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RESEARCH ARTICLE
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COMPARATIVE STUDY ON INTRATHECAL MAGNESIUM SULFATE AND FENTANYL AS A SPINAL ADJUVANT, COMBINED WITH 0.5% HYPERBARIC BUPIVACAINE FOR INFRAUMBILICAL SURGERIES

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Abstract

1. Introduction

Spinal anesthesia benefits from adjuvants that prolong block duration. Fentanyl is widely used, but magnesium sulfate, a non-opioid NMDA antagonist, is emerging as a promising alternative in regional anesthesia.

2. Aims and Objectives

This study aims to evaluate and compare the onset, duration, and safety profile of intrathecal magnesium sulfate versus fentanyl, with a control group, to determine whether magnesium provides analgesic efficacy on par with the established opioid adjuvant.

3. Materials and Methods

Seventy-five ASA I–II patients undergoing elective infraumbilical surgeries were randomized into three groups: Control (bupivacaine + saline), M100 (bupivacaine + 100 mg magnesium sulfate), and F (bupivacaine + 25 mcg fentanyl). Spinal anesthesia was administered under standard conditions. Parameters including onset and duration of sensory and motor block, and adverse effects like hypotension and bradycardia, were monitored. Data were analyzed using ANOVA, Chi-square, and posthoc LSD tests. A p-value < 0.05 was considered statistically significant.

4.Results

Group F demonstrated the longest sensory and motor block durations, while M100 showed a faster onset and moderately prolonged duration compared to Control. Control had the shortest block durations. Ephedrine usage, indicative of hypotension, was highest in M100 (32%), followed by F (24%), and none in Control, showing significant hemodynamic impact. Sensory and motor durations across all groups were statistically significant ($p < 0.001$), suggesting that both adjuvants enhanced block characteristics, with magnesium showing performance comparable to fentanyl.

5.Conclusions

Magnesium sulfate stands on par with fentanyl in prolonging spinal anesthesia, offering comparable block durations with a non-opioid profile. While onset is slower, its efficacy and safety render it a valuable alternative, particularly in patients where opioid use is limited or contraindicated. These findings support magnesium sulfate as a clinically relevant intrathecal adjuvant and justify its further use and study in spinal anesthesia protocols.

Keywords – spinal anaesthesia, hyperbaric bupivacaine, magnesium sulphate, fentanyl

INTRODUCTION

Spinal anesthesia is widely used technique for performing different orthopedic, urological, obstetrical, and other infraumbilical surgical procedures.
Recent developments have led to greater patient satisfaction and accelerated functional recovery, and shortened the duration of stay in the hospital significantly. Combination with adjuncts like epinephrine, clonidine, neostigmine, opioids, midazolam and magnesium have been used to prolong analgesia and reduce the incidence of adverse events.
These spinal adjuvants allow the use of lower dose of local anaesthetic agents, also prolong and intensify the subarachnoid block and offer hemodynamic stability. Opioids such as fentanyl are commonly used as additive to local anaesthetics to prolong the duration and intensify the effects of subarachnoid block. However significant side effects of opioids such as pruritis, urinary retention, respiratory depression, hemodynamic instability and occasionally severe nausea and vomiting may limit their use. Newer methods of prolonging the duration of subarachnoid block and reducing post-operative analgesic requirements are of special interest in major surgical procedures.

One of the mechanisms implicated in the persistence of postoperative pain is central sensitization, which is an activity-dependent increase in the excitability of spinal neurons . Central sensitization has been shown to depend on the activation of dorsal horn N-methyl-D aspartate (NMDA) receptors by excitatory amino acid transmitters such as aspartate and glutamate.

NMDA receptor antagonists prevent central sensitization induced by peripheral nociceptive stimuli by blocking dorsal horn NMDA receptor activation. Magnesium (Mg^{2+}) is a non-competitive N-methyl-Daspartate (NMDA) receptor antagonist that blocks ion channels in a voltage dependent fashion.

