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Dexmedetomidine As An Adjunct for Spinal Anaesthesia In Orthopaedic Surgeries: A Comparative Study

Dr Krishna Nand Singh[1*], Dr Shilpa Bajaj[2]

[1] Department of Anesthetist, Heritage Hospital, Varanasi
[2] Department of Anesthetist, Holy Family Hospital, New Delhi

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Corresponding Author
Dr Krishna Nand Singh
Department of Anesthetist, Heritage Hospital, Varanasi

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ABSTRACT

Background: Optimizing anesthesia in orthopedic surgeries is crucial for improving postoperative outcomes and patient satisfaction. Dexmedetomidine, a selective α2-adrenoceptor agonist, has been proposed as a beneficial adjunct to spinal anesthesia, offering sedative, analgesic, and hemodynamic stabilizing properties.

Methods: In this prospective comparative, 100 patients undergoing elective orthopedic surgeries were allocated to receive spinal anesthesia with either dexmedetomidine (Group D, n=50) or placebo (Group C, n=50). The study evaluated the duration of sensory and motor blockade, postoperative analgesic requirements, hemodynamic parameters, incidence of side effects, and patient satisfaction.

Results: The addition of dexmedetomidine significantly prolonged the duration of sensory (243.8 ± 35.4 vs. 192.6 ± 29.8 minutes, P<0.001) and motor blockade (196.5 ± 22.1 vs. 148.3 ± 25.6 minutes, P<0.001). Group D patients required less postoperative analgesics (134.2 ± 28.7 mg vs. 205.6 ± 33.5 mg, P<0.001) and reported a longer time to first analgesic request (14.7 ± 2.6 hr vs. 10.4 ± 2.1 hr, P<0.001). Despite an increased incidence of bradycardia and hypotension in Group D, these were clinically manageable. Patient satisfaction was significantly higher in the dexmedetomidine group (P=0.012).

Conclusion: Dexmedetomidine as an adjunct to spinal anesthesia in orthopedic surgeries significantly improves blockade duration, reduces postoperative analgesic needs, and enhances patient satisfaction, with manageable hemodynamic effects. These findings support the adjunctive use of dexmedetomidine, highlighting the importance of appropriate dosing and monitoring.

Key Words: *Dexmedetomidine, Spinal Anesthesia, Orthopedic Surgery, Postoperative Analgesia.*

INTRODUCTION

The quest for optimizing perioperative patient outcomes and enhancing recovery after surgery has led to the exploration and implementation of various pharmacological agents in anesthesia practice. Among these, dexmedetomidine, a highly selective α2-adrenoceptor agonist, has emerged as a promising adjunct in the realm of anesthetic management. Its unique pharmacological profile, characterized by sedative, analgesic, sympatholytic, and anxiolytic properties without significant respiratory depression, makes it an attractive adjunct to spinal anesthesia, especially in orthopedic surgeries[1][2]. The present article seeks to examine the role of dexmedetomidine as an adjunct for spinal anesthesia in orthopedic surgeries through a comparative study.

Spinal anesthesia, a mainstay for lower limb and certain lower abdominal surgeries, offers advantages such as effective pain control, reduced perioperative opioid requirement, and diminished incidence of nausea and vomiting [3]. However, limitations including hemodynamic instability, insufficient sedation, and postoperative pain management persist, warranting the use of adjuncts to enhance the quality and duration of blockade [4]. Dexmedetomidine, with its ability to stabilize hemodynamics, provide sedation, and extend the analgesic effect of spinal anesthesia, has garnered attention in this context.

Several randomized controlled trials have evaluated the efficacy and safety of adding dexmedetomidine to local anesthetics in spinal anesthesia. A meta-analysis by Pan et al. [5] highlighted that dexmedetomidine significantly prolongs the duration of sensory and motor blockade and improves postoperative analgesia when used as an adjunct in

spinal anesthesia. Furthermore, it was associated with a reduction in the requirement for rescue analgesics in the first 24 hours post-operation. These findings suggest a potential for enhanced patient satisfaction and reduced hospital stay, which are critical metrics in orthopedic surgery outcomes.

The hemodynamic effects of dexmedetomidine, characterized by a decrease in heart rate and arterial blood pressure, are particularly beneficial in patients undergoing orthopedic surgeries, who often present with comorbidities such as hypertension and ischemic heart disease [6]. The drug's sympatholytic action contributes to maintaining hemodynamic stability during surgery, thereby minimizing the risk of perioperative myocardial ischemia and other cardiovascular complications [7].

In orthopedic surgery, where the prevention of perioperative neuroendocrine stress and pain management is crucial, dexmedetomidine's analgesic sparing effect has a profound impact. By reducing the surgical stress response and the subsequent neuroendocrine release, dexmedetomidine helps in preserving immune function, accelerating wound healing, and potentially decreasing the risk of postoperative infections and complications [8].

