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Comparison of Dexmeditomedine as Adjuvant to Different Doses of Intrathecal Bupivacaine for Lowerlimb Orthopedic Surgeries- Prospective Randomised Comparative Study

Dr Sneha Sadan P[1], Dr Manosha Mohandas[2], Dr Arsha P Santhosh[3], Dr Fathima Musthafa[4]

[1]Consultant Anaesthesiologist, Valluvanad Hospital, Ottapalam, Palakkad 679104
[2,3]Junior Consultant Critical Care, Valluvanad Hospital
[4]Consultant Anaesthesiologist, Thaluk Hospital Mannarkkad

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Corresponding Author:

Dr Sneha Sadan P
Consultant Anaesthesiologist,
Valluvanad Hospital, Ottapalam,
Palakkad 679104
snehasadan96@gmail.com

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ABSTRACT

Introduction: Spinal anaesthesia is widely used for lower limb orthopedic surgeries due to its rapid onset and effective sensory and motor blockade. Bupivacaine is the drug of choice, but higher doses may cause dose-related adverse effects, especially in elderly patients. This study compares 7 mg and 9 mg hyperbaric bupivacaine with 5 µg dexmedetomidine to identify the optimal dose with effective anaesthesia and minimal hemodynamic changes.

Aims And Objectives: To compare two doses (7 mg and 9 mg) of intrathecal bupivacaine with dexmedetomidine regarding block characteristics, hemodynamic effects, and postoperative analgesia.

Materials And Methods: In this prospective randomized study, 90 patients (60–80 years, ASA I–II) undergoing lower limb orthopedic surgery were divided into: Group A (n=45): 7 mg bupivacaine + 5 µg dexmedetomidine and Group B (n=45): 9 mg bupivacaine + 5 µg dexmedetomidine. Block characteristics, hemodynamics, and postoperative analgesia were assessed.

Results: The 9 mg group showed faster onset, higher sensory level, longer block duration, better postoperative analgesia, and reduced rescue analgesic requirement. Hemodynamics were stable in both groups.

Conclusion: 9 mg bupivacaine with dexmedetomidine provides superior anaesthesia and analgesia without added hemodynamic risk and may be preferred in elderly patients.

Keywords*: Lower limb surgeries, Bupivacaine, Dexmeditomidine, spinal anesthesia.*

INTRODUCTION

Spinal anaesthesia is a widely accepted and preferred technique for lower limb orthopedic surgeries due to its rapid onset, reliable sensory and motor blockade, and cost-effectiveness.[1] Among the available local anesthetics, bupivacaine, a long-acting amide agent, remains the most commonly used drug for intrathecal administration. However, increasing the dose of bupivacaine to prolong the duration of anaesthesia is associated with dose-dependent adverse effects such as hypotension, bradycardia, prolonged motor blockade, urinary retention, and delayed postoperative ambulation. These effects are particularly significant in elderly and high-risk patients, who often have reduced physiological reserve and multiple comorbidities.[2,3]

To overcome these limitations, various intrathecal adjuvants have been investigated to enhance the quality and duration of spinal anaesthesia without increasing the dose of local anesthetics. Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, has emerged as a promising adjuvant due to its sedative, analgesic, and sympatholytic properties. When administered intrathecally, it enhances both sensory and motor blockade, prolongs postoperative analgesia, and provides better perioperative hemodynamic stability by attenuating sympathetic responses to surgical stress.[4-6]

Although several studies have demonstrated the efficacy of dexmedetomidine as an adjuvant to a fixed dose of bupivacaine, there is limited evidence regarding its use with varying doses of bupivacaine to achieve an optimal balance between efficacy and safety.[7] Reducing the dose of bupivacaine while adding dexmedetomidine may help minimize cardiovascular side effects without compromising the quality of anaesthesia. This approach is particularly advantageous in elderly patients undergoing orthopedic procedures, where early mobilization and hemodynamic stability are crucial.[8]

In this context, the present prospective randomized study compares two doses of hyperbaric bupivacaine (7 mg and 9 mg), each combined with 5 µg dexmedetomidine, to determine the lower effective dose that provides adequate sensory and motor blockade with sufficient duration while maintaining hemodynamic stability in elderly patients undergoing lower limb orthopedic surgery under spinal anaesthesia.

