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Postoperative Analgesic Efficacy and Hemodynamic Effects of Magnesium Sulphate as an Adjuvant to Ropivacaine in Ultrasound Guided Costoclavicular Brachial Plexus Block

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ABSTRACT

Background; Ultrasound-guided costoclavicular brachial plexus block is an effective regional anaesthesia technique for upper limb surgeries. Magnesium sulphate has been used as an adjuvant to local anaesthetics to prolong postoperative analgesia and improve pain control.

Aim; To evaluate the postoperative analgesic efficacy and hemodynamic effects of magnesium sulphate as an adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block.

Materials and Methods; This prospective, randomized, double-blinded, controlled comparative study was conducted in the Department of Anaesthesiology at AI Ameen Medical College Hospital over a period of 18 months from April 2023 to October 2024. A total of 60 patients undergoing elective upper limb surgeries were randomly divided into two groups of 30 each. Group R received 30 mL of 0.5% ropivacaine with 1 mL normal saline, while Group RM received 30 mL of 0.5% ropivacaine with magnesium sulphate 150 mg diluted to 1 mL. Postoperative analgesia, Visual Analogue Scale (VAS) scores, rescue analgesic requirement, hemodynamic parameters, and adverse effects were assessed. Statistical analysis was performed using SPSS version 26.0, and $p<0.05$ was considered statistically significant.

Results; Duration of postoperative analgesia was significantly prolonged in Group RM compared to Group R (712.8 ± 63.5 min vs 468.3 ± 54.2 min; $p<0.001$). Postoperative VAS scores at all measured intervals up to 24 hours were significantly lower in the magnesium group ($p<0.001$). Rescue analgesic requirement was significantly reduced in Group RM (1.3 ± 0.5) compared to Group R (2.4 ± 0.6). Hemodynamic parameters remained stable and comparable between both groups throughout the perioperative period. No major adverse effects or complications were observed.

Conclusion; Magnesium sulphate is an effective and safe adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block. Its addition significantly prolonged postoperative analgesia, reduced VAS scores, and decreased rescue analgesic requirement without causing significant hemodynamic instability or major adverse effects.

Keywords: *Costoclavicular brachial plexus block; Magnesium sulphate; Ropivacaine; Postoperative analgesia; Hemodynamic effects; Ultrasound-guided regional anaesthesia.*

INTRODUCTION

Regional anaesthesia has become an important component of modern anaesthetic practice because of its advantages in providing effective perioperative analgesia, reduced opioid consumption, early mobilization, and improved patient satisfaction.[1] Brachial plexus block is widely used for upper limb surgeries because it offers excellent anaesthesia and postoperative pain relief.[2]

The introduction of ultrasound guidance has significantly improved the safety and success rate of brachial plexus blocks by enabling real-time visualization of neural structures, surrounding vessels, and needle trajectory.[3] The costoclavicular approach to infraclavicular brachial plexus block is a relatively newer ultrasound-guided technique in which the cords of the brachial plexus are clustered together lateral to the axillary artery, facilitating reliable blockade and improved needle visualization.[4]

The costoclavicular approach has gained popularity because of its rapid onset, dense blockade, reduced risk of pneumothorax, and improved catheter stability compared to conventional infraclavicular approaches.[5,6] Ropivacaine is a long-acting amide local anaesthetic commonly used in peripheral nerve blocks due to its prolonged duration of action and lower cardiotoxicity profile.[7] However, postoperative analgesia produced by ropivacaine alone may be inadequate in prolonged upper limb surgeries, leading to increased postoperative analgesic requirements.

