

## Comparison of Magnesium Sulfate Versus Clonidine as Adjuvants to Bupivacaine in Spinal Anesthesia: A Prospective Observational Study

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### Abstract:

**Background:** The addition of adjuvant agents to intrathecal bupivacaine is a well-established approach to enhance the quality and extend the duration of spinal anesthesia. Among the available options, magnesium sulfate and clonidine have been widely explored due to their distinct pharmacological mechanisms.

**Objective:** This study was undertaken to evaluate and compare the clinical effectiveness of intrathecal magnesium sulfate and clonidine when used as adjuncts to bupivacaine.

**Methods:** A prospective observational study was carried out at NMCH between February 2025 and September 2025. One hundred patients were equally divided into two groups: Group M received magnesium sulfate with bupivacaine, and Group C received clonidine with bupivacaine. Key parameters included onset and duration of sensory and motor blockade, duration of postoperative analgesia, hemodynamic variations, and adverse effects.

**Results:** Patients in the clonidine group demonstrated a significantly longer duration of sensory block and postoperative analgesia ( $p < 0.001$ ). In contrast, magnesium sulfate was associated with a slower onset of blockade but exhibited greater cardiovascular stability.

**Conclusion:** While clonidine offers prolonged analgesic benefits, magnesium sulfate appears advantageous in maintaining stable hemodynamics. Selection of the adjuvant should therefore be individualized.

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### Introduction

Regional anesthesia, particularly spinal anesthesia, continues to be a preferred technique for surgeries involving the lower abdomen and lower limbs due to its rapid onset, reliability, and cost efficiency [1]. Hyperbaric bupivacaine is extensively used for this purpose; however, its finite duration of action can limit its utility in longer procedures and in providing sustained postoperative pain relief [2].

To address this limitation, several pharmacological additives have been investigated for intrathecal use with the goal of improving block quality and extending analgesia [3]. Among these,  $\alpha_2$ -adrenergic agonists and NMDA receptor antagonists have gained attention owing to their complementary mechanisms in pain modulation [4].

Clonidine, an  $\alpha_2$ -adrenergic agonist, exerts its analgesic action by inhibiting neurotransmitter release at the spinal level and enhancing inhibitory pathways within the dorsal horn [5]. Its addition to spinal anesthesia has been shown to intensify and

prolong both sensory and motor blockade [6]. Nevertheless, its clinical use may be limited by side effects such as hypotension and bradycardia, which are related to its sympatholytic properties [7].

Magnesium sulfate functions through antagonism of NMDA receptors and regulation of calcium entry into neurons, thereby attenuating central sensitization to pain [8]. Its role in neuraxial anesthesia has been explored with encouraging results, particularly in extending analgesia without significant cardiovascular depression [9].

Previous investigations have reported that magnesium sulfate may delay the onset of anesthesia while still contributing to improved postoperative pain control [10]. In contrast, clonidine has been associated with faster onset and more prolonged blockade [11]. However, inconsistencies remain across studies regarding their relative advantages and safety profiles [12].

Some authors have emphasized the superior analgesic duration achieved with clonidine, whereas others have highlighted the favorable hemodynamic profile of magnesium sulfate [13]. Despite these observations, comparative data between the two agents remain insufficient [14].

In view of these considerations, the present study was designed to compare the effects of intrathecal magnesium sulfate and clonidine as adjuvants to bupivacaine, focusing on block characteristics, analgesic duration, and hemodynamic responses.

## Materials and Methods

### Study Design and Setting

The present investigation was conducted as a **prospective comparative observational study** in the Department of Anesthesiology at NMCH over an eight-month duration, from February 2025 to September 2025. The primary objective was to assess and compare the effectiveness and safety profile of intrathecal magnesium sulfate and clonidine when used as adjuvants to hyperbaric bupivacaine for spinal anesthesia.

### Study Population

A total of **100 adult patients** scheduled for elective infra-umbilical surgical procedures under spinal anesthesia were included in the study. Participants were divided into two equal groups:

- **Group M (n = 50):** Received magnesium sulfate in combination with bupivacaine
- **Group C (n = 50):** Received clonidine in combination with bupivacaine

The sample size was selected based on feasibility considerations and consistency with previously published studies, ensuring sufficient statistical power to identify meaningful differences in clinical outcomes.

