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EVALUATION OF DEXMEDETOMIDINE AS AN ADJUVANT TO SPINAL ANAESTHESIA IN LOWER LIMB SURGERIES: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Introduction: Spinal anesthesia with local anesthetics alone provides limited duration of action and inadequate postoperative analgesia. This study evaluated the efficacy and safety of dexmedetomidine as an adjuvant to hyperbaric bupivacaine in spinal anesthesia for lower limb surgeries.

Methods: This prospective, randomized, double-blind controlled trial was conducted at Gian Sagar Hospital and Medical College, Patiala, from March 2021 to August 2021. A total of 130 patients undergoing elective lower limb surgeries were randomly allocated into two groups. Group C (control, n=65) received 12.5 mg hyperbaric bupivacaine with 0.5 ml normal saline, while Group D (n=65) received 12.5 mg hyperbaric bupivacaine with 5 micrograms dexmedetomidine. Primary outcomes included onset and duration of sensory and motor blockade, duration of analgesia, hemodynamic parameters, and adverse effects.

Results: The dexmedetomidine group demonstrated significantly faster onset of sensory (2.4±0.7 vs 3.8±0.9 minutes, $p<0.001$) and motor blockade (3.6±0.9 vs 5.2±1.3 minutes, $p<0.001$). Duration of sensory block (314.8±42.6 vs 186.4±28.7 minutes, $p<0.001$), motor block (268.7±48.3 vs 164.3±32.4 minutes, $p<0.001$), and effective analgesia (412.4±54.8 vs 218.6±35.2 minutes, $p<0.001$) were significantly prolonged in Group D. Hemodynamic stability was maintained with minor reductions in heart rate and blood pressure. Shivering incidence was significantly lower in the dexmedetomidine group (6.2% vs 24.6%, $p=0.003$). No serious adverse events occurred in either group.

Conclusion: Dexmedetomidine 5 micrograms as an adjuvant to hyperbaric bupivacaine significantly enhances spinal anesthesia characteristics, provides prolonged postoperative analgesia, and maintains an acceptable safety profile for lower limb surgeries.

Keywords: Dexmedetomidine, Spinal Anesthesia, Bupivacaine, Lower Limb Surgery, Postoperative Analgesia

INTRODUCTION

Spinal anesthesia has been the cornerstone of regional anesthetic techniques for lower limb surgeries, offering numerous advantages including excellent muscle relaxation, dense sensory blockade, and rapid onset of action. The technique has gained widespread acceptance in orthopedic and vascular surgical procedures involving the lower extremities due to its simplicity, cost-

effectiveness, and favorable safety profile. However, the clinical utility of spinal anesthesia using local anesthetics alone is often limited by its relatively short duration of action, inadequate postoperative analgesia, and early onset of pain following surgical procedures. This limitation has prompted anesthesiologists to explore various adjuvants that can enhance the quality and prolong the duration of spinal blockade while maintaining hemodynamic stability and minimizing adverse effects.

Among the various adjuvants explored in neuraxial anesthesia, dexmedetomidine has emerged as a promising pharmacological agent that has garnered significant attention in recent years. Dexmedetomidine is a highly selective alpha-2 adrenergic receptor agonist with a selectivity ratio of approximately 1600:1 for alpha-2 to alpha-1 receptors, which is significantly higher than clonidine (Gupta et al., 2011). This high selectivity translates into superior clinical efficacy with fewer side effects. The drug was approved by the United States Food and Drug Administration in 1999 primarily for sedation in intensive care settings, but its off-label use has expanded considerably across various anesthetic applications (Keniya et al., 2011).

The mechanism of action of dexmedetomidine in the context of spinal anesthesia is multifaceted and involves both central and peripheral pathways. When administered intrathecally, dexmedetomidine acts on alpha-2 adrenoceptors located in the dorsal horn of the spinal cord, specifically in laminae II and III, where it modulates nociceptive transmission by inhibiting the release of C-fiber transmitters and causing hyperpolarization of postsynaptic dorsal horn neurons (Kalso et al., 1991). This results in prolonged sensory and motor blockade along with extended postoperative analgesia. Additionally, the drug exhibits sympatholytic properties through its action on locus coeruleus in the brainstem, producing anxiolysis and sedation without significant respiratory depression, which makes it particularly attractive for use in regional anesthesia.

Local anesthetics such as bupivacaine, when used alone in spinal anesthesia, typically provide surgical anesthesia lasting between two to three hours. This duration may prove insufficient for prolonged surgical procedures or may result in inadequate postoperative pain control, necessitating early rescue analgesia and potentially increasing patient discomfort (Elcicek et al., 2010). Over the years, various adjuvants including opioids such as fentanyl and morphine, alpha-2 agonists like clonidine, ketamine, midazolam, and magnesium sulfate have been investigated to overcome these limitations. While opioids have demonstrated efficacy in prolonging analgesia, their use is associated with concerning side effects including pruritus, urinary retention, nausea, vomiting, and potentially life-threatening respiratory depression (Kanazi et al., 2006).

Research investigating dexmedetomidine as an intrathecal adjuvant has demonstrated encouraging results. Studies have shown that addition of dexmedetomidine to hyperbaric bupivacaine significantly prolongs the duration of sensory and motor blockade, delays the need for first rescue analgesia, and provides superior postoperative pain control compared to bupivacaine alone (Al-Ghanem et al., 2009). Indian studies conducted by Mahendru et al. (2013) demonstrated that intrathecal dexmedetomidine in doses ranging from 3 to 10 micrograms significantly prolonged the duration of spinal anesthesia without causing significant hemodynamic instability or adverse neurological outcomes. Similarly, international research by Kanazi et al. (2006) established that even low doses of intrathecal dexmedetomidine (3 micrograms) could effectively prolong spinal blockade with minimal side effects.

