Comparison of Duration of Action in Spinal Anesthesia of 0.5% Bupivacaine and 0.5% Bupivacaine with Dexmedetomidine

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LINK MEDICAL INTERFACE

Muhammad Afnan Riaz[1], Saad Bin Qamar[1], Aisha Siddiqi[1], Sarmad Sardar[1], Waqas Tariq[1], Syed Qasim Ali Shah[1], Muhammad Farrukh Habib[2]

Correspondence
Muhammad Farrukh Habib
muhammadfarrukhhabib@gmail.com
Affiliations
1 Combined Military Hospital, Malir, Karachi, Pakistan
2 Shifa Tameer-e-Millat University, Islamabad, Pakistan

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ABSTRACT

Background: Spinal anesthesia is a common technique for surgeries below the navel, utilizing bupivacaine, a local anesthetic. Adding adjuncts like dexmedetomidine may enhance the efficacy and duration of the block.

Objective: To compare the duration of action of 0.5% bupivacaine versus 0.5% bupivacaine with dexmedetomidine in spinal anesthesia.

Methods: This quasi-experimental trial included 60 patients aged 20-60 years, ASA grade 1 or 2, undergoing general, plastic, orthopedic, or urological surgery at CMH Karachi. Patients were non-randomly assigned to Group B (0.5% bupivacaine, n=30) or Group BD (0.5% bupivacaine plus 5 mcg dexmedetomidine, n=30). Onset and duration of sensory and motor blocks, duration of analgesia, and adverse effects were recorded. Data were analyzed using SPSS version 25, with a p-value ≤ 0.05 considered significant.

Results: Group BD showed faster onset of sensory block (7.08 ± 0.54 mins vs. 13.48 ± 0.73 mins, $p < 0.001$) and motor block (10.32 ± 0.91 mins vs. 17.55 ± 0.69 mins, $p < 0.001$). Duration of motor block was longer in Group BD (284.06 ± 5.64 mins vs. 133.93 ± 5.72 mins, $p < 0.001$), as was duration of analgesia (218.07 ± 4.86 mins vs. 125.36 ± 5.42 mins, $p < 0.001$).

Conclusion: The addition of dexmedetomidine to 0.5% bupivacaine significantly enhances the onset and duration of spinal anesthesia with a comparable safety profile.

INTRODUCTION

Spinal anesthesia is a widely used technique for surgical procedures involving the lower body, offering the advantages of reduced surgical stress response and decreased risk of thromboembolic events through the attenuation of catecholamine release (1). Bupivacaine, a long-acting amide local anesthetic, functions by blocking sodium channels, thereby inhibiting the propagation of nerve impulses, which results in both analgesic and anesthetic effects (2). The most commonly employed concentrations of bupivacaine in spinal anesthesia are 0.5% and 0.75%, both of which have demonstrated efficacy in achieving adequate analgesia and anesthesia for various surgical interventions (3). To enhance the quality of spinal anesthesia, several adjunctive agents such as fentanyl, morphine, tramadol, and dexmedetomidine have been explored; however, none has been universally accepted as the gold standard (4).

Dexmedetomidine, an alpha-2 adrenergic agonist, has gained prominence due to its multi-faceted pharmacological profile, which includes sedative, anxiolytic, sympatholytic, and analgesic effects (5). Its application extends beyond spinal anesthesia to nerve blocks and sedation in intensive care settings, with additional antiemetic and antishivering benefits postoperatively. Compared to clonidine, another alpha-2 agonist, dexmedetomidine demonstrates tenfold higher affinity for the receptor, conferring superior analgesic properties (6). Despite these benefits, there remains a gap in the literature, as previous studies have often limited their evaluation of dexmedetomidine to specific surgical procedures. The current study aims to assess the efficacy of dexmedetomidine as an adjunct to 0.5% bupivacaine versus bupivacaine alone in spinal anesthesia across a broader range of surgical contexts, hypothesizing that this combination could provide synergistic effects, including balanced anesthesia and reduced opioid requirements, thereby mitigating opioid-related adverse effects and enhancing postoperative outcomes.

The inclusion of dexmedetomidine as an adjuvant to spinal anesthesia may offer several advantages, such as faster onset and prolonged duration of both sensory and motor blockade, which can be critical in optimizing the intraoperative experience and postoperative recovery (7). This approach aligns with the ongoing evolution of anesthesia practices aimed at improving patient comfort, minimizing side effects, and enhancing the overall quality of care. Moreover, dexmedetomidine's distinct mechanism of action, which involves modulation of sympathetic outflow and enhancement of natural pain modulation pathways, supports its utility in reducing the intraoperative requirement for systemic analgesics and anesthetics (8). Furthermore, this study addresses a critical need to evaluate dexmedetomidine in a broader clinical context, as prior research has predominantly focused on its use in

single surgical domains, thereby limiting the generalizability of findings.