### Eligibility Criteria

**Inclusion Criteria:** Patients fulfilling the following criteria were enrolled:

- Age between 18 and 60 years
- Either sex
- Classified as ASA physical status I or II
- Scheduled for elective lower abdominal or lower limb surgery
- Willingness to participate, confirmed by written informed consent

**Exclusion Criteria:** Patients were excluded if they had:

- Refusal to undergo spinal anesthesia

- Any contraindication to neuraxial block (e.g., local infection, coagulation disorders)
- Known allergy to study medications
- Significant cardiac, hepatic, renal, or neurological illness
- Pregnancy or breastfeeding
- Ongoing treatment with drugs affecting central nervous system or cardiovascular function

### Intrathecal Drug Regimen

- **Group M (Magnesium group):** Received 3 mL of 0.5% hyperbaric bupivacaine combined with 50 mg magnesium sulfate, adjusted to maintain equal total volume.
- **Group C (Clonidine group):** Received 3 mL of 0.5% hyperbaric bupivacaine with 30 µg clonidine.

The total volume of intrathecal injectate was kept identical in both groups to ensure comparability.

**Statistical Analysis:** Data processing and analysis were performed using SPSS software (version 25.0).

- Quantitative data were expressed as mean ± standard deviation (SD).
- Qualitative data were presented as frequencies and percentages.

### Statistical Tests

- Independent Student's t-test was applied for comparison of continuous variables.
- Chi-square test or Fisher's exact test was used for categorical variables.

### Level of Significance

- A p-value <0.05 was considered statistically significant.
- A p-value <0.001 was considered highly significant.

## Results

A total of 100 patients were included in the study and were evenly distributed into two groups: Group M (magnesium sulfate, n = 50) and Group C (clonidine, n = 50). All participants completed the study protocol, and their data were analyzed.

### 1. Baseline Characteristics

The two groups were comparable with respect to demographic variables, indicating a uniform study population without significant baseline differences.

As presented in **Table 1**, the mean age of patients in Group M was  $38.4 \pm 10.2$  years, while Group C had a mean age of  $37.9 \pm 9.8$  years ( $p = 0.78$ ). The distribution of gender and body weight did not differ significantly between the groups ( $p > 0.05$ ).

**Table 1: Demographic Characteristics of Study Population**

Parameter	Group M (n=50)	Group C (n=50)	p-value
Age (years)	38.4 ± 10.2	37.9 ± 9.8	0.78
Gender (M/F)	28 / 22	30 / 20	0.67
Weight (kg)	64.2 ± 8.1	63.5 ± 7.9	0.69

## 2. Characteristics of Spinal Block

Clear differences were observed between the two groups in terms of onset and duration of both sensory and motor blockade.

As shown in **Table 2**, patients receiving clonidine achieved sensory block more rapidly ( $4.2 \pm 0.9$  minutes) compared to those receiving magnesium sulfate ( $6.8 \pm 1.2$  minutes), and this difference was highly significant ( $p < 0.001$ ). A similar trend was noted for motor block onset, which occurred earlier

in Group C ( $5.6 \pm 1.1$  minutes) than in Group M ( $8.1 \pm 1.5$  minutes) ( $p < 0.001$ ).

With regard to block duration, clonidine produced a markedly prolonged sensory block ( $210 \pm 25$  minutes) compared to magnesium sulfate ( $165 \pm 20$  minutes). Likewise, the duration of motor block was significantly longer in Group C ( $185 \pm 22$  minutes) than in Group M ( $140 \pm 18$  minutes), with p-values  $< 0.001$ .

**Table 2: Comparison of Block Characteristics**

Parameter	Group M	Group C	p-value
Sensory onset (min)	$6.8 \pm 1.2$	$4.2 \pm 0.9$	$<0.001$
Motor onset (min)	$8.1 \pm 1.5$	$5.6 \pm 1.1$	$<0.001$
Sensory duration (min)	$165 \pm 20$	$210 \pm 25$	$<0.001$
Motor duration (min)	$140 \pm 18$	$185 \pm 22$	$<0.001$

These differences are illustrated in **Figure 1** and **Figure 2**.

