

## A Prospective Single-Blind Randomised Comparative Study of the Efficacy of Intrathecal Hyperbaric Bupivacaine With 5 µg, 7.5 µg and 10 µg of Dexmedetomidine as an Adjuvant for Lower Limb Surgeries

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### Abstract

**Background:** Spinal anaesthesia using hyperbaric bupivacaine is commonly employed for lower limb surgeries. However, its limited duration of action necessitates the addition of adjuvants. Dexmedetomidine, a selective  $\alpha_2$ -adrenergic agonist, prolongs sensory and motor blockade, although the optimal intrathecal dose remains uncertain.

**Aim:** To compare the efficacy of 5 µg, 7.5 µg, and 10 µg intrathecal dexmedetomidine as an adjuvant to hyperbaric bupivacaine in patients undergoing lower limb surgeries.

**Materials and Methods:** This prospective, single-blind, randomized comparative study was conducted among 90 ASA physical status I–II patients aged 18–60 years undergoing lower limb surgeries under spinal anaesthesia. Patients were randomly allocated into three equal groups. Group D5 received 15 mg hyperbaric bupivacaine with 5 µg dexmedetomidine, Group D7.5 received 15 mg hyperbaric bupivacaine with 7.5 µg dexmedetomidine, and Group D10 received 15 mg hyperbaric bupivacaine with 10 µg dexmedetomidine. Sensory and motor blockade characteristics, hemodynamic parameters, and adverse effects were evaluated.

**Results:** The onset of sensory blockade was significantly faster in Group D10 ( $4.9 \pm 0.9$  minutes) compared with Group D7.5 ( $5.6 \pm 1.3$  minutes) and Group D5 ( $5.8 \pm 1.6$  minutes). The time for two-segment sensory regression was longest in Group D10 ( $111.4 \pm 11.4$  minutes), followed by Group D7.5 ( $100.2 \pm 11.0$  minutes) and Group D5 ( $95.0 \pm 12.2$  minutes;  $p < 0.005$ ). The onset of complete motor blockade was fastest in Group D10 ( $5.8 \pm 1.1$  minutes), while motor block regression to Bromage I was longest in Group D10 ( $365.0 \pm 26.52$  minutes), followed by Group D7.5 ( $340.0 \pm 27.25$  minutes) and Group D5 ( $331.0 \pm 28.11$  minutes). Greater hemodynamic variations and a higher reported incidence of hypotension, bradycardia, and nausea were observed in Group D10.

**Conclusion:** Intrathecal dexmedetomidine demonstrated dose-dependent prolongation of sensory and motor blockade when combined with hyperbaric bupivacaine. Although 10 µg provided the longest blockade, 7.5 µg appeared to offer a more favorable balance between anaesthetic efficacy and hemodynamic stability.

**Keywords:** Dexmedetomidine; Hyperbaric Bupivacaine; Spinal Anaesthesia; Sensory Blockade; Motor Blockade; Hemodynamic Stability; Lower Limb Surgery.

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### Introduction

Spinal anaesthesia is widely used for lower limb surgeries because of its rapid onset, effective sensory and motor blockade, reduced systemic complications, and favorable safety profile. Hyperbaric bupivacaine is commonly administered for spinal anaesthesia; however, its relatively limited duration of action and postoperative

analgesia necessitate the use of suitable adjuvants. Various intrathecal agents, including dexmedetomidine and magnesium sulphate, have been investigated to improve the quality and duration of spinal blockade [1]. Dexmedetomidine is a highly selective  $\alpha_2$ -adrenergic receptor agonist with sedative, analgesic, and sympatholytic

properties. When administered intrathecally with bupivacaine, it enhances sensory and motor blockade and prolongs postoperative analgesia without significantly increasing respiratory depression [2]. Previous studies have demonstrated that low-dose intrathecal dexmedetomidine improves the characteristics of spinal anaesthesia compared with local anaesthetic alone [3].

The addition of dexmedetomidine to intrathecal bupivacaine has been associated with prolonged sensory and motor blockade and improved perioperative analgesia [4].

