(e) ISSN Online: 2321-9599

(p) ISSN Print: 2348-6805

ORIGINAL ARTICLE

Comparative Study of Fentanyl and Magnesium Sulphate as Adjuvants to 0.375% Bupivacaine in Ultrasound-Guided Supraclavicular Brachial Plexus Block

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ABSTRACT:

Background: Ultrasound-guided supraclavicular brachial plexus block is a widely used regional anaesthetic technique for upper limb surgeries. Adding adjuvants like fentanyl and magnesium sulphate to local anaesthetics can enhance block quality, prolong analgesia, and improve patient satisfaction. **Aim:**To compare the effectiveness of adding magnesium sulphate (150 mg) and fentanyl (50 µg) to 0.375% bupivacaine versus placebo in ultrasound-guided supraclavicular brachial plexus block. **Material and Methods:**This prospective, randomized, double-blind study included 90 patients aged 18–60 years, divided into three groups: Group F (fentanyl), Group M (magnesium sulphate), and Group P (placebo). Each received 20 mL of 0.375% bupivacaine with the respective adjuvant. Onset and duration of sensory and motor block, VAS pain scores, and complications were assessed over 24 hours. **Results:**The fentanyl group showed the longest sensory and motor block duration, followed by the magnesium group, both significantly longer than placebo ($p < 0.001$). Onset of block was fastest in the placebo group. VAS pain scores were significantly lower in Groups F and M up to 18 hours postoperatively compared to placebo. No major complications were observed. **Conclusion**:Fentanyl and magnesium sulphate are effective adjuvants to bupivacaine for supraclavicular brachial plexus block, providing superior analgesia compared to placebo. Fentanyl demonstrated the longest duration of analgesia, while magnesium sulphate offers a valuable opioid-sparing alternative.

Keywords: Supraclavicular brachial plexus block, fentanyl, magnesium sulphate, bupivacaine, ultrasound-guided block, regional anaesthesia, analgesia

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This article may be cited as: Shringi PR. Comparative Study of Fentanyl and Magnesium Sulphate as Adjuvants to 0.375% Bupivacaine in Ultrasound-Guided Supraclavicular Brachial Plexus Block. J Adv Med Dent Scie Res 2017;5(6):157-160.

INTRODUCTION

The supraclavicular brachial plexus block has emerged as one of the most dependable and widely used regional anaesthetic techniques for surgeries involving the upper limb, particularly the forearm and hand. It offers the advantage of rapid onset, dense anaesthesia, excellent muscle relaxation, and reduced need for general anaesthesia or opioids, thereby improving patient comfort and postoperative recovery [1].

Ultrasound guidance has revolutionized regional anaesthesia by enabling real-time visualization of neural structures, reducing block performance time, increasing success rates, and minimizing complications such as pneumothorax or vascular puncture [2]. Among local anaesthetics, bupivacaine remains a popular choice due to its prolonged duration of sensory and motor block. However, efforts continue to improve block quality and extend analgesia by adding various adjuvants to local anaesthetic solutions [3].

Opioids, particularly fentanyl, have been commonly used as adjuvants in peripheral nerve blocks. Fentanyl, a synthetic µ-opioid receptor agonist, provides synergistic analgesia when combined with local anaesthetics, enhancing the quality and duration of the block and reducing postoperative analgesic requirements [4]. Its rapid onset, lipophilicity, and spinal action make it a preferred adjuvant in many regional anaesthesia protocols [5]. However, the use of opioids carries potential adverse effects such as nausea, vomiting, pruritus, and respiratory depression, raising the need for non-opioid alternatives [6].

Magnesium sulphate ($MgSO_4$) has recently gained attention as a promising non-opioid adjuvant in regional anaesthesia. Acting as a physiological calcium antagonist and an NMDA receptor blocker, magnesium modulates nociceptive transmission and reduces central sensitization, resulting in prolonged analgesia without opioid-related side effects [7]. Several studies have demonstrated that the addition of magnesium to local anaesthetics in nerve blocks enhances the quality and duration of sensory and motor blockade, reduces opioid consumption, and improves patient satisfaction [8].

Despite these promising findings, few studies have directly compared fentanyl and magnesium sulphate as adjuvants in ultrasound-guided supraclavicular brachial plexus block, especially in the Indian context. Comparative evaluation of these two agents will help determine the optimal adjuvant strategy to improve

block characteristics, prolong analgesia, and enhance patient outcomes while minimizing side effects [9,10]. This study aims to compare the effectiveness of adding magnesium sulphate (150 mg) and fentanyl (50 micrograms) to 0.375% bupivacaine versus placebo in ultrasound-guided supraclavicular brachial plexus block in patients undergoing upper limb surgery, providing valuable evidence for optimizing regional anaesthesia practice.