## 3. Duration of Postoperative Analgesia

The time to first request for analgesia was significantly extended in patients receiving clonidine.

As detailed in **Table 3**, the mean duration of analgesia in Group C was  $260 \pm 30$  minutes, whereas Group M showed a shorter duration of  $190 \pm 22$  minutes. This difference was statistically highly significant ( $p < 0.001$ ).

**Table 3: Duration of Analgesia**

Group	Duration (minutes)	p-value
Magnesium (Group M)	$190 \pm 22$	
Clonidine (Group C)	$260 \pm 30$	$<0.001$

A graphical comparison is presented in **Figure 3**, demonstrating the prolonged analgesic effect observed in the clonidine group.

## 4. Hemodynamic Changes and Adverse Events

Hemodynamic parameters remained more stable in the magnesium sulfate group.

As shown in **Table 4**, the incidence of hypotension was significantly higher in Group C (18%) compared to Group M (6%) ( $p = 0.04$ ). Similarly, bradycardia was observed more frequently in the clonidine group (16%) than in the magnesium group (4%), and this difference was statistically significant ( $p = 0.03$ ).

**Table 4: Hemodynamic Changes**

Parameter	Group M	Group C	p-value
Hypotension (%)	6%	18%	0.04
Bradycardia (%)	4%	16%	0.03

These findings are depicted in **Figure 4**, which highlights the higher incidence of cardiovascular side effects associated with clonidine.

