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EVALUATING THE EFFICACY OF MGSO4 AS AN ADJUVANT TO 0.5% BUPIVACAINE IN SUPRACLAVICULAR-INTERCOSTOBRACHIAL NERVE BLOCKS FOR UPPER EXTREMITY HEMODIALYSIS VASCULAR ACCESS SURGERY

Albert[1], Tjokorda Gde Agung Senapathi[2], I Made Agus Kresna Sucandra[3]
Universitas Udayana, Indonesia
Email: albertadipurnama@icloud.com, tjoksenapathi@unud.ac.id, kresnasucandra@unud.ac.id

ABSTRACT

Magnesium sulfate ($MgSO_4$) has garnered increasing attention as an adjunct to regional anesthesia, particularly for patients with compromised kidney function requiring upper limb surgery for hemodialysis access. While peripheral nerve blocks are commonly selected for their safety and efficacy in such populations, their delayed onset of action can pose a clinical drawback. To address this issue, a randomized clinical study was conducted at RSUP Prof. I.G.N.G. Ngoerah to investigate the benefits of adding 200 mg of 20% $MgSO_4$ to supraclavicular-intercostobrachial nerve blocks. A total of 28 participants were randomized into two groups: one receiving the magnesium additive and another as a control. The study assessed onset time for full sensory and motor block as well as analgesia duration. Results indicated that patients in the $MgSO_4$ group experienced faster sensory (average 10.08 minutes) and motor block onset (average 17.98 minutes), compared to the control group (17.19 and 25.19 minutes, respectively). Moreover, the duration of pain relief was substantially extended in the $MgSO_4$ group, exceeding 470 minutes on average. Secondary observations also revealed a lower intraoperative requirement for fentanyl and a potential regulatory effect on inflammation-related biomarkers, such as neutrophil-to-lymphocyte and platelet-to-lymphocyte ratios. Overall, the findings suggest that $MgSO_4$ can serve as a valuable and safe enhancer of nerve block performance, especially in vulnerable surgical populations.

KEYWORDS *MgSO4, hemodialysis vascular access, total sensory block, total motor block, duration of analgesia, supraclavicular-intercostobrachial block.*

INTRODUCTION

Ensuring sustained and efficient regional anesthesia plays a vital role in surgical procedures, especially for individuals undergoing vascular access operations for hemodialysis treatment (Bilir et al., 2007). Procedures to establish vascular access for hemodialysis in the upper limbs frequently cause significant pain and discomfort, highlighting the need for accurate and effective anesthesia methods to enhance patient comfort, minimize surgical risks, and improve overall outcomes (Cuschieri, 2019). Techniques like the supraclavicular-intercostobrachial nerve block are commonly utilized for regional anesthesia in these procedures, as they offer focused pain relief while limiting systemic adverse effects.

Vascular access interventions, while essential for dialysis treatment, are frequently accompanied by various complications that can adversely affect clinical outcomes. Arteriovenous fistulas and grafts, commonly used access methods, are susceptible to issues such as narrowing of the vessel (stenosis), blood clot formation (thrombosis), and mechanical failures like access site malfunction. Patients may also experience more severe problems, including the development of aneurysms or pseudoaneurysms due to repeated needle

insertions, as well as heart complications resulting from high-volume blood flow through the shunt. Additionally, some individuals encounter symptoms like swelling-induced venous hypertension in the limb, skin discoloration, thickening, and even ulcer formation. Although pseudoaneurysms are less frequent reported in approximately 2% to 10% of cases they remain clinically significant due to their potential risks and association with repeated vascular trauma (Dahake et al., 2024). Repetitive needle punctures at the vascular access site can result in extended bleeding and the eventual development of pseudoaneurysms. Although minor pseudoaneurysms have the potential to clot and resolve on their own, this spontaneous healing is unreliable. As a result, surgical treatment is often required to avoid localized complications or prevent the pseudoaneurysm from increasing in size and severity (ELShamaa et al., 2014; Elyazed & Mogahed, 2018).

