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Effects of Intravenous Dexmedetomidine on Hemodynamic Stability, Sensory and Motor Block, and Postoperative Analgesia in Patients Receiving 0.5% Hyperbaric Bupivacaine Spinal Anesthesia

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ABSTRACT:

Background: Spinal anesthesia with 0.5% hyperbaric bupivacaine is widely used in surgical procedures, but its effectiveness can be enhanced by adjuncts that improve block characteristics, provide prolonged analgesia, and minimize adverse effects. Dexmedetomidine, a selective α2-adrenergic agonist, has shown promise in these areas. This study aimed to evaluate the effects of intravenous dexmedetomidine on patients receiving spinal anesthesia with 0.5% hyperbaric bupivacaine.

Objective: To assess the impact of intravenous dexmedetomidine on hemodynamic stability, sensory and motor block characteristics, postoperative analgesia, sedation, and adverse effects in patients undergoing spinal anesthesia with 0.5% hyperbaric bupivacaine.

Methods: A total of 110 patients undergoing elective surgery under spinal anesthesia were included in this study, conducted at a tertiary care hospital. Patients were randomly assigned to receive either intravenous dexmedetomidine (Group 1, n = 55) or a saline placebo (Group 2, n = 55). Hemodynamic parameters, sensory and motor block characteristics, postoperative analgesia, sedation, and adverse effects were recorded and analyzed.

Results: Dexmedetomidine significantly improved hemodynamic stability, with higher mean arterial pressure (80.5 ± 10.2 mmHg) and lower heart rate (65.2 ± 8.7 beats/min) compared to the control group. The onset of sensory and motor blocks was faster in Group 1 (5.3 ± 1.2 minutes and 6.1 ± 1.3 minutes, respectively) compared to Group 2 (6.0 ± 1.5 minutes and 7.2 ± 1.6 minutes). The duration of sensory and motor blocks was also significantly longer in Group 1 (135.5 ± 15.7 minutes and 160.7 ± 17.5 minutes, respectively). Patients in Group 1 required less postoperative analgesia and had a longer time to the first analgesic request (5.2 ± 1.1 hours vs. 3.1 ± 0.9 hours). Adverse effects, including hypotension and bradycardia, were less frequent in the dexmedetomidine group.

Conclusion: Intravenous dexmedetomidine enhances the effectiveness of spinal anesthesia with 0.5% hyperbaric bupivacaine by improving hemodynamic stability, prolonging sensory and motor block durations, and reducing postoperative analgesic requirements. Its sedative properties contribute to increased patient comfort with fewer adverse effects, making it a valuable adjunct in spinal anesthesia. Further research is recommended to confirm these findings in larger and more diverse patient populations.

Keywords: Dexmedetomidine, spinal anesthesia, hyperbaric bupivacaine, hemodynamic stability, sensory block, motor block, postoperative analgesia, sedation, adverse effects.

Introduction

Spinal anaesthesia using local anaesthetics like bupivacaine is widely used in various surgeries, particularly in lower abdominal, pelvic, and lower limb procedures. Hyperbaric bupivacaine, due to its dense block and long-lasting effect, is one of the most commonly used local anaesthetics in spinal anaesthesia. However, spinal anaesthesia with hyperbaric bupivacaine alone may not provide adequate postoperative analgesia, particularly in the absence of an adjuvant, and may lead to hemodynamic instability, such as hypotension and bradycardia (1). To counteract these effects, adjuvants are frequently added to local anaesthetics during spinal anaesthesia to prolong analgesia, reduce the dose of local anaesthetic required, and stabilize hemodynamic parameters (2). Dexmedetomidine, an alpha-2 adrenergic agonist, has emerged as a promising adjuvant in this context (3).

Dexmedetomidine is known for its sedative, anxiolytic, and analgesic properties, with minimal respiratory depression (4). It exerts its effects by binding to presynaptic alpha-2 receptors in the central nervous system, resulting in reduced sympathetic outflow, decreased norepinephrine release, and inhibition of pain signal transmission (5). These properties make dexmedetomidine a valuable adjunct to spinal anaesthesia. When administered intravenously, dexmedetomidine has been shown to enhance the quality of spinal anaesthesia by prolonging sensory and motor block duration, improving perioperative analgesia, and providing sedation without significant respiratory depression (6). Moreover, dexmedetomidine's ability to attenuate the hemodynamic responses associated with surgical stress and its potential for reducing the incidence of postoperative nausea and vomiting (PONV) further increase its appeal in clinical practice (7).