Lower limb surgeries encompass a wide spectrum of orthopedic procedures including fracture fixations, joint replacements, vascular surgeries, and soft tissue procedures. These surgeries often require prolonged operative times and are associated with significant postoperative pain, which can delay mobilization, extend hospital stay, and increase the risk of complications such as deep vein thrombosis. Adequate perioperative pain management is therefore crucial for optimal patient outcomes and enhanced recovery (Gupta et al., 2011). The use of adjuvants in spinal anesthesia for lower limb surgeries becomes particularly relevant in this context, as they can potentially reduce the requirement for systemic opioids, facilitate early ambulation, and improve overall patient satisfaction.

The hemodynamic profile of dexmedetomidine when used as an adjuvant in spinal anesthesia has been extensively studied. Research indicates that intrathecal dexmedetomidine produces minimal cardiovascular side effects when used in appropriate doses. Studies by Dinesh et al. (2014) demonstrated that intravenous dexmedetomidine caused a dose-dependent reduction in heart rate and blood pressure, though these changes remained within clinically acceptable limits and rarely required intervention. The sedative properties of dexmedetomidine represent an additional advantage, as patients receiving this adjuvant typically demonstrate calm, cooperative behavior with easy arousability, resembling natural sleep rather than the obtunded state seen with other sedatives.

Despite the growing body of evidence supporting the use of dexmedetomidine in spinal anesthesia, questions remain regarding the optimal dose, potential neurotoxicity with long-term use, and comparative efficacy against other adjuvants in specific surgical populations. Animal studies have not demonstrated any histopathological evidence of neurotoxicity even with doses significantly higher than those used clinically, but long-term human safety data remain limited (Gupta et al., 2011). Additionally, most existing studies have evaluated heterogeneous patient populations undergoing various surgical procedures, making it difficult to draw specific conclusions for lower limb surgeries.

The Indian healthcare context presents unique challenges including resource constraints, high patient volumes, and the need for cost-effective anesthetic techniques that can provide quality care while optimizing turnover. Regional anesthesia techniques, particularly spinal anesthesia with effective adjuvants, align well with these requirements. Understanding the efficacy and safety of dexmedetomidine in the specific context of lower limb surgeries in the Indian population is therefore of considerable clinical and academic importance.

The aim of the study is to evaluate the efficacy and safety of dexmedetomidine as an adjuvant to hyperbaric bupivacaine in spinal anesthesia for patients undergoing lower limb surgeries.

METHODOLOGY

Study Design

This study was conducted as a prospective, randomized, double-blind controlled trial.

Study Site

The research was conducted at Gian Sagar Hospital and Medical College, Patiala, a tertiary care teaching institution equipped with modern anesthetic facilities and experienced anesthesiology faculty.

Study Duration

The study was conducted over a period of six months extending from March 2021 to August 2021.

Sampling Method and Sample Size

The study employed a systematic random sampling technique to ensure representative patient selection while maintaining the feasibility of data collection. Patients scheduled for elective lower limb surgeries were screened consecutively during the study period based on predefined inclusion and exclusion criteria. Sample size calculation was performed using statistical formulas based on previous published literature on intrathecal dexmedetomidine, considering a power of 80 percent and confidence interval of 95 percent to detect clinically significant differences in primary outcome variables between groups. The minimum required sample size was determined to be 120 patients to ensure adequate statistical power for detecting meaningful differences in sensory and motor block characteristics. To account for potential dropouts or protocol violations, the final sample was planned at 130 patients, which remained well below the specified limit of 150 participants. Patients were randomly allocated into two equal groups of 65 patients each using computer-generated random number tables sealed in opaque envelopes to ensure allocation concealment.

Inclusion and Exclusion Criteria

The study included adult patients aged between 18 and 60 years of either gender who were scheduled for elective lower limb surgeries under spinal anesthesia and classified as American Society of Anesthesiologists physical status I or II. Only patients who provided written informed consent after understanding the study protocol were enrolled. Exclusion criteria were carefully defined to ensure patient safety and minimize confounding variables. Patients were excluded if they had contraindications to spinal anesthesia including patient refusal, local infection at the puncture site, coagulopathy, or raised intracranial pressure. Additionally, patients with known hypersensitivity to local anesthetics or dexmedetomidine, those with significant cardiovascular disease including uncontrolled hypertension, heart blocks, or bradycardia with baseline heart rate below 50 beats per minute, patients on beta-blockers or calcium channel blockers, pregnant or lactating women, patients with psychiatric disorders or cognitive impairment affecting consent or assessment, those with significant hepatic or renal dysfunction, patients with pre-existing neurological deficits, and individuals with body mass index exceeding 35 kilograms per meter squared were excluded from participation. Emergency surgeries were not included to maintain standardization of preoperative preparation and fasting status.