However, the optimal dose remains uncertain because increasing doses may produce greater prolongation of blockade while potentially increasing adverse effects such as hypotension and bradycardia. Naaz et al. [5] evaluated different doses of intrathecal dexmedetomidine and demonstrated dose-dependent improvements in analgesic efficacy, emphasizing the importance of selecting an appropriate dose.

Gupta et al. [6] compared 2.5 µg, 5 µg, and 10 µg of intrathecal dexmedetomidine and reported dose-dependent prolongation of sensory and motor blockade. Although higher doses may improve anaesthetic duration, their effects on hemodynamic stability require careful consideration. The pharmacological properties of dexmedetomidine, including its sympatholytic activity, may contribute to cardiovascular changes during anaesthesia [7].

Therefore, the present study was undertaken to compare the efficacy of 5 µg, 7.5 µg, and 10 µg of intrathecal dexmedetomidine as an adjuvant to

0.5% hyperbaric bupivacaine in patients undergoing lower limb surgeries, with particular emphasis on sensory and motor blockade, hemodynamic stability, and adverse effects.

## Materials and Methods

**Study Design and Setting:** This prospective, single-blind, randomized comparative study was conducted in the Department of Anaesthesiology, Yenepoya Medical College, Mangalore, over two years, from October 2020 to October 2022.

**Study Population and Sample Size:** A total of 90 patients, aged 18–60 years, belonging to American Society of Anesthesiologists (ASA) physical status I or II and scheduled for lower limb surgeries under spinal anaesthesia, were included.

Patients were randomly allocated into three groups of 30 each. The uploaded manuscript specifies the enrolled sample size but does not provide a formal sample size calculation.

**Preoperative Assessment:** After obtaining Institutional Ethics Committee approval and written informed consent, all patients underwent detailed pre-anaesthetic evaluation, including medical history, physical examination, airway assessment, spinal examination, and routine investigations. Patients were instructed to maintain preoperative fasting for six hours.

**Study Groups:** Patients were allocated into three groups according to the dose of intrathecal dexmedetomidine administered with 0.5% hyperbaric bupivacaine.

**Table 1:**

| Group             | Intervention                                                 | Sample size |
|-------------------|--------------------------------------------------------------|-------------|
| <b>Group D5</b>   | 15 mg (3 mL) hyperbaric bupivacaine + 5 µg dexmedetomidine   | 30          |
| <b>Group D7.5</b> | 15 mg (3 mL) hyperbaric bupivacaine + 7.5 µg dexmedetomidine | 30          |
| <b>Group D10</b>  | 15 mg (3 mL) hyperbaric bupivacaine + 10 µg dexmedetomidine  | 30          |
| <b>Total</b>      |                                                              | <b>90</b>   |

Dexmedetomidine was diluted with normal saline to a volume of 0.5 mL, maintaining a total intrathecal injection volume of 3.5 mL in all three groups.

**Anaesthetic Technique:** On arrival in the operating theatre, baseline heart rate, blood pressure, respiratory rate, electrocardiogram, and peripheral oxygen saturation were recorded. Intravenous access was secured using an 18-gauge cannula, and intravenous fluids were administered.

Under aseptic precautions, subarachnoid block was performed in the sitting or lateral position, preferably at the L3–L4 intervertebral space, using a 23-gauge Quincke spinal needle. The allocated study medication was administered intrathecally, following which patients were positioned supine.

## Assessment of Sensory and Motor Blockade

**Sensory Blockade:** Sensory blockade was assessed using loss of temperature sensation with a spirit-soaked swab. The onset of sensory blockade was defined as the time from intrathecal injection to loss of temperature sensation at the T10 dermatome. The duration of sensory blockade was assessed by the time required for two-segment regression from the maximum sensory level.

**Motor Blockade:** Motor blockade was assessed using the modified Bromage scale (0–3). The onset of motor blockade was defined as the time required to achieve Bromage grade I, while the time to complete motor blockade was recorded at Bromage grade III. Motor block recovery was assessed by regression to Bromage grade I.

**Hemodynamic Monitoring:** Heart rate and blood pressure were monitored at baseline and every three minutes during the first 15 minutes, followed by 15-minute intervals up to one hour and 30-minute intervals thereafter until completion of surgery.

