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Research Article

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Comparison of Intrathecal Clonidine and Dexmedetomidine as Adjuvants to Hyperbaric Bupivacaine for Lower Limb Surgery

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Abstract

Introduction

Effective pain management in lower limb surgeries is crucial for patient care. Spinal anesthesia, commonly used for its rapid onset, can be enhanced by adjuvants like clonidine and dexmedetomidine. These α2-adrenergic agonists prolong sensory and motor blockade, improving postoperative analgesia. Clonidine, inhibits norepinephrine release, while dexmedetomidine, more selective, offers profound analgesia without significant sedation.

Methods

This prospective, randomized, double-blind study compared intrathecal clonidine and dexmedetomidine as adjuvants to hyperbaric bupivacaine in lower limb surgery. Adult participants undergoing elective procedures were included, and randomization was computer-generated with concealed allocation. Primary outcome was sensory blockade duration; secondary outcomes included motor blockade duration, postoperative analgesia, hemodynamic parameters, and adverse effects. Data collection, statistical analysis, and ethical considerations were conducted rigorously, adhering to ethical guidelines and obtaining informed consent from participants.

Results

Dexmedetomidine significantly prolongs sensory blockade compared to Clonidine, with median regression times of 120 vs. 90 minutes. Dexmedetomidine significantly extends the duration of motor blockade compared to Clonidine, with median regression times of 210 minutes versus 150 minutes. Group B (Dexmedetomidine) required significantly less postoperative analgesia within the first 24 hours, with an average consumption of 15 mg morphine equivalent, compared to 20 mg in Group A (Clonidine). Both drugs maintained stable hemodynamic conditions during and after surgery, with no significant differences observed.

Conclusion

Our study clearly demonstrates that Dexmedetomidine serves as a superior adjuvant to Clonidine when combined with hyperbaric Bupivacaine for spinal Anesthesia in lower limb surgeries.

Keywords: Clonidine, Dexmedetomidine, Adjuvants in Regional Anesthesia, Hyperbaric Bupivacaine, Lower Limb Surgery

1. Introduction

Pain management in the perioperative setting is a critical aspect of patient care, aiming not only to alleviate suffering but also to enhance recovery outcomes and overall satisfaction [1]. Spinal anesthesia has become a cornerstone in lower limb surgeries due to its effectiveness and rapid onset of action [2]. However, the duration and quality of spinal anesthesia can be optimized through the addition of adjuvants to local anesthetics. Among these adjuvants, clonidine and dexmedetomidine have emerged as promising candidates, demonstrating potential benefits in prolonging the duration of sensory and motor blockade, as well as providing superior postoperative analgesia [3].

Lower limb surgeries, including procedures such as knee arthroplasty and lower limb fracture repair, pose unique challenges in terms of achieving effective anesthesia and postoperative pain control. The choice of adjuvants in spinal anesthesia plays a pivotal role in determining the success of these procedures [4]. Clonidine, an α2-adrenergic agonist, and dexmedetomidine, a more selective α2-adrenergic agonist, have both shown promise in various regional anesthesia techniques. Intrathecal administration of these agents, when combined with hyperbaric bupivacaine, has been reported to enhance the duration of sensory blockade and improve postoperative analgesia.

Spinal anesthesia, while providing rapid and reliable block for lower limb surgeries, is often associated with a limited duration of action. Adjuvants are frequently employed to reduce the requirement for systemic analgesics, and enhance patient comfort during the perioperative period [5]. Both clonidine and dexmedetomidine, by acting on α2-adrenergic receptors in the spinal cord, exert their analgesic effects through a variety of mechanisms, including inhibition of norepinephrine release and modulation of pain pathways.

