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Original Research Article

Comparing the Hemodynamic Effects of Dexmedetomidine and Midazolam for Sedation Under Regional Anesthesia

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Abstract: Background: Maintaining hemodynamic stability during spinal anesthesia is a major concern, particularly when intravenous sedatives are used to improve patient comfort. Objective: To compare the hemodynamic effects of dexmedetomidine and midazolam administered as BIS-guided sedatives in patients undergoing surgery under spinal anesthesia. Methodology: This randomized controlled trial was conducted at Dow University Hospital, Ojha Campus, Karachi, from January to June 2022. A total of 106 adult patients undergoing elective surgery under spinal anesthesia were randomly allocated into two equal groups. Group A received midazolam infusion (0.01–0.03 mg/kg/hour), while Group B received dexmedetomidine infusion (0.2–0.3 µg/kg/hour). Results: The mean age of patients was 38.74 ± 6.57 years. Dexmedetomidine was associated with a significantly lower mean heart rate compared to midazolam (71.2 ± 6.1 vs. 78.4 ± 6.9 beats/min; $p < 0.001$), with bradycardia occurring more frequently in the dexmedetomidine group (35.8% vs. 17.0%; $p = 0.026$). In contrast, mean arterial pressure was significantly lower in the midazolam group (75.8 ± 7.5 mmHg) compared to the dexmedetomidine group (80.9 ± 8.0 mmHg; $p < 0.001$), and hypotension was more common with midazolam (86.8% vs. 45.3%; $p = 0.0005$). Respiratory rate and oxygen saturation remained comparable between groups, with no episodes of oxygen desaturation. Conclusion: Both dexmedetomidine and midazolam provide effective BIS-guided sedation during spinal anesthesia with preserved respiratory stability. However, dexmedetomidine is associated with a higher incidence of bradycardia, whereas midazolam is linked to more frequent hypotension.

Keywords: Spinal anesthesia, Dexmedetomidine, Midazolam, Hemodynamic stability, Bispectral index, Sedation.

INTRODUCTION

Maintaining hemodynamic stability throughout the intraoperative period is one of the major aims of anesthetic care, especially with patients who have regional anesthesia. It is normal and usual that change in heart rate and blood pressure during surgery can result in serious perioperative morbidity, such as arrhythmias, myocardial ischemia, stroke, and increased post-anesthesia care unit (PACU) time and even cardiac arrest [1][2]. These risks are additional enhanced by the things because of the administration of sedative agents, which interfere with the autonomic tone and cardiovascular reflexes. Regional anesthesia, particularly the spinal anesthesia is more commonly used in lower abdominal, pelvic, and lower limb surgeries due to their favorable profile, namely, reduced stress response, excellent analgesia, and avoidance of airway manipulation. Nevertheless, spinal anesthesia in itself often comes with hypotension and bradycardia as a result of

sympathetic blockage, pooling of blood, and lack of systemic vascular resistance [3]. The cardiovascular dynamics may also be altered by the supplementation of intravenous sedative drugs to the procedure in addition to enhancing the acceptability and comfort of patients of regional procedures, which affects the overall hemodynamic stability. Midazolam is a short acting benzodiazepine that was historically utilized in sedation in the area of regional anesthesia due to the rapid onset of the drug, anxiolytic and amnestic effects and titration. Its cardiovascular effects are typically said to be mild, but midazolam can add to the effect of hypotension especially when coupled with a neuraxial blockade, opioids or other anesthetic agents [4][5]. Additionally, midazolam does not contain inherent analgesic properties, but can induce dose-dependent respiratory depression in elderly or high-risk patients in particular [6].

The application of a highly selective 2-adrenergic receptor agonist, dexmedetomidine has been an appealing alternative sedative in regional anesthesia. Its pharmacologic activity action comprises of sedation that is comparable to natural sleep, anxiolysis, analgesia, sympatholysis and minimal respiratory depression [7]. Such features are especially attractive to dexmedetomidine, which is used in cases of a procedure under spinal anesthesia, when it is preferable to retain spontaneous ventilation. However, dexmedetomidine has been reported to cause considerable cardiovascular effects, dose-dependent bradycardia and hypotension both through central sympatholysis and peripheral vascular effects [8]. A number of clinical trials have attempted to compare dexmedetomidine and midazolam in their use in sedation in a number of surgical and procedural procedures. Other studies have also shown that there was a decrease in heart rate and mean arterial pressure with dexmedetomidine when compared to midazolam, which implies better control over sympathetic responses [9]. In contrast, a higher rate of clinically significant bradycardia during dexmedetomidine and a higher rate of hypotension during midazolam have been reported in other studies, which demonstrates the complexity of the hemodynamic interaction during neuraxial anesthesia [10][11]. Such discrepancies indicate the necessity of additional controlled studies, especially in the environments in which spinal anesthesia as such modifies the physiology of the cardiovascular baselines. Bispectral index (BIS) monitoring has provided an objective aspect to the evaluation of the depth of sedation. BIS-monitored sedation permits adjustment of sedative drugs to reach sufficient hypnosis without overdosing with a risk of hemodynamic instability or slow recuperation [12]. And it is particularly significant to maintain similar depths of sedation by BIS monitoring when the pharmacodynamic profiles of the two agents and the case of dexmedetomidine and midazolam are compared. Although there is an increasing global body of research, there is a paucity of research comparing the hemodynamic effects of dexmedetomidine versus midazolam during BIS-guided sedation during spinal anesthesia, especially on the local and regional population. Patient demographics, anesthetic practice, and the use of perioperative practices also affect the study area, which is why the institution-specific studies are reasonable [13]. The benefits of a better understanding of the cardiovascular effects of these agents can help anesthesiologists choose the correct sedatives in patients at risk of experiencing hemodynamic changes. Thus, this study aimed to compare the hemodynamic outcomes of dexmedetomidine and midazolam as a form of continuous infusion in the case of patients undergoing surgery under spinal anesthesia when guided by the use of BIS. Assessing the dynamics of heart rate, blood pressure, respiratory variables, and the occurrence of adverse cardiovascular events, the study will add some valuable evidence to the idealization of sedative decision-making and enhancement of perioperative safety [14].