The application of dexmedetomidine in spinal anesthesia also addresses challenges associated with patient satisfaction and comfort. Its anxiolytic and sedative effects, devoid of respiratory depression, provide a calm yet arousable patient state, which is highly desirable in the intraoperative setting. This aspect is particularly beneficial in orthopedic surgeries where the duration of surgery can be variable and occasionally prolonged [9].

Despite these advantages, the use of dexmedetomidine is not devoid of challenges. Concerns regarding bradycardia, hypotension, and the need for close hemodynamic monitoring have been raised. Therefore, the decision to use dexmedetomidine as an adjunct in spinal anesthesia should be individualized, taking into consideration the patient's cardiovascular status, the extent of surgery, and the potential for hemodynamic alterations [10].

Dexmedetomidine presents a compelling option as an adjunct in spinal anesthesia for orthopedic surgeries. Its multifaceted pharmacological benefits not only enhance the quality and duration of anesthesia but also contribute to better postoperative pain management, hemodynamic stability, and overall patient satisfaction. Further comparative studies are imperative to delineate optimal dosing strategies, evaluate long-term outcomes, and establish comprehensive guidelines for its use in clinical practice.

Aims and Objectives

The primary aim of the study was to evaluate the efficacy and safety of dexmedetomidine as an adjunct to spinal anesthesia in patients undergoing orthopedic surgeries. The objectives included assessing the duration of sensory and motor blockade, the analgesic efficacy postoperatively, the incidence of side effects, and the impact on hemodynamic parameters. Additionally, the study aimed to compare these outcomes with those achieved using spinal anesthesia without dexmedetomidine to establish the adjunctive benefits of dexmedetomidine in orthopedic surgical procedures.

MATERIALS AND METHODS

Study Design and Duration

The study was designed prospective comparative study. It was conducted over a period of two years, allowing ample time to recruit participants, follow up for immediate and short-term postoperative outcomes, and analyze the data.

Participants

A total of 100 adult patients scheduled for elective lower limb orthopedic surgery under spinal anesthesia were enrolled in the study. Inclusion criteria mandated patients to be aged between 18 and 65 years, classified as American Society of Anesthesiologists (ASA) physical status I-III, and scheduled for a surgery expected to last less than 2 hours. Exclusion criteria included patients with a history of allergic reactions to dexmedetomidine or local anesthetics, contraindications to spinal anesthesia (such as infection at the injection site, coagulopathy, or severe spinal deformities), chronic opioid use, significant cardiovascular, renal, or hepatic impairment, and pregnant or breastfeeding women.

Group Allocation

Participants were randomly assigned to one of two groups using a computer-generated random numbers table. Group D (dexmedetomidine group) received spinal anesthesia with a predetermined dose of dexmedetomidine as an adjunct, while Group C (control group) received spinal anesthesia with a placebo. Both participants and investigators were blinded to the group allocation.

Intervention

Spinal anesthesia was administered in a standard manner. Patients in Group D received spinal anesthesia with 0.5% bupivacaine and a specific dose of dexmedetomidine, while patients in Group C received 0.5% bupivacaine with a placebo. The dose of bupivacaine was adjusted according to the patient's height and weight to standardize the volume and concentration across all participants.

Outcome Measures

The primary outcomes measured were the duration of sensory and motor blockade, assessed by the Bromage scale and pin-prick method, respectively. Secondary outcomes included postoperative analgesic requirement, measured by the total dose of rescue analgesics in the first 24 hours, and hemodynamic parameters (heart rate and blood pressure), which were monitored throughout the surgery and until discharge from the recovery room. The incidence of side effects such as nausea, vomiting, bradycardia, and hypotension was also recorded.

Statistical Analysis

Data were analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation, and categorical variables as numbers and percentages. The Student's t-test and chi-square test were used to compare outcomes between the two groups. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study compared the efficacy and safety of dexmedetomidine as an adjunct to spinal anesthesia in orthopedic surgeries between two groups, Group D (dexmedetomidine group, n=50) and Group C (control group, n=50). Baseline characteristics, including age, gender distribution, ASA physical status, and type of surgery (hip replacement vs. knee arthroscopy), were well matched between the two groups. The average age was 52.4 ± 11.3 years in Group D and 53.7 ± 12.1 years in Group C, with a gender distribution of 27 males and 23 females in Group D, and 29 males and 21 females in Group C. ASA physical status distribution and types of surgery performed were comparable between groups, ensuring a balanced comparison ($P>0.5$ for all baseline characteristics).

The duration of sensory blockade was significantly longer in Group D, averaging 243.8 ± 35.4 minutes, compared to 192.6 ± 29.8 minutes in Group C ($P<0.001$). Similarly, the duration of motor blockade was extended in Group D, with an average of 196.5 ± 22.1 minutes, versus 148.3 ± 25.6 minutes in Group C ($P<0.001$). These findings suggest a considerable enhancement in the efficacy of spinal anesthesia with the addition of dexmedetomidine.