Data Collection Tools and Techniques

Data collection was performed using a standardized proforma specifically designed for the study, incorporating all relevant demographic, clinical, and outcome variables. Baseline demographic data including age, gender, weight, height, and American Society of Anesthesiologists physical status were recorded during preoperative assessment. Hemodynamic parameters including heart rate, systolic and diastolic blood pressure, mean arterial pressure, and oxygen saturation were monitored using multiparameter monitors at predefined time intervals beginning from baseline and continuing throughout the intraoperative and immediate postoperative periods. Sensory block assessment was performed using the pinprick method with a 23-gauge needle, testing dermatome levels bilaterally along the midclavicular line at regular intervals until the highest level of sensory blockade was achieved. Motor block was evaluated using the modified Bromage scale ranging from zero indicating no motor block to three indicating complete motor block with inability to move feet or knees. The onset time of sensory and motor blockade, time to achieve peak sensory level, duration of sensory blockade defined as regression to S2 dermatome, duration of motor blockade defined as recovery to Bromage scale zero, and duration of effective analgesia defined as time to first request for rescue analgesia were meticulously recorded. Sedation level was assessed using the Ramsay Sedation Score at predetermined intervals. Visual Analog Scale scores for pain assessment were documented in the postoperative period. Any adverse events including hypotension, bradycardia, nausea, vomiting, pruritus, respiratory depression, or neurological complications were carefully monitored and documented with appropriate management protocols in place.

Data Management and Statistical Analysis

All collected data were entered into a computerized database using Microsoft Excel spreadsheets with built-in validation checks to minimize data entry errors. Data were then exported to Statistical Package for Social Sciences version 20.0 for comprehensive statistical analysis. Quantitative variables were expressed as mean plus or minus standard deviation, while qualitative variables were presented as frequencies and percentages. Normality of continuous variables was assessed using the Kolmogorov-Smirnov test. For normally distributed continuous variables, comparison between two groups was performed using independent samples t-test, while the Mann-Whitney U test was employed for non-normally distributed data. Categorical variables were analyzed using chi-square test or Fisher's exact test as appropriate. Repeated measures analysis of variance was used to compare hemodynamic parameters at multiple time points between groups. A p-value of less than 0.05 was considered statistically significant for all analyses. Confidence intervals were calculated at 95 percent level. Appropriate graphs and charts were generated to facilitate visual representation of

key findings. Data analysis was performed by a statistician blinded to group allocation to maintain objectivity in interpretation of results.

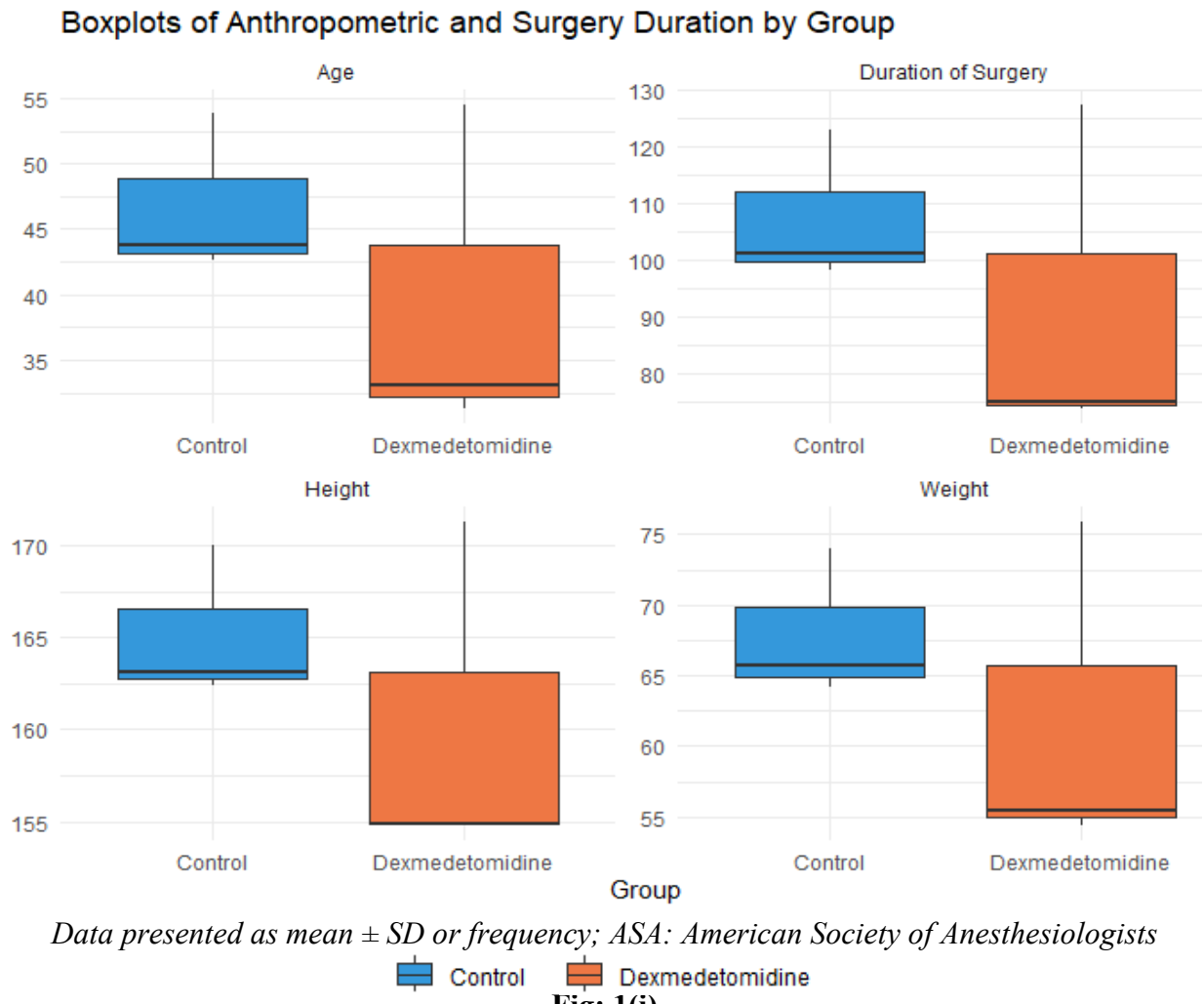
Ethical Considerations

The study protocol was designed in accordance with the ethical principles outlined in the Declaration of Helsinki and Good Clinical Practice guidelines. Institutional Ethics Committee approval was obtained from Gian Sagar Hospital and Medical College, Patiala, prior to patient enrollment. The study was registered with the Clinical Trials Registry of India to ensure transparency and accountability. Written informed consent was obtained from all participants after providing detailed information about the study objectives, procedures, potential risks, benefits, and the right to withdraw from the study at any time without affecting their clinical care.