Various adjuvants such as dexamethasone, clonidine, dexmedetomidine, fentanyl, and magnesium sulphate have been investigated to improve postoperative analgesia in peripheral nerve blocks.[8] Magnesium sulphate has emerged as a useful adjuvant because of its analgesic and antinociceptive properties. It acts mainly through antagonism of N-methyl-D-aspartate (NMDA) receptors and regulation of calcium influx into cells, thereby reducing central sensitization and pain transmission.[9,10]

Magnesium sulphate also inhibits catecholamine release and stabilizes excitable membranes, contributing to improved analgesic efficacy.[11] Previous studies have demonstrated that magnesium sulphate prolongs postoperative analgesia and reduces analgesic consumption when used as an adjuvant in brachial plexus blocks.[12–14]

The hemodynamic effects of magnesium sulphate are another important consideration during anaesthesia. Magnesium possesses vasodilatory and sympatholytic properties that may influence perioperative cardiovascular stability.[15] However, studies evaluating magnesium sulphate as a perineural adjuvant have generally reported stable hemodynamic parameters without significant adverse cardiovascular effects.[16]

Limited literature is available regarding the use of magnesium sulphate specifically in ultrasound-guided costoclavicular brachial plexus block. Therefore, the present study was undertaken to evaluate the postoperative analgesic efficacy and hemodynamic effects of magnesium sulphate as an adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block in patients undergoing elective upper limb surgeries.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, double-blinded, controlled comparative study was conducted in the Department of Anaesthesiology at AI Ameen Medical College Hospital after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all patients participating in the study.

Study Duration

The study was conducted over a period of 18 months from April 2023 to October 2024.

Sample Size

A total of 60 patients were included in the study and randomly allocated into two groups of 30 patients each.

Study Population

Patients scheduled for elective upper limb surgeries under ultrasound-guided costoclavicular brachial plexus block were enrolled in the study.

Inclusion Criteria

- Patients aged between 18 and 65 years
- Patients of either gender
- American Society of Anesthesiologists (ASA) physical status I and II
- Patients undergoing elective upper limb surgeries below the level of shoulder joint
- Patients willing to provide written informed consent

Exclusion Criteria

- Patient refusal
- Known allergy or hypersensitivity to local anaesthetics or magnesium sulphate
- Patients with coagulopathy or bleeding disorders
- Infection at the site of injection
- Severe hepatic, renal, cardiac, or respiratory illness
- Neuromuscular disorders
- Pregnant and lactating women
- Body mass index (BMI) >35 kg/m²
- Patients receiving calcium channel blockers or magnesium therapy

Randomization and Group Allocation

The enrolled patients were randomly divided into two groups of 30 each using computer-generated randomization.

Group R (Control Group)

Patients received 30 mL of 0.5% ropivacaine with 1 mL normal saline.

Group RM (Magnesium Group)

Patients received 30 mL of 0.5% ropivacaine with magnesium sulphate 150 mg diluted to 1 mL.
The total volume of drug administered in both groups was maintained equally.

Preoperative Assessment

A detailed pre-anaesthetic evaluation was carried out in all patients, including complete medical history, physical examination, airway assessment, and routine laboratory investigations. All patients were advised to fast overnight for at least 6–8 hours before surgery.

On arrival in the operating room, standard monitoring, including electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and heart rate monitoring, was instituted. Baseline hemodynamic parameters were recorded before administration of the block. An 18-G intravenous cannula was secured, and intravenous crystalloid infusion was started.

Technique of Costoclavicular Brachial Plexus Block

Under strict aseptic precautions, an ultrasound-guided costoclavicular brachial plexus block was performed using a high-frequency linear ultrasound transducer.

The patient was placed in the supine position with the arm abducted. The ultrasound probe was positioned inferior to the clavicle in the costoclavicular region to identify the axillary artery and the cords of the brachial plexus clustered together lateral to the artery.

A 22-G insulated block needle was introduced using an in-plane technique under real-time ultrasound guidance. After negative aspiration, the study drug solution was injected incrementally with intermittent aspiration. Adequate spread of local anaesthetic around the cords was confirmed sonographically.

Hemodynamic Parameters

Hemodynamic parameters, including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and oxygen saturation (SpO_2), were recorded at baseline, after administration of the block, intraoperatively at regular intervals, and postoperatively.