The potential for dexmedetomidine to enhance the efficacy of spinal anesthesia with bupivacaine, while maintaining a favorable safety profile, could represent a significant advancement in anesthetic practice. The broader application of this combination, as investigated in the present study, seeks to validate its effectiveness across diverse surgical procedures, thereby contributing valuable insights into its role in contemporary anesthesia management. Ultimately, this investigation aims to elucidate the comparative benefits of adding dexmedetomidine to bupivacaine, potentially setting a precedent for more widespread use in clinical practice, optimizing anesthesia care, and improving patient outcomes.

MATERIAL AND METHODS

The study was designed as a quasi-experimental trial conducted in the Anesthesia Department at CMH Karachi over a period of six months, from January 2024 to June 2024, following ethical approval obtained from the hospital's Ethical Review Committee. The sample size was determined using the WHO sample size calculator, aiming for a 95% power and a 5% level of significance based on a mean duration of spinal anesthesia of 126.34 ± 7.687 minutes in patients receiving bupivacaine alone, compared to 283.96 ± 11.167 minutes in patients receiving bupivacaine with dexmedetomidine. A total of 60 patients were included in the study using a non-randomized convenience sampling method, with 30 patients allocated to Group B (0.5% bupivacaine alone) and 30 patients to Group BD (0.5% bupivacaine plus 5 mcg dexmedetomidine).

Participants were adults aged 20-60 years with an American Society of Anesthesiologists (ASA) classification of grade 1 or 2, scheduled for general surgical, plastic surgery, orthopedic, or urological procedures. Patients with disorders of coagulation, spinal deformities, neurological disorders, localized infection, allergies to study drugs, or those unwilling to undergo spinal anesthesia were excluded. All participants underwent a comprehensive pre-anesthesia evaluation, including detailed medical history, physical examination, and laboratory assessments, to ensure fitness for the procedure. Informed written consent was obtained from each participant prior to enrollment in the study.

On the day of surgery, patients were kept nil per oral for eight hours and were hydrated while maintaining stable vital parameters. Upon arrival in the operating room, standard non-invasive monitoring, including blood pressure, electrocardiography, pulse oximetry, and temperature measurement, was instituted. A peripheral intravenous line was established using an 18-gauge cannula, and intravenous crystalloid infusion was initiated at 10 mL/kg over 20 minutes. Baseline vital signs were recorded before the administration of anesthesia. Spinal anesthesia was administered under sterile conditions with the patient in a sitting position. After identifying the L4-L5 interspace, the area was disinfected, and local anesthesia with 3 mL of 2% lignocaine was applied. A 25-gauge Quincke needle was used to perform the spinal block after confirming the free flow of cerebrospinal fluid.

For patients in Group B, 12 mg of 0.5% bupivacaine was administered intrathecally, diluted with normal saline to a total volume of 3 mL. For patients in Group BD, the intrathecal injection consisted of 12 mg of 0.5% bupivacaine combined with 5 mcg of dexmedetomidine, also diluted with normal saline to a total volume of 3 mL. Following the administration of spinal anesthesia, patients were positioned supine, and oxygen was delivered via a face mask at 3 L/min. Continuous monitoring was maintained throughout the procedure, with vital signs recorded every five minutes for the first 30 minutes, followed by 10-minute intervals until the end of the surgery. The onset of sensory block was assessed using a blunt needle at the midline every two minutes, with the time to reach the T10 dermatome recorded. Motor block onset and duration were evaluated using the Bromage scale, where the onset was noted at Bromage score 3 and regression was assessed when the score returned to 0.