Hypotension was defined as a reduction in systolic blood pressure exceeding 30% from baseline or systolic blood pressure below 90 mmHg and was managed using intravenous fluids and incremental doses of mephentermine 6 mg.

Bradycardia was defined as heart rate below 50 beats/minute and was treated with intravenous atropine 0.6 mg.

Adverse events, including nausea, vomiting, shivering, hypotension, and bradycardia, were recorded and managed according to the institutional protocol.

**Statistical Analysis:** Data were analyzed using appropriate statistical methods. Continuous variables were expressed as mean  $\pm$  standard deviation, while categorical variables were presented as frequencies and percentages.

One-way analysis of variance (ANOVA) was used for comparisons of continuous variables among the three groups, followed by appropriate post hoc testing where required. Chi-square or Fisher's exact tests were used for categorical variables. Repeated-

measures analysis was considered for hemodynamic parameters recorded at multiple time intervals.

A p-value  $<0.05$  was considered statistically significant.

**Ethical Considerations:** The study was conducted after obtaining Institutional Ethics Committee approval. Written informed consent was obtained from all participants before enrollment. Patient confidentiality was maintained throughout the study.

## Results

A total of 90 patients undergoing lower limb surgeries under spinal anaesthesia were included in this prospective, single-blind, randomized comparative study. Patients were equally distributed into three groups: Group D5 (5  $\mu$ g dexmedetomidine,  $n=30$ ), Group D7.5 (7.5  $\mu$ g dexmedetomidine,  $n=30$ ), and Group D10 (10  $\mu$ g dexmedetomidine,  $n=30$ ). All groups received 15 mg of 0.5% hyperbaric bupivacaine intrathecally.

The three groups were comparable regarding baseline demographic characteristics. Increasing doses of dexmedetomidine were associated with faster onset and prolonged duration of sensory and motor blockade. However, greater hemodynamic variations and adverse effects were reported with higher doses.

**Table 1: Comparison of Demographic and Baseline Characteristics among Study Groups (N=90)**

| Parameter                                    | Group D5<br>(n=30) | Group D7.5<br>(n=30) | Group D10<br>(n=30) | Statistical<br>significance |
|----------------------------------------------|--------------------|----------------------|---------------------|-----------------------------|
| Age (years), mean $\pm$ SD                   | 47.7 $\pm$ 11.2    | 47.6 $\pm$ 11.4      | 48.4 $\pm$ 11.1     | Not significant             |
| Male, n (%)                                  | 19 (63.3%)         | 17 (56.7%)           | 19 (63.3%)          | Not significant             |
| Female, n (%)                                | 11 (36.7%)         | 13 (43.3%)           | 11 (36.7%)          | Not significant             |
| Weight (kg), mean                            | 66.5               | 65.1                 | 66.3                | Not significant             |
| Height (cm), mean $\pm$ SD                   | 154.9 $\pm$ 2.7    | 150.6 $\pm$ 18.9     | 149.9 $\pm$ 24.9    | Not significant             |
| Duration of surgery (minutes), mean $\pm$ SD | 105.5 $\pm$ 10.3   | 110.8 $\pm$ 10.1     | 118.0 $\pm$ 11.6    | Reported as significant     |

The three groups demonstrated comparable demographic characteristics, including age, sex distribution, weight, and height. The mean age ranged from 47.6 to 48.4 years. A male

predominance was observed in all groups. The duration of surgery increased progressively from Group D5 to Group D10, with the longest mean operative duration observed in Group D10.