Clonidine, a non-selective α2-adrenergic agonist, has been extensively studied for its potential benefits in spinal anesthesia. Its ability to inhibit norepinephrine release in the spinal cord results in analgesia and sympatholytic [7]. In combination with hyperbaric bupivacaine, clonidine has shown promise in prolonging the duration of sensory blockade without compromising motor blockade significantly. Furthermore, clonidine's sedative properties may contribute to a reduction in perioperative stress responses, making it an attractive adjuvant in the context of lower limb surgeries.

Dexmedetomidine, a more selective α2-adrenergic agonist compared to clonidine, has gained popularity for its favorable pharmacokinetic profile and potential to produce profound analgesia without significant sedation [8]. When added to hyperbaric bupivacaine in spinal anesthesia, dexmedetomidine has demonstrated efficacy in prolonging the duration of sensory and motor blockade. Additionally, its neuroprotective properties and minimal respiratory depression make it an intriguing option for enhancing the safety profile of spinal anesthesia, especially in elderly or high-risk patients.

Various studies have investigated the use of clonidine and dexmedetomidine as adjuvants in spinal anesthesia, with varying results and outcomes [6]. While both agents have demonstrated efficacy in prolonging the duration of sensory blockade, it remains crucial to elucidate potential differences in their clinical effects, side effect profiles, and overall impact on patient recovery.

The primary objective of this research is to compare the efficacy of intrathecal clonidine and dexmedetomidine when used as adjuvants to hyperbaric bupivacaine in lower limb surgery.

2. Methods

2.1 Study Design

This study adopted a prospective, randomized, double-blind, and controlled design to compare the effects of intrathecal clonidine and dexmedetomidine as adjuvants to hyperbaric bupivacaine in lower limb surgery. This design was chosen to minimize bias and provide a robust basis for comparing the efficacy and safety of the two adjuvants.

2.2 Study Participants

All the participants were enrolled as per the strict inclusion criteria. The study included adult participants (age 18-75) scheduled for elective lower limb surgery, such as knee arthroplasty or lower limb fracture repair and other surgeries. Exclusion criteria involved contraindications to spinal anesthesia, allergy to study medications, and pre-existing neurological or psychiatric disorders. All participants provided informed consent prior to their enrollment.

2.3 Randomization and Blinding

Participants were assigned randomly to two groups through a computer-generated randomization sequence. The allocation was concealed from both the participants and the investigators. The anesthesiologist administering the spinal anesthesia, data collectors, and data analysts were blinded to the assigned group.

2.4 Intervention

Participants in Group A received intrathecal clonidine (1 μg/kg) along with hyperbaric bupivacaine, while Group B received intrathecal dexmedetomidine (1 μg/kg) with hyperbaric bupivacaine. The dosage of clonidine and dexmedetomidine was selected based on previous studies demonstrating their efficacy and safety in spinal anesthesia.

3. Outcome Measures

3.1 Primary Outcome

• Duration of sensory blockade: assessed using pinprick test at regular intervals after spinal anesthesia

3.2 Secondary Outcomes

• Duration of motor blockade: assessed using modified Bromage scale
• Postoperative analgesic requirement: recorded in the first 24 hours
• Hemodynamic parameters: monitored throughout the intraoperative and postoperative period
• Incidence of adverse effects: including hypotension, bradycardia, sedation, and respiratory depression

4. Data Collection

Trained personnel, blinded to group allocation, collected data on demographic characteristics, intraoperative variables, and postoperative outcomes. The collected data was recorded on standardized data collection forms.

5. Statistical Analysis

Statistical analysis was performed using appropriate software. Descriptive statistics was used to summarize demographic and baseline characteristics. Continuous variables were compared using t-tests or Mann-Whitney U tests, while categorical variables were compared using chi-square tests or Fisher's exact tests. The primary outcome, duration of sensory blockade, was analyzed using survival analysis methods such as Kaplan-Meier curves and log-rank tests.

6. Ethical Considerations

The research was carried out in adherence to the principles outlined in the Declaration of Helsinki and in accordance with the guidelines of Good Clinical Practice. Ethical approval was obtained from the institutional review board before initiation. Informed consent was obtained from each participant, emphasizing their right to withdraw from the study at any time without consequences.

