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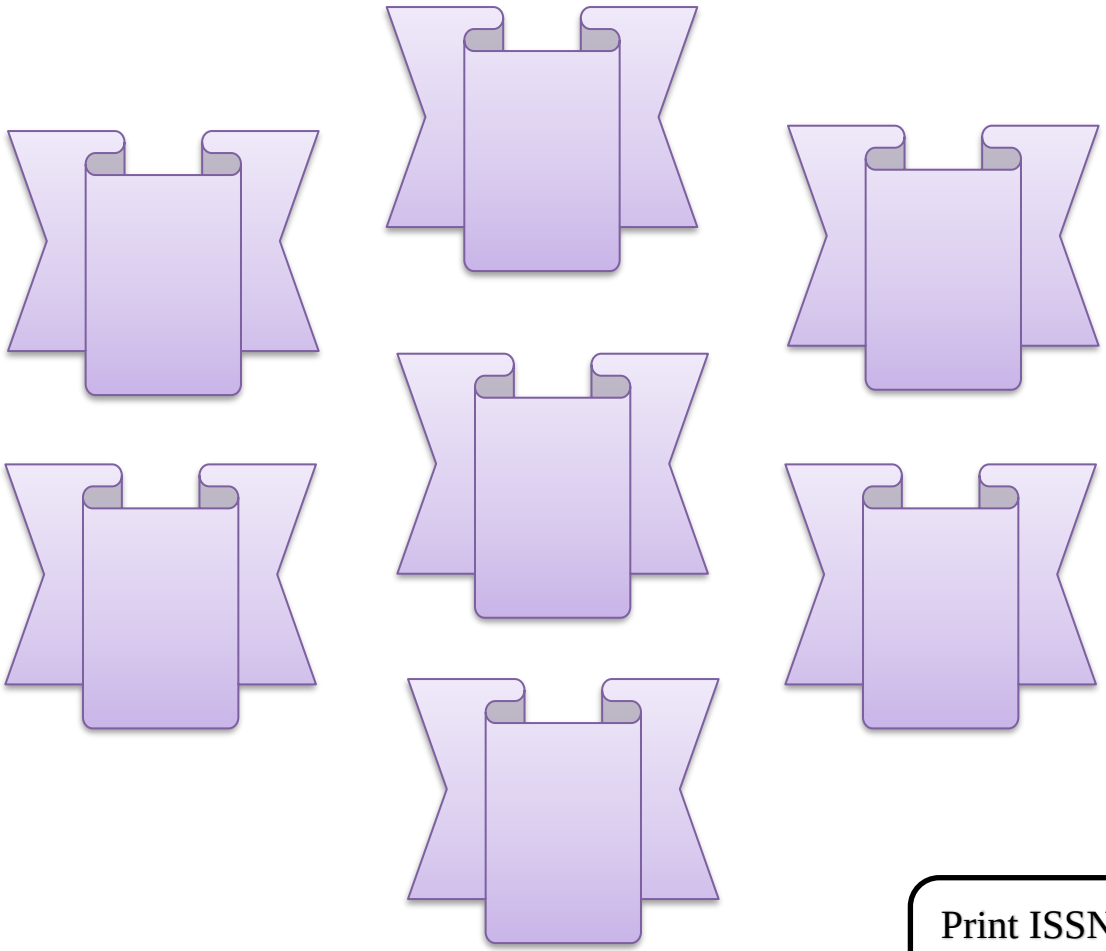

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Original Article

Effect of Adding Magnesium Sulphate as An Adjuvant to Bupivacaine in Ultrasound-Guided Transversus Abdominis Plane [TAP] Block for Postoperative Analgesia after Moderate-Sized Umbilical Hernia Repair

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ABSTRACT

Background: The transversus abdominis plane [TAP] block is a recognized method for blocking the neural afferents of the abdominal wall. Various adjuvants have been employed to enhance the quality and duration of local anesthetics.

Aim of the work: This study aims to evaluate the effectiveness and safety of magnesium sulfate as an adjuvant to local anesthesia in ultrasound-guided TAP block for patients undergoing moderate-sized umbilical hernia repair under general anesthesia. The study will assess the postoperative pain and opioid consumption levels using the Visual Analogue Scale [VAS].