MATERIAL AND METHODS

This was a prospective, randomized, double-blind comparative study conducted at the Department of Anaesthesiology at tertiary care hospital in India.A total of 90 adult patients, aged 18–60 years, with ASA physical status I or II, scheduled for elective upper limb surgeries under ultrasound-guided supraclavicular brachial plexus block, were enrolled.

Inclusion Criteria

- Patients aged 18–60 years.
- ASA grade I or II.
- Scheduled for elective forearm or hand surgery.
- Provided written informed consent.

Exclusion Criteria

- Known allergy to study drugs.
- Bleeding disorders or anticoagulant use.
- Infection at the injection site.
- History of chronic pain, opioid use, or neurological disorders.
- Pregnancy or lactation.

Patients were randomized into three groups (n = 30 each) using a computer-generated randomization table:

- **Group P (Placebo group):** Received 20 mL of 0.375% bupivacaine + 2 mL saline.
- **Group M (Magnesium group):** Received 20 mL of 0.375% bupivacaine + 150 mg magnesium sulphate (2 mL).
- **Group F (Fentanyl group):** Received 20 mL of 0.375% bupivacaine + 50 μg fentanyl (2 mL).

Anaesthetic Technique

- All patients were premedicated with oral midazolam 0.05 mg/kg 30 minutes before surgery.
- Under aseptic precautions, ultrasound-guided supraclavicular brachial plexus block was performed using a high-frequency linear probe and a 22G nerve block needle.
- The respective drug mixtures were prepared by an anaesthesiologist not involved in data collection and injected slowly after negative aspiration for blood.

Data Collection

- **Demographic data:** Age, gender, weight, ASA status.
- **Onset time:** Time from drug injection to complete sensory and motor block.
- **Duration of block:** Time from onset to regression of sensory and motor block.
- **Duration of analgesia:** Time from block completion to first analgesic request.
- **Haemodynamic parameters:** Heart rate, blood pressure, oxygen saturation at baseline and every 10 min intraoperatively.
- **Complications:** Hypotension, bradycardia, nausea, vomiting, pruritus, respiratory depression.

Outcome Measures

- **Primary outcome:** Duration of analgesia.
- **Secondary outcomes:** Onset and duration of sensory and motor block, haemodynamic stability, and incidence of complications.

Statistical Analysis

Data was analyzed using SPSS software. Continuous variables were expressed as mean ± SD and compared using ANOVA and post hoc Tukey test. Categorical variables were compared using the chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1 presents the demographic data of the participants. The mean age and weight were comparable across all three groups with no statistically significant differences. The gender distribution was balanced, and most patients were ASA I across groups, ensuring uniformity of baseline characteristics.

Table 2 summarizes the onset and duration of sensory and motor blockade. The onset of sensory and motor block was significantly faster in the placebo group compared to fentanyl and magnesium groups, with p-values <0.001. However, the duration of both sensory and motor block was significantly prolonged in Group F (fentanyl) compared to Group M (magnesium) and Group P (placebo). These results highlight the superior prolongation of analgesia with fentanyl, followed by magnesium, over placebo.

Table 3 shows the VAS scores over 24 hours postoperatively. Group F and Group M had significantly lower VAS scores at 6, 8, 12, and 18 hours compared to Group P, with p-values <0.001 in most comparisons, indicating better analgesic profiles. At 24 hours, the VAS scores equalized across groups, showing no significant difference.

Table 1: Demographic Data of Study Participants in Three Groups

Variables	Group F (Fentanyl)	Group M (Magnesium Sulphate)	Group P (Normal Saline)	p-value
Age (years) [Mean ± SD]	35.8 ± 11.2	36.5 ± 12.5	31.6 ± 11.4	0.320
Weight (kg) [Mean ± SD]	64.8 ± 9.1	62.7 ± 8.1	63.1 ± 7.7	0.610
Gender [n (%)]	Male 17 (68)	16 (64)	18 (72)	0.880
	Female 8 (32)	9 (36)	7 (28)	
ASA Grade [n (%)]	I: 25 (100)	22 (88)	24 (96)	0.550
	II: 0	3 (12)	1 (4)	