Postoperative Analgesia

Postoperative pain was assessed using the Visual Analogue Scale (VAS), ranging from 0 to 10, where 0 indicated no pain, and 10 indicated the worst imaginable pain. VAS scores were recorded at 1, 2, 4, 6, 8, 10, 12, 16, 20, and 24 hours postoperatively.

Duration of postoperative analgesia was defined as the time interval between completion of block administration and the first request for rescue analgesia. Rescue analgesia was administered when VAS score was ≥4 using intravenous diclofenac sodium 75 mg. Total rescue analgesic requirement during the first 24 hours postoperatively was also recorded.

Outcome Measures

Primary Outcome

- Duration of postoperative analgesia

Secondary Outcomes

- Hemodynamic changes
- Postoperative VAS scores
- Total rescue analgesic consumption within 24 hours
- Incidence of adverse effects and complications

Adverse Effects and Complications

Patients were monitored for:

- Hypotension
- Bradycardia
- Nausea and vomiting
- Local anaesthetic systemic toxicity
- Pneumothorax
- Hematoma
- Vascular puncture
- Respiratory distress

Statistical Analysis

All collected data were entered into Microsoft Excel and analysed using SPSS software version 26.0. Quantitative variables were expressed as mean ± standard deviation (SD), while qualitative variables were expressed as frequencies and percentages.

Comparison of continuous variables between the two groups was performed using Student's independent t-test. Categorical variables were analysed using the chi-square test or Fisher's exact test, wherever applicable. A p-value <0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS

A total of 60 patients were enrolled and randomly allocated into two groups of 30 patients each.

- Group R: Received 0.5% ropivacaine with normal saline
- Group RM: Received 0.5% ropivacaine with magnesium sulphate

Both groups were comparable regarding demographic characteristics and baseline hemodynamic parameters.

Table 1: Demographic Characteristics of Study Participants

Parameter	Group R (n=30) Mean ± SD / n (%)	Group RM (n=30) Mean ± SD / n (%)	P value
Age (years)	39.8 ± 10.4	41.2 ± 9.8	0.58
Weight (kg)	64.5 ± 8.6	66.1 ± 7.9	0.46
Male	18 (60%)	17 (56.7%)	0.79
Female	12 (40%)	13 (43.3%)	

No statistically significant difference was observed between the groups regarding demographic characteristics (p>0.05).

Table 2: Comparison of Duration of Postoperative Analgesia Between the Groups

Parameter	Group R Mean ± SD	Group RM Mean ± SD	P value
Duration of Analgesia (min)	468.3 ± 54.2	712.8 ± 63.5	<0.001

Duration of postoperative analgesia was significantly prolonged in Group RM compared to Group R.

Table 3: Comparison of Postoperative Visual Analogue Scale (VAS) Scores up to 24 Hours

Time Interval	Group R Mean ± SD	Group RM Mean ± SD	P value
1 Hour	1.8 ± 0.7	1.2 ± 0.5	0.001
2 Hours	2.5 ± 0.8	1.5 ± 0.6	<0.001
4 Hours	3.6 ± 0.9	2.1 ± 0.8	<0.001
6 Hours	4.3 ± 1.0	2.8 ± 0.8	<0.001
8 Hours	5.1 ± 1.0	3.4 ± 0.9	<0.001
10 Hours	4.8 ± 0.9	3.1 ± 0.8	<0.001
12 Hours	4.3 ± 0.8	2.9 ± 0.7	<0.001
16 Hours	3.5 ± 0.7	2.3 ± 0.6	<0.001
20 Hours	2.6 ± 0.6	1.7 ± 0.5	<0.001
24 Hours	1.8 ± 0.5	1.2 ± 0.4	0.001

Postoperative VAS scores were significantly lower in Group RM at all postoperative intervals.

Table 4: Comparison of Hemodynamic Parameters (Heart Rate)

Time Interval	Group R Mean ± SD	Group RM Mean ± SD	P value
Baseline	82.4 ± 6.2	81.7 ± 5.9	0.68
15 Minutes	80.8 ± 5.8	79.9 ± 5.4	0.54
30 Minutes	79.6 ± 5.1	78.4 ± 4.9	0.39
60 Minutes	78.9 ± 4.8	77.5 ± 4.6	0.28

Hemodynamic parameters remained stable and comparable between both groups throughout the perioperative period.

