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Original Research Article

Dexmedetomidine versus dexamethasone as intrathecal adjuvants for tibiofibular fracture fixation under spinal anaesthesia: a prospective randomised double-blind study

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ABSTRACT

Background: Postoperative pain following tibiofibular fracture fixation may outlast the analgesic duration of hyperbaric bupivacaine used for spinal anaesthesia. Intrathecal adjuvants such as dexmedetomidine and dexamethasone have been used to improve block characteristics and prolong postoperative analgesia. To compare the analgesic efficacy and safety of intrathecal dexmedetomidine and dexamethasone as adjuvants to hyperbaric bupivacaine in adults undergoing spinal anaesthesia for tibiofibular fracture fixation.

Methods: In this prospective randomised double-blind trial, 68 ASA I–II patients scheduled for unilateral tibiofibular fracture fixation were randomised to receive 15 mg hyperbaric bupivacaine with either 5 µg dexmedetomidine (BDM, n=34) or 4 mg dexamethasone (BDA, n=34). The primary outcome was duration of analgesia, defined as the interval between onset of sensory block and a Numerical Rating Scale pain score >3. Secondary outcomes included onset of sensory and motor block, postoperative pain scores, adverse events, and patient satisfaction.

Results: Baseline characteristics were comparable between groups. Compared with dexamethasone, dexmedetomidine produced a faster onset of sensory block (3.0±0.82 vs 3.8±0.9 min; p=0.001) and motor block (4.1±0.9 vs 5.0±1.1 min; p=0.001), and significantly prolonged analgesia (328.6±28.1 vs 263.0±26.1 min; p<0.001). Pain scores at 4 hours were lower and patient satisfaction was higher in the dexmedetomidine group (both p<0.001). However, hypotension occurred more frequently with dexmedetomidine (29.4% vs 2.9%; p=0.003).

Conclusion: Intrathecal dexmedetomidine provided superior block characteristics, longer postoperative analgesia, lower pain scores, and greater patient satisfaction than intrathecal dexamethasone, although these benefits were accompanied by an increased incidence of intraoperative hypotension.

Keywords: Dexmedetomidine, Dexamethasone, Spinal anaesthesia, Tibiofibular fracture, Postoperative analgesia, Intrathecal adjuvant

INTRODUCTION

Tibiofibular fractures are among the most common lower limb injuries requiring operative fixation and are frequently associated with significant postoperative pain.[1,2] Effective postoperative analgesia remains a fundamental component of perioperative care because inadequate pain control may delay mobilisation, prolong hospital stay, increase patient dissatisfaction, and contribute to postoperative morbidity.[3] Although spinal anaesthesia using hyperbaric bupivacaine remains the preferred anaesthetic technique for many lower limb orthopaedic procedures, the duration of analgesia provided by bupivacaine alone is often insufficient to cover the period of greatest postoperative pain intensity.[4] To improve the quality and duration of spinal anaesthesia, several intrathecal adjuvants have been investigated. While opioids have traditionally been used

to prolong neuraxial analgesia, their use is associated with adverse effects such as nausea, vomiting, pruritus, urinary retention, and respiratory depression.[5-7] These limitations have encouraged the search for effective non-opioid alternatives.[8] Dexmedetomidine is a highly selective α_2-adrenergic receptor agonist that produces analgesia through inhibition of nociceptive neurotransmitter release and hyperpolarization of dorsal horn neurons.[5,9] Intrathecal dexmedetomidine has been shown to accelerate the onset of sensory and motor blockade, prolong block duration, and improve postoperative analgesia.[10,11] Dexamethasone is a synthetic glucocorticoid with anti-inflammatory and analgesic properties. Its analgesic effects have been attributed to suppression of inflammatory mediators, inhibition of nociceptive C-fibre transmission, and reduction of neural sensitisation.[5,9] Previous studies have demonstrated prolonged sensory block and postoperative analgesia when dexamethasone is used as an adjuvant to intrathecal bupivacaine.[4,12]

