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Effect of Intrathecal Magnesium Sulfate as an Adjuvant to Bupivacaine on Spinal Block Characteristics in Lower Limb Surgeries

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ABSTRACT

Background: Spinal anaesthesia with bupivacaine is a standard method for lower limb surgeries. However, its duration of analgesia may be limited in extended procedures. Magnesium sulfate, an N-methyl-D-aspartate receptor antagonist, has been explored as an adjuvant to enhance spinal block characteristics. To evaluate the effect of intrathecal magnesium sulfate as an adjuvant to bupivacaine on the onset and duration of sensory and motor blocks, postoperative analgesia, and hemodynamic stability in lower limb surgeries.

Methods: A prospective, randomised, single-blinded study was conducted on 70 adult patients, divided into two groups. Group M received 15 mg of 0.5% hyperbaric bupivacaine with 50 mg of $MgSO_4$, while Group B received the same dose of bupivacaine with 0.2 mL of normal saline. Spinal block onset, duration, analgesic effect, and hemodynamic parameters were recorded and compared.

Results: Group M showed a delayed onset of sensory (4.33±0.9 min) and motor blocks (7.66±1.26 min) compared to Group B (3.3±0.7 min and 4.96±1.21 min, respectively; $p<0.001$). However, the duration of sensory (218.5±22.52 min), motor block (190.66±21.2 min), and effective analgesia (225.76±24.81 min) was significantly prolonged in Group M ($p<0.001$). Hemodynamic parameters and adverse effects were comparable between groups ($p>0.05$).

Conclusion: The study concluded that the addition of magnesium sulfate to intrathecal bupivacaine in lower limb surgeries does not significantly alter perioperative pulse rate, mean arterial pressure, or the incidence of adverse effects.

Key-words: Intrathecal magnesium sulfate, Bupivacaine, Spinal anaesthesia, Lower limb surgeries, Sensory block, Motor block, Postoperative analgesia

INTRODUCTION

Spinal anaesthesia, due to its rapid onset, favourable safety profile dependable sensory and motor blockade, is an extensively employed method for lower limb surgeries. Bupivacaine is usually used in this situation as a long-acting amide local anaesthetic. However, bupivacaine may provide inadequate analgesia for prolonged procedures, encouraging the use of adjuvants to improve its duration and effectiveness [1].

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Magnesium sulphate has garnered attention as an intrathecal adjuvant in view of its antagonistic action on N-methyl-D-aspartate receptors, which are implicated in nociceptive transmission and central sensitisation. By inhibiting NMDA receptors, magnesium may potentiate analgesia and prolong the effects of local anaesthetics. Numerous studies have investigated the addition of intrathecal magnesium to bupivacaine, with variable consequences [2].

In a randomised controlled trial, Ozalevli et al. assessed the effect of adding 50 mg of intrathecal magnesium sulfate to bupivacaine-fentanyl spinal anaesthesia in patients experiencing lower limb surgery. The study found that magnesium delayed the onset of both sensory and motor blockade but significantly prolonged

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the duration of spinal anaesthesia without additional side effects [3].

A meta-analysis by Wang et al. as an analgesic adjuvant in spinal anaesthesia measured the efficacy of intrathecal magnesium. The analysis determined that magnesium encompasses the time to first analgesic request and the duration of tolerable sensory block, without increasing the frequency of side effects such as hypotension, bradycardia, nausea, vomiting, or pruritus [4].

Similarly, a meta-analysis by Pasqual-Ramirez et al. included 12 randomised clinical trials with a total of 817 patients. The study reported that intrathecal magnesium (50–100 mg) continued the duration of sensory and motor blocks and delayed the onset of sensory block by around 2.4 minutes. Importantly, no important adverse effects, including neurotoxicity, were observed [5].

In lower limb orthopaedic surgeries, Prabhavathi et al. studied the effect of adding 100 mg of intrathecal magnesium sulfate to 0.5% hyperbaric bupivacaine. The results established an important prolongation of sensory and motor block durations and extended postoperative analgesia without prominent side effects [6].