Patients and Methods: This study included 60 patients who undergone surgical umbilical hernia repair. Patients have been randomly placed into two equal groups: Group I [M]: Ultrasound-guided Transversus abdominis plane block with Bupivacaine 0.25% [18 ml] [sunnybupivacaine] and 200 mg [2 ml] MgSO4, and Group II [S]: Ultrasound-guided Transversus abdominis plane block with Bupivacaine 0.25% 18 ml and [2 ml] normal saline.

Results: There was a statistically significant decreased postoperative pain measured through VAS score all over the 24 hours postoperatively, and increased time of postoperative analgesia with less dose needed from analgesics in MgSO4 added to bupivacaine group compared to bupivacaine alone with p-value <0.001.

Conclusion: The addition of MgSO4 to Bupivacaine in an ultrasound-guided TAP block results in lower postoperative pain scores, an extended duration of analgesia, and a reduced need for rescue analgesics.

Keywords: Magnesium Sulfate; Bupivacaine; Abdominal Muscles; Analgesia; Umbilical Hernia.

INTRODUCTION

The majority of patients who are scheduled for surgery tend to experience emotional stress, primarily due to anxiety about the pain that they are expected to experience during the post-operative period [1].

Over 80% of patients who undergo surgery suffer from acute postoperative pain, with 75% of them rating the pain severity as moderate, severe, or extreme. Studies have shown that less than 50% of patients who undergo surgery report adequate relief from postoperative pain [2]. Additionally, if pain is not promptly managed after surgery, it can hinder a patient's ability to walk, potentially causing adverse effects such as thromboembolism, myocardial ischemia, and arrhythmia [3].

The transversus abdominis plane block [TAPB] is a peripheral abdominal field block that effectively blocks the ilioinguinal [L1], hypogastric [T12-L3], and lower intercostal [T7-T11] nerves. It is a simple and viable alternative to other methods [4]. **Kuppuvelumani *et al.*** [5] first described this method in 1993, and it was subsequently documented by **Rafi** in 2001 [6].

The lumbar triangle of Petit is used in the TAPB technique to block the neural afferents of the abdominal wall. The goal of a TAPB is to inject local anesthetics into the space between the internal oblique [IO] and transversus abdominis [TA] muscles, targeting the spinal nerves in that area [7].

Bupivacaine attaches to the intracellular segment of voltage-gated sodium channels located on the axonal membrane. This action prevents the influx of sodium ions, which are crucial for depolarizing the membrane. As a result, there is no initiation or propagation of action potentials [8].

Research has demonstrated that magnesium sulfate [MgSO4] has an analgesic effect by blocking N-methyl-D-aspartate [NMDA] receptors and associated calcium channels, thereby preventing central sensitization that arises due to peripheral nociceptive stimulation. Although NMDA receptors are mainly found centrally, recent studies have identified their presence in the skin, muscles, and knee joints, where they participate in the sensory signaling of noxious signals peripherally [9].

Incorporating MgSO4 into local anesthetics can enhance the quality of analgesia. However, there is a limited amount of clinical research examining the use of magnesium in peripheral nerve blocks [3].

The selection of anesthetic block method is determined by the intended surgical incision site. The transversus abdominis plane [TAP] block is a new technique that involves injecting a local anesthetic into the space between the internal oblique and transversus abdominis muscles [9].

The objective of this study is to assess the effectiveness and safety of using magnesium sulfate as an adjuvant to bupivacaine for analgesia in ultrasound-guided TAP block for patients receiving surgical repair for moderate-sized umbilical hernias.

PATIENTS AND METHODS

This is a double-blind randomized controlled study conducted at Al-Azhar University Hospital in Damietta, involving 60 male and female adult patients between the ages of 21 and 45, with an ASA classification of I or II. The patients were scheduled to undergo elective surgical repair for moderate-sized umbilical hernias with mesh insertion under general anesthesia.

Exclusion criteria: Patient refusal, BMI ≥ 35 kg/m^2, patient inability to properly describe postoperative pain to investigator [dementia, delirium, psychiatric and neurological disorder], coagulopathy, infection at site of injection, pre-operative use opioid or non-steroidal anti-inflammatory drugs within 24 hours, allergy or contraindication to anesthetic agents or studied medication.