Although both agents have demonstrated efficacy as intrathecal adjuvants, comparative evidence remains limited, particularly among patients undergoing lower limb orthopaedic surgery in resource-limited settings. Furthermore, few studies have specifically evaluated these agents in patients undergoing tibiofibular fracture fixation.[13] This study therefore compared dexmedetomidine and dexamethasone as intrathecal adjuvants to hyperbaric bupivacaine for fixation of tibiofibular fractures under spinal anaesthesia. Authors hypothesized that dexmedetomidine would provide superior block characteristics and longer postoperative analgesia than dexamethasone, albeit with a greater incidence of haemodynamic adverse effects.[14-16]

METHODS

Study design and setting

This prospective randomised double-blind trial was conducted at the main theatre, emergency theatre, post anaesthesia care unit, and orthopaedic ward of university college Hospital Ibadan.

Ethical approval

Ethical approval was obtained from the Joint University of Ibadan/University College Hospital Ethical Review Committee through the Institute for Advanced Medical Research and Training (IAMRAT) (Approval No. UI/EC/22/0123). Written informed consent was obtained from all participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Participants

Adult patients aged 18–65 years with American Society of Anesthesiologists (ASA) physical status I or II scheduled for unilateral tibiofibular fracture fixation under spinal anaesthesia were eligible. Exclusion criteria included contraindications to spinal anaesthesia, allergy to study drugs, chronic pain requiring long-term analgesics, anticoagulant therapy, cognitive impairment, and procedures expected to exceed two hours.

Sample size

The sample size was calculated using the Kirkwood formula17 for the comparison of two groups. Based on previous studies18 and allowing for 10% attrition, a minimum sample size of 34 participants per group was calculated, yielding a total sample size of 68 patients.

Randomisation and blinding

Participants were randomised using computer-generated block randomisation prepared by a theatre pharmacist. Patients were allocated equally to either the dexmedetomidine group (BDM) or dexamethasone group (BDA). The pharmacist prepared all study medications, ensuring identical appearance and volume. Both participants and investigators were blinded to treatment allocation.

Interventions

Group BDM received intrathecal 15 mg (3 ml) of 0.5% hyperbaric bupivacaine plus 5 µg dexmedetomidine (1 ml), while Group BDA received intrathecal 15 mg (3 ml) hyperbaric bupivacaine plus 4 mg dexamethasone (1 ml). The doses were selected based on previous studies demonstrating efficacy and acceptable safety profiles.[10,12,19]

Anaesthetic technique

Following standard monitoring and intravenous preload with normal saline, spinal anaesthesia was performed at the L3–L4 or L4–L5 interspace using a 25-gauge Whitacre needle. Sensory block was assessed using loss of temperature sensation, while motor block was assessed using the Modified Bromage Scale. Surgery commenced after achievement of T10 sensory blockade.

Outcome measures

The primary outcome was duration of analgesia, defined as the interval between onset of sensory block and postoperative pain score greater than 3 on the numerical rating scale (NRS). Secondary outcomes included the onset of sensory and motor block, postoperative pain severity, adverse effects, and patient satisfaction.

Data were analysed using IBM SPSS version 23. Continuous variables were compared using independent-samples t-tests, while categorical variables were analysed using Chi-square or Fisher's exact tests. Statistical significance was set at $p<0.05$.