**Table 2: Comparison of Sensory Blockade Characteristics among Study Groups**

| Parameter                                             | Group D5<br>(n=30) | Group D7.5<br>(n=30) | Group D10<br>(n=30) | p-value              |
|-------------------------------------------------------|--------------------|----------------------|---------------------|----------------------|
| Time to achieve T10 sensory level (minutes)           | 5.8 $\pm$ 1.6      | 5.6 $\pm$ 1.3        | 4.9 $\pm$ 0.9       | $<0.05$              |
| Patients attaining maximum sensory level of T8, n (%) | 15 (50.0%)         | 16 (53.3%)           | 15 (50.0%)          | Reported significant |
| Time for two-segment sensory regression (minutes)     | 95.0 $\pm$ 12.2    | 100.2 $\pm$ 11.0     | 111.4 $\pm$ 11.4    | $<0.005$             |

The onset of sensory blockade was fastest in Group D10 (4.9  $\pm$  0.9 minutes), followed by Group D7.5 (5.6  $\pm$  1.3 minutes) and Group D5 (5.8  $\pm$  1.6 minutes). The time required for two-segment sensory regression increased progressively with increasing dexmedetomidine doses, being longest in Group D10 (111.4  $\pm$  11.4 minutes). These findings demonstrate a dose-dependent prolongation of sensory blockade.

**Table 3: Comparison of Motor Blockade Characteristics among Study Groups**

| Parameter                                 | Group D5<br>(n=30) | Group D7.5<br>(n=30) | Group D10<br>(n=30) | p-value              |
|-------------------------------------------|--------------------|----------------------|---------------------|----------------------|
| Time to achieve Bromage III (minutes)     | 6.5 ± 1.7          | 6.2 ± 1.0            | 5.8 ± 1.1           | <0.05                |
| Time to regression to Bromage I (minutes) | 331.0 ± 28.11      | 340.0 ± 27.25        | 365.0 ± 26.52       | Reported significant |

The onset of complete motor blockade was significantly faster in Group D10 (5.8 ± 1.1 minutes) compared with Group D7.5 (6.2 ± 1.0 minutes) and Group D5 (6.5 ± 1.7 minutes). Motor blockade duration increased with increasing doses

of dexmedetomidine. Group D10 demonstrated the longest time to regression to Bromage I (365.0 ± 26.52 minutes), followed by Group D7.5 (340.0 ± 27.25 minutes) and Group D5 (331.0 ± 28.11 minutes).

**Table 4: Comparison of Hemodynamic Changes and Adverse Effects among Study Groups**

| Parameter                                      | Group D5 | Group D7.5     | Group D10                  | Statistical findings                                   |
|------------------------------------------------|----------|----------------|----------------------------|--------------------------------------------------------|
| Heart rate changes                             | Present  | Present        | Greater variation reported | Significant differences at baseline and 30–150 minutes |
| Heart rate at 180 minutes                      | —        | —              | —                          | Not significant                                        |
| Systolic blood pressure changes                | Present  | Present        | Greater variation reported | Significant differences at 30, 60, and 90 minutes      |
| Systolic blood pressure at 150 and 180 minutes | —        | —              | —                          | Not significant                                        |
| Diastolic blood pressure changes               | Present  | Present        | Present                    | Significant differences at 90–180 minutes              |
| Hypotension                                    | Reported | Reported       | Higher incidence reported  | -                                                      |
| Bradycardia                                    | Reported | Reported       | Higher incidence reported  | -                                                      |
| Nausea                                         | Reported | Reported       | Higher incidence reported  | -                                                      |
| Overall adverse effects                        | Lower    | Lower than D10 | Higher                     | -                                                      |

Hemodynamic variations were observed among the three groups, particularly after 30 minutes of intrathecal drug administration. Group D10 demonstrated greater hemodynamic instability and a higher reported incidence of hypotension, bradycardia, and nausea compared with Groups D5 and D7.5. Although Group D10 provided the longest sensory and motor blockade, Group D7.5 appeared to offer a more favorable balance between block duration and hemodynamic stability.

### Discussion

Intrathecal dexmedetomidine is increasingly used as an adjuvant to hyperbaric bupivacaine because of its ability to enhance sensory and motor blockade and prolong postoperative analgesia. In the present study involving 90 patients undergoing lower limb surgeries, three doses of dexmedetomidine (5 µg, 7.5 µg, and 10 µg) were compared. A dose-dependent improvement in sensory and motor blockade was observed, with the 10 µg group demonstrating the longest duration of blockade. However, higher doses were associated with greater hemodynamic variations.