Patients were randomly divided into two equal groups: **Group I [M]:** Bilateral Ultrasound-guided TAP block with Bupivacaine 0.25% [18 ml] [sunny-bupivacaine] and 200 mg [2 ml] MgSo4. **Group II [S]:** Bilateral Ultrasound-guided TAP block with Bupivacaine 0.25% 18 ml and [2 ml] normal saline [NS] after end of surgery and before weaning of the patients from general anesthesia.

Primary outcome: Postoperative analgesic efficacy as regard pain relieve and duration of analgesia.

Secondary outcomes: Post-operative hemo-dynamics changes, time to the first rescue opioid

analgesic request, Post-operative complications to magnesium and bupivacaine.

Preoperative evaluation: Patients had a thorough evaluation process consisting of taking their medical history, conducting a clinical examination, and performing routine laboratory tests such as complete blood count, bleeding time, clotting time, PT, PTT, INR, urea, creatinine, AST, ALT, and blood sugar level. Additionally, an ECG will be administered to all patients.

Prior to receiving a US guided TAP block, patients will be educated about the procedure and trained to use a visual analogue scale [VAS] to assess their pain levels. Written consent will be obtained from all patients to confirm their agreement to the procedure.

Preoperative preparation

Before anesthesia, all patients received a premedication of midazolam [0.02 mg/kg] via intravenous injection two minutes prior. Upon admission to the operating theater, a peripheral line cannula [20 G] was inserted into each patient. To continuously monitor the electrocardiography of each patient, a multichannel monitor [Vamos-Drager Germany] was connected. This allowed for the monitoring of heart rate [measured in beats per minute] and detection of dysrhythmias [using lead II]. Additionally, noninvasive arterial blood pressure [NABP] and peripheral oxygen saturation [SpO2%] were monitored. Baseline monitoring data, including blood pressure, heart rate, and oxygen saturation, were recorded for use during the operation.

Intraoperative procedure

Surgical procedures were performed by same surgeons employing the Hernioplasty technique. After completion of the surgeries and before discontinuing anesthesia, lateral ultrasound-guided Transversus Abdominis Plane blocks were administered to all patients.

Anesthetic technique

Both groups were subjected to general anesthesia as follows:

All patients were placed in a supine position and pre-oxygenated with 100% oxygen through a face mask for 3 minutes. General anesthesia was then induced by slowly administering intravenous fentanyl at 1 microgram per kilogram and propofol at 2 milligrams per kilogram until the patients lost consciousness and 0.5 milligrams of atracurium per kilogram. Patients were then intubated and put on mechanical ventilation with anesthesia maintained using isoflurane between 1.2 to 1.5% in 100% oxygen along with incremental doses of atracurium as needed. Afterwards, an ultrasound guided TAP block was performed on all patients at the umbilical hernia site according to their respective study group.

Technique of ultrasound guided TAP block

Group I [M] has been injected by Bupivacaine 0.25% [18 ml] [sunny bupivacaine] and 200 mg [ml^2] Mgso4 bilaterally. Group II [S]: was injected by Bupivacaine 0.25% 18 ml and [2 ml] of normal saline [NS] bilaterally after end of surgery and before weaning of the patients from general anesthesia using needle 16-20 G after testing for patency

Technique of lateral TAP

We applied TAP block with lateral approach, patient is positioned in a supine position and 22 Gauge sono-sensitive using short bevel needle. The needle is injected in a sagittal plane about 3-4 cm medial to the ultrasound probe. The transducer transversely was put just below the xiphoid process and the paired rectus abdominis and the linea alba were located. The transducer was moved further to the side along the bottom edge of the ribs until the linea semilunaris aponeurosis appears, which is located next to the rectus abdominis muscle on the outer side.

The internal oblique and external oblique muscles are positioned exterior to the linea semilunaris. Three layers of muscles can be recognized: the transversus abdominis, internal oblique, and external oblique [from deep to superficial]. The TAP is located just above the transversus abdominis muscle.

The three muscle layers located between the costal margin and iliac crest at the mid-axillary line can be easily identified. After measuring the TAP depth using ultrasound, a needle is inserted at the same distance away from the transducer to ensure proper alignment for deep regional blocks. The needle is directed towards the space between the internal oblique and transversus abdominis muscles, and after negative suction to

avoid vascular puncture, a full dose of local anesthetic is injected to separate the two muscle layers and hydro-dissect the plane until the eye sign is observed, which is an elliptical, hypoechoic spread of local anesthetic. The surgical procedures were performed by the same surgeons using the Hernioplasty technique, and all patients underwent lateral ultrasound-guided TAP blocks after the surgery and before weaning from anesthesia.