Studies have evaluated use of magnesium intrathecally and shown to prolong the action of subarachnoid anaesthesia . However, most of these studies used an opioid along with magnesium, which could have contributed to the prolongation of blockade after subarachnoid block, Magnesium alone with LA in a dose of 50 mg and maximum upto 100 mg has been used in a few studies.

Hence the study is to compare the analgesic efficacy and side effects of magnesium with fentanyl as an additive to intrathecal bupivacaine in patients undergoing infraumbilical surgery.

AIMS AND OBJECTIVES

To compare the effect of Fentanyl and $MgSO_4$ as an adjuvant to spinal anaesthesia with the following

- **Primary objective**

Onset and duration of sensory and motor blockade

- **Secondary objective**

Side effects such hypotension, bradycardia and respiratory depression if any

➢ **Inclusion criteria:**

i. Adult patients aged 18 to 60 years of either sex.
ii. Patients belonging to American society of Anaesthesiologists Physical Status (ASA PS) 1 or 2.
iii. Patients undergoing elective infraubilical surgeries

➢ **Exclusion criteria:**

i. Patient's refusal
ii. ASA PS 3 and 4 patients
iii. Raised intracranial pressure
iv. Bleeding diathesis
v. Local infection

vi. Pregnancy

Methodology

A prospective randomized comparative study was conducted at S.S Institute Of Medical Sciences and Research Centre, Davangere. Patients posted for elective infraumbilical surgeries were taken for study.

The study was conducted on total of 75 subjects. The subjects were randomly allotted into three groups of 25 each- Group C, Group M100 and Group F using the envelope method. The details of groups are as follows:

i. Group C received 3ml of 0.5% hyperbaric Bupivacaine + 0.5cc normal saline
ii. Group M100 received 3ml of 0.5 % hyperbaric bupivacaine(15mg) + 100mg of 50% MgSO4 diluted to 0.5cc
iii. Group F will receive 3ml of 0.5% hyperbaric bupivacaine (15mg) + 25mcg of Fentanyl

The patient underwent a pre-anaesthetic evaluation and a written informed consent in the patient's own understanable language was obtained.

Patient were given premedications with Tab.Alprazolam 0.5 mg in sips of water the night before surgery and T. Pantoprazole 40mg in the morning on the day of surgery.

On arrival to the operating theatre baseline parameters like 3 lead electrocardiography(ECG), heart rate(HR), systolic blood pressure(SBP), diastolic blood pressure(DBP), respiratory rate(RR), peripheral oxygen saturation(SpO_2) were measured following which an intravenous line was secured with an 18 gauge cannula and appropriate intravenous fluid was initiated.

Spinal anaesthesia was performed under aseptic precautions in sitting position. L2-L3/L3-L4 interspace was identified and local infiltration of skin was done with 2% lignocaine. Spinal anaesthesia was performed with a 26G Quincke Babcock spinal needle via midline approach. The group specific drug was injected into the subarachnoid space after the confirmation of free flow of cerebrospinal fluid. Then, patient was made supine and the onset of sensory and motor blockade, duration of sensory and motor block were recorded.

Sensory block was assessed using the cold cotton wisp. Onset of sensory block was measured from completion of the injection of study drug till the patient did not feel cold cotton wisp at T10 level. Duration of sensory block was measured from the onset of sensory block till the patient needed first rescue analgesia.

Motor blockade was assessed using the Modified Bromage Scale.[27] It is as follows:
i. 0-no block, full straight leg raise possible
ii. 1-unable to straight leg raise
iii. 2- unable to flex knee, able to flex ankle
iv. 3- no motor movement, complete motor block

Onset of motor block was the time taken from injection of study drug till the patient attains modified Bromage scale grade 3 motor blockade. Duration of motor blockade was the time taken from the onset of motor blockade till the patient attained complete motor recovery.

If SBP was > 20% below baseline or 90 mmHg, intravenous (i.v.) ephedrine, 6 mg, was given repeatedly. If HR was < 50 beats/ min, 0.6 mg of atropine sulphate was administered intravenously.