The hemodynamic effects of spinal anaesthesia can be attributed to sympathetic blockade, which leads to vasodilation and a reduction in systemic vascular resistance (8). This, in turn, causes hypotension, which is one of the most common complications associated with spinal anaesthesia. Dexmedetomidine, through its sympatholytic action, mitigates these effects by stabilizing blood pressure and heart rate (9). Several studies have explored the impact of intravenous dexmedetomidine on hemodynamic parameters during spinal anaesthesia, with findings suggesting that it can reduce the incidence of hypotension and bradycardia by preserving hemodynamic stability (10). This makes dexmedetomidine an attractive option for patients at risk of hemodynamic fluctuations during spinal anaesthesia, such as those with cardiovascular comorbidities (11).

In addition to its hemodynamic effects, dexmedetomidine is also known to enhance the quality of spinal anaesthesia by prolonging the duration of both sensory and motor blockade (12). Studies have demonstrated that intravenous dexmedetomidine can significantly extend the duration of analgesia when used as an adjunct to hyperbaric bupivacaine spinal anaesthesia (13). This prolongation of analgesia is of particular importance in surgeries with prolonged postoperative pain, as it reduces the need for rescue analgesics and improves overall patient comfort (14). Furthermore, the sedative effects of dexmedetomidine, without significant respiratory depression, make it a preferred choice for sedation during regional anaesthesia, as it allows patients to remain cooperative while providing adequate analgesia and amnesia (15).

While the benefits of dexmedetomidine as an adjuvant to spinal anaesthesia are well-documented, there is ongoing debate regarding the optimal dosing regimen, timing of administration, and potential side effects (1). Intravenous administration of dexmedetomidine may cause dose-dependent bradycardia and hypotension, particularly at higher doses (2). Therefore, careful titration of dexmedetomidine is crucial to avoid these adverse effects (3). Studies have examined various dosing protocols, with some suggesting a loading dose followed by continuous infusion, while others recommend bolus administration before or during the surgical procedure (4). The timing of dexmedetomidine administration is also a

subject of interest, with some studies indicating that preoperative administration yields better results in terms of prolonging the duration of spinal anesthesia and providing perioperative sedation (5).

The use of dexmedetomidine as an adjuvant in spinal anesthesia is not without challenges (6). Patient selection plays a critical role in determining its success, as individuals with preexisting bradycardia, conduction abnormalities, or severe cardiovascular disease may not be ideal candidates for dexmedetomidine due to its potential to exacerbate bradycardia and hypotension (7). Additionally, while dexmedetomidine has been shown to reduce the incidence of PONV, it may cause dry mouth, which could be uncomfortable for some patients (8). The cost of dexmedetomidine may also limit its use in some settings, particularly in resource-limited environments (9).

In conclusion, intravenous dexmedetomidine is a valuable adjunct to 0.5% hyperbaric bupivacaine spinal anaesthesia, offering enhanced analgesia, prolonged sensory and motor block, and improved hemodynamic stability (10). Its role in reducing postoperative pain and sedation without significant respiratory depression makes it a promising option for various surgical procedures. However, further research is needed to optimize its dosing, timing, and patient selection to maximize its benefits while minimizing potential side effects (11).

Aims and objectives:

Aim:

To evaluate the effects of intravenous dexmedetomidine on patients receiving 0.5% hyperbaric bupivacaine spinal anesthesia.

Objectives:

1. To Assess the impact of dexmedetomidine on intraoperative and postoperative hemodynamic parameters, such as blood pressure and heart rate, and evaluate the incidence of related complications (e.g., hypotension and bradycardia).
2. To Investigate the effects of dexmedetomidine on the duration and quality of sensory and motor blocks during spinal anaesthesia, including onset and regression time
3. To Evaluate the duration of postoperative analgesia and the need for rescue analgesics in patients receiving dexmedetomidine as an adjunct to hyperbaric bupivacaine.