On the other hand, some studies have reported unpredictable or changeable results. Limbu et al. investigated the addition of 75 mg of intrathecal magnesium sulfate to bupivacaine in patients experiencing lower boundary orthopaedic surgery. The study found no important continuation of sensory or motor block durations, nor a reduction in postoperative analgesic consumption [7].

The unpredictability in consequences across studies may be attributed to differences in magnesium dosage, patient populations, and surgical procedures. However, the quality and duration of spinal anaesthesia permit supplementary investigation of the potential of intrathecal magnesium sulfate to improve [1].

This study purposes to assess the result of intrathecal magnesium sulfate as an accessory to bupivacaine on spinal block characteristics in patients experiencing lower limb surgeries. The primary objectives include measuring the onset and duration of sensory and motor blocks, as well as the duration of postoperative analgesia. Secondary objectives encompass assessing hemodynamic stability and the occurrence of adverse effects.

MATERIALS AND METHODS

Research Design- This prospective, randomized, single-blinded study was conducted in the Department of Anaesthesiology, over six months from March 2024 to February 2025, following approval by the Institutional Ethical Committee. Written informed consent was obtained from all participants in their native language before inclusion. Seventy adult patients scheduled for elective lower limb surgeries under spinal anaesthesia were enrolled based on predefined inclusion and exclusion criteria. 70 Participants were randomized into two groups (n=35 each), labelled either Group B or Group M. This was a single-blinded study in which the patients were unaware of the drug administered. All patients received a subarachnoid block in the left lateral position using a 23-G Quincke-Babcock spinal needle inserted at either the L2–L3 or L3–L4 intervertebral space, followed by supine positioning. Group M received heavy bupivacaine 15 mg, 3 mL of 0.5% with 0.2 mL of 50% magnesium sulfate, while Group B received heavy bupivacaine 15 mg, 3 mL of 0.5% with 0.2 mL of normal saline. Parameters recorded included time of initiation of the subarachnoid block, onset time of sensory block, time to reach maximum sensory block level, total duration of sensory block, time to achieve complete motor block, total duration of motor block, duration of surgery, and time to administration of rescue analgesia. Standard monitoring, non-invasive blood pressure, pulse oximetry, and ECG were employed. Baseline vitals were recorded preoperatively, then at 5–15-minute recesses intraoperatively, and every 30 minutes postoperatively until rescue analgesia was given. Hypotension, defined as a >20% reduction in mean arterial pressure from baseline, was treated with intravenous fluids and incremental doses of IV mephenteramine (3 mg), while bradycardia was accomplished with a 0.5 mg IV bolus of atropine sulfate.

Inclusion Criteria

- Age: 18 to 55 years
- Sex: Both male and female
- American Society of Anaesthesiologists physical status I or II
- Experiencing elective lower limb surgeries

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Exclusion Criteria

- Age <18 years or >55 years
- Pregnant patients
- ASA grade >II
- Important cardiac, renal, hepatic, or neuromuscular diseases
- Patients on calcium channel blockers, opioids, or magnesium sulfate
- Contraindications to regional anaesthesia or study medications

Statistical analysis- Data were analysed using SPSS Software. Descriptive statistics were used to summarise demographic data and outcome variables. Microsoft Word and Excel were used for data presentation, including tables and graphs. Appropriate statistical tests were applied to compare intergroup differences, and a $p<0.05$ was considered significant.

RESULTS

Both groups were comparable in terms of demographic characteristics (age and sex) and the mean duration of surgery, with no statistically significant difference ($p>0.05$). The onset of both sensory and motor blocks was significantly delayed in Group M (magnesium sulfate group) compared to Group B (control group), with $p<0.001$. However, Group M showed a significantly prolonged duration of sensory block, motor block, and effective analgesia ($p<0.001$ for all), indicating enhanced and prolonged anaesthetic effects (Table 1).

