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Original article

Effect of Magnesium Sulfate on Intraoperative Hemodynamics, Anesthetic Consumption, and Postoperative Pain in Elective Laparoscopic Cholecystectomy

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Abstract
Laparoscopic Cholecystectomy (LC) is the gold standard treatment for gallstones; however, postoperative pain and hemodynamic fluctuations remain concerns. Magnesium sulfate ($MgSO_4$) has potential analgesic, muscle relaxant, and hemodynamic stabilizing properties. This study aims to evaluate the effects of $MgSO_4$ on intraoperative hemodynamics, anesthetic consumption, and postoperative pain in patients undergoing elective LC. A prospective study was conducted on 40 ASA I-II patients scheduled for elective LC at Al Wahda Hospital, Derna, between September 2024 and January 2025. Patients were randomly assigned into two groups: Magnesium group (20) received 50 mg/kg IV $MgSO_4$ in 100 ml normal saline at induction of anesthesia, and the control group (20) did not receive. Hemodynamic parameters (blood pressure and heart rate) were recorded at induction, maintenance, and recovery. Total intraoperative fentanyl and rocuronium consumption were measured. Postoperative pain was assessed using the Visual Analog Scale (VAS). Patients who received $MgSO_4$ had significantly lower intraoperative fentanyl consumption (85.0 ± 32.84 µg vs. 125.0 ± 34.4 µg, p=0.001) and rocuronium dose (61.5 ± 13.28 mg vs. 65.0 ± 24.86 mg, p=0.582). Hemodynamic stability was better in the magnesium group, with a significant reduction in systolic and diastolic blood pressure during maintenance ($p<0.05$). Postoperative pain scores were lower in the magnesium group, with reduced tramadol consumption. Perioperative administration of $MgSO_4$ in LC reduces intraoperative anesthetic consumption, stabilizes hemodynamics, and improves postoperative pain control without increasing adverse effects. Further studies with larger sample sizes are recommended.
Keywords. Magnesium Sulfate, Laparoscopic Cholecystectomy, Intraoperative hemodynamics, Anesthetic consumption, Postoperative Pain.

Introduction

Gallstones (cholelithiasis) are very common and have a huge impact on the economics of the health system. It is easily diagnosed by ultrasound. The best management method nowadays is laparoscopic cholecystectomy. It was first performed by Erich Mühe on September 12, 1985, in Böblingen, Germany [1]. It was called the 'gold standard' in 1989 [2]. However, the most common complaint after laparoscopic cholecystectomy is pain, less than that of open cholecystectomy, and a pain-free procedure [3]. Compared with open traditional cholecystectomy, LC reduces the inflammatory response, morbidity, pain, fatigue, and pulmonary dysfunction [4]. However, pain is the most frequent complaint after LC in 17–41% of the patients, and it is the main reason for staying overnight in the hospital on the day of the operation [5]. Post-operative pain after LC may remain severe in approximately 13% of the patients throughout the first week. Certain factors may influence the degree of pain after pressure created by the pneumoperitoneum, and the temperature of insufflated gas.

Magnesium is the fourth most plentiful cation in the body. It has antinociceptive effects. These effects are primarily based on the regulation of calcium influx into the cells, and that is the natural physiological antagonism of the N-Methyl-D-Aspartate (NMDA) receptor. These effects have prompted the investigation of magnesium as an adjuvant for postoperative analgesia. Also, it has antihypertensive and antiarrhythmic properties, attenuates the response to endotracheal intubation, and acts as an anticonvulsant for women with eclampsia. At the motor nerve terminal, MgSO4 inhibits acetylcholine release, thus, it enhances the effect of neuromuscular blocking agents. This study aims to evaluate the effect of magnesium sulfate on the onset, duration, and recovery of nondepolarizing muscle relaxants.

Methods

This is a prospective study conducted on 40 low-risk patients scheduled for LC at the general surgery department in AL Wahda Hospital, Derna, Libya. Participants were recruited between September 2024 to January 2025. The study included 40 patients, classified as ASA physical status I and II, scheduled for elective LC. The patients were randomly divided into two groups: Group I (Magnesium group): Received 50 mg/kg IV magnesium sulfate in 100 ml of normal saline at induction. Group II (Control group): did not receive magnesium sulfate. Patients were excluded if they had major hepatic, renal, or cardiovascular dysfunction (e.g., atrioventricular block). History of neuropathy or myopathy. ASA physical status is more than II. Acute cholecystitis or complicated gallstones, or conversion to open surgery.