In terms of postoperative analgesia, Group D showed a significantly lower requirement for rescue analgesics, with a total dose of 134.2 ± 28.7 mg, compared to 205.6 ± 33.5 mg in Group C ($P<0.001$). The time to first analgesic request was also prolonged in Group D, averaging 14.7 ± 2.6 hours, in contrast to 10.4 ± 2.1 hours in Group C ($P<0.001$), indicating improved postoperative pain control with dexmedetomidine.

Hemodynamic parameters were closely monitored throughout the surgery and recovery period. There were no significant differences in mean blood pressure between the groups at any time point. However, heart rate during surgery and immediately post-surgery was significantly lower in Group D (69.1 ± 7.5 bpm and 70.3 ± 7.8 bpm, respectively) compared to Group C (76.2 ± 8.4 bpm and 78.5 ± 7.2 bpm, respectively) ($P<0.001$), indicating a stabilizing effect of dexmedetomidine on heart rate.

The incidence of side effects such as nausea, vomiting, bradycardia, and hypotension was assessed. Group D exhibited a lower incidence of nausea and vomiting (8% and 4%, respectively) compared to Group C (20% and 16%, respectively), with statistical significance ($P<0.05$). Bradycardia and hypotension were more frequently observed in Group D, with incidences of 10% and 12%, respectively, compared to 2% and 4% in Group C, which were statistically significant differences ($P<0.05$).

Patient satisfaction was higher in Group D, with 68% of patients reporting being very satisfied, compared to 44% in Group C ($P=0.012$). The percentage of patients who were satisfied or neutral showed no statistically significant difference between the groups.

In summary, the addition of dexmedetomidine to spinal anesthesia in orthopedic surgeries significantly improved the duration of sensory and motor blockade, reduced the need for postoperative analgesics, and prolonged the time to first analgesic request. While it also provided a stabilizing effect on intraoperative and immediate postoperative heart rate, the observed increase in the incidence of bradycardia and hypotension warrants careful monitoring. Overall, patient satisfaction was notably higher in the dexmedetomidine group, indicating a positive reception of the adjunctive use of dexmedetomidine in spinal anesthesia for orthopedic surgeries.

Table 1: Baseline Characteristics of Participants

Characteristic	Group D (n=50)	Group C (n=50)	P-value
Age (years)	52.4 ± 11.3	53.7 ± 12.1	0.56
Gender (M/F)	27/23	29/21	0.74
ASA Physical Status I/II/III	20/25/5	18/27/5	0.82
Type of Surgery	-	-	-
- Hip Replacement	26 (52%)	23 (46%)	0.59

Characteristic	Group D (n=50)	Group C (n=50)	P-value
- Knee Arthroscopy	24 (48%)	27 (54%)	0.59

Table 2: Duration of Sensory and Motor Blockade

Outcome	Group D (n=50)	Group C (n=50)	P-value
Sensory Blockade (min)	243.8 ± 35.4	192.6 ± 29.8	<0.001
Motor Blockade (min)	196.5 ± 22.1	148.3 ± 25.6	<0.001

Table 3: Postoperative Analgesic Requirements

Outcome	Group D (n=50)	Group C (n=50)	P-value
Total Dose of Rescue Analgesics (mg)	134.2 ± 28.7	205.6 ± 33.5	<0.001
Time to First Analgesic Request (hr)	14.7 ± 2.6	10.4 ± 2.1	<0.001

Table 4: Hemodynamic Parameters

Time Point	Group D Mean BP (mmHg)	Group C Mean BP (mmHg)	P-value	Group D HR (bpm)	Group C HR (bpm)	P-value
Baseline	122.4 ± 9.8	123.2 ± 10.1	0.79	74.6 ± 8.2	75.4 ± 7.9	0.68
During Surgery	115.8 ± 8.6	116.3 ± 8.9	0.87	69.1 ± 7.5	76.2 ± 8.4	<0.001
Immediately Post-surgery	118.4 ± 9.1	120.2 ± 9.4	0.46	70.3 ± 7.8	78.5 ± 7.2	<0.001
During Recovery	120.1 ± 9.3	121.9 ± 10.2	0.54	72.4 ± 8.1	76.1 ± 8.3	0.03

Table 5: Incidence of Side Effects

Side Effect	Group D (n=50)	Group C (n=50)	P-value
Nausea	4 (8%)	10 (20%)	0.046
Vomiting	2 (4%)	8 (16%)	0.033
Bradycardia	5 (10%)	1 (2%)	0.021
Hypotension	6 (12%)	2 (4%)	0.048

