International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

To Study the Efficacy of Magnesium Sulphate as an Adjuvant to Ropivacaine Under Usg-Guided Costoclavicular Approach of Infraclavicular Block

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Received: 05-06-2026
Accepted: 22-06-2026
Available online: 07-07-2026

ABSTRACT

Background: Ultrasound-guided costoclavicular brachial plexus block is an effective regional anaesthetic technique for upper limb surgeries. Various adjuvants have been used to enhance the efficacy of local anaesthetics. Magnesium sulfate, due to its NMDA receptor antagonism, may improve block characteristics and postoperative analgesia.

Aim: To evaluate the efficacy of magnesium sulfate as an adjuvant to 0.5% ropivacaine in ultrasound-guided costoclavicular infraclavicular brachial plexus block.

Methods: This prospective, double-blinded, randomized controlled study was conducted on 60 patients undergoing elective upper limb surgeries below the mid-humerus level. Patients were randomly allocated into two groups: Group R received 20 mL of 0.5% ropivacaine with 1 mL normal saline, and Group RM received 20 mL of 0.5% ropivacaine with 150 mg magnesium sulfate. Primary outcomes included onset and duration of sensory and motor block and duration of postoperative analgesia. Secondary outcomes included haemodynamic stability, VAS scores, and complications.

Results: Group RM showed significantly faster onset of sensory (7.85 ± 1.90 vs 11.50 ± 2.12 min, $p < 0.001$) and motor block (10.45 ± 1.78 vs 14.80 ± 2.05 min, $p < 0.001$). Duration of sensory block (397.30 ± 21.10 vs 292.60 ± 18.80 min, $p < 0.001$) and postoperative analgesia (598.70 ± 22.35 vs 412.40 ± 25.10 min, $p < 0.001$) were significantly prolonged in the magnesium group. Motor block duration and haemodynamic parameters were comparable between groups.

Conclusion: Magnesium sulfate is an effective and safe adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block, improving block onset and prolonging postoperative analgesia without adverse haemodynamic effects.

Keywords: *Magnesium sulfate; Ropivacaine; Costoclavicular block; Infraclavicular brachial plexus block; Ultrasound-guided regional anaesthesia; Postoperative analgesia; Peripheral nerve block; NMDA receptor antagonist.*

INTRODUCTION

Regional anaesthesia plays a pivotal role in modern perioperative practice by providing effective surgical anaesthesia and superior postoperative analgesia while minimizing opioid consumption and associated adverse effects.[1] The widespread adoption of ultrasound guidance has further revolutionized peripheral nerve blocks by improving accuracy, reducing complications, and increasing success rates through real-time visualization of neural structures and local anaesthetic spread.[2]

The infraclavicular brachial plexus block is commonly used for surgeries of the upper limb below the mid-humerus. Among its various approaches, the costoclavicular technique is a relatively newer modification in which the cords of the brachial plexus are closely clustered lateral to the axillary artery, allowing easier identification and a more consistent block performance under ultrasound guidance.[3]

Ropivacaine, a long-acting amide local anaesthetic, is widely preferred for peripheral nerve blocks due to its reduced cardiotoxicity and favourable sensory-motor separation. However, its duration of analgesia may still be insufficient for extended postoperative pain control, particularly in major upper limb surgeries.[4] This limitation has led to increasing interest in the use of adjuvants to enhance block quality and prolong analgesia.

Magnesium sulfate has emerged as a promising adjuvant in regional anaesthesia owing to its NMDA receptor antagonistic action and calcium channel blocking properties. It reduces calcium influx at presynaptic terminals, inhibits neurotransmitter release, and attenuates central sensitization involved in postoperative pain pathways.[5]

Evidence from previous studies suggests that magnesium sulfate can improve the onset and duration of peripheral nerve blocks without significant neurotoxicity or systemic adverse effects when used in appropriate doses.[6] Additionally, its role in reducing postoperative analgesic requirements has been well documented in various regional anaesthetic techniques.[7]

Despite growing evidence supporting magnesium as an adjuvant, there is limited literature specifically evaluating its efficacy in ultrasound-guided costoclavicular infraclavicular brachial plexus block. Therefore, the present study was undertaken to evaluate the efficacy of magnesium sulfate as an adjuvant to ropivacaine in this technique, with respect to onset of block, duration of analgesia, haemodynamic stability, and postoperative pain control.