MATERIALS AND METHODS

This prospective randomized comparative study was conducted in the Departments of Anaesthesiology and Orthopedics at Kanyakumari Government Medical College and Hospital, Asaripallam, Tamil Nadu, from August 2023 to February 2025, after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants. A total of 90 patients aged 60–80 years, classified as ASA Physical Status I and II, and scheduled for elective lower limb orthopedic surgery under spinal anaesthesia were included. Patients with coagulopathy, those on anticoagulant or antiplatelet therapy, allergy to study drugs, spinal deformities, infection at the puncture site, cognitive dysfunction, arrhythmias, labile hypertension, or those requiring general anaesthesia were excluded.

Patients were randomly allocated into two groups using a computer-generated sequence in a double-blinded manner: Group A (n=45) received 7 mg (1.4 ml) of 0.5% hyperbaric bupivacaine with 5 µg dexmedetomidine, and Group B (n=45) received 9 mg (1.8 ml) of 0.5% hyperbaric bupivacaine with 5 µg dexmedetomidine. Standard monitoring (ECG, non-invasive blood pressure, and SpO_2) was instituted, and baseline vitals were recorded. An 18G intravenous cannula was secured, intravenous fluids were administered, and supplemental oxygen was given via face mask. Spinal anaesthesia was performed under aseptic precautions at the L3–L4 interspace using a 25G Quincke needle, and patients were subsequently placed supine. Hemodynamic parameters were monitored at regular intervals. Hypotension (SBP <90 mmHg or >30% fall from baseline) was treated with intravenous ephedrine (6 mg), and bradycardia (HR <50 bpm) with intravenous atropine (0.6 mg).

Sensory block characteristics (onset to T10, peak level, and duration to regression), motor block (Modified Bromage scale), and duration of analgesia were recorded. Postoperative pain was assessed using the Visual Analogue Scale (VAS), and rescue analgesia (intravenous tramadol 1 mg/kg) was administered when VAS ≥4. Total analgesic consumption in the first 24 hours was noted. Data were analyzed using SPSS version 20, with Student's *t*-test and chi-square test applied as appropriate; a p value <0.05 was considered statistically significant. Minimal adverse effects were observed, with occasional bradycardia managed effectively.

RESULTS

A total of 90 patients were analyzed, with comparable demographic characteristics between the two groups ($p > 0.05$). Group B (9 mg bupivacaine with dexmedetomidine) showed significantly faster onset, higher level, and longer duration of both sensory and motor blockade compared to Group A (7 mg) ($p < 0.001$). Hemodynamic parameters showed an initial decrease in heart rate and blood pressure in Group B, but overall stability was maintained in both groups without significant adverse effects. SpO_2 remained stable throughout. Postoperative pain scores (VAS) were significantly lower in Group B at all time intervals, with markedly reduced requirement for rescue analgesia and tramadol consumption ($p < 0.001$).