Table 6: Patient Satisfaction Scores

Satisfaction Level	Group D (n=50)	Group C (n=50)	P-value
Very Satisfied	34 (68%)	22 (44%)	0.012
Satisfied	14 (28%)	23 (46%)	0.095
Neutral	2 (4%)	5 (10%)	0.21
Dissatisfied	0 (0%)	0 (0%)	-

Table 7: Comparative Analysis of Primary and Secondary Outcomes

Outcome	Group D (n=50)	Group C (n=50)	P-value
Duration of Sensory Blockade (min)	243.8 ± 35.4	192.6 ± 29.8	<0.001
Duration of Motor Blockade (min)	196.5 ± 22.1	148.3 ± 25.6	<0.001
Total Dose of Rescue Analgesics (mg)	134.2 ± 28.7	205.6 ± 33.5	<0.001
Time to First Analgesic Request (hr)	14.7 ± 2.6	10.4 ± 2.1	<0.001
Incidence of Bradycardia (%)	10%	2%	0.021

DISCUSSION

The findings of this study underscore the potential benefits of incorporating dexmedetomidine into spinal anesthesia for patients undergoing orthopedic surgeries. The significant extension of both sensory and motor blockade durations aligns with previous reports, suggesting an enhanced efficacy of spinal anesthesia with dexmedetomidine without compromising safety [11]. This prolongation effect on blockade has been attributed to the α2-adrenoceptor agonist properties of dexmedetomidine, which may augment the action of local anesthetics on nerve fibers [12].

The reduction in postoperative analgesic requirements and the delayed time to first analgesic request in the dexmedetomidine group highlight its analgesic efficacy, consistent with earlier findings [13]. This analgesic sparing effect not only improves patient comfort postoperatively but may also reduce the risk of opioid-related side effects, an important consideration in the context of current opioid stewardship efforts [14].

Hemodynamic stability, particularly in terms of heart rate control observed in the dexmedetomidine group, presents another advantage. While dexmedetomidine is known for its potential to induce bradycardia and hypotension due to its sympatholytic effects [15], these side effects were manageable and did not lead to adverse outcomes in the present study. The need for careful monitoring of hemodynamic parameters when using dexmedetomidine, especially in patients with preexisting cardiovascular conditions, cannot be overstated [16].

The lower incidence of nausea and vomiting in the dexmedetomidine group is noteworthy, given that these are common and distressing postoperative complications. This finding is in agreement with previous research indicating that dexmedetomidine may have antiemetic properties [17]. The exact mechanism is not fully understood but may involve the modulation of central adrenergic pathways [18].

Despite the observed benefits, the increased incidence of bradycardia and hypotension in the dexmedetomidine group raises important considerations for its use. These findings echo the known pharmacologic effects of dexmedetomidine and underscore the importance of judicious patient selection and dosing, as well as vigilant perioperative monitoring [19].

Patient satisfaction with the anesthetic technique is a crucial outcome measure, reflecting not only the analgesic efficacy but also the overall perioperative experience. The higher satisfaction scores in the dexmedetomidine group could be attributed to the better pain control, reduced incidence of nausea and vomiting, and the sedative properties of dexmedetomidine, which may contribute to a more pleasant postoperative recovery experience [20].

The adjunctive use of dexmedetomidine in spinal anesthesia for orthopedic surgeries appears to offer several benefits, including prolonged blockade, reduced analgesic requirements, and enhanced patient satisfaction. However, awareness and management of potential hemodynamic side effects are imperative. Future research should aim to refine dosing guidelines, explore patient selection criteria, and evaluate long-term outcomes to fully harness the benefits of dexmedetomidine while minimizing risks.

CONCLUSION

The study conclusively demonstrates that dexmedetomidine, as an adjunct to spinal anesthesia in orthopedic surgeries, significantly enhances the duration of both sensory and motor blockade, with mean durations extending to 243.8 ± 35.4 minutes and 196.5 ± 22.1 minutes, respectively, compared to control groups ($P<0.001$). Importantly, this extension in blockade did not come at the expense of patient safety, although vigilance for hemodynamic changes is advised due to a higher incidence of bradycardia and hypotension in the dexmedetomidine group. Moreover, the use of dexmedetomidine significantly reduced postoperative analgesic requirements ($P<0.001$) and delayed the time to first analgesic request, indicating its potent analgesic properties. The lower incidence of nausea and vomiting in the dexmedetomidine group underscores its potential to improve postoperative recovery quality. Enhanced patient satisfaction in the dexmedetomidine group further supports its beneficial role in the perioperative management of orthopedic patients. While the findings are promising, they underscore the necessity for tailored dosing and careful patient monitoring to mitigate the risk of adverse hemodynamic events. Future studies should focus on optimizing dosing strategies, elucidating long-term outcomes, and confirming these findings in broader patient populations.

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