Measurements

Hemodynamics: Heart rate [beats per minute], Mean arterial blood pressure [MABP] in mmHg, and O_2 saturation [SpO_2%].

Visual analogue scale during rest and movement: The pain assessment tool comprises an ungraded straight line, 1-10 mm in length, with the phrase "no pain" marked at one end and "the worst possible pain" at the other end. Patients are instructed to mark a cross on the line to indicate the point that most closely corresponds to their level of pain. They are asked to indicate where their pain falls on the line relative to the two extremes.

Time to the first rescue opioid analgesic dose: The duration between the conclusion of the surgery and the administration of the initial dose of analgesic [Nalofen] was documented in minutes.

Total dose of opioids analgesic requirements [mg]: The amount of nalbuphine administered to the patients after the surgery was computed and analyzed using statistical methods [0.1-0.2 mg/kg taken over 10-15 minutes, days don does not exceed 1.6 mg/kg may be repeated every 8 h or 12 hours].

Postoperative complications: cardio-vascular system affection as hypotension, bradycardia. Central nervous system affection as hypotonia and hyporeflexia. Nausea and vomiting

Ethical Considerations: Agreement of the responsible authorities was taken prior to conducting this study. Study participants legally were informed the aim, objectives, and methods of this study, and were provided written informed consent for the participation. They were not disadvantaged in any way if they refused to join the study. Confidentiality of the collected data was strictly kept, and data was used for only the research purpose of this study. Privacy of the participants was guaranteed during data collection. Participants had the right to withdraw at any time without giving reasons. The participants were informed by the results.

Sample size calculation: The sample size was determined using the statistical calculator "MedCalc® version 12.3.0.0 program Ostend, Belgium," with a confidence level of 95% and a study power of 80%, and an alpha error rate of 5%. Based on the formula at least 30 patients were required in both groups to investigate whether there is a significant difference at α value of 0.05 and power of study 80%. Assumptions used in the formula were based on results of previous study [10]. Accordingly, we will include a total of 60 participants.

Statistical analysis: Using the [statistical package for the social sciences] SPSS, version 21, data input and statistical analyses were carried out [SPSS Inc., Chicago, IL, USA]. Mean and standard deviation have been calculated to express continuously distributed, normally distributed data. The Kolmogorov-Smirnov test has also been used to determine the normality of the quantitative data. Continuous normally distributed data will be analyzed through the use of the independent sample t test [student t test]. Statistical significance was considered when the probability [P] value was less than or equal to 0.05.

RESULTS

This study was conducted on 60 patients with umbilical hernia who underwent umbilical hernia repair with the mean age 39±3 years, most of them are females [63.3%] and 36.7% are males with female to male ration 1.7:1 [table 1].

Table [2] indicates no statistically significant difference among MB group and B group as regards baseline systolic, diastolic blood pressures, oxygen saturation and heart rate, with p-value >0.05.

Table [3] shows statistically significant decreased HR with bupivacaine alone group early compared to MgSO4 group with p-value <0.001, while after 4 hours it became significantly decreased with MgSO4 group more than bupivacaine group with p-value <0.001 till 5.5 hours postoperatively.

Table [4] shows a statistically significant decreased postoperative pain measured by VAS score all over the 24 hours postoperatively in MgSO4 added to bupivacaine group compared to bupivacaine alone with p-value <0.001.

Table [5] shows a statistically significant increased time of postoperative analgesia with less dose needed from analgesics among MgSO4 added to bupivacaine group compared to bupivacaine only group with p-value <0.001.

Table [6] shows non-statistically significant difference between both groups as regards postoperative complications except for bradycardia being more in bupivacaine group with p-value >0.05.