Considering the complexities involved, it is crucial to improve anesthetic approaches to support more effective surgical outcomes, reduce patient discomfort, and lower the likelihood of complications during and after the procedure. Although agents like 0.5% bupivacaine are commonly used and generally effective, their ability to deliver long-lasting pain relief or maintain adequate analgesia throughout the perioperative period may be limited in certain situations (Kovesdy, 2022). To address these limitations, incorporating adjuvants such as magnesium sulfate ($MgSO_4$) has gained attention as a potential enhancement to anesthetic practice. By inhibiting N-methyl-D-aspartate (NMDA) receptors and blocking calcium channels, $MgSO_4$ exhibits neuromodulatory properties that may extend the duration of analgesia and contribute to more effective and consistent anesthetic results.

This study seeks to evaluate the benefits of supplementing 0.5% bupivacaine with magnesium sulfate ($MgSO_4$) in a combined supraclavicular–intercostobrachial nerve block technique. Conducted among patients undergoing vascular access surgery for hemodialysis at RSUP Prof. I.G.N.G. Ngoerah, the research aims to generate evidence-based insights into improving anesthetic quality, optimizing patient recovery, and tackling the specific challenges posed by complications related to vascular access.

METHODS

This study utilized an experimental methodology through a single-blind randomized clinical trial, structured with a randomized pre- and post-test control group design. Participants were selected using a consecutive sampling method and then randomly assigned into two separate groups to ensure comparability and minimize selection bias:

a. Group A received a supraclavicular–intercostobrachial nerve block using 0.5% bupivacaine combined with magnesium sulfate ($MgSO_4$) as an adjuvant.
b. Group B received the same nerve block using 0.5% bupivacaine alone, without any additional adjuvant.

Sample allocation in this study was carried out using block randomization, ensuring balanced group distribution. The randomization process was executed with the aid of the QuickCalcs tool provided by GraphPad Software, Inc.

Table 1. Sample allocation.

1	2	3	4	5	6	7	8	9	10
A	A	B	B	A	B	B	A	B	A
11	12	13	14	15	16	17	18	19	20
B	A	B	A	A	B	B	A	A	B
21	22	23	24	25	26				
A	B	B	B	A	A				

Source Resource: Data Primmer (2025)

To assess the comparative effectiveness of the two interventions, the study focused on several critical outcome measures. The study measured several parameters, including the NLR and PLR levels before and after the intervention, the duration needed to establish full sensory and motor block, the time elapsed until the first demand for postoperative pain relief, and the cumulative amount of fentanyl administered within the first 24 hours following surgery. Data were gathered at RSUP Prof. I.G.N.G. Ngoerah, involving multiple departments such as the main operating theater, the emergency care unit, and Wing Amerta. The research proceeded until the target number of participants was reached to maintain adequate statistical reliability for analysis.

This research involved adult individuals aged 18 and above who were planned to receive vascular access surgeries in the upper limbs for the purpose of hemodialysis treatment. Participants were excluded if they exhibited uncooperative behavior, experienced hemodynamic instability classified as ASA IV or above, had known allergies to local anesthetics or magnesium sulfate, showed signs of active infection at the block site, had blood clotting disorders, suffered from neurological conditions that could alter pain perception, or declined to give informed consent. This careful selection process was designed to minimize confounding variables and enhance the validity of the results, thereby reinforcing the evidence supporting the use of $MgSO_4$ as an effective adjuvant for improving anesthetic efficacy and clinical outcomes.