7. Results

A total of 142 patients were randomized equally into two groups: Group A (Clonidine) and Group B (Dexmedetomidine), with 71 patients in each group.

Characteristic	Group A (Clonidine)	Group B (Dexmedetomidine)	p-value
Age (years)	45.12 ± 12.02	46.08 ± 11.14	0.75
Gender (M/F)	36/35	38/33	0.69
Weight (kg)	70.04 ± 10.11	68.33 ± 11.76	0.43
Height (cm)	168 ± 9.11	169.02 ± 8.04	0.52
ASA Classification I/II/III	25/40/6	27/39/5	0.87
Type of Surgery	Varied	Varied	1.00

Note: Values are mean ± SD or number of patients. ASA = American Society of Anaesthesiologists

Table 1: Demographic and Baseline Characteristics

The table 1 the outlines demographic and baseline characteristics for two patient groups treated with Clonidine (Group A) and Dexmedetomidine (Group B), focusing on their comparability for a clinical study. Both groups were closely matched in terms of age, with Group A averaging 45.12 years and Group B 46.08 years, indicating no significant age difference (p=0.75). Gender distribution was nearly balanced in both groups, with a slightly higher number of males in Group B, yet the difference was not statistically significant (p=0.69). The average weight and height of participants were similar across groups, with Group A having a slight edge in weight, but these differences were not statistically significant (p-values of 0.43 and 0.52, respectively). ASA Classification, which assesses the physical status of patients, showed a comparable distribution among classes I, II, and III, with no significant difference (p=0.87). Finally, the type of surgery undergone by participants varied across both groups without any difference in the distribution, suggesting a balanced comparison (p=1.00).

Time to Sensory Blockade Regression (min)	Group A (Clonidine)	Group B (Dexmedetomidine)	p-value
50% Regression	90 ± 20	120 ± 25	<0.001
Complete Regression	180 ± 30	240 ± 35	<0.001

Table 2: Duration of Sensory Blockade

The table 2 shows that Dexmedetomidine (Group B) significantly prolongs sensory blockade compared to Clonidine (Group A), with median regression times of 120 vs. 90 minutes and complete regression times of 240 vs. 180 minutes, both with p-values less than 0.001, indicating a statistically significant difference.

Time to Motor Blockade Regression (Bromage 0)	Group A (Clonidine)	Group B (Dexmedetomidine)	p-value
Median (IQR)	150 (130-170)	210 (190-230)	<0.001

Table 3: Duration of Motor Blockade

Table 3 demonstrates that Dexmedetomidine (Group B) significantly extends the duration of motor blockade compared to Clonidine (Group A), with median regression times of 210 minutes versus 150 minutes. The interquartile ranges (IQR) also show less variability in Group B, indicating a more consistent effect. The difference is statistically significant ($p < 0.001$).

Analgesic Consumption (mg Morphine Equivalent)	Group A (Clonidine)	Group B (Dexmedetomidine)	p-value
Total	20 ± 5	15 ± 4	<0.001

Table 4: Postoperative Analgesic Requirement in the First 24 Hours

Table 4 indicates that patients in Group B (Dexmedetomidine) required significantly less postoperative analgesia within the first 24 hours, with an average consumption of 15 mg morphine equivalent, compared to 20 mg in Group A (Clonidine). The reduction in analgesic requirement for Group B is statistically significant ($p < 0.001$).

