for enhancing perioperative results.

Limitations

The results may not be as broadly applicable as they could be because the current study was carried out at a single tertiary care facility with a very small sample size. Perioperative comparisons may have been impacted by significant baseline differences in hemodynamic parameters between the two groups. Furthermore, blood magnesium levels after medication delivery and long-term postoperative outcomes were not assessed. To confirm the results, more multicentric research with bigger sample sizes and consistent baseline characteristics is advised.

Ethical approval

Ethical approval for this study was obtained from the Institutional Ethics Committee prior to the commencement of the study. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and applicable institutional guidelines.

Informed Consent

Written informed consent was obtained from all participants prior to their enrolment in the study.

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Conflict of Interest Declaration

The authors declare no conflict of interest.

Data Availability Statement

All data generated or analysed during this study are available from the corresponding author upon reasonable request.

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