The following equation was applied to calculate the required number of subjects per group:

$$Sg^2 = \frac{\lfloor S1^2\ x\ (n1-1) + \ S2^2\ x\ (n2-1) \rfloor}{n1+n2-2}$$

$$Sg^2 = \frac{\lfloor 37.2^2\ x\ (27-1) + \ 40.8^2\ x\ (27-1) \rfloor}{27+27-2}$$

$$Sg = \ 39.04$$

The sample size was calculated using a standard deviation of 39.04, applying the formula for hypothesis testing to compare the means of two independent populations. The formula used is as follows:

$$n1 = n2 = \frac{2\ (Za+Zb)^2\ Sg^2}{(X1-X2)^2}$$

$$n1 = n2 = \frac{2\,(1.96 + 1.64)^2\ 39.04^2}{(60)^2}$$

$$n1 = n2 = \ 10.97 \ \approx 11$$

Verma et al. (2017) examined this study explores how the administration of a supraclavicular brachial plexus block, utilizing bupivacaine either by itself or in conjunction with $MgSO_4$ as an additive, influences clinical outcomes in individuals scheduled for surgical procedures on the upper limbs (Lee et al., 2012). The findings revealed that participants receiving the treatment experienced a significantly quicker onset of complete motor block, averaging 11.13±4.6 minutes, in contrast to 28.47±7 minutes observed in the control group. Each group consisted of 30 individuals. Although the minimum sample size required per group, based on statistical power analysis, was 11 subjects, the number was increased to 26 per group to accommodate a projected dropout rate of 20%.

In this investigation, all variables were defined using specific operational standards to ensure consistency and reproducibility. $MgSO_4$ served as an adjuvant, prepared at a 20% concentration with a dose of 200 mg diluted in 0.9% sodium chloride to yield a 1 ml solution. A mixture containing 0.5% plain bupivacaine was prepared to reach a final volume of 20 ml for the supraclavicular brachial plexus block and 5 ml for the intercostobrachial nerve block. The supraclavicular block procedure was carried out using real-time ultrasound imaging and a 50 mm Stimuplex needle inserted through the Corner-Pocket approach. To optimize needle placement and confirm anatomical landmarks, the Hydro-Location technique was utilized by injecting 3–5 ml of 0.9% saline solution after clear visualization of surrounding structures. This same ultrasound-guided technique, including Hydro-Location, was applied for the intercostobrachial nerve block. The time to achieve full sensory and motor block was measured from the moment the supraclavicular block was administered until complete anesthesia of the upper extremity was observed. Sensory assessment was performed using the pinprick method over four key nerve areas ulnar, median, musculocutaneous, and radial at 5-minute intervals for a total observation period of 30 minutes. The outcomes were categorized based on the degree of blockade, identified as either complete or partial. Motor performance was assessed using a modified Bromage scale with scores ranging from 0 to 2, where a score of 2 reflected total motor paralysis and a score of 0 indicated normal motor activity; all observations were systematically recorded. The duration of analgesia was determined by measuring the time from the nerve block administration to the patient's initial request for additional pain relief, noted in minutes. Postoperative opioid consumption was tracked over a 24-hour period through the use of PCA devices, which were configured to dispense fentanyl at a concentration of 10 mcg/ml per activation, with a lockout period of 10 minutes and a ceiling dose of 100 mcg within any four-hour timeframe. Total fentanyl intake was calculated and expressed in micrograms. Additionally, inflammatory response was assessed through changes in the NLR and PLR, derived from complete blood counts taken 24 hours prior to surgery and again 4 hours after the procedure.

The analysis in this study integrated both descriptive and inferential statistical approaches to evaluate and present the data effectively. Descriptive statistics were applied to outline baseline characteristics of participants and summarize key study variables within each treatment group. Normally distributed continuous data were expressed as means accompanied by SD, whereas data not conforming to a normal distribution were reported as medians with IQR. Categorical variables were described using relative frequencies and percentages, commonly arranged in cross-tabulation tables to facilitate comparison across groups. Before conducting group comparisons, assumption testing was undertaken to ensure the appropriateness of statistical methods. The Shapiro-Wilk test was applied to assess data normality, with p-values greater than 0.05 indicating a normal distribution. Homogeneity of variances across groups was evaluated using Levene's test, where p-values above 0.05 signified equal variance.