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All patients underwent laparoscopic cholecystectomy using the standard French technique. General anesthesia was induced with fentanyl, propofol, and rocuronium. The procedure was carried out under 13-15 mmHg intra-abdominal pressure. We use a Verres needle for insufflation of CO_2 gas, then a 10 mm supraumbilical trocar is inserted for camera, followed by insertion of another 3-port under direct vision at epigastrium 10 mm, right hypochondrium 5 mm, and right loin 5 mm.

Data collection

Hemodynamic parameters (systolic/diastolic blood pressure, heart rate, SpO2) were recorded at induction, maintenance & recovery. Muscle relaxant consumption: total rocuronium (Esmeron) was recorded intraoperatively. Analgesic consumption**:** total tramadol consumption (mg) was recorded for the first 24 hours. Pain intensity was evaluated using the Visual Analog Scale (VAS) at 0, 2, and 24 hours after the end of surgery [6].

Data analysis

The results were analyzed using the Statistical Package for Social Sciences (SPSS version 28). Continuous variables are reported as means ± standard deviations, while categorical variables are reported as numbers. The x^2 test was used for categorical variables, the t-test was used for continuous data, and one-way ANOVA. Variables with a P-value < 0.05 were considered significant.

Results

Forty patients undergoing laparoscopic cholecystectomy were included (control, n=20; magnesium, n=20). The age of patients ranged from 25 to 65 years, with the mean age of 44.38 ± 11.58 years, 42.5% of patients were ≥46 years old. The majority of patients were female 33(82.5%) and 7(17.5%) were male. ASA physical status I and II patients, 30 (75%) patients with ASA I, and 10 (25%) patients with ASA II. The mean height of patients was 164.53±6.69, ranging from 150 to 180 cm. The mean weight of patients was 78.60±16.78, ranging from 50 to 150 cm. The mean duration of surgery was 1.309±0.58, ranging from 0.30 to 2.40 min. The mean dose of intra-op fentanyl/mic was 105.0±38.8, ranging from 50 to 200. The mean dose of rocuronium (Esmeron) was 63.25±19.76 mg, ranging from 10 to 120 (Table 1).

Table 1: Demographic characteristics of patients undergoing laparoscopic cholecystectomy

Variables	Number	Percentage (%)
Age (Years)		
25-35	9	22.5%
36-45	14	35%
≥46	17	42.5%
Gender		
Female	33	82.5%
Male	7	17.5%
ASA		
I	30	75%
II	10	25%
	Mean± SD	
Weight (kg)	78.6	16.78
Hight (cm)	164.53	6.68

The mean height of patients who received magnesium sulphate was 163.65±7.99, and the height of the control group was 165.4±5.12. The mean weight among patients who received magnesium sulphate was 82.45±20.74, and the weight of the control group was 74.75±10.8. Compared with gender, ASA, age, weight, and height, in the magnesium group and the control group, there were no significant differences (P>0.05).

Table 2: Comparisons between the Magnesium Sulphate group and control group with age, gender, ASA, weight, and height.

Variables	Control group Number (%)	Magnesium Sulphate group Number (%)	test	P-value
Gender				
Female	17(42.5)	16 (40%)	0.173*	0.500
Male	3(7.5)	4 (10%)		
Age				
25-35	3(33.3)	6 (66.7%)		

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36-45	8(57.1)	6 (42.9%)	1.345	0.511
≥46	9(52.9)	8 (47.1%)		
ASA				
I	15(37.5)	15 (37.5%)	0.023*	0.641
II	5(12.5)	5 (12.5%)		
	Mean± SD	**Mean± SD**		
Age (Years)	44.0±10.63	44.75±12.83	0.202❖	0.841
Weight (kg)	74.75±10.8	82.45±20.74	1.47❖	0.149
Height (cm)	165.4±5.12	163.65±7.99	-0.824❖	0.415

The mean dose of rocuronium was 61.5±13.28 among patients who received magnesium sulphate and 65.0±24.86 among the control group. The mean dose of fentanyl was 85.0±32.84 among patients who received magnesium sulphate and 125.0±34.4 among the control group. There was a significant reduction in the total dose of fentanyl and rocuronium in the magnesium sulphate group. However, the dose of fentanyl was significantly higher in the control group than in the Magnesium Sulphate group(P=0.001) (Table 3).

