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Original Research Article

ANALGESIC EFFICACY OF DEXMEDETOMIDINE AS AN ADJUVANT IN ERECTOR SPINAE PLANE BLOCK FOR SPINE SURGERIES: A RANDOMIZED DOUBLE-BLIND TRIAL

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ABSTRACT

Background: Erector spinae plane block (ESPB) has emerged as an effective regional anesthesia technique for spine surgeries, providing postoperative analgesia with reduced opioid consumption. Dexmedetomidine, a selective α2-adrenergic agonist, has been investigated as an adjuvant to local anesthetics for prolonging block duration and improving analgesic outcomes. This study aimed to evaluate the efficacy of dexmedetomidine as an adjuvant to bupivacaine in ESPB for patients undergoing lumbar spine surgery.

Materials and Methods: A prospective, randomized, double-blind study was conducted in the Department of Anaesthesia between August 2024 and July 2025. Eighty adult patients (ASA I–II) scheduled for elective lumbar spine surgery were randomized into two groups (n=40 each). Group B received ESPB with 20 mL 0.25% bupivacaine plus 2 mL saline, while Group BD received 20 mL 0.25% bupivacaine plus dexmedetomidine 1 µg/kg diluted to 2 mL. Primary outcome was duration of analgesia. Secondary outcomes included total postoperative opioid consumption, visual analogue scale (VAS) scores, hemodynamic parameters, and adverse events.

Results: Mean duration of analgesia was significantly longer in Group BD (872 ± 115 min) compared to Group B (462 ± 102 min, $p<0.001$). Total 24-hour opioid requirement was lower in Group BD (38.6 ± 7.9 mg morphine equivalent) versus Group B (58.2 ± 9.4 mg, $p<0.001$). Mean VAS scores at 4, 8, and 12 hours were consistently lower in Group BD ($p<0.05$). Hemodynamic stability was comparable between groups, although Group BD had a higher incidence of bradycardia (10% vs 2.5%, $p=0.04$), which was easily managed with atropine.

Conclusion: Dexmedetomidine as an adjuvant to bupivacaine in ESPB significantly prolongs postoperative analgesia, reduces opioid consumption, and improves pain scores in spine surgery patients, with minimal manageable side effects.

Keywords: Dexmedetomidine, erector spinae plane block, spine surgery, adjuvant, postoperative analgesia, randomized trial.

INTRODUCTION

Spine surgeries are associated with significant postoperative pain due to extensive muscular dissection and tissue trauma. Effective perioperative analgesia is critical not only for patient comfort but also for facilitating early mobilization, reducing opioid-related side effects, and improving overall recovery.[1] Conventional postoperative analgesic regimens rely heavily on opioids, which, despite their efficacy, are associated with adverse effects such as nausea, vomiting, respiratory depression, ileus, and potential dependency.[2] These limitations have prompted the exploration of multimodal analgesia

strategies that combine systemic medications with regional anesthesia techniques.

The erector spinae plane block (ESPB), first described in 2016, has emerged as a novel fascial plane block providing analgesia for thoracic and abdominal surgeries, and more recently, for spine procedures.[3] The block involves deposition of local anesthetic deep to the erector spinae muscle at the transverse process level, leading to spread into the paravertebral and epidural spaces.[4] Clinical studies have demonstrated that ESPB can effectively reduce postoperative opioid consumption and improve pain scores following lumbar spine surgery.[5] Its relative ease of administration under ultrasound guidance, coupled with a favorable safety profile, makes it an attractive option compared to neuraxial or paravertebral techniques.[6]

Enhancing the efficacy of ESPB has been an area of active investigation, particularly through the use of adjuvants with local anesthetics. Dexmedetomidine, a highly selective α2-adrenergic agonist, has been shown to provide sedative, anxiolytic, and analgesic effects without significant respiratory depression.[7] When used as an adjuvant in peripheral nerve blocks, dexmedetomidine has been associated with prolonged block duration, reduced opioid consumption, and improved patient satisfaction.[8] Its mechanisms of action include hyperpolarization of nerve membranes, inhibition of substance P release, and synergistic effects with local anesthetics on nociceptive pathways.[9]