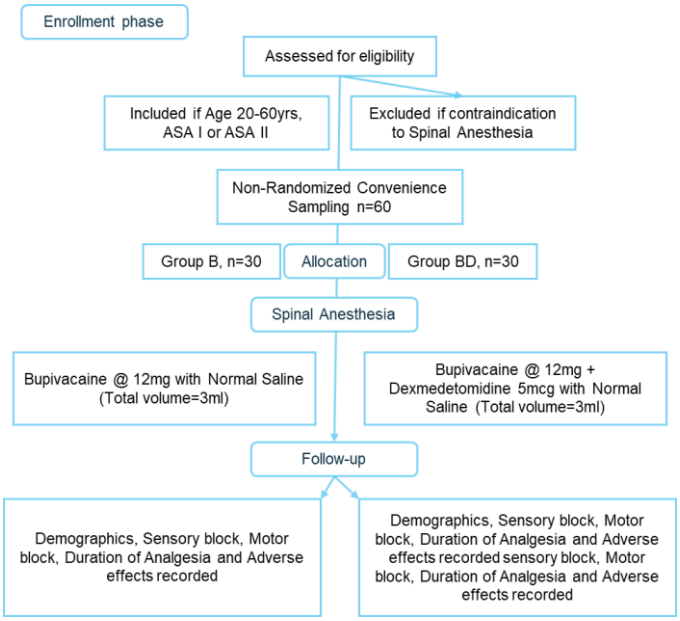

Figure 1 CONSORT Flowchart

Adverse events, such as hypotension and bradycardia, were defined as a 20% reduction from baseline measurements and managed with intravenous fluids and medications including phenylephrine (50 mcg) and atropine (1 mg), respectively. Episodes of nausea or vomiting were treated with intravenous ondansetron (8 mg). Data collection included demographic information, onset and duration of sensory and motor blocks, duration of analgesia, and adverse events. Data were analyzed using SPSS version 25. Continuous variables were summarized as means and standard deviations, and categorical variables were presented as frequencies and percentages. The normality of data distribution was assessed using the Shapiro-Wilk test. Independent sample t-tests were utilized for continuous variables, while chi-square tests were used to analyze categorical data. A p-value of ≤ 0.05 was considered statistically significant, allowing for the evaluation of the

differences in spinal anesthesia effects between the two groups. The study was conducted in accordance with the Declaration of Helsinki, ensuring ethical standards for medical research involving human subjects were maintained throughout the trial.

RESULTS

The results of the study involved 60 patients with a mean age of 42.30 ± 7.02 years, showing a male predominance of 63.3%.

The most common surgical procedure performed under spinal anesthesia was orthopedic surgery, accounting for 50% of the cases. In Group B, 70% of patients were classified as ASA I, compared to 73.3% in Group BD, with the remaining patients classified as ASA II. The demographic and baseline characteristics between the two groups were comparable, with no significant differences observed in terms of gender, age, ASA classification, type of surgery, or baseline systolic and diastolic blood pressures.

The onset of sensory and motor blocks was significantly faster in Group BD compared to Group B, with Group BD showing an onset of sensory block at 7.08 ± 0.54 minutes versus 13.48 ± 0.73 minutes in Group B ($p < 0.001$). Similarly, the onset of motor block was observed at 10.32 ± 0.91 minutes in Group BD, which was significantly shorter than 17.55 ± 0.69 minutes in Group B ($p < 0.001$). The duration of motor block and analgesia was also notably longer in Group BD, with motor block lasting 284.06 ± 5.64 minutes compared to 133.93 ± 5.72 minutes in Group B, and analgesia lasting 218.07 ± 4.86 minutes in Group BD versus 125.36 ± 5.42 minutes in Group B, both with p-values less than 0.001.

Table 1 Demographic Parameters

Variables	Group B (n = 30)	Group BD (n = 30)	p-value
Gender - Males	20 (66.7%)	18 (60%)	0.592
Gender - Females	10 (33.3%)	12 (40%)	0.592
Age (years) - Mean ± S.D	42.80 ± 7.62	41.80 ± 6.46	0.586
ASA-I	21 (70%)	22 (73.3%)	0.774
ASA-II	09 (30%)	08 (26.7%)	0.774
General Surgery	06 (20%)	04 (13.3%)	0.402

Table 2 Quality of Anesthesia among Groups

Variables	Group B (n = 30) - Mean ± S.D	Group BD (n = 30) - Mean ± S.D	p-value
Onset of sensory block (mins)	13.48 ± 0.73	7.08 ± 0.54	<0.001
Onset of motor block (mins)	17.55 ± 0.69	10.32 ± 0.91	<0.001
Duration of motor block (mins)	133.93 ± 5.72	284.06 ± 5.64	<0.001
Duration of analgesia (mins)	125.36 ± 5.42	218.07 ± 4.86	<0.001

Table 3 Complications among Groups

Complications	Group B (n = 30)	Group BD (n = 30)	p-value
Nausea/Vomiting - Yes	01 (3.3%)	02 (6.7%)	0.554
Nausea/Vomiting - No	29 (96.7%)	29 (93.3%)	0.554
Hypotension - Yes	02 (6.7%)	04 (13.3%)	0.389
Hypotension - No	28 (93.3%)	26 (86.7%)	0.389
Bradycardia - Yes	0	01 (3.3%)	0.313
Bradycardia - No	30 (100%)	29 (96.7%)	0.313

Regarding complications, adverse reactions such as nausea/vomiting, hypotension, and bradycardia were recorded and were found to be comparable between the groups. Nausea or vomiting occurred in 3.3% of patients in Group B and 6.7% in Group BD, hypotension was observed in 6.7% of Group B compared to 13.3% in Group BD, and bradycardia was reported in 3.3% of Group BD, with no cases in Group B. None of these differences reached statistical significance, indicating that the addition of dexmedetomidine did not significantly increase the incidence of these adverse effects.