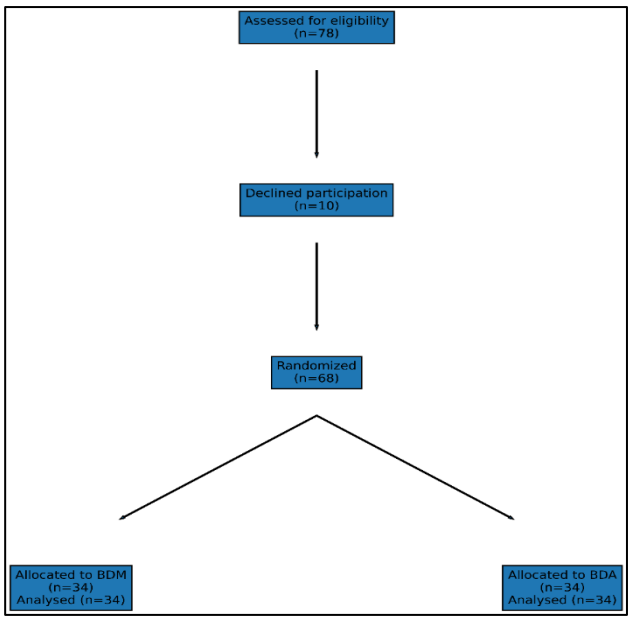

Figure 1: CONSORT participant flow diagram for the randomised double-blind trial.

RESULTS

Demographic/clinical characteristics

Seventy-eight patients were assessed for eligibility. Ten patients declined to participate, leaving 68 patients who were randomised equally to the BDM and BDA groups. All randomised participants completed the study and were included in the final analysis. Table I shows the demographic and clinical characteristics of the patients studied. The groups were comparable regarding age, weight, sex distribution, ASA physical status, and duration of surgery. Patients with Dukes A stage did not receive postoperative chemotherapy and were advised regular follow up. 38 patients received post-operative chemotherapy. 18 patients were given radiotherapy. New evidence suggests a role for anti-inflammatory drugs in the treatment and prevention of colon and rectal cancers.

Block characteristics and duration of analgesia

Table 2 shows the block characteristics and duration of analgesia. The Sensory block onset was significantly faster in the dexmedetomidine group (3.0±0.82 minutes) than in the dexamethasone group (3.8±0.9 minutes; p=0.001). Motor block onset was similarly faster with dexmedetomidine (4.1±0.9 vs 5.0±1.1 minutes; p=0.001). However, the mean duration of analgesia was significantly longer in the dexmedetomidine group than in the dexamethasone group (328.6±28.1 vs 263.0±26.1 minutes; p<0.001).

Postoperative pain and satisfaction

No patient experienced pain during the first three postoperative hours. At four hours post-block, pain severity was significantly lower in the dexmedetomidine group (p<0.001).

Patient satisfaction, assessed using the 5-point Likert satisfaction scale, was significantly higher among patients receiving dexmedetomidine. Most patients in the BDM group reported being "very satisfied," compared with those in the BDA group (85.3% vs 41.2%; p<0.001) Figure 2.

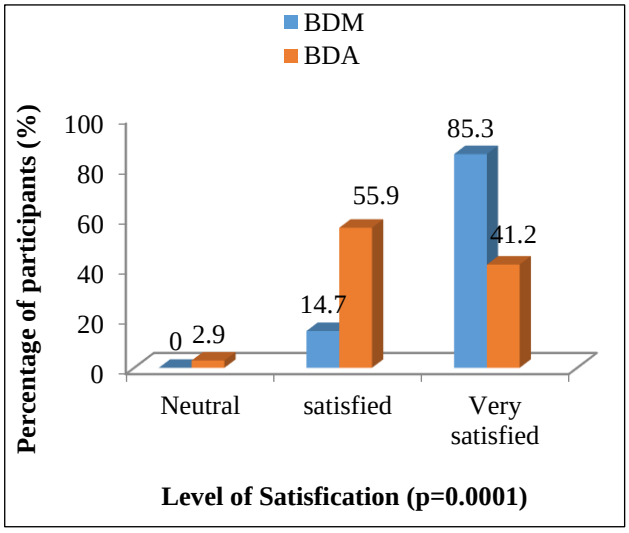

Figure 2: Level of satisfaction with postoperative pain control in the bupivacaine/dexmedetomidine and bupivacaine/dexamethasone groups using the 5-point Likert scale.

Table 3 shows the adverse effects observed in this study. Hypotension occurred more frequently in the dexmedetomidine group (29.4%) than in the dexamethasone group (2.9%; p=0.003). The incidence of bradycardia and tachycardia was comparable between groups. No episodes of respiratory depression, nausea, vomiting, or shivering occurred.

Table 1: Age distribution of patients.

