

INFLUENCE OF INTRAVENOUS MAGNESIUM SULPHATE ON HEMODYNAMIC PARAMETERS IN RESPONSE TO PNEUMOPERITONEUM DURING LAPAROSCOPIC CHOLECYSTECTOMY

Dr. Maria Munir^{*1}, Prof. Dr. M. Sirajuddin², Dr. Warisha Ismail³, Dr. Javeria Muneer⁴,
Dr. Uruba Shamshad⁵, Dr. Layla Khalid⁶

^{*1}(PG Trainee FCPS Anesthesiology), Liaquat National Hospital & Medical College, Karachi.

²(MCPS, FCPS), Professor of Anesthesiology, Liaquat National Hospital & Medical College, Karachi.

^{3,5}(RMO), Liaquat National Hospital & Medical College, Karachi.

⁴(RMO General Surgery), Liaquat National Hospital & Medical College, Karachi.

DOI: <https://doi.org/10.5281/zenodo.15771467>

Keywords

Pneumoperitoneum, Magnesium sulfate, Hemodynamics

Article History

Received on 23 May 2025

Accepted on 23 June 2025

Published on 30 June 2025

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Corresponding Author: *

Dr. Maria Munir

Abstract

Objective: To evaluate the effect of Magnesium sulphate in attenuating hemodynamic responses to pneumoperitoneum during laparoscopic cholecystectomy (LC).

Methods: For this randomized controlled trial (RCT), we enrolled patients aged 20-60 years who were scheduled for LC. The study took place in the Department of Anesthesiology at Liaquat National Hospital and Medical College in Karachi from March 2025 to April 2025. The intervention group (Group M), received an intravenous injection of the MgSO₄ 30 mg/Kg over a period of five minutes prior to the establishment of pneumoperitoneum. In contrast, the Control group (Group C) was treated with an equal volume of 0.9% normal saline (NS). Hemodynamics i.e. SBP, DBP, MAP and HR were noted at different time intervals.

Results: The average age of participants in Group C was 48.67 (±15.03) years, while Group M had an average age of 47.40 (±15.03) years. There was no significant difference in hemodynamic variables at baseline and before creation of pneumoperitoneum. Ten minutes after pneumoperitoneum, significant increases were observed in SBP for Group C at 150.9 ± 23.2 mmHg compared to 127.7 ± 13.7 mmHg for Group M (p < 0.0001). DBP also rose significantly, measuring 92.6 ± 10.0 mmHg for Group C and 72.63 ± 11.0 mmHg for Group M (p < 0.0001). The MAP increased to 112.7 ± 11.5 mmHg for Group C versus 90.1 ± 11.9 mmHg for Group M (p < 0.0001), and HR for Group C was recorded at 91.3 ± 12.0 bpm compared to 75.2 ± 9.0 bpm for Group M (p < 0.0001). However, before extubation again there was no difference in hemodynamic variables DBP that was significantly lower in M group.

Conclusion: Administering intravenous magnesium sulfate (MgSO₄) immediately before the induction of pneumoperitoneum significantly helps sustain heart rate and arterial pressure. This intervention promotes hemodynamic stability during the entire period of pneumoperitoneum.

INTRODUCTION

Laparoscopic cholecystectomy has quickly become a favored approach over traditional open cholecystectomy for treating gallstones. This minimally invasive procedure offers several benefits, including reduced tissue damage, decreased post-surgical pain, a shorter hospitalization period, a faster return to usual activities, and notable cost savings.^{1, 2}

Although laparoscopic surgery offers several benefits, it can lead to complications stemming from significant physiological alterations that occur during the procedure. These changes are primarily caused by the pressure from the gas used in the closed cavity, typically carbon dioxide (CO₂). Other contributing factors include the patient's positioning on the operating table, the type of anesthesia administered, and the patient's overall cardiopulmonary health.^{3, 4}

Pneumoperitoneum leads to elevated plasma levels of catecholamines and increased pressure within the thoracic cavity. This heightened intrathoracic pressure stimulates the release of vasopressin, which contributes to a rise in mean arterial pressure (MAP) without causing a notable change in heart rate (HR).^{5, 6} Achieving hemodynamic stability can involve various medications, including opioids, vasodilators, beta blockers, and alpha-2 agonists. It is essential to note, however, that none of these agents directly inhibit catecholamine activity.^{7, 8}

Magnesium sulfate, initially designed to manage eclamptic seizures, has since expanded its applications in the field of anesthesia. It is frequently used to mitigate the vasopressor response associated with intubation by inhibiting the release of catecholamines from the adrenal medulla and nerve terminals. Furthermore, magnesium sulfate is known to directly influence blood vessels directly, aiding in the reduction of vasopressin-induced vasodilation.^{9, 10} The aim of the present study was to evaluate the effect of Magnesium sulphate in attenuating hemodynamic responses to pneumoperitoneum during laparoscopic cholecystectomy (LC).