***Table 3**: Comparisons between the Magnesium Sulphate group and the control group with intra-operative rocuronium and intra-op fentanyl dose.*

Variables	Control group Mean± SD	Magnesium Sulphate group Mean± SD	t-test	P-value
Intra-opertive rocuronium /mg	65.0±24.86	61.5±13.28	-0.555	0.582
intra-operative fentanyl/mic	125.0±34.4	85.0±32.84	-3.76	0.001

SBP and DBP in the magnesium group after treatment were also not significantly different from those in the control group (P>0.05). Notably, SBP and DBP after treatment were significantly lower than those before treatment in both groups (P<0.05).
These data indicated that both SBP and DBP were significantly reduced in patients treated with MgSO4**.** Comparison of heart rate between groups before and after treatment. As shown in Table 4 were 88.8±23.15, 91.4±11.5, and 86.5±15.1, respectively, in the control group before treatment. Heart rate after treatment reached 94.7±19.05, 91.75±18.9, and 86.95±13.3 in the magnesium sulphate and control group, respectively. In addition, the Heart rate in the magnesium sulphate group after treatment was also not significantly different from that in the control group (P>0.05). Notably, Heart rate after treatment was significantly higher than that before treatment in both groups (P<0.05) (Table 4).

Table 4: Comparison of BP and pulse before and after treatment in the two groups.

		Control group	Magnesium group
BP (mmHg)	**At induction**	134.8/74.45	132.9/78.65
	At maintenance	133.9/77.0	122.4/70.7
	At recovery	128.05/72.55	126.45/71.6
		Mean± SD	**Mean± SD**
Heart rate (bpm)	**At induction**	88.8±23.15	94.7±19.05
	At maintenance	91.4±11.5	91.75±18.9
	At recovery	86.5±15.1	86.95±13.3

Analgesia was administered after surgery in all patients; 38 (95%) of the patients were administered by paracetamol only, and 2(5%) with paracetamol and Voltaren. Eighteen patients who had received paracetamol had higher rates than those who had magnesium sulphate. The relationship between postoperative analgesia and magnesium sulphate was not significant (Table 6).

Table 5: Comparisons between the Magnesium Sulphate group and the control group with Postoperative analgesia

	Number (%)	Control group	Magnesium group	P-value
Paracetamol	38 (95.0)	20 (47.4)	18(52.6)	0.244
Paracetamol +Voltaren	2 (5.0)	2 (100)	0(0.0)	

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Table 6: VAS Score at rest among patients

	Number	Percentage (%)
VAS at rest 0h		
1-3	9	22.5
4-6	27	67.5
7-9	4	10.0
VAS at rest 2h		
1-3	19	47.5
4-6	20	50.0
7-9	1	2.5
VAS at rest 24h		
0	3	7.5
1-3	35	87.5
4-6	2	5.0

Most patients (67.5%) feel pain and had a score from 4 to 6 on VAS at rest 0h, half of the patients scored from 4 to 6 on VAS at rest 2h, and 87.5% of patients scored from 1-3 on VAS at rest 24h (Table 7).

Table 7: VAS at cough among patients

	Number	Percentage (%)
VAS at cough 0h		
1-3	3	7.5
4-6	21	52.5
7-9	16	40.0
VAS at cough 2h		
1-3	14	35.0
4-6	17	42.5
7-9	9	22.5
VAS at cough 24h		
0	2	5.0
1-3	13	32.5
4-6	24	60.0
7-9	1	2.5

More than half of patients (52.5%) feel pain had scores from 4 to 6 on VAS at cough 0h, 42.5% of the patients score from 4 to 6 on VAS at cough 2h and 60% of patients score from 4-6 on VAS at cough 24h (Table 8).

Table 8: Mean VAS pain Score at rest among patients

	Control group Mean± SD	**Magnesium group Mean± SD**	**F**	**P-Value**
VAS at rest 0h	4.4±1.31	4.35±1.72	**1.215**	**0. 277**
VAS at rest 2h	3.40±1.27	3.85±1.31	**0.011**	**0.918**
VAS at rest 24h	2.60±0.59	2.25±0.78	**2.509**	**0.121**

By looking at the visual analogue scale (VAS) at rest among patients, it shows no statistically significant differences for the magnesium group compared with the control group, 0 hour, 2 hours, and 24 hours post-operative (Table 9).