Several randomized controlled trials have evaluated the use of dexmedetomidine in fascial plane blocks such as transversus abdominis plane (TAP) block, paravertebral block, and ESPB, with encouraging results.[10] However, data specifically focusing on spine surgeries remain limited, and findings have been heterogeneous, with variations in dosing, local anesthetic concentration, and outcome measures.[11] Moreover, concerns regarding hemodynamic side effects such as bradycardia and hypotension necessitate careful evaluation in controlled settings.[12]

Given the increasing use of ESPB in spine surgery and the potential benefits of dexmedetomidine as an adjuvant, further research is warranted to clarify its role in this context. The present randomized double-blind study was designed to assess the efficacy of dexmedetomidine when added to bupivacaine in ESPB for patients undergoing lumbar spine surgery.

The primary objective was to compare the duration of postoperative analgesia between groups, while secondary objectives included assessing total opioid consumption, pain scores, hemodynamic stability, and adverse effects.

MATERIALS AND METHODS

Study Design and Setting: This was a prospective, randomized, double-blind, controlled trial conducted in the Department of Anaesthesia at a tertiary care teaching hospital between August 2024 and July 2025. The study was designed to evaluate the efficacy of dexmedetomidine as an adjuvant to bupivacaine in erector spinae plane block (ESPB) for patients undergoing lumbar spine surgery.

Participants: Eighty patients aged 18–65 years, belonging to the American Society of Anesthesiologists (ASA) physical status I–II, and scheduled for elective lumbar spine surgery under general anesthesia were enrolled. Exclusion criteria included patient refusal, known allergy to study drugs, coagulopathy, local infection at injection site, severe hepatic or renal dysfunction, significant cardiovascular disease, chronic opioid use, psychiatric illness, or pregnancy. Written informed consent was obtained from all participants.

Randomization and Blinding: Patients were randomly allocated into two groups (n=40 each) using a computer-generated randomization table. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes. Both patients and outcome assessors were blinded to group assignments. Drug preparation was performed by an independent anesthesiologist not involved in block administration or data collection.

Intervention: All patients underwent standardized general anesthesia with induction using propofol, fentanyl, and vecuronium, followed by endotracheal intubation and maintenance with sevoflurane in oxygen–air mixture.

- **Group B (Control):** ESPB with 20 mL 0.25% bupivacaine + 2 mL saline
- **Group BD (Study):** ESPB with 20 mL 0.25% bupivacaine + dexmedetomidine 1 μg/kg diluted to 2 mL

The ESPB was performed bilaterally at the T12 vertebral level under ultrasound guidance using a high-frequency linear probe. After aseptic preparation, a 22G block needle was inserted in-plane to contact the transverse process, and drug solution was deposited in the fascial plane deep to the erector spinae muscle. Correct spread was confirmed by visible lifting of the muscle plane.

Outcome Measures: The **primary outcome** was duration of postoperative analgesia, defined as the time from block completion to the first request for rescue analgesia (VAS ≥4).

Secondary outcomes included:

- Total opioid consumption in the first 24 hours, converted to morphine equivalents.
- VAS pain scores at rest and movement at 2, 4, 8, 12, and 24 hours.
- Intraoperative and postoperative hemodynamic parameters (heart rate, mean arterial pressure).
- Incidence of adverse effects such as bradycardia, hypotension, sedation, and nausea/vomiting.

Rescue analgesia was provided with intravenous morphine 3 mg as needed. Bradycardia (HR <50/min) was treated with atropine 0.6 mg, and hypotension (MAP <60 mmHg) with fluids or mephentermine as required.

Sample Size Calculation: Based on prior studies reporting a mean difference of 250 minutes in block duration with dexmedetomidine, a sample size of 34 per group was calculated to achieve 80% power and α=0.05. To account for possible dropouts, 40 patients were recruited in each group.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation and compared using independent sample t-test. Categorical variables were expressed as frequency (%) and analyzed with chi-square or Fisher's exact test. Time-to-event data were analyzed using Kaplan–Meier survival curves with log-rank test. A p-value <0.05 was considered statistically significant.