Table 5: Comparison of Rescue Analgesic Requirement and Complications

Parameter	Group R (n=30)	Group RM (n=30)	P value
Rescue Analgesic Requirement (24 hrs)	2.4 ± 0.6	1.3 ± 0.5	<0.001
Nausea/Vomiting	2 (6.7%)	1 (3.3%)	0.55
Hypotension	1 (3.3%)	1 (3.3%)	1.00
Bradycardia	1 (3.3%)	0 (0%)	0.31
Vascular Puncture	1 (3.3%)	1 (3.3%)	1.00

Patients receiving magnesium sulphate required significantly lesser rescue analgesia. The incidence of adverse effects and complications was comparable between the groups.

DISCUSSION

The present prospective randomized comparative study was conducted to evaluate the postoperative analgesic efficacy and hemodynamic effects of magnesium sulphate as an adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block.

In the present study, duration of postoperative analgesia was significantly prolonged in the magnesium sulphate group compared to the control group. The mean duration of analgesia in Group RM was 712.8 ± 63.5 minutes compared to 468.3 ± 54.2 minutes in Group R. Magnesium sulphate exerts analgesic effects primarily through antagonism of NMDA receptors and regulation of calcium influx, thereby reducing nociceptive transmission and central sensitization.[8–10] Similar findings were reported by Mukherjee et al., Verma et al., and Lee et al., who observed prolonged postoperative analgesia and delayed requirement for rescue analgesics with magnesium sulphate as an adjuvant in brachial plexus blocks.[11–13]

Postoperative VAS scores were significantly lower in Group RM at all measured postoperative intervals up to 24 hours. Lower VAS scores indicate better postoperative pain control and improved patient comfort. In addition, rescue analgesic requirement during the first 24 hours was significantly reduced in the magnesium group compared to the control group. These findings are consistent with previous studies demonstrating that magnesium sulphate improves postoperative analgesia and decreases analgesic consumption when added to local anaesthetics in peripheral nerve blocks.[12–14] Effective postoperative analgesia also contributes to enhanced recovery, early mobilization, and reduced opioid-related adverse effects.[16,17]

Hemodynamic parameters remained stable and comparable between both groups throughout the perioperative period. No statistically significant differences in heart rate or blood pressure were observed between the groups. Although magnesium possesses vasodilatory and sympatholytic properties, the dose used in the present study did not produce clinically significant cardiovascular instability.[14] Similar hemodynamic stability has been reported in previous studies evaluating magnesium sulphate as an adjuvant in regional anaesthesia.[13,15]

The incidence of adverse effects and complications in the present study was minimal and comparable between the two groups. No serious complications such as local anaesthetic systemic toxicity, pneumothorax, or respiratory distress were observed. The use of ultrasound guidance further enhances the safety and success of the costoclavicular brachial plexus block by allowing accurate visualisation of neural structures and spread of local anaesthetic.[3–5]

However, the present study had certain limitations, including a relatively small sample size and a single-centre study design. Further multicentric studies with larger sample sizes are recommended to validate the findings and establish the optimal dose of magnesium sulphate for peripheral nerve blocks.

Overall, the present study demonstrates that magnesium sulphate is an effective and safe adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block, providing prolonged postoperative analgesia, lower VAS scores, reduced rescue analgesic requirement, and stable hemodynamic profile.

CONCLUSION

Magnesium sulphate is an effective and safe adjuvant to ropivacaine in ultrasound-guided costoclavicular brachial plexus block. Its addition significantly prolonged postoperative analgesia, reduced VAS scores, and decreased rescue analgesic requirement without causing significant hemodynamic instability or major adverse effects. Therefore, magnesium sulphate can be considered a useful adjuvant for upper limb surgeries under costoclavicular brachial plexus block.

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