Table [1]: Demographic data of the studied patients

		Group I [M] No.=30	Group II [S] No.=30	Test	P value
Age	Mean ± SD	38.23±3.6	39.57±3.92	1.38	0.17
Sex	Females Males	18 [60%] 12 [40%]	20 [67%] 10 [33%]	0.287	0.59
Body mass index	Mean ± SD	30.45±2.3	29.72±3.1	1.03	0.30
ASA	I II	24 [80%] 6 [20%]	21 [70%] 9 [30%]	0.80	0.37

Table [2]: Baseline vital signs values in both groups

	Group I [M] No.=30	Group II [S] No.=30	Independent t-test	P
	Mean ± SD	**Mean ± SD**		
Systolic blood pressure	111±7	109±7	-0.86	0.389
Diastolic blood pressure	81±5	79±6	-1.36	0.172
Heart rate	83±4	80±5	-1.83	0.067
SPO2	95±3	96±1	-1.11	0.266

Table [3]: Postoperative serial heart rate readings in both groups

	Group I [M] No.=30	Group II [S] No.=30	Independent t-test	P
	Mean ± SD	**Mean ± SD**		
HR 15 min	75±3	75±3	-0.50	0.615
HR 30 minutes	83±3	78±2	-5.54	**<0.001***
HR 45 minutes	77±3	77±2	-0.42	0.673
HR 60 minutes	80±1	76±2	-5.28	**<0.001**
HR 1.5 h	89±4	84±2	-5.85	**<0.001**
HR 2 h	79±4	80±3	0.00	1
HR 2.5 h	85±5	84±3	-1.48	0.139
HR 3 h	91±4	90±4	-0.26	0.796
HR 3.5 h	88±5	88±6	-0.23	0.816
HR 4 h	85±6	91±4	-4.15	**<0.001**
HR 4.5 h	90±4	90±4	-0.24	0.808
HR 5 h	91±4	92±4	-1.41	0.158
HR 5,5 h	89±5	92±4	-2.43	**0.015***
HR 6 h	92±4	91±4	-0.48	0.628
HR 8 h	92±3	92±4	-0.32	0.746
HR 10 h	92±4	91±3	-0.34	0.733
HR 12 h	92±4	91±4	-0.51	0.607
HR 14 h	92±3	91±3	-0.48	0.629
HR 16 h	90±4	90±4	-0.23	0.815
HR 18 h	93±3	92±3	-0.90	0.366
HR 20 h	92±4	92±4	-0.28	0.78
HR 22 h	92±4	92±4	-0.21	0.831
HR 24 h	92±3	93±3	-0.39	0.698

Table [4]: Serial VAS score values in both groups

	Group I [M] No.=30	Group II [S] No.=30	Mann-Whitney test	P
	Median [IQR]	Median [IQR]		
VAS recovery	4 [3-6]	6 [4-7]	-4.73	**<0.001**
VAS 1 h	4 [3-6]	5 [4-7]	-5.38	**<0.001**
VAS 2 h	3 [1-4]	4 [3-6]	-4.63	**<0.001**
VAS 3 h	3 [1-4]	4 [3-6]	-6.27	**<0.001**
VAS 4 h	3 [2-4]	5 [4-7]	-6.16	**<0.001**
VAS 8 h	3 [2-4]	4 [3-6]	-4.51	**<0.001**
VAS 12 h	2 [1-3]	3 [2-5]	-4.83	**<0.001**
VAS 16 h	2 [1-3]	3 [2-4]	-4.67	**<0.001**
VAS 20 h	2 [1-3]	3 [1-3]	-4.86	**<0.001**
VAS 24 h	1 [0-1]	2 [0-3]	-4.57	**0.001**

Figure [5]: Time to first rescue opioid analgesia and total dose required analgesia/mg in both groups

	Group I [M] No.=30	Group II [S] No.=30	Independent t-test	P
	Mean ± SD	**Mean ± SD**		
Time to first rescue opioid analgesia dose [min.]	18±2	7±2	-6.69	**<0.001**
Total dose required analgesia [mg]	0.8±0.2	1.9±0.3	-6.69	**<0.001**

Table [6]: Side Effects in both groups

		Group I [M] No.=30		Group II [S] No.=30		X^2 test	P
		No.	%	No.	%		
Hypotension	No	25	83.3%	25	83.3%	0.001	1
	Yes	5	16.7%	5	16.7%		
Bradycardia	No	23	76.7%	25	83.3%	0.001	0.021
	Yes	7	23.3%	5	16.7%		
Hypotonia	No	28	93.3%	29	96.7%	0.351	0.554
	Yes	2	6.7%	1	3.3%		
Hyporeflexia	No	27	90.0%	28	93.3%	0.218	0.271
	Yes	3	10.0%	2	6.7%		
Nausea/vomiting	No	16	53.3%	18	60.0%	0.271	0.602
	Yes	14	46.7%	12	40.0%		

DISCUSSION

The TAP block is a modern pain management method that has demonstrated its effectiveness in perioperative pain treatment [11].