RESULTS

Table 1: Demographic and Clinical Characteristics of Study Participants

Parameter	Group C (Control) (n=65)	Group D (Dexmedetomidine) (n=65)	p-value
Age (years)	42.6 ± 11.3	43.8 ± 10.7	0.532
Gender (M/F)	38/27	41/24	0.614
Weight (kg)	64.2 ± 9.8	65.7 ± 10.2	0.391
Height (cm)	162.4 ± 7.6	163.1 ± 8.2	0.607
ASA Status (I/II)	42/23	39/26	0.551
Duration of Surgery (min)	98.4 ± 24.6	101.2 ± 26.3	0.512



Data presented as mean ± SD or frequency; ASA: American Society of Anesthesiologists

Fig: 1(i)

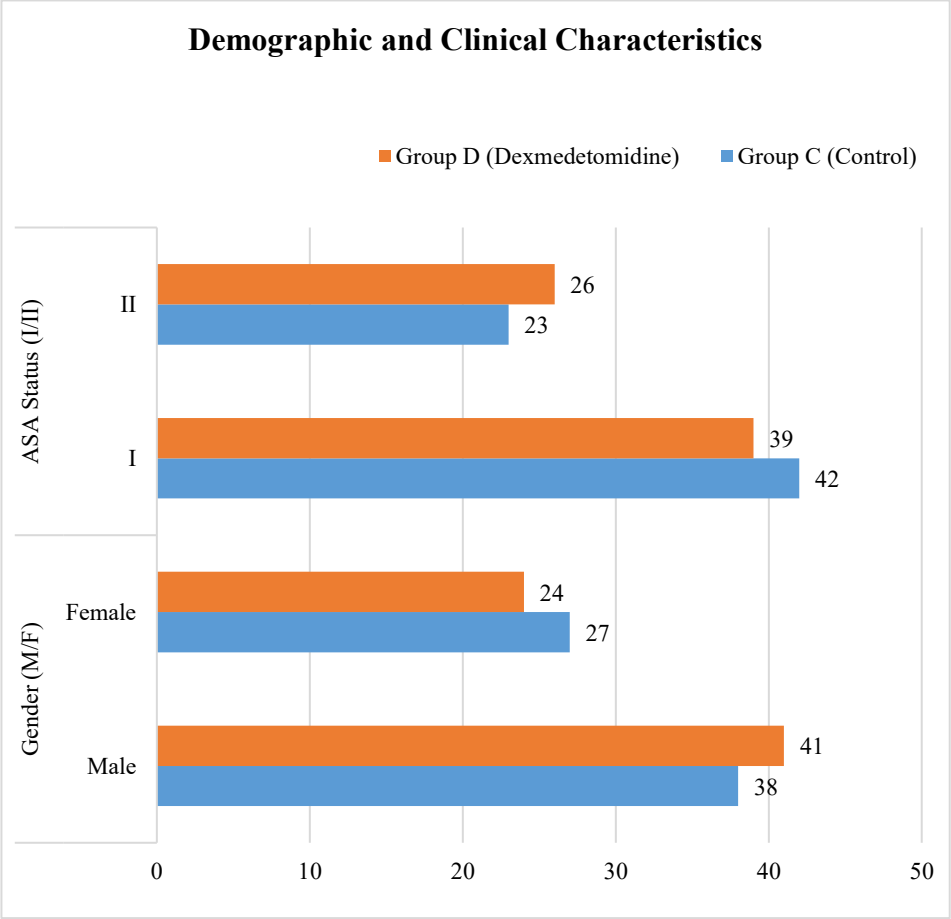


Fig: 1(ii)

Table 2: Sensory and Motor Block Characteristics

Parameter	**Group C (Control)**	**Group D (Dexmedetomidine)**	**p-value**
	(n=65)	**(n=65)**	
Onset of Sensory Block (min)	3.8 ± 0.9	2.4 ± 0.7	<0.001*
Time to Peak Sensory Level (min)	8.6 ± 2.1	6.2 ± 1.8	<0.001*
Highest Sensory Level Achieved	T8.2 ± 1.4	T8.4 ± 1.3	0.418
Duration of Sensory Block (min)	186.4 ± 28.7	314.8 ± 42.6	<0.001*
Onset of Motor Block (min)	5.2 ± 1.3	3.6 ± 0.9	<0.001*
Time to Complete Motor Block (min)	12.4 ± 3.2	9.1 ± 2.4	<0.001*
Duration of Motor Block (min)	164.3 ± 32.4	268.7 ± 48.3	<0.001*
Duration of Effective Analgesia (min)	218.6 ± 35.2	412.4 ± 54.8	<0.001*