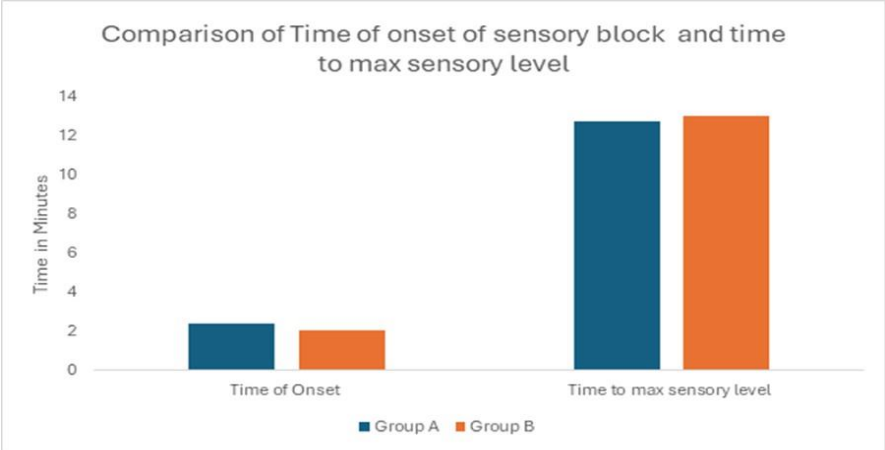

Figure 1: comparison of sensory block characteristics

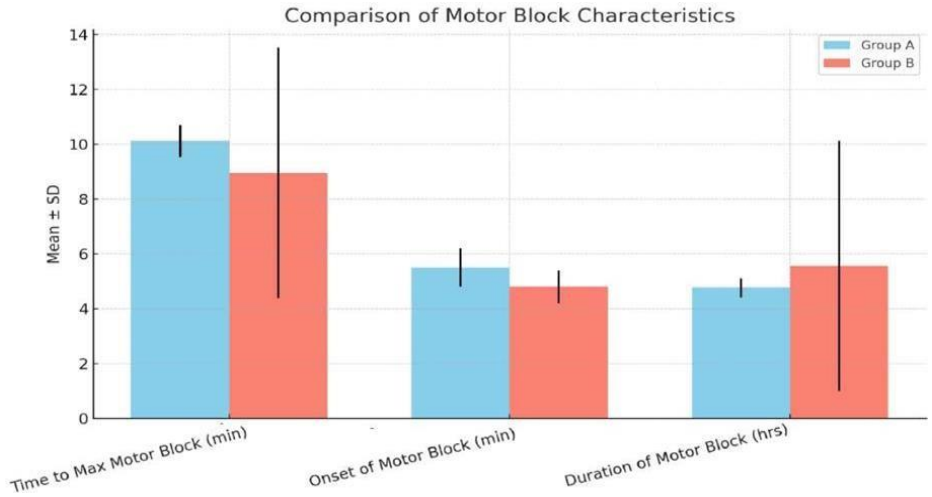

Figure 2: comparison of motor block characteristics

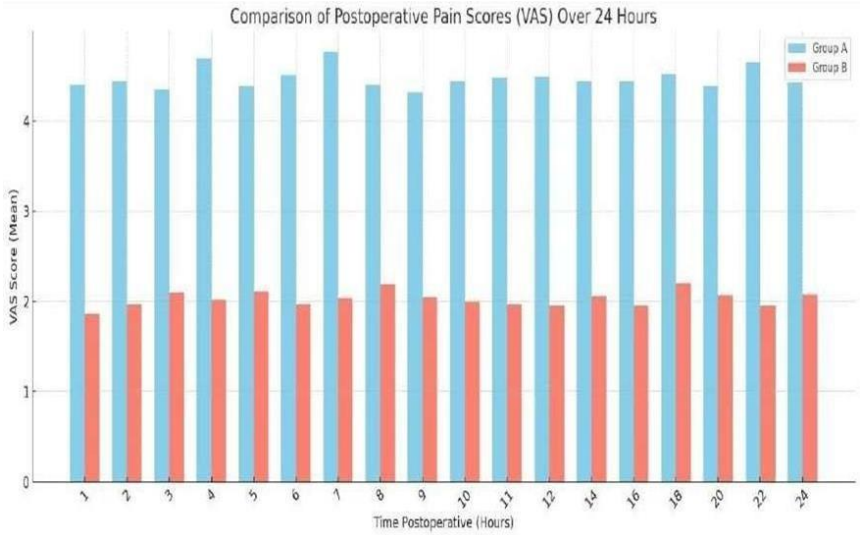

Figure 3: comparison of post operative pain score

DISCUSSION

The present prospective randomized comparative study was designed to evaluate the clinical efficacy and safety of two different doses of intrathecal hyperbaric bupivacaine (7 mg and 9 mg), both administered in combination with dexmedetomidine, in patients undergoing lower limb orthopedic surgeries. The study comprehensively assessed sensory and motor block characteristics, hemodynamic responses, duration and quality of postoperative analgesia, and rescue analgesic requirements. The findings provide valuable insights into dose optimization of bupivacaine when used with dexmedetomidine as an adjuvant in spinal anesthesia.

The demographic characteristics of the study population, including age, sex distribution, height, weight, and body mass index, were comparable between the two groups. This homogeneity minimizes potential confounding variables and strengthens the internal validity of the study outcomes. Similar methodological rigor has been emphasized in earlier studies by Salim et al.[9] and Gupta et al.[10], where comparable baseline characteristics were essential to accurately assess the pharmacodynamic effects of intrathecal adjuvants.

In the present study, sensory block characteristics showed a clear dose-dependent pattern. The group receiving 9 mg of hyperbaric bupivacaine demonstrated a significantly faster onset of sensory block, achieved a higher maximum sensory level, and exhibited prolonged duration of sensory blockade compared to the 7 mg group. The enhanced sensory block with the higher dose can be attributed to increased local anesthetic spread and greater neural blockade within the subarachnoid space. Additionally, dexmedetomidine, a highly selective α2-adrenergic agonist, acts synergistically with bupivacaine by inhibiting the release of nociceptive neurotransmitters and enhancing hyperpolarization of interneurons in the dorsal horn of the spinal cord. This results in prolonged sensory blockade and delayed regression.