Additionally, the research followed the CONSORT (Consolidated Standards of Reporting Trials) guidelines to uphold transparency, ethical accountability, and methodological rigor throughout the trial process (Li et al., 2016). Informed consent was secured from all participants before their inclusion in the study, and strict measures were taken to uphold their confidentiality and protect their rights throughout the research process.

RESULTS AND DISCUSSION

Out of 30 individuals initially screened for eligibility, 2 declined participation, resulting in 28 subjects who were randomized equally into two groups. The first group, comprising 14 participants, received a SCB combined with an ICB using $MgSO_4$ as an adjuvant. All participants in this group received the assigned intervention without complications, including no issues related to PCA device availability. The second group, also with 14 participants, underwent SCB combined with ICB but without the adjuvant. Similarly, all individuals in this group received their designated intervention without any PCA-related problems. No participants from either group were lost to follow-up or withdrew from the study. Consequently, all 28 participants 14 from each group were included in the final analysis, ensuring a fully complete dataset.

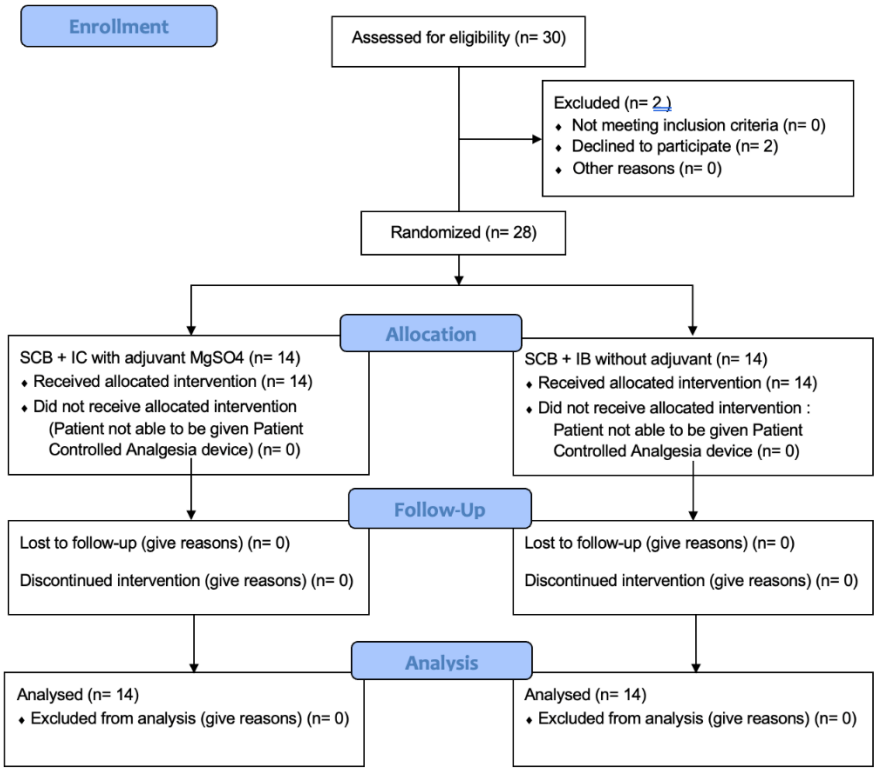

Figure 1. CONSORT 2010 flow diagram.
Source: Adapted from the CONSORT 2010 Statement: Schulz KF, Altman DG, Moher D. BMJ 2010;340:c332.