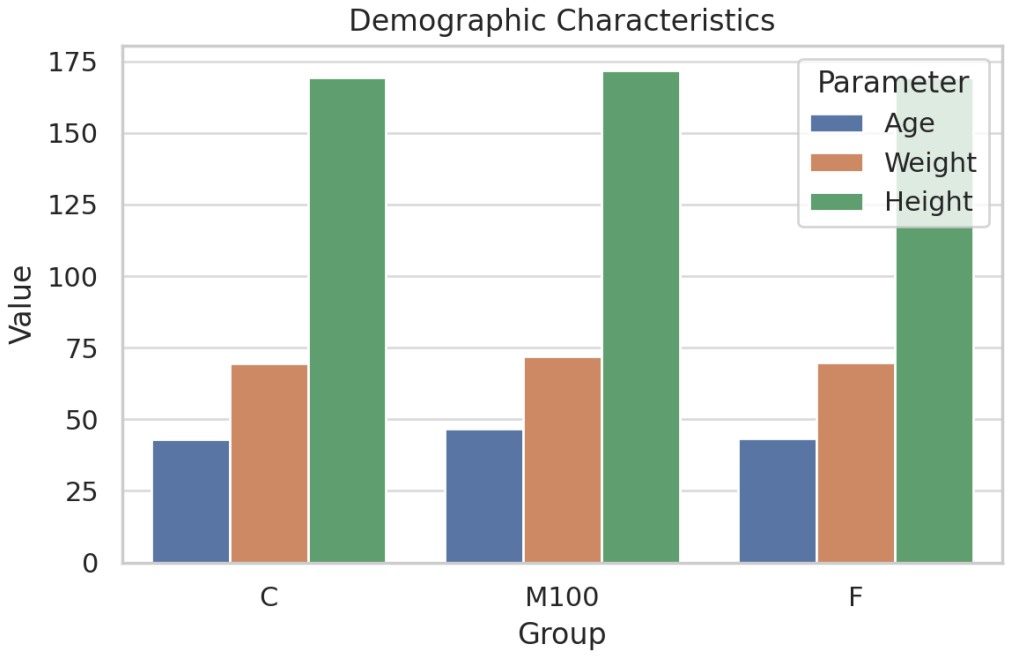
The incidence of hypotension (mean arterial pressure, < 20% of baseline), bradycardia (HR < 50 beats/min), hypoxemia, dizziness, nausea and vomiting were recorded.

Haemodynamic monitoring was done throughout the duration of procedure (every 5 minutes). Patients were transferred to PACU where postoperative vitals were monitored and then discharged after assessing Aldrete's Discharge criteria.