The effectiveness of incorporating MgSO4 as a supplementary agent to local anesthetics in regional procedures has been demonstrated in several clinical trials [12]. The addition of MgSO4 as a supplementary agent in TAP blocks for abdominal surgeries led to improved analgesic outcomes, including reduced VAS scores, decreased analgesic usage and longer-lasting pain relief [13].

This study included 60 patients with umbilical hernia who underwent TAP using magnesium sulphate added to bupivacaine compared to bupivacaine alone in postoperative analgesia.

The current study found no statistically significant difference among both groups in terms of demographic history and clinical history. Similar findings were reported by **Al-Refaey *et al.*** [10] who estimated the effect of adding MgSO4 to bupivacaine as postoperative analgesic effect and no statistically significant difference was found between both groups as regards clinical history.

The current study revealed statistically significant decreased MAP with bupivacaine alone group early intraoperatively compared to MgSO4 group, while after 2 hours it became significantly decreased with MgSO4 group more than bupivacaine group till 5.5 hours post-

operatively, while after 6 hours MgSO4 group started to regain normal blood pressure more than bupivacaine group. this goes in run with a previous Egyptian study by **AbdAlsalam *et al.*** [14] which was conducted on 75 cases underwent ultrasound guided lumbar plexus block in lower abdominal surgeries and revealed statistically significant decreased MAP in magnesium added bupivacaine group compared to bupivacaine group especially after 2 hours of the operation with p-value =0.026.

The current study found that adding MgSO4 to bupivacaine significantly decreases post-operative pain assessed by VAS score through 24 hours compared to bupivacaine only. This goes in run with a study concluded by **Al-Refaey *et al.*** [10] on ninety patients undergoing laparoscopic cholecystectomy, and concluded similar results as co-administration of MgSo4 with bupivacaine results in lower VAS pain score and prolonged duration of action than bupivacaine only group, where mean duration of analgesia in the group of magnesium plus bupivacaine was 1140±132 mins while in bupivacaine group only was 960+-150 mins with p-value <0.001.

One possible explanation for the impact of adding MgSO4 to bupivacaine is that magnesium inhibits the nerve action potentials triggered by bupivacaine, resulting in a significant increase in the amplitude of compound nerve action potentials from 15.1% with bupivacaine alone to 35.43% when combined with magnesium [15].

Rafi [6] was the first to introduce TAP, a technique that involves injecting local anesthetic into the neuro-fascial plane between the internal oblique and transversus abdominis muscles, to manage pain by blocking sensory nerves.

The present study found no statistically significant difference between the two groups as regards postoperative complications. This goes in run with **Asaad *et al.*** [16]'s study which was conducted to assess the effect of adding MgSO4 to bupivacaine in prolongation of the duration of analgesia and improving analgesia quality and revealed no statistically significant difference between using bupivacaine alone or bupivacaine and MgSO4 as regards postoperative adverse events with p-value =0.448.

Limitations: Although the TAP block was conducted using real-time ultrasound, it is unclear if all blocks produced a sensory blockade since sensory assessments were not performed. The evaluation of pain scores and side effects was restricted to the first 24 hours after the operation, even though the analgesic efficacy of the TAP block was indicated to last for up to 48 hours. This was due to local protocol not supporting the routine use of systemic opioid analgesia beyond 24 hours after surgery and the encouragement of active patient mobilization, which would have been uncomfortable with the morphine pump.

Conclusion: The introduction of 200 mg of MgSO4 to bupivacaine in TAP blocks leads to reduced postoperative VAS scores, a longer period of pain relief, and fewer requests for rescue analgesia. However, more research is necessary to validate the effectiveness of magnesium in TAP blocks. Additional longitudinal studies with a larger sample size are required to better understand the impact of adding MgSO4 to bupivacaine, including its postoperative pain relief effect, and to track the outcomes for up to 48 hours.

Conflict of Interest and Financial Disclosure: None.

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