The comparison between the two groups revealed similar baseline characteristics, with no participants dropping out during the study. Although 2 out of 30 eligible individuals chose not to participate after receiving information about the study, all other candidates were successfully randomized and included in the final analysis. The average age was nearly identical between groups, with the adjuvant group averaging 52 years (SD 15.16) and the non-adjuvant group averaging 50 years (SD 10.83), showing no meaningful age-related differences ($p = 0.691$). Gender distribution also did not differ significantly between groups ($p = 0.127$), as determined by Chi-square analysis. Height measurements were consistent, with means of 155.14 cm (SD 4.01) and 156.5 cm (SD 4.94) for the adjuvant and non-adjuvant groups, respectively ($p = 0.432$). Weight analysis using the Mann-Whitney test indicated no significant variation, with medians of 55 kg and 54 kg across the two groups ($p = 0.502$). Similarly, BMI values were statistically comparable, averaging 23.66 kg/m² in the adjuvant group and 22.7 kg/m² in the non-adjuvant group ($p = 0.328$). Furthermore, all participants were categorized as ASA Class III, suggesting an equivalent level of preoperative anesthetic risk across both cohorts.

Table 2. Baseline Characteristics of Participants

Variable	Block with Adjuvant MgSO4 (n = 14)	Block without Adjuvant (n = 14)	p-value
Age (years)	52.43 ± 15.16	50.43 ± 10.83	0.691†
Body Weight (kg)	55.0 (6.0)	54.0 (9.5)	0.502*
Height (cm)	155.14 ± 4.01	156.50 ± 4.94	0.432†
BMI (kg/m²)	23.66 ± 2.38	22.70 ± 2.69	0.328†
Gender: Male	8.0	4	0.127‡
Gender: Female	6.0	10	
ASA: III	14.0	14	#

†: Independent t-test
*: Mann-Whitney test
‡: Chi-square test
#: Statistical test not applicable

Source: by Researcher

Participants receiving $MgSO_4$ as an adjuvant experienced notably faster onset of both sensory and motor blockades, with the sensory block initiating in 10.08 ± 0.90 minutes and the motor block in 17.98 ± 1.26 minutes. In contrast, those in the non-adjuvant group had significantly longer block times of 17.91 ± 1.85 minutes and 25.19 ± 2.22 minutes, respectively ($p < 0.001$ for both comparisons). Additionally, the duration until the first request for pain relief was substantially extended in the adjuvant group, averaging 473.43 ± 28.69 minutes versus 266.50 ± 22.79 minutes in the control group ($p < 0.001$), indicating more prolonged analgesia. This enhanced effect was further supported by a marked reduction in postoperative fentanyl consumption, with the adjuvant group requiring only 10 mcg (IQR: 0) compared to 45 mcg (IQR: 15) in the non-adjuvant group ($p < 0.001$). A detailed breakdown of these findings can be found in Table 2 of the study.

Table 3. Intraoperative and Postoperative Outcomes

Variable	Block with Adjuvant MgSO4 (n = 14)	Block without Adjuvant (n = 14)	p-value
Sensory block time (minutes)	10.08 ± 0.90	17.91 ± 1.85	< 0.001†
Motor block time (minutes)	17.98 ± 1.26	25.19 ± 2.22	< 0.001†
Time to first analgesic request (minutes)	473.43 ± 28.69	266.50 ± 22.79	< 0.001†
Total postoperative fentanyl (mcg)	10 (0)	45 (15)	< 0.001*

†: Independent t-test
*: Mann-Whitney test

Source: by Researcher

Postoperative levels of both NLR and PLR rose across all participants; however, the magnitude of these increases varied notably based on the inclusion of $MgSO_4$ as an adjuvant. Patients who received $MgSO_4$ exhibited a more modest rise in NLR, with a delta value of 1.93 ± 1.24, compared to a greater change of 2.65 ± 3.61 in the group without the adjuvant (p = 0.009). A similar trend was observed for PLR, where the $MgSO_4$ group demonstrated a smaller increase (delta PLR: 48.40 ± 73.63) relative to the non-adjuvant group (delta PLR: 114.90 ± 132.18, p = 0.05). These findings suggest a potential anti-inflammatory effect associated with $MgSO_4$ use. Comprehensive data on NLR and PLR values, categorized by treatment group, are presented in Table 3 and Table 4, respectively.