The comprehensive results demonstrate that the addition of dexmedetomidine to 0.5% bupivacaine in spinal anesthesia not only accelerates the onset of sensory and motor blocks but also significantly extends their duration and the duration of analgesia, without a notable increase in adverse effects, suggesting a favorable safety and efficacy profile for this combination in clinical practice.

DISCUSSION

The findings of this quasi-experimental study demonstrated that the combination of 0.5% bupivacaine with dexmedetomidine in spinal anesthesia significantly improved the onset and duration of sensory and motor blocks compared to 0.5% bupivacaine alone. The results indicated that the addition of dexmedetomidine led to a faster onset of sensory and motor blockades, as well as a prolonged duration of analgesia, which aligns with previous studies that have reported similar benefits of dexmedetomidine as an adjuvant in regional anesthesia (8). The accelerated onset of anesthesia observed in Group BD can be attributed to dexmedetomidine's action on alpha-2 adrenergic receptors, which enhances the efficacy of local anesthetics by inhibiting the release of norepinephrine and

decreasing sympathetic outflow (5). This mechanism not only facilitates rapid onset but also contributes to prolonged analgesic effects, as evidenced by the extended duration of motor block and analgesia in patients receiving the combination.

The study's results are consistent with prior meta-analyses and randomized controlled trials that have reported enhanced block characteristics and reduced analgesic requirements when dexmedetomidine is used in conjunction with bupivacaine (9, 10). For instance, a systematic review concluded that dexmedetomidine significantly prolongs the duration of sensory and motor blocks compared to bupivacaine alone, which is similar to the observations in this study where Group BD showed prolonged block duration and enhanced quality of anesthesia (9). Furthermore, the use of dexmedetomidine has been associated with reduced opioid consumption postoperatively, potentially mitigating opioid-related side effects such as nausea, vomiting, and respiratory depression (10). In the current study, the incidence of adverse effects such as hypotension, bradycardia, and nausea was not significantly different between the groups, suggesting that the addition of dexmedetomidine did not markedly increase the risk of these complications, which supports its safety profile (17, 18).

The study's strength lies in its comparative approach, evaluating the effects of dexmedetomidine across a range of surgical procedures, thereby broadening the applicability of findings beyond single surgical domains as seen in previous studies. However, several limitations must be acknowledged. The non-randomized design and convenience sampling technique may have introduced selection bias, and the sample size was relatively small, which limits the generalizability of the findings. Additionally, the study was conducted in a single center, and all participants were from the same locality, which may not fully represent the broader population. A multicenter, randomized controlled trial with a larger and more diverse sample could provide more robust data and further validate the findings. Moreover, the study focused solely on short-term outcomes related to block characteristics and immediate postoperative analgesia, without evaluating long-term patient-reported outcomes or quality of recovery, which are also important considerations in anesthesia management.

Future research should explore varying doses of dexmedetomidine to determine the optimal concentration that balances efficacy and safety, as some studies have suggested that higher doses may further prolong block duration without significantly increasing adverse effects (14). Additionally, investigating the use of dexmedetomidine in combination with other local anesthetics or in different regional anesthesia techniques could expand its utility in clinical practice. The potential synergistic effects of dexmedetomidine with other adjuvants also warrant further exploration, as this could enhance analgesic efficacy while minimizing the need for opioids and their associated risks.

Overall, the study provides valuable insights into the enhanced performance of spinal anesthesia with dexmedetomidine as an adjunct, reinforcing its role in optimizing anesthetic care through improved block characteristics and patient comfort. These findings support the inclusion of dexmedetomidine in anesthetic protocols, particularly in settings where rapid onset and prolonged analgesia are desired outcomes. This approach not only aligns with the goals of effective pain management but also contributes to reducing the burden on healthcare systems by minimizing complications and enhancing postoperative recovery.

CONCLUSION

The study concluded that the addition of dexmedetomidine to 0.5% bupivacaine in spinal anesthesia significantly accelerates the onset and prolongs the duration of sensory and motor blocks, as well as extends the duration of analgesia, compared to bupivacaine alone, without a substantial increase in adverse effects. These findings highlight the potential of dexmedetomidine as an effective adjunct in spinal anesthesia, offering enhanced anesthetic quality and patient comfort. The implications for human healthcare include improved perioperative pain management, reduced reliance on systemic opioids, and potentially better surgical outcomes, which collectively contribute to a more efficient and patient-centered approach in anesthesia practice.

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