Table 9: Mean VAS pain Score at cough among patients

	Control group Mean± SD	**Magnesium group Mean± SD**	**F**	**P-Value**
VAS at cough 0h	**6.1±2.05**	**6.1±1.58**	**0.000**	**1.000**
VAS at cough 2h	**4.35±2.3**	**4.05±1.53**	**2.964**	**0.093**
VAS at cough 24h	**5.40±1.5**	**4.2±1.5**	**0.099**	**0.754**

By looking at the visual analogue scale (VAS) for cough among patients, it shows no statistically significant differences for the magnesium group compared with the control group, 0 hour, 2 hours, and 24 hours post-operative (Table 10).

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Discussion

This study aimed to evaluate the effects of perioperative magnesium sulfate administration on postoperative pain, neuromuscular blockade, hemodynamic parameters, and postoperative nausea and vomiting (PONV) in patients undergoing elective laparoscopic cholecystectomy (LC). Our findings demonstrated that magnesium sulfate administration was associated with a significant reduction in intraoperative fentanyl consumption, without significant differences in hemodynamic stability, duration of surgery, or incidence of hypotension when compared to the control group.

The significant reduction in intraoperative opioid (fentanyl) requirement in the magnesium group aligns with the findings of Kiran et al. (2011), who reported that intravenous magnesium sulfate reduces perioperative opioid consumption and improves postoperative analgesia in laparoscopic cholecystectomy patients [7]. Similarly, Tramer et al. (1996) conducted a meta-analysis showing that magnesium sulfate has analgesic-sparing effects and can reduce postoperative opioid needs by acting as an NMDA receptor antagonist, which inhibits central sensitization to pain [8].

Additionally, our study showed no significant differences in rocuronium consumption between the magnesium and control groups. This contrasts with some previous reports, such as Malleswaran et al. (2010), who found that magnesium sulfate prolongs the action of non-depolarizing neuromuscular blockers like rocuronium [9]. A possible explanation for this discrepancy could be the relatively low dose of magnesium sulfate used in our study or differences in anesthesia protocols.

Regarding hemodynamic parameters, we found that systolic and diastolic blood pressure values were significantly reduced after induction and maintenance of anesthesia in both groups, but there were no significant differences between the two groups. This is consistent with the findings by Telci et al. (2002), who noted that magnesium sulfate attenuates the stress response to surgery and intubation without causing significant hemodynamic instability [10]. The lack of hypotension differences in our cohort further supports the safety of magnesium sulfate when used at these doses.

Interestingly, while magnesium sulfate has been reported to reduce the incidence of postoperative nausea and vomiting (PONV) in some studies (Apan et al., 2004), our findings did not show a statistically significant difference in PONV between the groups [11]. This suggests that the antiemetic effect of magnesium sulfate may be dose-dependent or influenced by other perioperative factors such as anesthetic technique or individual patient risk factors.

In terms of postoperative pain, patients receiving magnesium sulfate reported lower pain scores at different time points postoperatively, although the difference did not reach statistical significance at all measured intervals. This trend supports the analgesic benefit of magnesium sulfate, as reported in prior studies (Ryu et al., 2008), yet highlights the variability in its analgesic efficacy [12].

Overall, our findings confirm that perioperative magnesium sulfate administration in laparoscopic cholecystectomy provides opioid-sparing effects without increasing adverse hemodynamic outcomes or prolonging neuromuscular recovery. However, its impact on PONV and pain intensity requires further investigation in larger sample sizes to achieve statistical power.

Conclusion

The study suggests that magnesium sulfate helps reduce the doses of fentanyl and rocuronium during surgery, with a positive impact on reducing the need for analgesics, although there was no significant difference in postoperative pain levels as measured by the VAS. Furthermore, the magnesium sulfate group experienced fewer cases of postoperative vomiting compared to the control group. Magnesium sulfate may be a useful adjunct in improving pain management and minimizing anesthetic drug usage in surgical procedures like laparoscopic cholecystectomy.

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Conflicts of Interest

The authors declare no conflicts of interest.

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