METHODS:

For this randomized controlled trial (RCT), we enrolled patients aged 20-60 years who were scheduled for laparoscopic cholecystectomy (LC) with an ASA classification of I or II. The study took

place in the Department of Anesthesiology at Liaquat National Hospital and Medical College in Karachi from March 2025 to April 2025. We excluded patients taking calcium channel blockers, those with kidney dysfunction, bleeding disorders, or those who required an open procedure.

A pre-anesthetic evaluation was performed the day prior to the surgical procedure. This assessment included a comprehensive medical history and a physical examination, which covered baseline heart rate (HR), blood pressure (BP), respiratory rate (RR), and a systemic examination. Necessary baseline investigations were carried out, which included a complete blood count, liver function tests (LFT), renal function tests (RFT), a complete urine analysis, random blood sugar (RBS) testing, electrocardiography (ECG), and a chest X-ray. All patients were instructed to remain nil per os (NPO) overnight. They were then randomly assigned into two groups, each consisting of 30 patients. The intervention group (Group M), received an intravenous injection of the MgSO₄ 30 mg/Kg over a period of five minutes prior to the establishment of pneumoperitoneum. In contrast, the Control group (Group C) was treated with an equal volume of 0.9% normal saline (NS).

The administration and preparation of the drugs were conducted by an individual other than the observer responsible for maintaining the records. At the conclusion of the study, the results were revealed and analyzed.

Carbon dioxide (CO₂) was introduced into the abdominal cavity to establish pneumoperitoneum (PP). The intra-abdominal pressure was consistently held at 15 mmHg during the laparoscopic surgery, with measurements taken using a pressure transducer system. Patients underwent mechanical ventilation, ensuring that the end-tidal CO₂ (EtCO₂) levels remained between 35 and 40 mmHg. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were documented at various points: baseline, prior to establishing pneumoperitoneum, immediately after, 10 minutes into pneumoperitoneum, and at the conclusion of the procedure.

SPSS version 21 was used for data compilation and analysis. An independent sample t-test was employed

to compare the mean HR, SBP, DBP, and MAP between the two groups, considering a p-value ≤ 0.05 as indicative of a significant association.

RESULTS:

The baseline study characteristics for the two groups, Group C and Group M, each consisting of 30 participants, were analyzed. The average age of participants in Group C was 48.67 (± 15.03) years, while Group M had an average age of 47.40 (± 15.03) years, resulting in a p-value of 0.75. In terms of weight, Group C had an average of 66.66 kg (± 9.50), compared to Group M's 68.03 kg (± 7.42), with a p-value of 0.53. Gender distribution showed that 80.0% of Group C participants were male (24 out of 30) compared to 66.7% in Group M (20 out of 30), p-value 0.24. When considering hypertension, 14 (46.7%) of Group C participants reported having the condition, compared to 16 (53.3%) in Group M, p-value 0.60. Lastly, the prevalence of diabetes in Group C was 9 (30.0%), compared to 7 (23.3%) in Group M, p-value 0.55 (Table 1).

At baseline, the mean systolic blood pressure (SBP) was 126.9 $\pm$ 8.9 mmHg for Group C and 127.7 $\pm$ 17.2 mmHg for Group M, with a p-value of 0.80. The diastolic blood pressure (DBP) for Group C was 71.63 $\pm$ 13.3 mmHg versus 77.46 $\pm$ 13.6 mmHg for Group M (p = 0.09). The mean arterial pressure (MAP) recorded was 91.9 $\pm$ 10.4 mmHg for Group C and 94.2 $\pm$ 13.5 mmHg for Group M (p = 0.48), while the heart rate (HR) was 72.5 $\pm$ 12.8 bpm for