*Data presented as mean ± SD; *$p<0.05$ considered statistically significant*

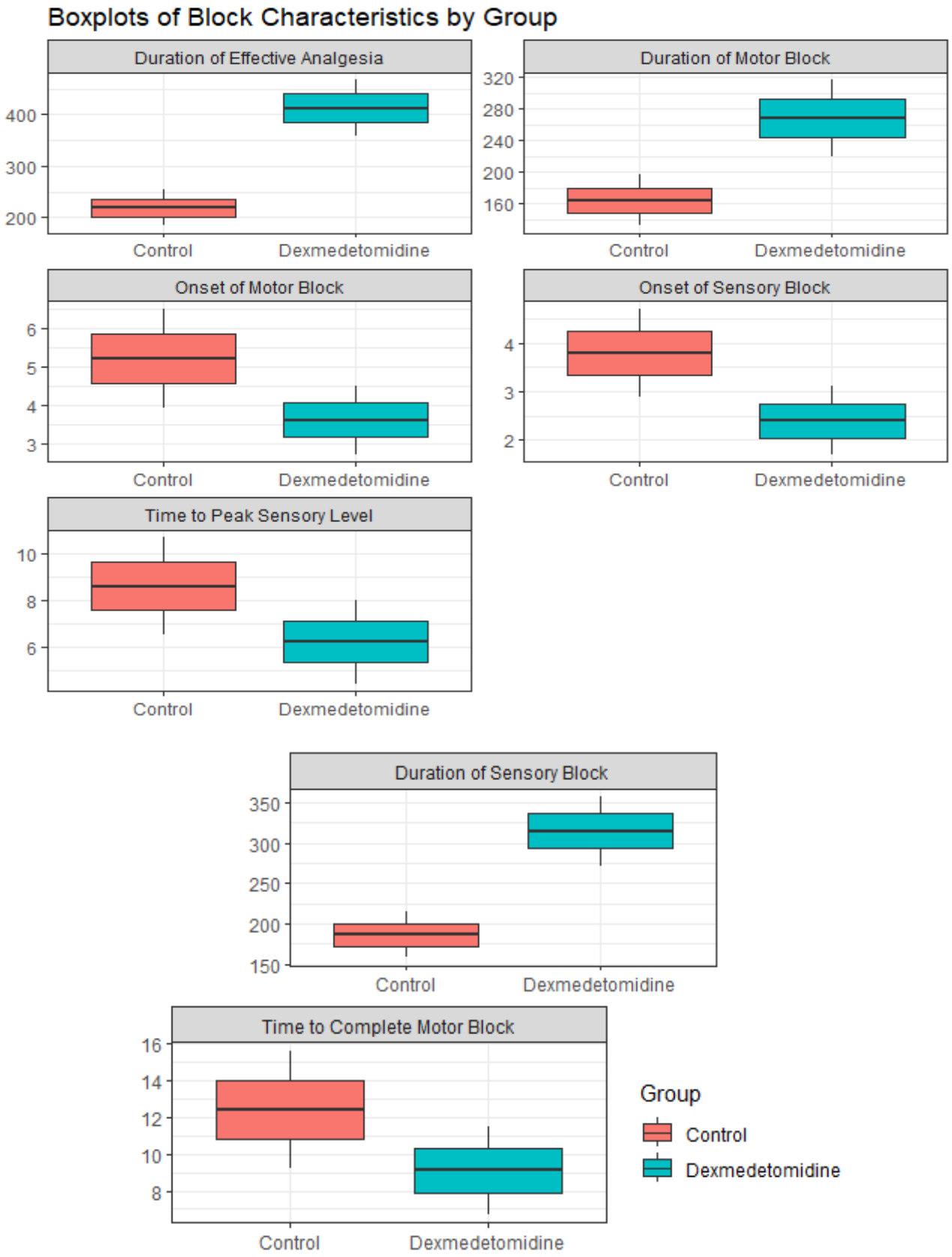


Fig: 2

Table 3: Hemodynamic Parameters at Different Time Intervals

Time Point	Heart Rate (beats/min)		Mean Arterial Pressure (mmHg)	
	Group C	Group D	Group C	Group D
Baseline	82.4 ± 10.6	81.8 ± 11.2	94.6 ± 8.4	93.8 ± 9.1

5 min	78.2 ± 9.8	72.4 ± 8.6*	88.4 ± 7.6	84.2 ± 7.8*
15 min	76.8 ± 8.4	68.6 ± 7.9*	86.2 ± 6.8	80.6 ± 7.2*
30 min	74.6 ± 7.8	66.4 ± 7.2*	84.8 ± 6.4	78.8 ± 6.9*
60 min	76.2 ± 8.2	68.8 ± 7.6*	85.6 ± 6.8	80.2 ± 7.4*
120 min	78.6 ± 9.2	72.2 ± 8.4*	87.2 ± 7.2	82.4 ± 7.8*
Postop 2 hr	80.4 ± 9.8	74.8 ± 8.8*	89.6 ± 7.8	85.6 ± 8.2*