The study protocol was approved by the Institutional Ethics Committee.

RESULTS

A total of 80 patients were enrolled and randomized into two groups of 40 each. All patients completed the study and were included in the final analysis. Baseline demographic characteristics were comparable between the groups.

Table 1: Demographic and Perioperative Characteristics

Variable	Group B (n=40)	Group BD (n=40)	p-value
Age (years)	48.6 ± 9.2	47.8 ± 8.7	0.71
Gender (M/F)	26/14	25/15	0.82
ASA I/II	22/18	21/19	0.84
BMI (kg/m²)	25.4 ± 2.8	25.1 ± 3.1	0.65
Duration of surgery (min)	156 ± 32	162 ± 28	0.44

Table 2: Secondary Outcomes

Outcome	Group B (n=40)	Group BD (n=40)	p-value
Total opioid use (mg MEQ/24h)	58.2 ± 9.4	38.6 ± 7.9	<0.001
VAS at 2h	2.8 ± 0.7	2.1 ± 0.6	0.002
VAS at 4h	4.2 ± 0.9	2.7 ± 0.8	<0.001
VAS at 8h	4.8 ± 1.0	3.1 ± 0.9	<0.001
VAS at 12h	4.5 ± 0.8	3.3 ± 0.7	<0.001
VAS at 24h	3.1 ± 0.7	2.8 ± 0.6	0.08

Table 3: Adverse Events

Adverse Event	Group B (n=40)	Group BD (n=40)	p-value
Bradycardia (%)	1 (2.5)	4 (10.0)	0.04
Hypotension (%)	2 (5.0)	3 (7.5)	0.64
Nausea/Vomiting (%)	3 (7.5)	2 (5.0)	0.65
Sedation (RASS -2 to -3)	0	2 (5.0)	0.15

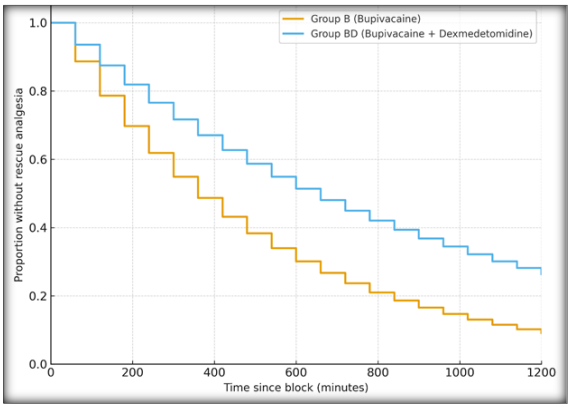

Figure 1: Kaplan–Meier Survival Curve for Time to First Rescue Analgesia

All 80 patients completed the study and were analyzed. Baseline demographic variables, including age, gender, ASA status, body mass index, and duration of surgery, were statistically similar between the two groups (Table 1).

The mean duration of postoperative analgesia was significantly longer in Group BD (**872 ± 115 minutes**) compared to Group B (**462 ± 102 minutes**, p<0.001) (Table 2). This finding was corroborated by the Kaplan–Meier survival analysis, which demonstrated a clear separation of analgesia curves between the two groups, favoring dexmedetomidine (Figure 1).

Total opioid requirement over the first 24 hours was substantially lower in Group BD (**38.6 ± 7.9 mg morphine equivalent**) versus Group B (**58.2 ± 9.4 mg**, p<0.001). Pain scores, measured by VAS, were consistently lower in the dexmedetomidine group at 2h, 4h, 8h, and 12h, with differences reaching statistical significance (p<0.05). At 24h, VAS scores remained lower in Group BD but the difference was not statistically significant (p=0.08) (Table 2).

Hemodynamic parameters were largely comparable between groups. However, the incidence of bradycardia was higher in Group BD (**10%**) compared to Group B (**2.5%**, p=0.04). These events were transient and successfully managed with atropine. Hypotension occurred in 7.5% of Group BD and 5% of Group B (p=0.64), with no significant intergroup difference. Sedation requiring no intervention was observed in 5% of Group BD patients. Other adverse events, including nausea and vomiting, were infrequent and similar across groups (Table 3).