Table 1: Comparison of Demographic and Clinical Parameters Between Group B and Group M

Parameter	Group B (n=35)	Group M (n=35)	p-value
Age (in years, Mean)	38.93	42.36	>0.05
Sex (F/M)	16 / 19	17 / 18	>0.05
Mean duration of surgery (in minutes)	81.25	79.7	0.05
Onset of sensory block (in mins)	3.3±0.7	4.33±0.9	<0.001
Onset of motor block (in mins)	4.96±1.21	7.66±1.26	<0.001
Duration of sensory block (in mins)	171.5±18.76	218.5±22.52	<0.001
Duration of motor block (in mins)	152.5±11.87	190.66±21.2	<0.001
Duration of effective analgesia (in mins)	168.5±16.56	225.76±24.81	<0.001

In this study involving 70 patients (35 in each group), perioperative pulse rates were monitored at multiple time intervals from baseline up to 720 minutes postoperatively. Both Group B (bupivacaine only) and Group M (bupivacaine with magnesium sulfate) demonstrated comparable trends in pulse rate throughout the monitoring period. Although minor fluctuations were observed at different time points, none of the differences between the groups reached statistical significance ($p>0.05$) (Table 2).

Table 2: Comparison of Perioperative Pulse Rate Trends Between Intrathecal Bupivacaine with and Without Magnesium Sulfate in Lower Limb Surgeries

Time (minutes)	Group B (PR in bpm)	Group M (PR in bpm)	p-value
Pre-op (0)	81.5	79.33	>0.05
1	82.16	77.8	>0.05
5	78.7	77.3	>0.05
10	74.83	73.56	>0.05
20	75.33	72.16	>0.05
30	74.23	72.7	>0.05
45	80.1	83.03	>0.05
60	84.83	84	>0.05
90	87.43	86.83	>0.05

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120	88.56	86.2	>0.05
180	88.8	86.36	>0.05
240	88.06	88.23	>0.05
300	89	89.63	>0.05
360	88.33	90.03	>0.05
420	88.9	89	>0.05
480	87.53	88.93	>0.05
540	89.49	87.66	>0.05
600	89.26	87.46	>0.05
660	87.9	86.9	>0.05
720	89.23	87.63	>0.05

This comparative analysis of mean arterial pressure tendencies in 70 patients receiving intrathecal bupivacaine with or without magnesium sulfate demonstrates that both groups maintained stable hemodynamics throughout the perioperative and postoperative period. While minor MAP variations were noted at various intervals, none were statistically significant ($p>0.05$). The lowest MAP values were observed between 20–45 minutes post-spinal, with gradual normalisation thereafter. The addition of magnesium sulfate did not result in significant hypotension or hemodynamic instability compared to bupivacaine alone, confirming its safety as an intrathecal adjuvant in the studied doses (Table 3).

Table 3: Comparison of Mean Arterial Pressure Tendencies Between Intrathecal Bupivacaine with and Without Magnesium Sulfate in Lower Limb Surgeries

Time (minutes)	Group B (MAP mmHg)	Group M (MAP mmHg)	p-value
Pre-op (0)	87.2	85.9	>0.05
1	84.13	86.76	>0.05
5	78.58	80.23	>0.05
10	74.2	75.26	>0.05
20	69.5	72.1	>0.05
30	70	71.96	>0.05
45	70.16	71.33	>0.05
60	75.36	74	>0.05
90	80.93	78.13	>0.05
120	84.26	82.26	>0.05
180	87.6	85.6	>0.05
240	87.4	85.93	>0.05
300	82.76	82.8	>0.05
360	84.83	81.56	>0.05
420	85.63	83.36	>0.05
480	83.43	82.86	>0.05
540	84.16	84.4	>0.05
600	87.3	86.73	>0.05
660	82.53	84.86	>0.05
720	84.66	85.03	>0.05

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In this comparative study of 70 patients undergoing lower limb surgeries under spinal anaesthesia, the incidence of adverse effects was low and comparable between the two groups. Hypotension occurred in 8 patients in Group B and 6 in Group M, while bradycardia was observed in 6 and 4 patients, respectively—differences that were not statistically significant ($p>0.05$). Mild nausea and vomiting occurred in 4 patients in Group B and 5 in Group M, without a significant difference. No cases of respiratory depression or pruritus were reported in either group (Table 4).