RESULTS

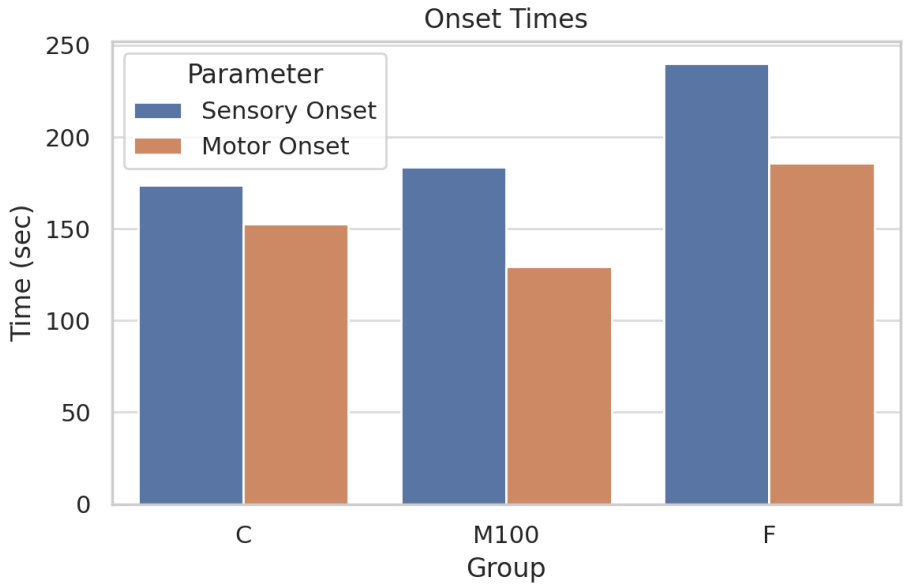
Demographic Characteristics

Group-wise comparisons of demographic data indicate no significant difference in mean age across the Control (43.04±12.08), M100 (46.76±12.1), and F (43.32±8.66) groups ($p = 0.421$), suggesting that the baseline age distribution was comparable. Weight differences also were not statistically significant ($p = 0.061$), although M100 had a marginally higher mean weight (72.0±3.27 kg). However, height was significantly different among groups ($p < 0.001$). The M100 group had the tallest mean height (171.96±2.7 cm), while the F and Control groups had similar shorter mean heights (169.32±1.8 and 169.44±2.08 cm, respectively). This statistically significant height difference is clinically relevant because it may influence the spread of intrathecal drugs, potentially explaining some variability in drug action and duration observed across the groups.



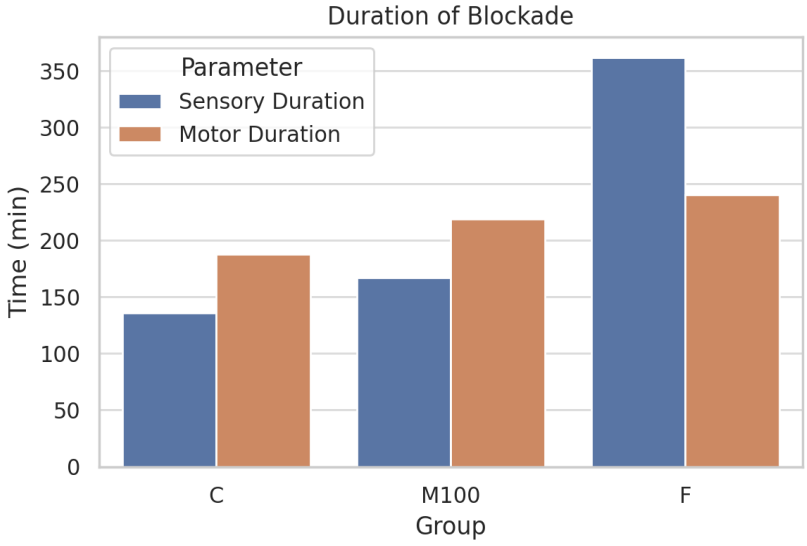
Onset of Sensory and Motor Blockade

The analysis of onset times revealed that the F group experienced the most delayed onset for both sensory and motor blockade. The sensory onset time was highest in Group F (240.28±93.61 sec), significantly more delayed compared to M100 (183.8±50.41 sec) and Control (173.64±73.26 sec) with a p-value of 0.005. Posthoc LSD comparison confirmed that the difference between F and M100 was significant ($p = 0.0321$), while the difference between Control and M100 was not ($p = 1.0$). Motor onset showed a similar trend: Group F had the slowest onset (186.0±45.01 sec), followed by Control (152.48±64.97 sec), and the fastest onset was in M100 (129.4±51.63 sec), with an overall significant ANOVA result ($p = 0.002$). Posthoc analysis showed a highly significant difference between F and M100 ($p = 0.0004$), suggesting that the formulation used in Group F may have slower penetration or action onset at the neural level, whereas M100 provided a faster and more clinically desirable onset profile.