MATERIALS AND METHODS

Study Design

This study was a prospective, double-blinded, randomised controlled trial conducted to evaluate the efficacy of magnesium sulfate as an adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block for upper limb surgeries.

Study Setting

The study was carried out in the Department of Anesthesiology and Critical Care at Al Ameen Medical College and Hospital over a period of April 2023 to October 2024 (18 months).

Study Population

A total of 60 patients scheduled for elective upper limb surgeries below the mid-humerus level were enrolled in the study. Patients were randomly divided into two equal groups (n = 30 each).

Group Allocation

- Group R (Control group): Received 20 mL of 0.5% ropivacaine + 1 mL normal saline (total 21 mL).
- Group RM (Study group): Received 20 mL of 0.5% ropivacaine + 150 mg magnesium sulfate diluted in 1 mL normal saline (total 21 mL).

Randomization and Blinding

Patients were randomly allocated into two groups using a computer-generated random number table. Allocation concealment was ensured using sealed opaque envelopes.

This was a double-blinded study, in which:

- Patients were unaware of group allocation.
- The anesthesiologist performing the block and collecting data was blinded.
- The anesthesiologist preparing drug solutions was not involved in patient management or data collection.

Inclusion Criteria

- Age between 18–60 years
- Either sex
- ASA physical status I and II
- Patients undergoing elective upper limb surgeries below mid-humerus including:
    - Forearm fractures
    - Hand and wrist surgeries
    - Carpal tunnel release
    - Tendon repairs

    - Soft tissue surgeries
- Patients who provided written informed consent

Exclusion Criteria
- Refusal to consent
- ASA grade III and IV
- Pregnancy or lactation
- Allergy to local anesthetics or magnesium sulfate
- Pre-existing brachial plexus neuropathy
- Coagulopathy or anticoagulant therapy
- Severe cardiac, hepatic, or renal disease
- Infection at injection site
- BMI > 35 kg/m²

Preoperative Evaluation
All patients underwent detailed pre-anesthetic evaluation including history, clinical examination, and relevant laboratory investigations. Standard fasting guidelines were followed.

Preoperative Management
Standard monitoring included:
- Non-invasive blood pressure (NIBP)
- Heart rate (HR)
- Oxygen saturation (SpO_2)
- Electrocardiography (ECG)

Intravenous access was secured with a 20G cannula, and Ringer's lactate infusion was started. Premedication included:
- Midazolam 0.02 mg/kg IV
- Fentanyl 1 µg/kg IV

Block Technique
Patient Position
Patients were placed supine with the ipsilateral arm abducted at 90°, palm facing upward, and head turned contralaterally.

Ultrasound Guidance
A high-frequency linear ultrasound probe (6–13 MHz) was used. The costoclavicular space was identified below the clavicle, visualizing the axillary artery and the cords of the brachial plexus.

Needle Technique
A 21G, 50 mm Stimuplex needle was introduced in-plane from lateral to medial direction. After negative aspiration, the study drug was injected incrementally.

Intraoperative Monitoring
Heart rate, blood pressure, SpO_2, and ECG were recorded:
- Every 5 minutes for the first 30 minutes
- Every 15 minutes thereafter during surgery

Block Assessment
Sensory Block
Evaluated using pinprick test:
- 0 = No block
- 1 = Analgesia
- 2 = Complete loss of sensation

Motor Block
Assessed using a 3-point Bromage scale:
- 0 = Full movement
- 1 = Movement against gravity
- 2 = Flicker of movement
- 3 = Complete motor block

Postoperative Monitoring
Patients were monitored for:

- Vital signs every 2 hours for first 6 hours, then every 4 hours
- Pain using Visual Analog Scale (VAS)
- Duration of sensory and motor block
- Duration of postoperative analgesia (time to first rescue analgesic)

Rescue analgesia was given when VAS score exceeded 3.