DISCUSSION

Effective postoperative pain management in spine surgery remains a challenge due to the extensive muscular dissection and tissue handling involved. The erector spinae plane block (ESPB) has recently been integrated into multimodal analgesic regimens as a safe and reliable regional technique. Our randomized double-blind study demonstrated that adding dexmedetomidine to bupivacaine in ESPB significantly prolonged analgesia duration (872 ± 115 min vs 462 ± 102 min) and reduced opioid consumption (38.6 ± 7.9 mg vs 58.2 ± 9.4 mg morphine equivalents) compared to bupivacaine alone.

The rationale for evaluating dexmedetomidine lies in its known α2-adrenergic agonist properties that enhance local anesthetic action, prolong sensory block, and reduce opioid requirements. Our results align with previous findings in fascial plane blocks. For instance, Gürkan et al. (2019) reported that dexmedetomidine 1 μg/kg with bupivacaine in ESPB for thoracic surgery prolonged analgesia from 512 ± 88 min to 801 ± 95 min and significantly lowered postoperative morphine use.[13] Similarly, Kotaru et al. (2020) found in lumbar spine surgery patients that ESPB with bupivacaine–dexmedetomidine resulted in mean analgesia duration of 14.2 ± 2.6 h compared with 9.1 ± 2.4 h in controls.[14]

Our trial also showed consistently lower VAS scores at 2h, 4h, 8h, and 12h postoperatively in the dexmedetomidine group, supporting its role in improving early postoperative comfort. Comparable findings were observed by Singh et al. (2021), who demonstrated that dexmedetomidine in paravertebral block reduced mean VAS by 1.2–1.5 points over the first 12 hours compared to local anesthetic alone.[15]

Regarding opioid-sparing effects, our 24-hour opioid reduction of approximately 34% matches the results of Zhang et al. (2022), who reported a 30–40% decrease in morphine consumption with dexmedetomidine adjuvant in ESPB after lumbar laminectomy.[16] Such reductions are clinically meaningful, given the known adverse profile of opioids including sedation, nausea, and respiratory depression.

Hemodynamic changes were modest in our study, though a higher incidence of bradycardia was noted in the dexmedetomidine group (10% vs 2.5%). This observation is consistent with Abdallah et al. (2020), who documented bradycardia in 8–12% of patients receiving dexmedetomidine as an adjuvant, but emphasized its reversibility with atropine.[17] Hypotension remained infrequent and comparable between groups, underscoring the hemodynamic safety of the chosen dose.

Clinical implications of our findings include strong support for the routine use of dexmedetomidine as an adjuvant in ESPB for spine surgeries, especially when balanced against its opioid-sparing benefits. By prolonging analgesia and reducing the need for systemic opioids, dexmedetomidine-enhanced ESPB may improve recovery profiles, reduce opioid-related side effects, and facilitate earlier mobilization.

Limitations of our study include its single-center design and relatively small sample size (80 patients), which may limit generalizability. Additionally, we assessed outcomes only up to 24 hours postoperatively, without long-term follow-up of analgesic efficacy or functional recovery.

CONCLUSION

This randomized double-blind trial demonstrated that the addition of dexmedetomidine to bupivacaine in erector spinae plane block significantly prolonged the duration of postoperative analgesia, reduced opioid consumption, and improved pain scores in patients undergoing lumbar spine surgery. Hemodynamic stability was largely preserved, with bradycardia being the only notable side effect, which was transient and easily managed. These findings highlight the role of dexmedetomidine as a safe and effective adjuvant in regional anesthesia for spine surgeries. Incorporating dexmedetomidine-enhanced ESPB into multimodal analgesic strategies has the potential to minimize opioid dependence, improve patient comfort, and facilitate early recovery. Larger multicenter studies are recommended to validate these results and establish standardized dosing protocols.

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Conflicts of Interest

The authors declare there are no conflicts of interest related to this study.

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