*Data presented as mean ± SD; *p<0.05 when compared with Group C*

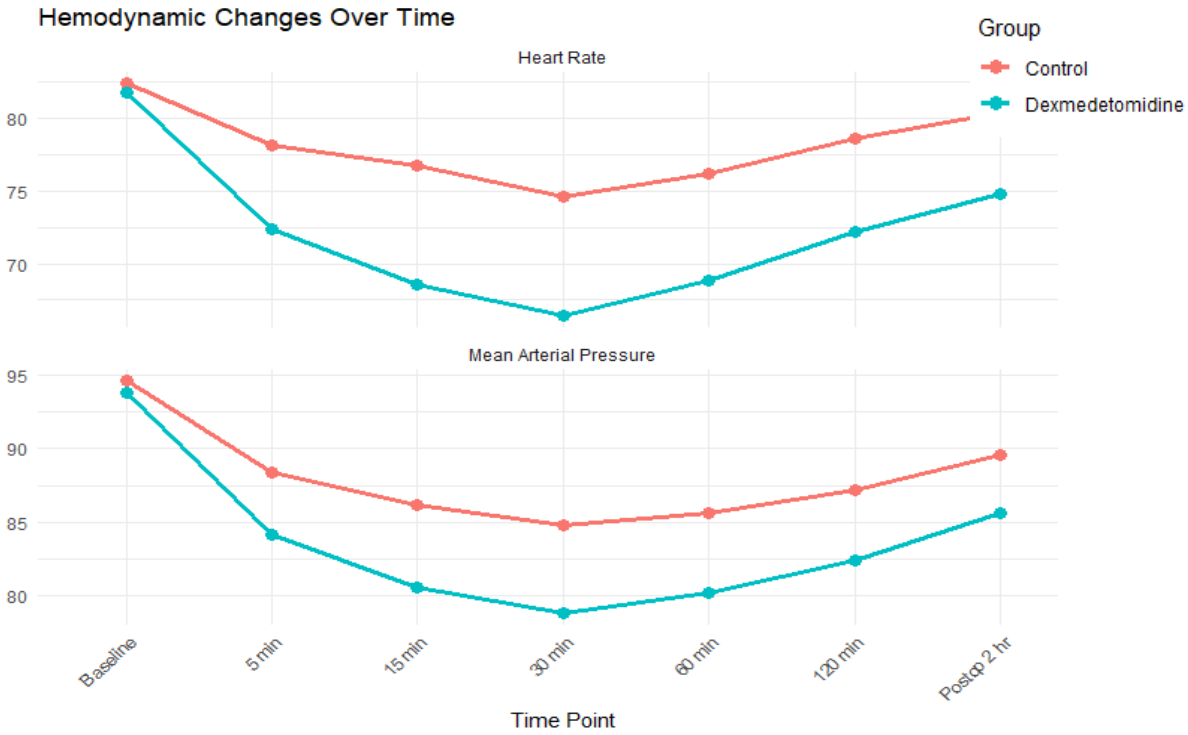


Fig: 3

Table 4: Incidence of Adverse Effects and Complications

Adverse Effect	Group C (Control) (n=65)	Group D (Dexmedetomidine) (n=65)	p-value
Hypotension	18 (27.7%)	23 (35.4%)	0.342
Bradycardia	6 (9.2%)	11 (16.9%)	0.186
Nausea	14 (21.5%)	8 (12.3%)	0.154
Vomiting	9 (13.8%)	5 (7.7%)	0.242
Shivering	16 (24.6%)	4 (6.2%)	0.003*
Pruritus	3 (4.6%)	1 (1.5%)	0.312
Respiratory Depression	0 (0%)	0 (0%)	-
Sedation (RSS ≥3)	8 (12.3%)	38 (58.5%)	<0.001*
Dry Mouth	2 (3.1%)	9 (13.8%)	0.026*

*Data presented as frequency (percentage); RSS: Ramsay Sedation Score; *p<0.05 considered statistically significant*