Outcome Measures
Primary outcomes:

- Onset of sensory block
- Onset of motor block
- Duration of sensory block
- Duration of postoperative analgesia

Secondary outcomes:

- Hemodynamic stability
- VAS pain scores
- Complications (e.g., pneumothorax, vascular puncture, neurotoxicity, magnesium toxicity)

Sample Size Calculation
Sample size was calculated using Snedecor and Cochran formula based on previous studies.
Assumptions:

- $\alpha = 0.05$
- Power = 90%
- Standard deviation = 2.1
- Minimum detectable difference = 1.5

The calculated sample size was 30 patients per group, accounting for dropouts.

Statistical Analysis
Data were analyzed using SPSS version 23 (IBM Corp.).
Statistical tests used:

- Student's t-test: Continuous variables
- Chi-square test/Fisher's exact test: Categorical variables
- Repeated measures analysis for hemodynamic variables
- $p < 0.05$ was considered statistically significant

RESULTS AND OBSERVATIONS
A total of 60 patients undergoing elective upper limb surgeries were enrolled and divided equally into two groups:

- Group R (0.5% Ropivacaine + NS)
- Group RM (0.5% Ropivacaine + Magnesium Sulphate)

Both groups were comparable in demographic variables and perioperative parameters.

TABLE 1: AGE DISTRIBUTION

Group	Mean Age (years)	SD	p-value
Group R	38.20	6.45	≥0.05
Group RM	39.65	5.98	

Age distribution was comparable between groups.

TABLE 2: GENDER DISTRIBUTION

Group	Male n (%)	Female n (%)
Group R	13 (43.3%)	17 (56.7%)
Group RM	15 (50.0%)	15 (50.0%)

Gender distribution was comparable (no significant difference).

TABLE 3: BMI DISTRIBUTION

Group	Mean BMI	SD	p-value
Group R	24.10	2.25	≥0.05
Group RM	24.85	2.10	

BMI was comparable in both groups.

TABLE 4: ASA PHYSICAL STATUS

Group	ASA I n (%)	ASA II n (%)
Group R	19 (63.3%)	11 (36.7%)
Group RM	20 (66.7%)	10 (33.3%)

ASA distribution was similar in both groups.

TABLE 5: HEART RATE (bpm)

Group	Mean HR	SD	p-value
Group R	78.20	6.45	≥0.05
Group RM	77.35	6.10	

Hemodynamic stability was maintained in both groups.

TABLE 6: MEAN ARTERIAL PRESSURE (mmHg)

Group	Mean MAP	SD	p-value
Group R	89.50	4.80	≥0.05
Group RM	88.60	4.65	

MAP remained stable and comparable.

TABLE 7: SpO_2 (%)

Group	Mean SpO_2	SD	p-value
Group R	97.80	0.95	≥0.05
Group RM	98.10	0.90	

Oxygenation was adequate in both groups.

TABLE 8: ONSET OF SENSORY & MOTOR BLOCK

Parameter	Group R (Mean ± SD)	Group RM (Mean ± SD)	p-value
Sensory onset (min)	11.50 ± 2.12	7.85 ± 1.90	<0.001
Motor onset (min)	14.80 ± 2.05	10.45 ± 1.78	<0.001

Significantly faster block onset in magnesium group.

TABLE 9: DURATION OF BLOCK

Parameter	Group R	Group RM	p-value
Sensory block (min)	292.60 ± 18.80	397.30 ± 21.10	<0.001
Motor block (min)	295.40 ± 20.80	301.10 ± 19.75	≥0.05

Sensory block significantly prolonged; motor block unchanged.

TABLE 10: POSTOPERATIVE ANALGESIA

Group	Duration (min)	SD	p-value
Group R	412.40	25.10	<0.001
Group RM	598.70	22.35	

Magnesium significantly prolonged analgesia duration.

TABLE 11: VAS SCORE COMPARISON (FIRST 12 HOURS)

Time	Group R	Group RM	p-value
2 hr	1.45 ± 0.48	0.95 ± 0.35	<0.001
4 hr	3.05 ± 0.66	2.10 ± 0.51	<0.001
6 hr	4.25 ± 0.60	2.65 ± 0.63	<0.001
8 hr	4.55 ± 0.75	3.15 ± 0.68	<0.001
10 hr	3.48 ± 1.00	2.60 ± 0.85	<0.01
12 hr	2.90 ± 1.20	2.25 ± 0.95	0.045

Magnesium group had significantly lower pain scores early postoperatively.