Group C and 75.3 $\pm$ 9.5 bpm for Group M (p = 0.34). Before pneumoperitoneum, the SBP decreased to 122.7 $\pm$ 18.6 mmHg for Group C and 115.7 $\pm$ 19.2 mmHg for Group M (p = 0.15), while the DBP showed a significant difference at 76.8 $\pm$ 13.3 mmHg for Group C compared to 67.9 $\pm$ 9.4 mmHg for Group M (p = 0.004). The MAP was 90.4 $\pm$ 14.3 mmHg for Group C and 85.8 $\pm$ 11.9 mmHg for Group M (p = 0.19), with HR of 73.2 $\pm$ 10.5 bpm for Group C and 72.4 $\pm$ 9.8 bpm for Group M (p = 0.75). Ten minutes after pneumoperitoneum, significant increases were observed in SBP for Group C at 150.9 $\pm$ 23.2 mmHg compared to 127.7 $\pm$ 13.7 mmHg for Group M (p < 0.0001). DBP also rose significantly, measuring 92.6 $\pm$ 10.0 mmHg for Group C and 72.63 $\pm$ 11.0 mmHg for Group M (p < 0.0001). The MAP increased to 112.7 $\pm$ 11.5 mmHg for Group C versus 90.1 $\pm$ 11.9 mmHg for Group M (p < 0.0001), and HR for Group C was recorded at 91.3 $\pm$ 12.0 bpm compared to 75.2 $\pm$ 9.0 bpm for Group M (p < 0.0001). Before extubation, the SBP measured at 143.7 $\pm$ 15.1 mmHg for Group C and 137.9 $\pm$ 13.1 mmHg for Group M (p = 0.1). The DBP was significantly different at 80.6 $\pm$ 13.4 mmHg for Group C compared to 71.8 $\pm$ 14.4 mmHg for Group M (p = 0.02). However, the MAP showed no significant difference, with values of 100.3 $\pm$ 8.7 mmHg for Group C and 96.9 $\pm$ 12.3 mmHg for Group M (p = 0.21). Lastly, the HR were 82.9 $\pm$ 11.7 bpm for Group C and 84.7 $\pm$ 6.4 bpm for Group M (p = 0.47) [Table 2].

Table 1. Baseline Study Characteristics.

	Group C (N=30)	Group M (N=30)	P-value
Age (years)	48.67 $\pm$ 15.03	47.40 $\pm$ 15.03	0.75
Weight (Kg)	66.66 $\pm$ 9.50	68.03 $\pm$ 7.42	0.53
Gender (%)			
Male	24 (80.0%)	20 (66.7%)	0.24
Female	06 (20.0%)	10 (33.3%)	
Hypertension (%)	14 (46.7%)	16 (53.3%)	0.60
Diabetes (%)	09 (30.0%)	07 (23.3%)	0.55

Table 2. Comparison of Hemodynamic Variables Between the Groups.

	Group C (N=30)	Group M (N=30)	P-value
<i>Baseline</i>			
SBP	126.9 $\pm$ 8.9	127.7 $\pm$ 17.2	0.80
DBP	71.63 $\pm$ 13.3	77.46 $\pm$ 13.6	0.09

MAP	91.9±10.4	94.2±13.5	0.48
HR	72.5±12.8	75.3±9.5	0.34
<i>Before Pneumoperitoneum</i>			
SBP	122.7±18.6	115.7±19.2	0.15
DBP	76.8±13.3	67.9±9.4	0.004
MAP	90.4±14.3	85.8±11.9	0.19
HR	73.2±10.5	72.4±9.8	0.75
<i>10 Minutes after Pneumoperitoneum</i>			
SBP	150.9±23.2	127.7±13.7	<0.0001
DBP	92.6±10.0	72.63±11.0	<0.0001
MAP	112.7±11.5	90.1±11.9	<0.0001
HR	91.3±12.0	75.2±9.0	<0.0001
<i>Before Extubation</i>			
SBP	143.7±15.1	137.9±13.1	0.1
DBP	80.6±13.4	71.8±14.4	0.02
MAP	100.3±8.7	96.9±12.3	0.21
HR	82.9±11.7	84.7±6.4	0.47

DISCUSSION:

The cardiovascular response to positive pressure (PP) ventilation includes an increase in arterial pressure, a reduction in cardiac output, and a significant rise in systemic vascular resistance.¹¹ Magnesium sulfate (MgSO₄) exhibits a broad range of actions; it inhibits the release of catecholamines from adrenergic nerve terminals and adrenal glands. This property makes it valuable in managing conditions such as pheochromocytoma, pre-eclampsia, and eclampsia.¹² MgSO₄ promotes vasodilation by directly affecting blood vessels and can mitigate vasoconstriction mediated by vasopressin. Additionally, it is utilized to reduce the blood pressure response associated with tracheal intubation. The drug also has antinociceptive properties due to its regulation of calcium influx into cells, acting as a natural physiological antagonist of the NMDA receptor. Given these diverse properties, MgSO₄ is being investigated for various clinical applications, including its role in moderating the hemodynamic response to PP during laparoscopic cholecystectomy.¹³⁻¹⁵

This study was designed as a randomized, double-blind trial to assess the impact of IV MgSO₄ on hemodynamic responses during pneumoperitoneum in laparoscopic cholecystectomy. Prior to the creation of pneumoperitoneum, no significant differences were observed between the two groups (p-

value >0.05). However, following the establishment of pneumoperitoneum, the group receiving MgSO₄ exhibited notably reduced heart rate, as well as lower systolic and diastolic blood pressure compared to the control group. In our study, the systolic and diastolic blood pressures of the M group were significantly lower than the C group at 15 minutes after generation of pneumoperitoneum till extubation (p value <0.05). These results aligned with previous research findings.

Kalra et al. conducted a significant study involving 120 patients scheduled for elective LC, whom they randomly divided into four groups of 30. Participants in Group M were administered 50 mg/kg of MgSO₄ mixed with normal saline (totalling 50 ml) at the same interval as Group K, which received 50 ml of normal saline 15 minutes after induction and just before the pneumoperitoneum phase. Meanwhile, Group C1 received 1.0 µg/kg of clonidine, and Group C2 received 1.5 µg/kg of clonidine, both in a total volume of 50 mL of normal saline. The results indicated that during the pneumoperitoneum phase, the systolic blood pressure of the control group was notably higher than that of the other groups. The researchers concluded that the administration of either clonidine or MgSO₄ effectively mitigates the hemodynamic response associated with pneumoperitoneum.¹⁶

Bansal and colleagues observed a notable decrease in both systolic and diastolic blood pressure 10 minutes after the establishment of pneumoperitoneum, continuing until the extubation phase. This effect was particularly pronounced in patients treated with MgSO₄ compared to those receiving normal saline (C group), with a statistically significant p-value of less than 0.05. Additionally, MgSO₄ demonstrated a positive impact on mitigating the potential adverse hemodynamic effects associated with pneumoperitoneum.¹⁷

Kamble SP found that the heart rate (HR) of patients in the non-steroidal (NS) group was significantly higher than that in the MgSO₄ (Group M: 50 mg/kg IV MgSO₄ before percutaneous procedures) and clonidine (Group C) groups. This difference in HR was observed five minutes following the procedure and continued until the 40-minute mark, with a p-value of less than 0.001. Additionally, the HR for Group M was consistently lower than that of Group NS at all measured time points.¹⁸

A study conducted by Paul and colleagues reported a notable decrease in Mean Arterial Pressure (MAP) at 15 minutes following the onset of pneumoperitoneum until extubation in patients who received MgSO₄, compared to those in the control group.¹⁹

AlShanableh et al. Reported that MgSO₄ can mitigate the hypertensive effects of epinephrine, helping to maintain stable mean arterial pressure during its administration. Several physiological mechanisms have been proposed to explain how intravenous MgSO₄ lowers blood pressure. One key factor is its potential to cause mild myocardial depression and function as a vasodilator, which may lead to decreased peripheral vascular resistance and cardiac contractility.²⁰ Additionally, studies have shown that MgSO₄ can inhibit the release of catecholamines. Findings from Crozier et al. revealed that participants in the magnesium group exhibited lower levels of vasopressin, epinephrine, and norepinephrine compared to those in the control group.²¹ However, it is important to note that our study did not measure catecholamine concentrations.

CONCLUSION:

Administering intravenous magnesium sulfate (MgSO₄) immediately before the induction of pneumoperitoneum significantly helps sustain heart rate and arterial pressure. This intervention promotes hemodynamic stability during the entire period of pneumoperitoneum.

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