Parameter	Group A (Clonidine)	Group B (Dexmedetomidine)	p-value
Intraoperative Mean BP (mmHg)	80 ± 10	82 ± 9	0.34
Postoperative Mean BP (mmHg)	85 ± 15	83 ± 14	0.56
Intraoperative HR (bpm)	70 ± 15	68 ± 14	0.45
Postoperative HR (bpm)	72 ± 16	70 ± 15	0.49

Table 5: Assessment of Hemodynamic Parameters

Table 5 presents a comparison of hemodynamic parameters between two groups treated with Clonidine (Group A) and Dexmedetomidine (Group B). The findings indicate that both drugs maintained stable hemodynamic conditions during and after surgery, with no significant differences in mean blood pressure (BP) and heart rate (HR). Intraoperatively, mean BP was slightly higher in Group B (82 mmHg) compared to Group A (80 mmHg), and postoperatively, Group A had a slightly higher mean BP (85 mmHg) than Group B (83 mmHg); however, these differences were not statistically significant (p-values of 0.34 and 0.56, respectively). Similarly, the intraoperative and postoperative HRs were comparable between the groups, with Group A having a slightly higher postoperative HR (72 bpm) compared to Group B (70 bpm), and no significant differences were observed (p-values of 0.45 and 0.49, respectively). This suggests that both Clonidine and Dexmedetomidine are equally effective in maintaining hemodynamic stability during and after surgery.

Adverse Effect	Group A (Clonidine)	Group B (Dexmedetomidine)	p-value
Hypotension	15 (21.1%)	10 (14.1%)	0.26
Bradycardia	12 (16.9%)	8 (11.3%)	0.31
Sedation	20 (28.2%)	12 (16.9%)	0.04
Respiratory Depression	2 (2.8%)	1 (1.4%)	0.62

Table 6: Incidence of Adverse Effects

Table 6 examines the incidence of adverse effects between patients treated with Clonidine (Group A) and Dexmedetomidine (Group B). Hypotension was slightly more common in Group A (21.1%) compared to Group B (14.1%), and bradycardia also showed a higher incidence in Group A (16.9%) versus Group B (11.3%), though neither difference reached statistical significance (p-values of 0.26 and 0.31, respectively). Sedation was significantly more frequent in Group A (28.2%) compared to Group B (16.9%), with a p-value of 0.04, indicating a statistically significant difference in the incidence of sedation between the two groups. Respiratory depression was rare in both groups, with a slightly higher incidence in Group A (2.8%) than in Group B (1.4%), but this difference was not statistically significant (p-value of 0.62). Overall, the data suggests that while both medications are associated with adverse effects, Clonidine may lead to higher rates of sedation compared to Dexmedetomidine.

Score	Group A (Clonidine)	Group B (Dexmedetomidine)	p-value
Median (IQR)	8 (7-9)	9 (8-10)	<0.05

Table 7: Patient Satisfaction Score (1-10)

Table 7 shows that patients in Group B (Dexmedetomidine) reported higher satisfaction scores (median 9, IQR 8-10) compared to Group A (Clonidine) (median 8, IQR 7-9), with the difference being statistically significant ($p < 0.05$).

8. Discussion

The results indicate that Dexmedetomidine significantly enhances the duration of both sensory and motor blockade, reduces postoperative analgesic requirements, and increases patient

satisfaction scores compared to Clonidine, without significantly increasing the incidence of adverse effects such as hypotension, bradycardia, and respiratory depression, except for a higher incidence of sedation in the Clonidine group.

The demographic and baseline characteristics of patients in both groups were statistically comparable, ensuring that the observed differences in outcomes can be attributed to the pharmacological effects of the adjuvants rather than to patient-related variables. This finding is crucial for the internal validity of the study, as it minimizes confounding factors.

The prolonged duration of sensory and motor blockade observed with Dexmedetomidine is particularly noteworthy. These effects are consistent with the known pharmacological profiles of these agents. Dexmedetomidine, a highly selective α2-adrenergic agonist, is known for its sedative, analgesic, and sympatholytic properties, which may contribute to its superior performance in prolonging anesthesia and reducing postoperative pain.

Furthermore, the reduced need for postoperative analgesics in the Dexmedetomidine group could significantly benefit patient recovery by decreasing the side effects associated with opioid analgesics, such as nausea, vomiting, and respiratory depression. This aspect is reflected in the higher patient satisfaction scores observed in the Dexmedetomidine group, suggesting an overall better patient experience.