Table 2: Duration and Onset of Sensory and Motor Blockade

Variables	Group F (Mean ± SD)	Group M (Mean ± SD)	Group P (Mean ± SD)	Overall p-value	F vs M	F vs P	M vs P
Onset of sensory block (min)	8.2 ± 2.4	8.5 ± 1.9	4.1 ± 0.9	<0.001	0.720	<0.001	<0.001
Duration of sensory block (hrs)	7.7 ± 1.0	6.3 ± 0.9	4.2 ± 0.6	<0.001	<0.001	<0.001	<0.001
Onset of motor block (min)	11.2 ± 3.2	11.8 ± 2.1	6.0 ± 0.9	<0.001	0.410	<0.001	<0.001
Duration of motor block (hrs)	8.2 ± 1.1	6.3 ± 0.9	4.3 ± 1.0	<0.001	<0.001	<0.001	<0.001

Table 3: VAS Scores in Study Participants Between Three Groups

Post-op Time	Group F (Mean ± SD)	Group M (Mean ± SD)	Group P (Mean ± SD)	Overall p-value	F vs M	F vs P	M vs P
4 hours	0.03 ± 0.2	0	0	0.600	0.350	0.320	0.880
6 hours	0.1 ± 0.4	0.2 ± 0.7	2.0 ± 1.2	<0.001	0.400	<0.001	<0.001
8 hours	0.3 ± 0.8	1.9 ± 1.2	3.7 ± 1.6	<0.001	<0.001	<0.001	<0.001
12 hours	2.6 ± 1.3	3.4 ± 1.3	3.7 ± 1.2	0.010	0.030	0.004	0.520
18 hours	3.2 ± 0.6	3.6 ± 0.7	3.9 ± 0.9	0.006	0.030	0.003	0.240
24 hours	3.9 ± 1.1	3.5 ± 0.9	3.9 ± 0.7	0.340	0.230	0.870	0.180

DISCUSSION

This study evaluated the comparative efficacy of fentanyl and magnesium sulphate as adjuvants to 0.375% bupivacaine in ultrasound-guided supraclavicular brachial plexus block. Our findings provide valuable insights into the block characteristics, analgesic profile, and patient outcomes across these three groups.

Demographic parameters were similar across groups, ensuring that age, weight, gender, and ASA classification did not confound the results. Similar homogeneity has been emphasized in previous studies as essential for valid outcome comparisons [11].

The onset of sensory and motor block was significantly faster in the placebo group compared to fentanyl and magnesium groups. This contrasts with the findings of Verma et al., who reported a quicker onset with magnesium sulphate [12]. This variation may be due to differences in dose, local anaesthetic concentration, or ultrasound technique.

The duration of both sensory and motor block was significantly prolonged in the fentanyl group compared to magnesium and placebo, and magnesium also showed a longer duration compared to placebo. These findings align with multiple studies indicating that both fentanyl and magnesium act synergistically with local anaesthetics to prolong block duration and postoperative analgesia [13,14]. Fentanyl's potent μ-receptor agonism enhances nociceptive modulation, while magnesium's NMDA antagonism reduces central sensitization and calcium-mediated neuronal excitability [15].

VAS scores demonstrated significantly better analgesic profiles in fentanyl and magnesium groups compared to placebo, particularly during the first 12–18 hours postoperatively. Several meta-analyses have confirmed that adding fentanyl or magnesium to peripheral nerve blocks improves early postoperative pain control and reduces rescue analgesia requirements [16,17]. Notably, fentanyl consistently outperformed magnesium in our study, particularly regarding block duration and pain scores up to 18 hours, highlighting its superior analgesic potency.

Importantly, no significant haemodynamic instability or major complications were observed across groups, supporting the safety of these adjuvants when used in appropriate doses under ultrasound guidance.

Overall, our results support the growing body of evidence favoring the use of both opioid and non-opioid adjuvants in regional anaesthesia to enhance block quality, prolong analgesia, and improve patient satisfaction. Future research should focus on optimizing doses, exploring multimodal adjuvant combinations, and evaluating long-term outcomes.

CONCLUSION

In conclusion, both fentanyl and magnesium sulphate are effective adjuvants to bupivacaine in ultrasound-guided supraclavicular brachial plexus block, offering prolonged sensory and motor block duration and superior postoperative analgesia compared to bupivacaine alone. Fentanyl demonstrated the longest duration of block and the most favorable VAS scores, making it a potent adjuvant choice. Magnesium, however, remains a valuable opioid-sparing alternative with a good safety profile. Incorporating these agents into regional anaesthesia protocols can improve analgesic outcomes and enhance perioperative care.

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