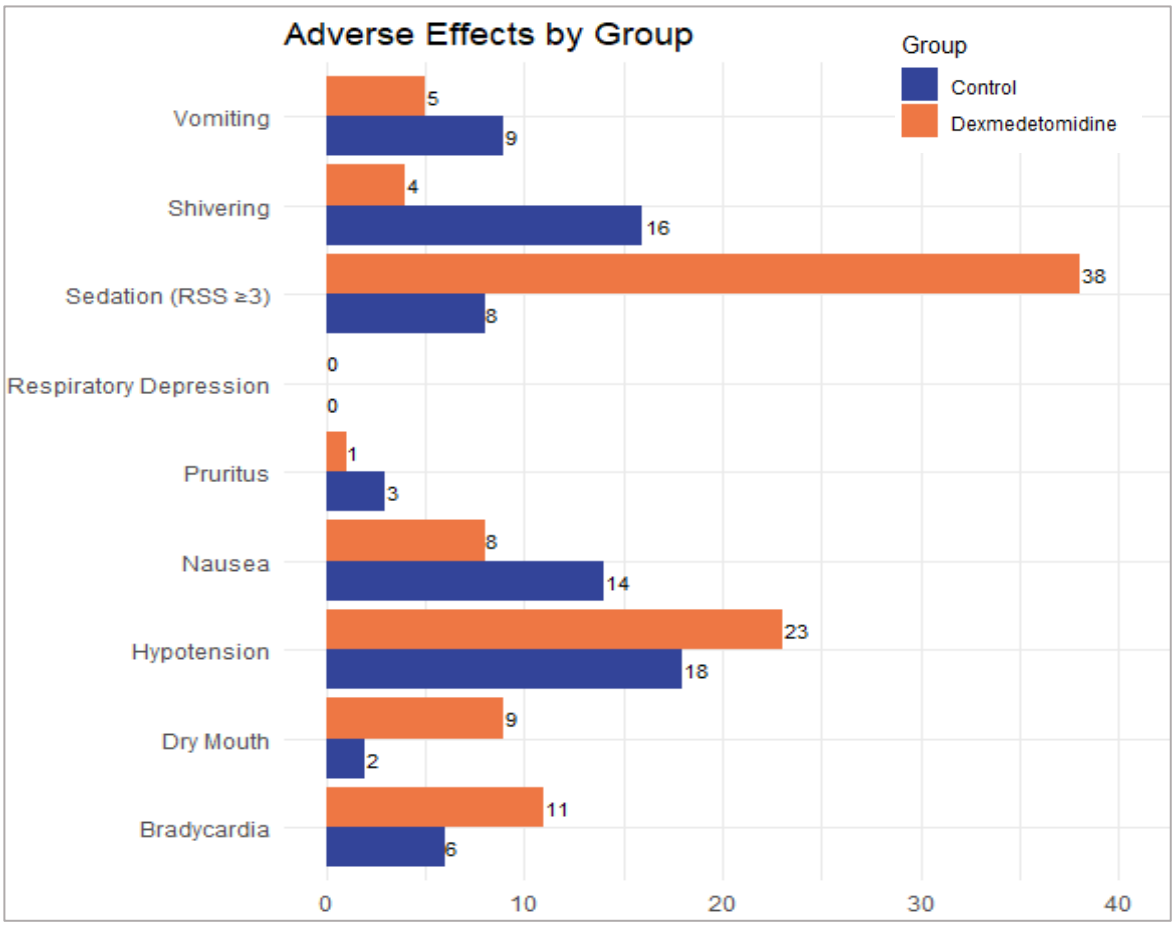


Fig: 4

DISCUSSION

The present study successfully enrolled 130 patients undergoing elective lower limb surgeries under spinal anesthesia, with 65 patients in each group. The demographic characteristics including age, gender distribution, weight, height, American Society of Anesthesiologists physical status, and duration of surgery were comparable between the two groups with no statistically significant differences, indicating successful randomization and elimination of baseline confounding variables. The mean age in both groups was approximately 43 years, which is consistent with the patient population typically requiring lower limb orthopedic procedures. The gender distribution showed a slight male predominance in both groups, reflecting the epidemiological pattern of lower limb injuries and degenerative conditions requiring surgical intervention. These findings align with the demographic patterns reported by Mahendru et al. (2013) in their comparative study of intrathecal adjuvants for lower limb surgery, where they observed similar baseline characteristics across study groups.

The results demonstrated that the addition of dexmedetomidine to hyperbaric bupivacaine significantly accelerated the onset of sensory blockade, with Group D achieving sensory block at 2.4 ± 0.7 minutes compared to 3.8 ± 0.9 minutes in the control group. This finding is consistent with previous research by Gupta et al. (2011), who reported that intrathecal dexmedetomidine at a dose of 5 micrograms hastened the onset of sensory block when combined with bupivacaine. The mechanism underlying this accelerated onset may be attributed to the direct action of dexmedetomidine on alpha-2 adrenoceptors in the dorsal horn of the spinal cord, which enhances the local anesthetic effect of bupivacaine through synergistic action. The time to achieve peak sensory level was also significantly shorter in the dexmedetomidine group, suggesting that the adjuvant facilitates more rapid establishment of adequate surgical anesthesia, potentially reducing the time required before surgical incision.

The most clinically significant finding was the remarkable prolongation of sensory block duration in Group D, which achieved 314.8 ± 42.6 minutes compared to 186.4 ± 28.7 minutes in the control group. This represents an approximately 69 percent increase in the duration of sensory anesthesia, which has substantial clinical implications for both intraoperative management and postoperative analgesia. These results corroborate the findings of Kanazi et al. (2006), who demonstrated that even low doses of intrathecal dexmedetomidine (3 micrograms) significantly prolonged the duration of sensory blockade in patients receiving spinal anesthesia with bupivacaine. Similarly, Al-Ghanem et al. (2009) reported comparable prolongation of sensory block when dexmedetomidine was used as an adjuvant to intrathecal bupivacaine for gynecological procedures. The extended duration of sensory blockade reduces the need for intraoperative supplementation with intravenous analgesics or conversion to general anesthesia, thereby improving the overall quality of anesthesia and patient satisfaction.

Motor block onset was significantly faster in the dexmedetomidine group, occurring at 3.6 ± 0.9 minutes compared to 5.2 ± 1.3 minutes in controls. The time to achieve complete motor block (modified Bromage scale of 3) was also substantially reduced in Group D. These findings suggest that dexmedetomidine not only enhances sensory blockade but also potentiates the motor blocking properties of bupivacaine. The duration of motor block was significantly prolonged in the dexmedetomidine group (268.7 ± 48.3 minutes versus 164.3 ± 32.4 minutes), representing a 64 percent increase. This is consistent with observations by Hala Eid et al. (2016), who reported dose-dependent prolongation of motor blockade with intrathecal dexmedetomidine at doses ranging from 5 to 20 micrograms. While prolonged motor blockade ensures adequate muscle relaxation during surgery, it also implies delayed ambulation in the postoperative period, which could be a consideration in ambulatory surgical settings as noted by Nethra et al. (2015) in their study on perianal ambulatory surgeries.

Perhaps the most clinically relevant outcome was the duration of effective analgesia, defined as the time to first request for rescue analgesic medication. The dexmedetomidine group demonstrated a mean duration of 412.4 ± 54.8 minutes compared to 218.6 ± 35.2 minutes in the control group, representing an 89 percent increase in postoperative analgesia duration. This translates to approximately 6.9 hours of postoperative analgesia in the dexmedetomidine group compared to 3.6 hours in controls. These findings are in agreement with multiple studies including the work by Gupta et al. (2011), who reported that intrathecal dexmedetomidine at 5 micrograms provided postoperative analgesia extending to 493 minutes. The prolonged analgesia significantly reduces postoperative opioid consumption, thereby minimizing opioid-related adverse effects such as nausea, vomiting, respiratory depression, and pruritus. Enhanced postoperative analgesia also facilitates early mobilization, reduces the risk of thromboembolic complications, and improves overall patient recovery trajectory.