DISCUSSION

The present prospective, double-blinded, randomized controlled study was conducted to evaluate the efficacy of magnesium sulfate as an adjuvant to 0.5% ropivacaine in ultrasound-guided costoclavicular infraclavicular brachial plexus block. The study demonstrated that magnesium sulfate significantly improved block characteristics by accelerating onset of sensory and motor block, prolonging sensory blockade, and extending duration of postoperative analgesia without affecting haemodynamic stability or increasing complications.

In continuation with the pharmacological basis discussed in the introduction, magnesium exerts its analgesic effects primarily through NMDA receptor antagonism and inhibition of calcium influx at presynaptic terminals, thereby reducing excitatory neurotransmitter release and central sensitization.[5] This mechanism explains the faster onset of block observed in the magnesium group, as reduced neuronal excitability enhances the action of local anaesthetics at the nerve membrane.

In the present study, the onset of both sensory and motor block was significantly faster in the magnesium group compared to the control group. These findings are consistent with previous studies demonstrating that magnesium enhances the action of local anaesthetics and improves block quality when used as an adjuvant in peripheral nerve blocks.[6]

The duration of sensory block and postoperative analgesia was significantly prolonged in the magnesium group. This prolonged analgesic effect may be attributed to magnesium-mediated blockade of NMDA receptors in the dorsal horn of the spinal cord, which plays a crucial role in preventing central sensitization and wind-up phenomena associated with postoperative pain.[7] Similar findings have been reported in systematic reviews and clinical trials where perineural magnesium significantly extended analgesia duration when combined with long-acting local anaesthetics.[6,7]

Importantly, motor block duration was not significantly affected by magnesium sulfate. This selective enhancement of sensory analgesia without prolonging motor blockade is clinically advantageous, particularly in upper limb surgeries where early mobilization is desirable. This finding aligns with previous literature suggesting that magnesium primarily enhances sensory pathways rather than motor conduction when used in peripheral nerve blocks.[8]

VAS score analysis in the present study further confirmed improved analgesic efficacy in the magnesium group, with significantly lower pain scores during the early postoperative period. This reduced pain intensity translated into a decreased requirement for rescue analgesics, thereby improving overall patient comfort and satisfaction.

Haemodynamic parameters, including heart rate, mean arterial pressure, and oxygen saturation, remained stable in both groups throughout the perioperative period. No episodes of hypotension, bradycardia, or respiratory depression were observed. These findings support the cardiovascular safety of magnesium sulfate when used in recommended doses for peripheral nerve block adjuvant therapy.[9]

The costoclavicular approach itself contributed to the consistency and reliability of the block. The compact arrangement of the brachial plexus cords in the costoclavicular space allows easier ultrasound identification and more uniform local anaesthetic spread, leading to high block success rates and reduced variability in onset and duration.[3]

No neurotoxicity, vascular complications, or signs of systemic magnesium toxicity were observed in this study. This further supports the safety profile of magnesium sulfate when used in peripheral nerve blocks, consistent with previously published clinical evidence.[10]

Overall, the findings of this study suggest that magnesium sulfate is an effective and safe adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block, improving block onset, prolonging sensory analgesia, and enhancing postoperative pain control without compromising haemodynamic stability or safety.
However, the study has certain limitations, including a relatively small sample size and short postoperative follow-up period. Future multicentric studies with larger sample sizes and comparison with other adjuvants such as dexmedetomidine may further strengthen the evidence.

CONCLUSION

Magnesium sulfate, when used as an adjuvant to 0.5% ropivacaine in ultrasound-guided costoclavicular infraclavicular block, significantly improves block quality by accelerating onset of sensory and motor block and prolonging duration of sensory block and postoperative analgesia. It also reduces postoperative pain scores and rescue analgesic requirement.

Motor block duration and haemodynamic parameters remain unaffected, and no significant adverse effects are observed, confirming its safety.

Thus, magnesium sulfate is an effective and safe adjuvant for improving analgesic outcomes in upper limb regional anaesthesia.

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