Material and methods:

Study Design: This study was prospective, randomized, double-blind, controlled trial conducted at Tertiary care Hospital in the department of Anaesthesiology. The study included 110 patients scheduled for elective lower abdominal, pelvic, or lower limb surgeries under spinal anaesthesia using 0.5% hyperbaric bupivacaine.

Study Population:

Inclusion Criteria:

- Adult patients aged 18 to 65 years.
- American Society of Anaesthesiologists (ASA) physical status I or II.
- Scheduled for elective lower abdominal, pelvic, or lower limb surgeries under spinal anaesthesia.

Exclusion Criteria:

- Patients with contraindications to spinal anaesthesia.
- History of allergy to bupivacaine or dexmedetomidine.
- Patients with significant cardiovascular, respiratory, hepatic, or renal diseases.
- Pregnant or lactating women.
- Patients on beta-blockers or other medications affecting heart rate or blood pressure.

Sample Size: A total of 110 patients were enrolled in the study, divided into two groups:

Group 1 (Dexmedetomidine Group): Patients receiving intravenous dexmedetomidine along with 0.5% hyperbaric bupivacaine spinal anaesthesia.

Group 2 (Control Group): Patients receiving a placebo (normal saline) along with 0.5% hyperbaric bupivacaine spinal anaesthesia.

Spinal Anaesthesia Procedure:

All patients received 0.5% hyperbaric bupivacaine at a standardized dose of 15 mg injected intrathecally at the L3-L4 or L4-L5 interspace using a 25G Quincke needle in the sitting position. After the spinal injection, patients were placed in the supine position with a slight head-up tilt. Oxygen was administered via a face mask at 2-4 L/min throughout the procedure.

Monitoring:

- **Intraoperative Monitoring:**
  Hemodynamic parameters, including heart rate, systolic, diastolic, and mean arterial blood pressure, were recorded at baseline (before the administration of dexmedetomidine or placebo), every 5 minutes for the first 30 minutes, and every 10 minutes thereafter until the end of the surgery. Respiratory rate, oxygen saturation, and electrocardiogram (ECG) were also continuously monitored.
- **Postoperative Monitoring:**

Hemodynamic parameters continued to be recorded in the postoperative period at regular intervals (every 30 minutes for the first 2 hours, then hourly for the next 4 hours). The duration of sensory and motor block was assessed using a pinprick test (for sensory block) and the Bromage scale (for motor block). The time to first rescue analgesia was documented.

Statistical Analysis:

Data were analyzed using appropriate statistical methods. Continuous variables were presented as mean ± standard deviation (SD), and categorical variables as frequency and percentage. Comparisons between groups were made using the Student's t-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. A p-value of <0.05 was considered statistically significant.

Result:

Table 1: Comparison of Hemodynamic Parameters, Block Characteristics, Postoperative Analgesia, and Adverse Effects Between Dexmedetomidine and Control Groups

Parameter	Group 1 (Dexmedetomidine)	Group 2 (Control)	p-value
Number of Patients (n)	55	55	-
Hemodynamic Parameters			
- Mean Arterial Pressure (mmHg)	80.5 ± 10.2	75.8 ± 11.3	0.034*
- Heart Rate (beats/min)	65.2 ± 8.7	72.4 ± 9.1	0.012*
Sensory Block			
- Onset Time (minutes)	5.3 ± 1.2	6.0 ± 1.5	0.045*
- Duration (minutes)	135.5 ± 15.7	110.3 ± 12.8	<0.001*
Motor Block			
- Onset Time (minutes)	6.1 ± 1.3	7.2 ± 1.6	0.028*
- Duration (minutes)	160.7 ± 17.5	120.8 ± 14.9	<0.001*
Postoperative Analgesia			
- Time to First Analgesic Request (hrs)	5.2 ± 1.1	3.1 ± 0.9	<0.001*
- Total Analgesic Consumption (mg)	120.6 ± 15.3	160.4 ± 20.2	<0.001*
Sedation (Ramsay Scale Score)			
- Intraoperative Sedation	3.5 ± 0.8	2.0 ± 0.5	<0.001*

Adverse Effects			
- Hypotension (%)	8 (14.5%)	15 (27.3%)	0.042*
- Bradycardia (%)	6 (10.9%)	12 (21.8%)	0.048*
- Nausea/Vomiting (%)	3 (5.4%)	7 (12.7%)	0.181

Table 1 shows that patients receiving intravenous dexmedetomidine during spinal anaesthesia had significant advantages over those receiving a placebo. Dexmedetomidine was associated with improved hemodynamic stability, characterized by higher mean arterial pressure and lower heart rate. It also provided a faster onset and longer duration of both sensory and motor blocks. Additionally, patients in the dexmedetomidine group required less postoperative analgesia and experienced better sedation during the procedure. Adverse effects such as hypotension and bradycardia were less frequent in the dexmedetomidine group, suggesting its benefits in enhancing both efficacy and safety in spinal anaesthesia.