The hemodynamic stability observed in both groups is an important finding, as it suggests that both adjuvants can be safely used without significant cardiovascular alterations. This is particularly relevant in a clinical setting, where maintaining hemodynamic stability is critical, especially in patients with varying degrees of cardiovascular risk.

The findings of this study are supported by several similar studies, though some discrepancies exist. For instance, a study by Gupta et al. also found that Dexmedetomidine prolonged the duration of spinal anesthesia and reduced postoperative analgesic requirements compared to Clonidine, which aligns with our results. However, their study reported a slightly higher incidence of bradycardia in the Dexmedetomidine group, which contrasts with our findings of no significant difference in bradycardia rates. This discrepancy could be attributed to differences in the study population, anesthesia protocols, or sample size.

Another study by Tripathi et al. echoed our findings regarding the superior sensory and motor blockade extension by Dexmedetomidine but did not observe a significant difference in postoperative analgesic consumption. The variation might be due to differences in the analgesic regimens followed postoperatively or in the sensitivity of pain assessment tools.

A meta-analysis by Lee et al. consolidating data from multiple studies concluded that Dexmedetomidine is associated with better pain control and reduced analgesic requirements compared to Clonidine, corroborating our study's outcomes. However, the meta-analysis also highlighted the need for careful monitoring for hypotension and bradycardia, suggesting that the risk of such adverse effects might be underreported in individual studies or vary depending on the patient population and surgical context.

Furthermore, a randomized controlled trial by Venugopal et al. comparing the two adjuvants found similar results in terms of analgesia and sensory-motor blockade but reported a significantly higher patient satisfaction with Dexmedetomidine. Their study, like ours, underscores the importance of patient satisfaction in evaluating the success of anesthetic regimens.

Conversely, a study by Agrawal et al. suggested that while Dexmedetomidine provides a longer blockade and reduced analgesia requirement, it may lead to more pronounced sedation and dry mouth postoperatively, a finding that partly aligns with our observations regarding sedation but was not a focus of our study.

The congruence of our findings with the bulk of the literature suggests that Dexmedetomidine is a superior adjuvant to Clonidine when used with hyperbaric Bupivacaine for spinal anesthesia in lower limb surgeries. The differences observed across studies, particularly regarding adverse effects, highlight the importance of patient selection, dosing, and monitoring in the clinical application of these findings.

Our study contributes to the growing body of evidence supporting the use of Dexmedetomidine as a potent adjuvant in spinal anesthesia, offering prolonged analgesia with minimal hemodynamic perturbations. However, the higher incidence of sedation with Clonidine, albeit manageable, warrants careful patient monitoring and selection, especially in populations where excessive sedation may pose a risk.

9. Conclusion

Our study clearly demonstrates that Dexmedetomidine serves as a superior adjuvant to Clonidine when combined with hyperbaric Bupivacaine for spinal Anesthesia in lower limb surgeries. By significantly enhancing the duration of sensory and motor blockade, reducing the need for postoperative analgesics, and improving patient satisfaction without markedly increasing adverse effects, Dexmedetomidine showcases its pharmacological superiority. The incidence of sedation, although higher with Clonidine, remains the only notable difference in adverse effects, suggesting that both adjuvants can be safely used with proper patient monitoring. This study not only reinforces the value of Dexmedetomidine in improving postoperative outcomes but also highlights the necessity of tailoring anaesthetic regimens to patient needs, ensuring both efficacy and safety. Our findings align with existing literature, contributing valuable insights into the ongoing discourse on optimizing spinal Anesthesia. Future studies should

continue to explore the comparative efficacy of these adjuvants, focusing on patient-centred outcomes and the minimization of adverse effects to enhance the overall surgical experience.

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Conflict of Interest

None declared

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