Table 4. An Analysis Was Carried Out to Compare the Neutrophil-to-Lymphocyte Ratio (NLR) Values Before Surgery, After Surgery, and the Difference Between Them (Delta NLR) in Two Groups of Patients.

Group	Preoperative NLR (Mean ± SD)	Postoperative NLR (Mean ± SD)	Delta NLR (Mean ± SD)
Block with MgSO4 Adjuvant	2.21 (1.46)	4.15 (2.03)	1.93 (1.24)
Block without Adjuvant	3.00 (2.00)	5.75 (4.90)	2.65 (3.61)
p-value	0.352*	0.009*	0.009*

Source: by Researcher

Table 5. This Research Focused on Evaluating the PLR Across Three Distinct Phases in Patients Undergoing Regional Nerve Block Anesthesia

Group	Preoperative PLR (Mean ± SD)	Postoperative PLR (Mean ± SD)	Delta PLR (Mean ± SD)
Block with MgSO4 Adjuvant	122.15 (77.56)	171.55 (110.85)	48.40 (73.63)
Block without Adjuvant	189.70 (130.55)	285.00 (188.80)	114.90 (132.18)
p-value	0.114*	0.014*	0.05*

Source: by Researcher

Discussion

This research investigated the role of $MgSO_4$ as an adjunct to 0.5% bupivacaine in supraclavicular-intercostobrachial nerve blocks for upper limb vascular access procedures in hemodialysis patients. The results clearly indicate that incorporating $MgSO_4$ leads to superior clinical performance of the nerve block technique. Specifically, it accelerated the onset and prolonged the duration of both sensory and motor blocks, significantly extended the time before the first need for postoperative analgesia, reduced the overall use of opioid analgesics, and contributed to a lower inflammatory response after surgery.

Enhanced Sensory and Motor Block Onset

The group administered magnesium sulfate ($MgSO_4$) demonstrated a significantly quicker onset of both sensory and motor blockade, averaging 10.08 ± 0.90 minutes and 17.98 ± 1.26 minutes, respectively, in contrast to the control group, which showed longer onset times

of 17.91 ± 1.85 minutes for sensory block and 25.19 ± 2.22 minutes for motor block. These results highlight the capacity of $MgSO_4$ to accelerate anesthetic onset. This enhancement is believed to stem from $MgSO_4$'s function as a calcium channel antagonist, which promotes neuronal hyperpolarization and amplifies the blockade of nerve transmission. Corroborating this explanation, evidence from a meta-analysis indicated that combining $MgSO_4$ with local anesthetics in peripheral nerve blocks significantly reduced motor block onset time, showing a mean difference of –1.17 minutes ($P < 0.0001$) when compared to local anesthetic use alone (Lok et al., 2020). Although the difference in sensory block onset between groups did not reach statistical significance, the observed trend indicated a tendency toward faster nerve blockade in the $MgSO_4$ group. This suggests that $MgSO_4$ may still play a contributory role in enhancing the onset of sensory anesthesia, potentially through its modulatory effects on calcium ion influx and neuronal excitability.

Prolonged Analgesic Duration

The significantly longer duration before the first request for analgesia in the $MgSO_4$ group (473.43 ± 28.69 minutes vs. 266.50 ± 22.79 minutes, $p < 0.001$) underscores its superior analgesic efficacy. This prolonged effect is consistent with prior research indicating that $MgSO_4$ mitigates nociceptive signaling by blocking NMDA receptors, thereby decreasing central sensitization to pain stimuli (Macfarlane et al., 2021). Adding to the evidence for this mechanism, a clinical study involving 66 patients undergoing arthroscopic rotator cuff repair demonstrated that supplementing a bupivacaine-epinephrine solution with magnesium sulfate significantly prolonged the duration of analgesia. Patients who received magnesium experienced pain relief for an average of 664 minutes, compared to 553 minutes in the control group ($P = 0.017$). These results emphasize the beneficial role of magnesium sulfate in extending postoperative pain control (Mert et al., 2003).