Variable	BDM (n=34)	BDA (n=34)	P value
Age (in years)	43.8±11.7	45.8±9.9	0.443
Weight (kg)	73.3±6.7	75.8±8.3	0.170
Male sex (%)	73.5	85.3	0.230
ASA I (%)	67.6	73.5	0.595
Duration of surgery (min)	98.9±10.4	99.9±8.3	0.654

Table 2: Block characteristics and duration of analgesia.

Variable	BDM	BDA	P value
Sensory onset (min)	3.0±0.82	3.8±0.90	0.001
Motor onset (min)	4.1±0.90	5.0±1.10	0.001
Duration of analgesia (min)	328.6±28.1	263.0±26.1	<0.001

Table 3: Adverse effects.

Adverse effect	BDM (%)	BDA (%)	P value
Hypotension	29.4	2.9	0.003
Bradycardia	11.8	5.9	0.393
Tachycardia	8.8	2.9	0.303
Nausea/vomiting	0	0	—
Shivering	0	0	—
Respiratory depression	0	0	—

DISCUSSION

The principal findings from this present study were that dexmedetomidine produced a significantly faster onset of sensory and motor blockade, prolonged postoperative analgesia, reduced postoperative pain severity, and improved patient satisfaction compared with dexamethasone. These benefits, however, were accompanied by a significantly higher incidence of intraoperative hypotension. Both agents provided effective spinal anaesthesia and demonstrated acceptable safety profiles.

The most important finding of this study was the significantly longer duration of analgesia observed in the dexmedetomidine group. Patients who received intrathecal dexmedetomidine experienced analgesia for approximately 66 minutes longer than those who received dexamethasone. This finding is clinically important because the immediate postoperative period following orthopaedic trauma surgery is characterised by substantial pain intensity and increased analgesic requirements. Prolongation of analgesia during this period may reduce the need for early rescue analgesics and improve overall patient comfort.

The superior analgesic efficacy of dexmedetomidine may be explained by its pharmacological action as a highly selective α_2-adrenergic receptor agonist.[20,21] At the spinal level, dexmedetomidine inhibits the release of nociceptive neurotransmitters from primary afferent neurons and enhances postsynaptic hyperpolarization within the dorsal horn.[5,20] These mechanisms suppress transmission of pain signals and potentiate the effects of local anaesthetics. Consequently, the addition of dexmedetomidine to intrathecal bupivacaine results in prolonged sensory blockade and enhanced postoperative analgesia. The present findings are consistent with previous studies evaluating dexmedetomidine as an intrathecal adjuvant. Mahendru and colleagues reported prolonged sensory block and postoperative analgesia with dexmedetomidine compared with clonidine and bupivacaine alone.[11] Similarly, Halder et al demonstrated improved block characteristics and prolonged analgesia in patients undergoing lower limb orthopaedic procedures.[10] These studies support the growing body of evidence favoring dexmedetomidine as an effective non-opioid intrathecal adjuvant.

Importantly, the results of the present study closely mirror those of Elshahawy et al and Abd El-Hamed Hassan et al who directly compared dexmedetomidine and dexamethasone as intrathecal adjuvants in lower-limb orthopaedic surgery.[22,23] Both investigators reported superior block characteristics and prolonged analgesia with dexmedetomidine compared with dexamethasone. Similar findings have also been reported by Ismaiel et al in a comparative study of both agents.[24] The findings of the current study therefore reinforce existing evidence and demonstrate similar outcomes in a West African orthopaedic population.

Although dexamethasone was less effective than dexmedetomidine in prolonging analgesia, it nevertheless provided satisfactory postoperative pain control. Dexamethasone exerts analgesic effects through suppression of inflammatory mediators, inhibition of prostaglandin synthesis, and reduction of peripheral and central sensitisation.[24] These mechanisms likely contributed to the prolonged analgesia observed in the dexamethasone group. Therefore, dexamethasone remains a clinically useful intrathecal adjuvant, particularly when preservation of haemodynamic stability is a priority.