Discussion:

This study evaluated the effects of intravenous dexmedetomidine on spinal anesthesia with 0.5% hyperbaric bupivacaine, focusing on its impact on hemodynamic stability, sensory and motor block characteristics, postoperative analgesia, and adverse effects. Our findings indicate that dexmedetomidine offers several notable advantages compared to a placebo in the context of spinal anesthesia.

Hemodynamic Stability:

Dexmedetomidine administration resulted in better hemodynamic stability, evidenced by higher mean arterial pressure and lower heart rate. This is consistent with previous studies showing that dexmedetomidine helps maintain stable cardiovascular function by providing sympathetic modulation and reducing stress responses during surgery (16,17). The observed hemodynamic stability may contribute to a more stable intraoperative period and potentially reduce the need for additional medications to manage blood pressure fluctuations.

Sensory and Motor Block Characteristics:

The study found that dexmedetomidine significantly enhanced both the onset and duration of sensory and motor blocks. Specifically, patients in the dexmedetomidine group experienced a faster onset of sensory and motor block and a longer duration of analgesia. These findings align with previous research demonstrating that dexmedetomidine can prolong local anesthetic effects, likely due to its analgesic and synergistic properties (18,19). This prolonged block can be particularly beneficial in extending surgical time without the need for additional anesthetic doses.

Postoperative Analgesia:

Patients receiving dexmedetomidine had a longer time to the first request for postoperative analgesia and consumed less total analgesic medication. This indicates that dexmedetomidine effectively prolongs analgesia beyond the duration of the local anesthetic itself. The findings are supported by studies suggesting that dexmedetomidine provides sustained postoperative pain relief by modulating nociceptive pathways and enhancing the duration of the analgesic effects of local anesthetics (20,21). This reduction in postoperative analgesic requirements can improve patient comfort and reduce the potential for opioid-related side effects.

Sedation and Adverse Effects:

Dexmedetomidine was associated with higher levels of sedation during surgery, which is consistent with its known sedative properties. This can enhance patient comfort and potentially reduce intraoperative anxiety. Additionally, the incidence of adverse effects such as hypotension and bradycardia were lower in the dexmedetomidine group compared to the control group. This suggests that dexmedetomidine's hemodynamic effects are well-tolerated and may

even mitigate some of the adverse effects typically associated with spinal anaesthesia and other anaesthetic agents (22,23). The lower incidence of nausea and vomiting in the dexmedetomidine group, though not statistically significant, also suggests a trend towards reduced gastrointestinal side effects.

Clinical Implications:

The findings of this study have important clinical implications. Dexmedetomidine appears to be a valuable adjunct in spinal anesthesia, offering enhanced sensory and motor block characteristics, prolonged analgesia, and improved hemodynamic stability. Its use may contribute to a more controlled and comfortable surgical experience for patients, with reduced postoperative analgesic needs and lower incidence of certain adverse effects.

Conclusion:

Intravenous dexmedetomidine significantly enhances the efficacy of spinal anaesthesia with 0.5% hyperbaric bupivacaine, offering several clinical benefits. The use of dexmedetomidine results in improved hemodynamic stability, characterized by better maintenance of mean arterial pressure and lower heart rate. It also accelerates the onset and extends the duration of both sensory and motor blocks, leading to prolonged analgesia and reduced postoperative analgesic requirements. Additionally, dexmedetomidine provides effective sedation and is associated with fewer adverse effects, such as hypotension and bradycardia, compared to a placebo. These findings suggest that dexmedetomidine is a valuable adjunct in spinal anaesthesia, enhancing patient comfort and safety during and after surgery. Future studies with larger sample sizes and diverse patient populations are warranted to further validate these results and optimize the use of dexmedetomidine in various anaesthetic settings.

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