Table 4: Comparison of Adverse Effects Between Intrathecal Bupivacaine Alone and Bupivacaine with Magnesium Sulfate in Lower Limb Surgeries

Adverse Effect	Group B (n = 35)	Group M (n = 35)	p-value
Hypotension	8	6	>0.05
Bradycardia	6	4	>0.05
Nausea/Vomiting	4	5	>0.05
Respiratory Depression	0	0	—
Pruritus	0	0	—

DISCUSSION

This study assessed the effects of adding intrathecal magnesium sulfate to bupivacaine in spinal anaesthesia for lower limb surgeries. The results indicate that adding $MgSO_4$ prolongs the duration of sensory and motor blocks and encompasses postoperative analgesia without important adverse effects.

The continuation of sensory and motor block durations observed in this study aligns with earlier investigations. For example, duration of sensory blockade and reduced postoperative analgesic requirements in patients experiencing lower limit Khalili *et al.* [8] reported that the addition of 100 mg of intrathecal $MgSO_4$ to 15 mg of bupivacaine suggestively increased the orthopaedic surgery. Similarly, Ozalevli *et al.* found that 50 mg of intrathecal $MgSO_4$ added to bupivacaine-fentanyl spinal anaesthesia prolonged the duration of spinal anaesthesia without additional side effects [9].

The mechanism by which $MgSO_4$ improves spinal anaesthesia is primarily attributed to its antagonistic action on N-methyl-D-aspartate receptors. Magnesium prolongs the effects of local anaesthetics and enhances analgesia by inhibiting NMDA receptors.

In the setting of lower limb surgeries, Faiz *et al.* established that the addition of $MgSO_4$ to bupivacaine increased the onset time of motor block and prolonged the duration of anaesthesia without important side effects. In addition, Özalevli *et al.* compared intrathecal magnesium, fentanyl, and placebo added to bupivacaine and found that magnesium prolonged the duration of sensory and motor blocks compared to placebo [10,3].

However, reported reliable findings are not from all studies. For example, a study by Wang et al. determined that intrathecal magnesium sulfate did not reduce the dose requirement of intrathecal bupivacaine but extended the duration of spinal anaesthesia. In addition, a study comparing intrathecal dexmedetomidine and magnesium sulfate found that dexmedetomidine had a more rapid onset and longer duration of sensory block compared to magnesium sulfate [4].

Despite these discrepancies, the complete indication supports the use of intrathecal $MgSO_4$ as an adjunct to bupivacaine for enhancing spinal anaesthesia. The addition of $MgSO_4$ appears to prolong the duration of sensory and motor blocks and extend postoperative analgesia without increasing the incidence of adverse effects [11-13]. These reduce the need for additional analgesics, minimise surgical consequences, probably improve complete benefits, and can improve patient comfort.

The findings of this study, along with existing literature, suggest that intrathecal $MgSO_4$ is a valuable adjuvant to bupivacaine in spinal anaesthesia for lower limb surgeries [14]. Its ability to provide postoperative analgesia without important side effects can improve both the quality and duration of spinal anaesthesia [15].

CONCLUSIONS

The study addition of magnesium sulfate to intrathecal bupivacaine in lower limb surgeries does not suggestively alter perioperative pulse rate, mean arterial pressure, or the occurrence of adverse effects. Both groups

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maintained stable hemodynamics and showed similar safety profiles throughout the perioperative period. This study supports the usage of intrathecal magnesium sulfate as a safe adjunct to bupivacaine for spinal anesthesia. It establishes that magnesium sulfate does not increase the risk of hemodynamic unpredictability or adverse events, making it a feasible choice for providing analgesia without compromising patient safety.

CONTRIBUTION OF AUTHORS

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Supervision- Dr. Seema Sharma
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REFERENCES

[1] Belal MM, Alazki OM, Bashir MN, Sbitan LY, Albelal D, et al. Intrathecal magnesium sulphate as an adjuvant to bupivacaine for infraumbilical surgeries: An updated systematic review and meta-analysis. Indian J Anaesth., 2025; 69: 86–107.