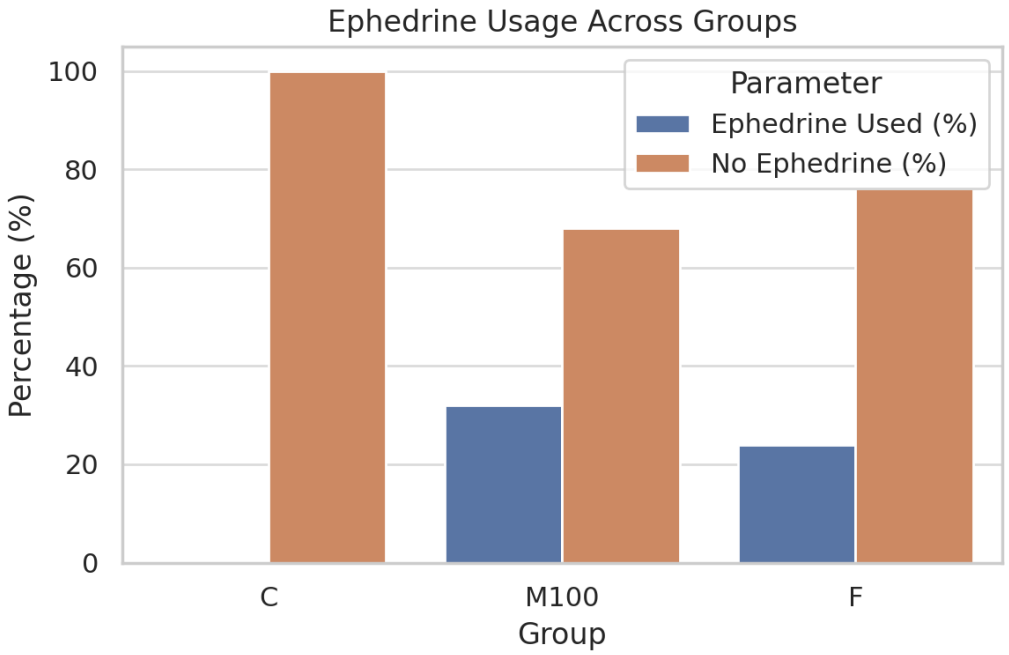
Duration of Sensory and Motor Blockade

Duration analysis highlighted a substantial difference between groups. The sensory blockade lasted the longest in Group F (362.24±39.56 min), almost more than twice the duration seen in Control (135.8±28.27 min) and significantly longer than M100 (167.4±23.01 min). This difference was statistically significant ($p < 0.001$), with posthoc analysis confirming that all pairwise group comparisons were significant (Control vs M100: $p = 0.0002$; Control vs F: $p = 0.0$; M100 vs F: $p = 0.0$). Similarly, motor blockade was most prolonged in Group F (240.24±53.33 min), followed by M100 (219.4±23.82 min) and Control (188.0±42.13 min). The p-value for the overall comparison was also significant at $p < 0.001$. While the Control group consistently showed the shortest durations, the difference between M100 and F for motor block was not statistically significant ($p = 0.2422$), suggesting a ceiling effect may exist with increasing dosage. These findings demonstrate a dose-dependent enhancement of both sensory and motor block durations with the tested agents, with the F group achieving the most prolonged anesthetic effect.



Ephedrine Requirement

Ephedrine requirement differed markedly among the groups. No patient in the Control group required ephedrine, compared to 24% in the F group and 32% in the M100 group. This difference was statistically significant (Chi-square test p = 0.01), implying a greater incidence of hypotension in the groups receiving magnesium formulations. The higher ephedrine requirement in M100 may be associated with deeper or more sustained sympathetic blockade. These hemodynamic effects are expected with intrathecal magnesium use due to its known vasodilatory properties. However, since all hypotension episodes were effectively managed, the clinical implications remain acceptable with vigilant monitoring.



Conclusions

This in-depth comparative study confirms significant pharmacodynamic differences between the tested agents. M100 offers a favorable balance of quick onset and adequate duration, making it a reliable choice for intermediate procedures. Group F, while showing delayed onset, provides the most prolonged anesthesia, ideal for extended surgical durations. Control yielded the shortest durations and no significant hemodynamic effects. Ephedrine usage highlights the need for precautionary measures during administration of higher-dose or extended-action formulations. These results underscore the importance of tailoring intrathecal adjuvant selection to the surgical requirement and patient profile, ensuring optimal outcomes and safety.

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