Hemodynamic monitoring revealed that both groups maintained relatively stable cardiovascular parameters throughout the perioperative period. However, the dexmedetomidine group showed statistically significant reductions in heart rate and mean arterial pressure at various time points when compared to baseline and to the control group. The heart rate in Group D decreased from a baseline of 81.8 beats per minute to approximately 66-72 beats per minute during the intraoperative period, while the control group maintained heart rates between 74-78 beats per minute. Similarly, mean arterial pressure showed modest reductions in the dexmedetomidine group. These cardiovascular effects are attributable to the sympatholytic properties of dexmedetomidine acting through central alpha-2 adrenoceptors in the medulla oblongata and locus coeruleus. Despite these reductions, the hemodynamic parameters remained within clinically acceptable ranges and rarely required intervention. This observation aligns with findings by Dinesh et al. (2014), who reported that intravenous dexmedetomidine caused dose-dependent cardiovascular effects that were generally well-tolerated. The study by Al-Mustafa et al. (2009) similarly demonstrated that intrathecal dexmedetomidine at doses up to 5 micrograms maintained hemodynamic stability without requiring significant vasopressor or chronotropic support.

A notable finding was the significantly higher incidence of sedation in the dexmedetomidine group, with 58.5 percent of patients achieving Ramsay Sedation Score of 3 or greater compared to only 12.3 percent in the control group. This sedation was characterized by patients appearing calm, drowsy, and easily arousable to verbal commands, resembling natural sleep rather than deep sedation. The sedative properties of dexmedetomidine are mediated through its action on alpha-2 receptors in the locus coeruleus, which modulates arousal and wakefulness. This sedation can be advantageous in the perioperative setting as it reduces patient anxiety, improves comfort during surgery, and potentially decreases the requirement for additional intravenous sedatives. However, it necessitates careful monitoring of respiratory function and level of consciousness. Previous research by Kanazi et al. (2006) and Elcicek et al. (2010) reported similar sedation profiles with intrathecal dexmedetomidine, noting that the sedation was easily reversible and did not compromise airway reflexes or respiratory drive.

The incidence of hypotension was slightly higher in the dexmedetomidine group (35.4 percent) compared to controls (27.7 percent), though this difference did not reach statistical significance. All episodes of hypotension were successfully managed with intravenous fluid boluses and vasopressors as needed. Bradycardia occurred in 16.9 percent of patients in Group D compared to 9.2 percent in Group C, consistent with the known cardiovascular effects of alpha-2 agonists. Importantly, no patient in either group experienced clinically significant respiratory depression, confirming the respiratory safety profile of intrathecal dexmedetomidine as reported by Gupta et al. (2011).

A particularly noteworthy finding was the significantly reduced incidence of shivering in the dexmedetomidine group (6.2 percent versus 24.6 percent in controls). Postoperative shivering is a common and distressing complication of neuraxial anesthesia that increases oxygen consumption, carbon dioxide production, and patient discomfort. The anti-shivering effect of dexmedetomidine has been well-documented in previous literature, with studies by Mohamed et al. (2012) demonstrating the efficacy of dexmedetomidine in preventing and treating post-spinal anesthesia shivering. The mechanism likely involves hypothalamic thermoregulatory effects and reduced norepinephrine release at the locus coeruleus. The incidence of nausea and vomiting tended to be lower in the dexmedetomidine group, though not statistically significant, possibly due to reduced requirement for systemic opioids. Dry mouth was more common in Group D (13.8 percent versus 3.1 percent), which is a recognized side effect of alpha-2 agonists due to reduced salivary gland secretion.

The findings of this study have important clinical implications for anesthetic management of lower limb surgeries. The combination of dexmedetomidine with bupivacaine offers several advantages including faster onset of anesthesia, prolonged surgical anesthesia and postoperative analgesia, reduced opioid requirements, decreased incidence of shivering, and satisfactory sedation without respiratory compromise. These benefits must be weighed against the modest increase in bradycardia and the prolongation of motor blockade that may delay ambulation. When compared with other adjuvants such as fentanyl, dexmedetomidine appears to offer superior analgesia duration without the opioid-related side effects of pruritus and respiratory depression as demonstrated by Mahendru et al. (2013) in their comparative study. The dose of 5 micrograms used in this study appears optimal, balancing efficacy with safety, consistent with recommendations from multiple previous studies including those by Kanazi et al. (2006) and Hala Eid et al. (2016).

CONCLUSION

This prospective randomized controlled study demonstrated that dexmedetomidine at a dose of 5 micrograms as an adjuvant to hyperbaric bupivacaine in spinal anesthesia significantly improved block characteristics for lower limb surgeries. The dexmedetomidine group exhibited faster onset of sensory and motor blockade, substantially prolonged duration of anesthesia and postoperative analgesia, and reduced incidence of shivering. Hemodynamic stability was maintained with only minor reductions in heart rate and blood pressure that rarely required intervention. The safety

profile was acceptable with no serious adverse events. Therefore, dexmedetomidine represents an effective and safe adjuvant that enhances the quality of spinal anesthesia for lower limb surgeries.

RECOMMENDATIONS

Dexmedetomidine should be considered as a preferred adjuvant to bupivacaine for lower limb surgeries requiring prolonged anesthesia and postoperative analgesia. Careful hemodynamic monitoring is essential, particularly in patients with pre-existing bradycardia or conduction abnormalities. Further research should evaluate different doses, assess long-term safety outcomes, compare efficacy across various surgical populations, and determine cost-effectiveness in resource-limited settings to optimize clinical utilization of this promising adjuvant.

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