Reduced Postoperative Analgesic Requirements

The postoperative fentanyl requirement was significantly reduced in patients receiving $MgSO_4$, with a median dose of 10 mcg (IQR: 0) compared to 45 mcg (IQR: 15) in the control group ($p < 0.001$). This notable reduction reflects not only improved analgesic effectiveness but also the potential for minimizing opioid-related side effects such as nausea, sedation, and respiratory depression. Consequently, this may contribute to faster recovery times and greater patient satisfaction. The opioid-sparing properties of $MgSO_4$ are well-documented in the literature, and these results further affirm its value in regional anesthesia protocols. A comprehensive review of several randomized controlled trials reinforces this finding, revealing that administering magnesium sulfate during the perioperative period can significantly decrease the need for opioids within the first 24 hours after surgery (Silva et al., 2024; Verma et al., 2017). A comprehensive systematic review of several RCTs concluded that administering $MgSO_4$ in the perioperative period leads to a significant reduction in opioid consumption within the first 24 hours after surgery (Wiederhold et al., 2024). For instance, a study included in the review demonstrated that patients who received $MgSO_4$ required significantly less morphine postoperatively averaging 8 mg compared to 13.2 mg in the control group ($P = 0.001$).

Mitigation of Postoperative Inflammation

The significant reduction in both NLR and PLR after surgery in the group treated with magnesium sulfate (NLR: 4.15 compared to 5.75, p = 0.009; PLR: 171.55 compared to 285.00, p = 0.014) highlights magnesium sulfate's possible role in exerting anti-inflammatory effects. Both NLR and PLR are well-recognized biomarkers of systemic inflammation, commonly elevated in response to surgical stress. The significant reductions in these values suggest that $MgSO_4$ may help modulate the inflammatory cascade triggered by surgical trauma, potentially contributing to better postoperative recovery and reduced complication risk (Yasim et al., 2006). This result is especially important for individuals undergoing multiple vascular access procedures, as persistent inflammation can compromise vascular health and jeopardize the long-term functionality of the access site.

Clinical Implications

The findings of this study highlight the promising role of magnesium sulfate ($MgSO_4$) as an effective adjuvant in regional anesthesia for upper extremity surgical procedures. Its ability to optimize block characteristics, extend the duration of analgesia, lower opioid requirements, and reduce postoperative inflammatory markers demonstrates a multifaceted benefit. Collectively, these effects contribute to enhanced perioperative management, offering a safer, more efficient approach to pain control and patient recovery in clinical practice (Yazdi et al., 2022). These benefits are especially relevant for hemodialysis patients, who frequently present with multiple comorbidities and heightened vulnerability to perioperative complications.

Limitations and Future Directions

Although the findings support the effectiveness of magnesium sulfate ($MgSO_4$), some limitations should be acknowledged. The research was confined to a single clinical site, which may restrict its applicability to broader populations. Moreover, it did not address long-term considerations such as the persistence of pain or the durability of vascular access. To enhance the reliability and scope of these results, future investigations should involve multiple centers, include larger participant groups, and incorporate extended follow-up periods. Further, studies aimed at uncovering the biological mechanisms through which $MgSO_4$ exerts its anti-inflammatory effects would be valuable in expanding our understanding of its potential therapeutic applications.

CONCLUSION

Incorporating magnesium sulfate ($MgSO_4$) into 0.5% bupivacaine for supraclavicular-intercostobrachial nerve blocks has been shown to substantially improve both anesthetic and analgesic efficacy, while also minimizing postoperative inflammatory responses. These results highlight the potential of $MgSO_4$ as a valuable adjunct in regional anesthesia protocols, presenting a compelling approach to enhance perioperative management in patients undergoing upper limb vascular access procedures for hemodialysis.

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