The onset of sensory blockade was significantly faster in Group D10 (4.9 ± 0.9 minutes) compared

with Group D7.5 (5.6 ± 1.3 minutes) and Group D5 (5.8 ± 1.6 minutes). Similarly, the time for two-segment sensory regression increased progressively from 95.0 ± 12.2 minutes in Group D5 to 111.4 ± 11.4 minutes in Group D10. Abdallah and Brull [8] demonstrated that dexmedetomidine enhances the characteristics of regional anaesthesia, supporting its role as an effective anaesthetic adjuvant. Niu et al. [9] also reported that intrathecal dexmedetomidine prolongs sensory blockade and improves the duration of spinal anaesthesia.

The present study demonstrated a dose-dependent prolongation of sensory blockade, with the greatest effect observed in patients receiving 10 µg dexmedetomidine. These findings are consistent with the dose-response relationship described by Zhang et al. [10], who evaluated the effects of different intrathecal dexmedetomidine doses on spinal anaesthesia. Sun et al. [11] also demonstrated improved block characteristics with dexmedetomidine compared with fentanyl as an intrathecal adjuvant, supporting its effectiveness in prolonging anaesthetic action. Motor blockade showed a similar dose-dependent pattern. The time required to achieve Bromage III was shortest in Group D10 (5.8 ± 1.1 minutes), while regression to

Bromage I was longest in the same group ( $365.0 \pm 26.52$  minutes). Wu et al. [12] reported that neuraxial dexmedetomidine improves the quality and duration of anaesthesia and analgesia. Qi et al. [13] also evaluated intrathecal dexmedetomidine as an adjuvant to bupivacaine, supporting its potential benefits in improving perioperative analgesic outcomes. Hemodynamic stability remains an important consideration when selecting the optimal intrathecal dexmedetomidine dose. In the present study, greater variations in heart rate and blood pressure were observed with increasing doses, particularly in Group D10. Hypotension, bradycardia, and nausea were reported more frequently in the  $10 \mu\text{g}$  group. Liu et al. [14] demonstrated the efficacy of  $5 \mu\text{g}$  intrathecal dexmedetomidine in improving spinal anaesthetic characteristics, suggesting that lower doses may provide clinically useful effects. Kaur and Singh [15] highlighted the sympatholytic properties of dexmedetomidine, which may contribute to hypotension and bradycardia during anaesthesia. Although Group D10 demonstrated the most prolonged sensory and motor blockade, Group D7.5 appeared to provide a more favorable balance between anaesthetic efficacy and hemodynamic stability. El-Boghdadly et al. [16] discussed safety considerations associated with local anaesthetic administration, emphasizing the importance of appropriate dosing and careful monitoring during regional anaesthesia. However, their review primarily concerns local anaesthetic systemic toxicity rather than dose-dependent intrathecal dexmedetomidine effects.

The strengths of the present study include its prospective randomized design, comparison of three intrathecal dexmedetomidine doses, and evaluation of sensory blockade, motor blockade, and hemodynamic parameters. However, the relatively small sample size, single-center setting, and single-blind design may limit generalizability. Furthermore, the absence of a bupivacaine-only control group and incomplete numerical reporting of adverse events limit definitive conclusions regarding comparative safety. Larger multicenter randomized controlled trials are required to establish the optimal intrathecal dexmedetomidine dose.

## Conclusion

The present study demonstrated that intrathecal dexmedetomidine produced a dose-dependent prolongation of sensory and motor blockade when administered as an adjuvant to 0.5% hyperbaric bupivacaine in patients undergoing lower limb surgeries. The  $10 \mu\text{g}$  dose provided the fastest onset and longest duration of sensory and motor blockade compared with  $5 \mu\text{g}$  and  $7.5 \mu\text{g}$ . However, increasing dexmedetomidine doses were associated with greater hemodynamic variations and a higher

reported incidence of adverse effects, particularly hypotension and bradycardia. Intrathecal dexmedetomidine at a dose of  $7.5 \mu\text{g}$  appeared to provide a favorable balance between prolonged sensory and motor blockade and hemodynamic stability, making it a potentially suitable adjuvant to hyperbaric bupivacaine for lower limb surgeries. Further studies with larger sample sizes are recommended to confirm these findings.

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