[2] Solanki NM, Bhimani MP, Mistry NS, Rajan D. Evaluation of adding magnesium sulphate to intrathecal bupivacaine in lower limb orthopaedic surgery. Ain-Shams J Anaesthesiol., 2023; 15.

[3] Özalevli M, Cetin TO, Unlugenc H, Guler T, Isik G. The effect of adding intrathecal magnesium sulphate to bupivacaine–fentanyl spinal anaesthesia. Acta Anaesthesiol Scand., 2005; 49: 1514–19.

[4] Wang J, Wang Z, Shi B, Wang N. The effect of adding intrathecal magnesium sulphate to bupivacaine-fentanyl spinal anaesthesia: A meta-analysis of randomised controlled trials. Medicine (Baltimore), 2020; 99: e22524.

[5] Pascual-Ramírez J, Gil-Trujillo S, Alcantarilla C. Intrathecal magnesium as analgesic adjuvant for spinal anaesthesia: A meta-analysis of randomised trials. Minerva Anestesiol., 2013; 79: 667–78.

[6] Prabhavathi R, Isaac GA, Reddy PN, Umanageshwarah P. A study to observe the effects of the addition of magnesium sulphate as an adjuvant to 0.5% bupivacaine for intrathecal anaesthesia in surgeries of the lower limbs. Indian J Clin Anaesth., 2017; 4: 338–44.

[7] Limbu PM, Khatiwada S, Sah BP, Singh SN, Pokharel K, et al. Intrathecal magnesium sulfate as analgesic and anaesthetic adjunct to bupivacaine in patients undergoing lower extremity orthopaedic surgery. J Soc Anesthesiol Nepal., 2018; 4: 74–80.

[8] Khalili G, Janghorbani M, Sajedi P, Ahmadi G. Effects of adjunct intrathecal magnesium sulfate to bupivacaine for spinal anesthesia: A randomized, double-blind trial in patients undergoing lower extremity surgery. J Anesth., 2011; 25: 892–97.

[9] Ozalevli M, Cetin TO, Unlugenc H, Guler T, Isik G. The effect of adding intrathecal magnesium sulphate to bupivacaine-fentanyl spinal anaesthesia. Acta Anaesthesiol Scand., 2005; 49(10): 1514-19. doi: 10.1111/j.1399-6576.2005.00793.x.

[10] Faiz SHR, Rahimzadeh P, Sakhaei M, Imani F, Derakhshan P. Anaesthetic effects of adding intrathecal neostigmine or magnesium sulphate to bupivacaine in patients under lower extremities surgeries. J Res Med Sci., 2012; 17: 918–22.

[11] Xiao F, Xu W, Feng Y, Fu F, Zhang X, et al. Intrathecal magnesium sulfate does not reduce the ED50 of intrathecal hyperbaric bupivacaine for cesarean delivery in healthy parturients: A prospective, double-blinded, randomised dose-response trial using the sequential allocation method. BMC Anesthesiol., 2017; 17.

[12] Swain A, Nag DS, Sahu S, Samaddar DP. Adjuvants to local anaesthetics: Current understanding and future trends. World J Clin Cases, 2017; 5: 307.

[13] Kumar A, Prasad C, Sinha C, Kumar A. A comparative study of intrathecal bupivacaine with and without magnesium sulphate for lower limb orthopedic surgeries. Anesth Essays Res., 2020; 14(3): 459–63.

[14] Telkabadi M, Banihashem N, Hashemi M. The effect of adding magnesium sulfate to bupivacaine in spinal anesthesia for orthopedic surgeries: A randomized clinical trial. Anesth Pain Med., 2022; 12(1): e120555. doi: 10.5812/aapm-120555.

doi: 10.21276/SSR-IIJLS.2025.11.4.8

[15]Jabalameli M, Pakzadmoghadam SH. Adding different doses of intrathecal magnesium sulfate to bupivacaine for spinal anesthesia in cesarean section: A prospective double-blind randomized clinical trial. Adv Biomed Res., 2012; 1: 07. doi: 10.4103/2277-9175.94419.