The significantly faster onset of both sensory and motor blockade observed in the dexmedetomidine group was another clinically relevant finding. Rapid establishment of adequate anaesthesia may improve operating room efficiency and reduce delays in the commencement of surgery. The enhanced onset characteristics observed in this study are consistent with previous reports and may

reflect synergistic interactions between dexmedetomidine and bupivacaine at the neuronal membrane level.[10,11,22] Pain severity assessment revealed significant differences between the groups at four hours after spinal block. Whereas most patients in the dexmedetomidine group remained pain-free, a substantial proportion of patients in the dexamethasone group experienced mild-to-moderate pain. This observation further supports the superior analgesic profile of dexmedetomidine and is consistent with the longer duration of analgesia demonstrated by the primary outcome analysis. Patient satisfaction was significantly greater among patients receiving dexmedetomidine. Satisfaction after anaesthesia is influenced by multiple factors, including comfort, adequacy of pain control, recovery experience, and the occurrence of adverse events.[25] The higher satisfaction scores observed in the dexmedetomidine group likely reflect its superior analgesic efficacy and reduced postoperative pain burden.

A notable finding of this study was the significantly higher incidence of hypotension among patients receiving dexmedetomidine. Approximately one-third of patients in the dexmedetomidine group experienced hypotension compared with only one patient in the dexamethasone group. This result is consistent with the known sympatholytic effects of dexmedetomidine and findings from previous clinical studies and meta-analyses.[19,26] Activation of central α_2-receptors reduces sympathetic outflow and vascular tone, thereby increasing susceptibility to hypotension during spinal anaesthesia.[21] Although all episodes were successfully managed without serious sequelae, clinicians should remain vigilant when administering dexmedetomidine, particularly in patients with limited cardiovascular reserve.

Despite the increased incidence of hypotension, no significant differences were observed in bradycardia, tachycardia, respiratory depression, nausea and vomiting, shivering, or excessive sedation. Furthermore, no serious adverse events occurred in either group. These findings suggest that both dexmedetomidine and dexamethasone possess acceptable safety profiles when administered intrathecally at the doses used in this study.

The findings of this study have important implications for clinical practice. Both dexmedetomidine and dexamethasone may be used effectively as intrathecal adjuvants to hyperbaric bupivacaine for tibiofibular fracture fixation. When prolonged postoperative analgesia and enhanced block characteristics are desired, dexmedetomidine appears to be the preferred option. However, clinicians should balance these benefits against the increased likelihood of hypotension. Dexamethasone remains a valuable alternative for patients for whom haemodynamic stability is of particular concern.

This study employed a prospective randomised double-blind design, minimizing selection and observer bias. All randomised participants completed follow-up, thereby eliminating attrition bias. A standardised anaesthetic technique was used for all participants, thereby reducing procedural variability. Finally, the study addressed a clinically relevant question in a population undergoing lower-limb orthopaedic trauma surgery.

This study was conducted at a single tertiary institution, which may limit generalizability to other settings. Postoperative follow-up was restricted to the early postoperative period, preventing evaluation of longer-term analgesic outcomes and total analgesic consumption. In addition, the absence of a hyperbaric bupivacaine-only control group precluded determination of the absolute contribution of each adjuvant to block prolongation. Finally, the study did not evaluate cost-effectiveness, which may influence adjuvant selection in resource-limited environments.

CONCLUSION

Intrathecal dexmedetomidine provided faster onset of sensory and motor blockade, significantly prolonged postoperative analgesia, reduced postoperative pain severity, and improved patient satisfaction compared with intrathecal dexamethasone in patients undergoing tibiofibular fracture fixation under spinal anaesthesia. These benefits were accompanied by a higher incidence of intraoperative hypotension. Both agents were effective intrathecal adjuvants to hyperbaric bupivacaine; however, dexmedetomidine demonstrated superior analgesic efficacy, whereas dexamethasone was associated with greater haemodynamic stability. Selection of an intrathecal adjuvant should therefore consider both analgesic requirements and patient-specific cardiovascular risk.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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