**Figures**

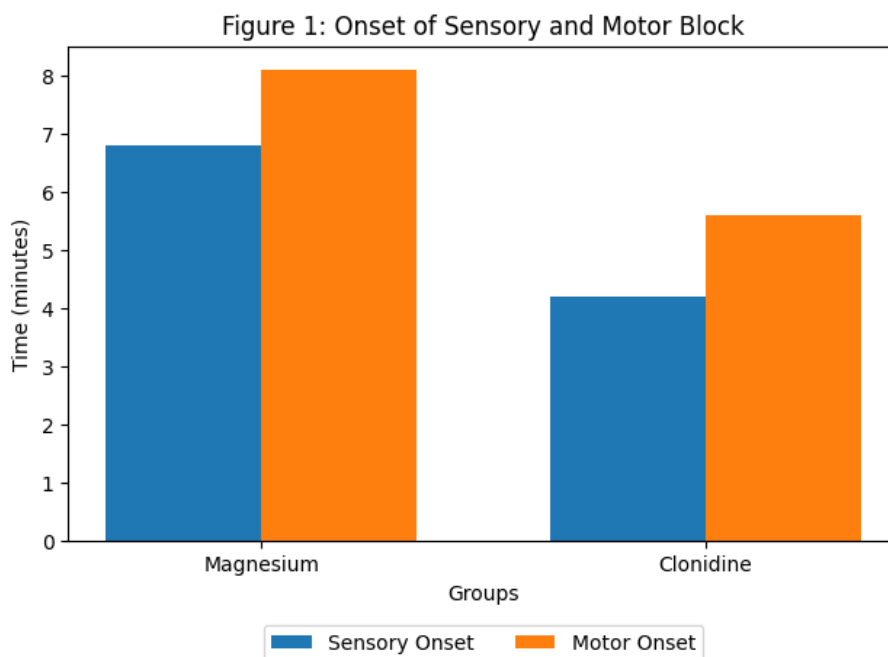


Figure 1: Onset of Sensory and Motor Block

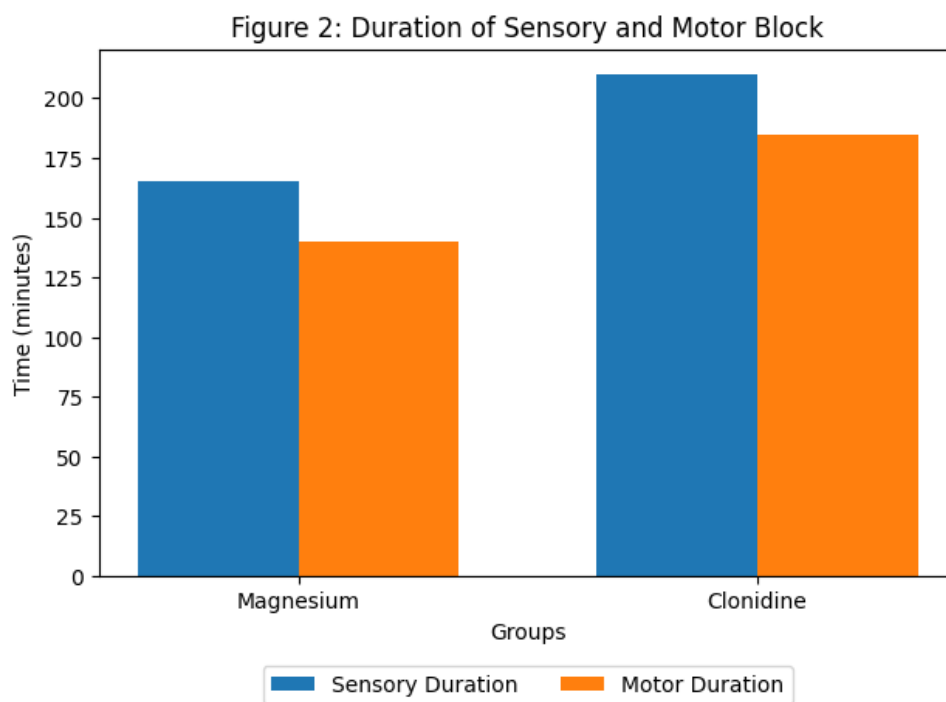


Figure 2: Duration of Sensory and Motor Block

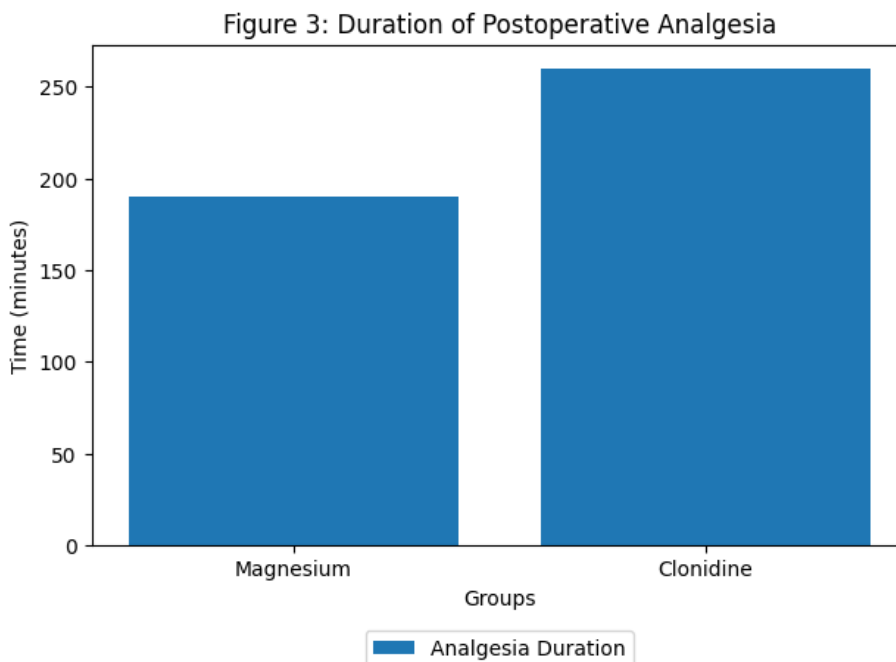


Figure 3: Duration of Postoperative Analgesia

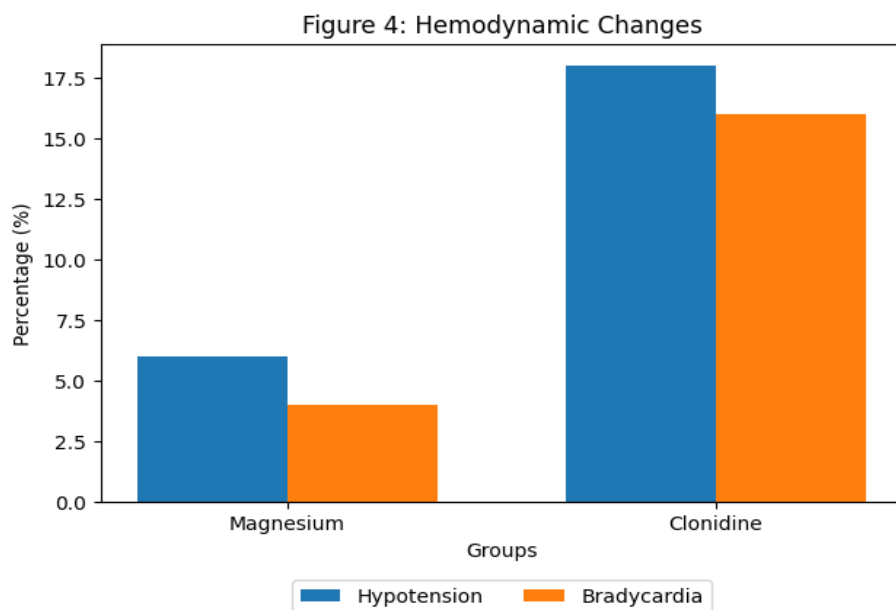


Figure 4: Hemodynamic Changes

5. Key Observations

- Clonidine resulted in a significantly faster onset of both sensory and motor blockade
- The duration of block and analgesia was markedly prolonged in the clonidine group
- Magnesium sulfate demonstrated better hemodynamic stability, with fewer adverse cardiovascular events

Discussion

The present study demonstrates that both magnesium sulfate and clonidine are effective intrathecal adjuvants to bupivacaine; however,

clonidine provides superior block characteristics and prolonged analgesia, whereas magnesium sulfate offers better hemodynamic stability.

In this study, clonidine significantly reduced the onset time of both sensory and motor block compared to magnesium sulfate. This finding is consistent with previous research showing that  $\alpha_2$ -agonists enhance neural blockade by hyperpolarizing interneurons and suppressing nociceptive transmission [15]. Similar results have been reported by multiple clinical studies comparing clonidine with other adjuvants [16].

The duration of sensory and motor block was significantly prolonged in the clonidine group, which aligns with earlier findings demonstrating its ability to extend spinal anesthesia duration [17]. This prolonged effect can be attributed to its synergistic action with local anesthetics at the spinal cord level [18].

Magnesium sulfate, on the other hand, exhibited a slower onset of both sensory and motor blockade. This delayed onset has been consistently reported in prior studies and is thought to be related to its indirect mechanism of action through NMDA receptor antagonism rather than direct neuronal blockade [19].