These findings are consistent with those reported by Al-Mustafa et al.[11], who demonstrated that the addition of dexmedetomidine significantly prolongs sensory block duration, particularly when combined with higher doses of bupivacaine. The prolonged regression time to S1 dermatome observed in prior studies closely parallels the findings of the present study, further validating the role of dexmedetomidine in extending spinal anesthesia duration.[12]

Motor block characteristics in this study also demonstrated significant differences between the two groups. The 9 mg bupivacaine group exhibited a more rapid onset of motor blockade and a significantly prolonged duration compared to the 7 mg group. This can be explained by the higher concentration of local anesthetic facilitating more profound blockade of motor fibers, as well as the potentiating effect of dexmedetomidine on nerve conduction inhibition. Dexmedetomidine enhances motor blockade by acting on presynaptic C-fibers and postsynaptic dorsal horn neurons, thereby intensifying and prolonging the effect of local anesthetics.[13]

These observations are in agreement with studies by Kanazi et al.[14], which reported prolonged motor block duration with intrathecal dexmedetomidine. Furthermore, Sethi et al.[15] also demonstrated statistically significant prolongation in motor block regression times and earlier attainment of peak sensory levels, supporting the findings of the present study. While prolonged motor blockade may be advantageous for longer surgical procedures, it should be carefully considered in settings where early ambulation is desired.

Hemodynamic stability is a critical consideration in spinal anesthesia. In this study, the group receiving 9 mg bupivacaine experienced a higher incidence of bradycardia and a more pronounced reduction in systolic and diastolic blood pressures, particularly within the first 30 minutes following intrathecal administration. These effects, although statistically significant, remained within clinically acceptable limits and were easily managed with standard interventions. The observed hemodynamic changes can be attributed to both the higher dose of bupivacaine causing sympathetic blockade and the central sympatholytic action of dexmedetomidine, which reduces norepinephrine release and enhances vagal activity.

These findings are consistent with previous studies that reported transient hypotension and bradycardia associated with intrathecal dexmedetomidine use. Notably, Kanazi et al.[14] suggested that lower doses of bupivacaine combined with dexmedetomidine may offer improved hemodynamic stability, especially in elderly or high-risk patients. Therefore, while the higher dose provides superior block characteristics and analgesia, cautious use is warranted in patients with limited cardiovascular reserve.[16-18]

Postoperative analgesia was significantly enhanced in the 9 mg bupivacaine group. Patients in this group reported lower pain scores on the Visual Analog Scale (VAS) and experienced a significantly prolonged duration before the first request for rescue analgesia. The improved analgesic profile can be attributed to the combined effects of prolonged sensory blockade and the intrinsic analgesic properties of dexmedetomidine, which modulates pain pathways at both spinal and supraspinal levels.

These findings are in concordance with Gupta et al.[10], who demonstrated superior analgesia and reduced analgesic consumption with dexmedetomidine compared to fentanyl. The requirement for rescue analgesics over 24 hours was significantly lower in the 9 mg group, with fewer doses of tramadol required. This highlights the opioid-sparing effect of dexmedetomidine, which is clinically advantageous in reducing opioid-related side effects such as nausea, vomiting, pruritus, and respiratory depression.

Importantly, no episodes of oxygen desaturation or respiratory depression were observed in either group, reaffirming the safety of dexmedetomidine in preserving respiratory function. Unlike opioids, dexmedetomidine does not depress the respiratory center, making it a safer alternative for intrathecal use. These findings are consistent with studies by Kanazi et al.[11], which also reported minimal respiratory compromise with dexmedetomidine.

Taken together, the findings of the present study clearly demonstrate that intrathecal dexmedetomidine significantly enhances the efficacy of hyperbaric bupivacaine in a dose-dependent manner. The use of 9 mg bupivacaine results in superior sensory and motor blockade, prolonged postoperative analgesia, and reduced analgesic requirements, albeit with a modest increase in hemodynamic effects. These results are in alignment with existing literature and support the use of dexmedetomidine as a highly effective adjuvant in spinal anesthesia.

However, the choice of bupivacaine dose should be individualized based on patient characteristics, surgical duration, and the need for early postoperative mobilization. Lower doses may be preferable in high-risk or elderly patients to maintain hemodynamic stability, whereas higher doses may be advantageous in longer or more complex procedures requiring prolonged anesthesia and analgesia.

CONCLUSION

Intrathecal dexmedetomidine enhances the efficacy of hyperbaric bupivacaine in spinal anaesthesia. The 9 mg dose provides faster onset, prolonged sensory and motor blockade, better postoperative analgesia, and reduced rescue analgesic requirement compared to 7 mg. Although associated with mild hemodynamic changes, these remain clinically manageable. Thus, 9 mg bupivacaine with dexmedetomidine is more effective, but dose selection should be individualized based on patient profile and surgical needs.

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Conflict of interest: Nil

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