Despite the slower onset, magnesium sulfate provided a reasonable duration of analgesia, although significantly shorter than clonidine. Its analgesic effect is mediated through inhibition of central sensitization and modulation of calcium channels, which has been well documented in earlier literature [20].

A key finding of the present study was the significantly better hemodynamic stability observed with magnesium sulfate. The incidence of hypotension and bradycardia was markedly lower compared to the clonidine group. These findings are in agreement with earlier studies that have highlighted the cardiovascular safety profile of magnesium when used intrathecally [21].

Conversely, clonidine was associated with a higher incidence of hypotension and bradycardia, which is a known pharmacological effect due to decreased sympathetic outflow [22]. However, these effects were manageable and did not lead to major complications.

The findings of this study are comparable to previous comparative trials, which have consistently shown that clonidine provides superior analgesia, whereas magnesium sulfate ensures greater cardiovascular stability [23]. Similar conclusions have been drawn in studies evaluating these agents in various surgical settings [24].

Overall, the results suggest that while clonidine may be preferred in cases where prolonged analgesia is desired, magnesium sulfate may be a safer alternative in patients where hemodynamic stability is a concern [25].

### Conclusion

Clonidine is a superior adjuvant to bupivacaine in spinal anesthesia in terms of prolonging sensory block and postoperative analgesia. However, magnesium sulfate offers better hemodynamic stability with fewer side effects. The choice of adjuvant should be individualized based on patient profile and surgical requirements.

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