Objective

To compare the hemodynamic effects of dexmedetomidine and midazolam administered as BIS-guided sedatives in patients undergoing surgery under spinal anesthesia.

METHODOLOGY

This was a randomized controlled trial conducted at the Operation Theatre, Dow University Hospital, Ojha Campus, Karachi, over a period of six months from January 2022 to June 2022, including 106 adult patients undergoing elective surgical procedures under spinal anesthesia.

Inclusion Criteria

- Patients of either gender
- Age between 18 and 60 years
- Patients undergoing elective surgery under spinal anesthesia
- American Society of Anesthesiologists (ASA) physical status I or II
- Patients requiring intraoperative sedation
- Patients willing to provide informed written consent

Exclusion Criteria

- Patients with known cardiovascular disease (e.g., arrhythmias, ischemic heart disease)
- History of uncontrolled hypertension or hypotension
- Patients with severe hepatic or renal impairment
- Known allergy or contraindication to dexmedetomidine or midazolam

- Patients on chronic β-blockers or sedative medications
- Pregnancy or lactation
- Patients unwilling to participate

Data Collection

After obtaining informed consent, patients were randomly allocated into two equal groups using a lottery method. Group A (n = 53) received midazolam infusion at a dose of 0.01–0.03 mg/kg/hour, while Group B (n = 53) received dexmedetomidine infusion prepared as 100 µg diluted in 49 mL of 0.9% normal saline, administered at 0.2–0.3 µg/kg/hour via infusion pump. All patients underwent spinal anesthesia using standard aseptic technique. Sedation was titrated to maintain a bispectral index (BIS) value between 60 and 80. Hemodynamic parameters, including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), respiratory rate (RR), and oxygen saturation (SpO_2) were recorded at baseline and at regular intervals intraoperatively. The incidence of bradycardia and hypotension was also documented. All observations were recorded on a predesigned structured proforma.

Statistical Analysis

Data were analyzed using SPSS version 24.0. Quantitative variables such as age, heart rate, blood pressure parameters, respiratory rate, and oxygen saturation were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and %ages. Comparison between the two groups was performed using the independent t-test for continuous variables and the chi-square test for categorical variables. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

The mean age of patients in the midazolam group was 38.92 ± 6.41 years, while in the dexmedetomidine group it was 38.56 ± 6.74 years, showing comparable age distribution (p = 0.81). Gender distribution was similar between groups, with males comprising 54.7% in the midazolam group and 58.5% in the dexmedetomidine group (p = 0.69). Mean body mass index was also comparable (25.8 ± 3.1 kg/m² vs. 26.1 ± 3.4 kg/m²; p = 0.62).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (N = 106)

Variable	Midazolam Group (n = 53)	Dexmedetomidine Group (n = 53)	p-value
Age (years), mean ± SD	38.92 ± 6.41	38.56 ± 6.74	0.81
Gender (Male/Female), n (%)	29 / 24 (54.7 / 45.3)	31 / 22 (58.5 / 41.5)	0.69
BMI (kg/m²), mean ± SD	25.8 ± 3.1	26.1 ± 3.4	0.62
ASA I / II, n (%)	34 / 19 (64.2 / 35.8)	36 / 17 (67.9 / 32.1)	0.68
Type of Spinal Anesthesia (Lower limb / Lower abdominal), n (%)	28 / 25 (52.8 / 47.2)	30 / 23 (56.6 / 43.4)	0.70

Mean intraoperative heart rate was significantly lower in the dexmedetomidine group at 71.2 ± 6.1 beats/min compared with 78.4 ± 6.9 beats/min in the midazolam group (p < 0.001). In contrast, systolic blood pressure was lower in the midazolam group (101.6 ± 9.4 mmHg) compared to the dexmedetomidine group (108.3 ± 10.1 mmHg), with a statistically significant difference (p < 0.001). Diastolic blood pressure followed a similar pattern, being lower in the midazolam group (62.9 ± 6.8 mmHg) than in the dexmedetomidine group (67.4 ± 7.1 mmHg; p = 0.002). Mean arterial pressure was also significantly reduced in the midazolam group (75.8 ± 7.5 mmHg) compared with dexmedetomidine (80.9 ± 8.0 mmHg; p < 0.001).

Table 2. Comparison of Intraoperative Hemodynamic Parameters Between Groups

Parameter	Midazolam Group (Mean ± SD)	Dexmedetomidine Group (Mean ± SD)	p-value
Heart Rate (beats/min)	78.4 ± 6.9	71.2 ± 6.1	<0.001
Systolic BP (mmHg)	101.6 ± 9.4	108.3 ± 10.1	<0.001
Diastolic BP (mmHg)	62.9 ± 6.8	67.4 ± 7.1	0.002
Mean Arterial Pressure (mmHg)	75.8 ± 7.5	80.9 ± 8.0	<0.001
Respiratory Rate (breaths/min)	14.6 ± 1.9	14.4 ± 2.0	0.58
Oxygen Saturation (%)	98.1 ± 1.2	98.3 ± 1.1	0.41

At baseline, heart rate and mean arterial pressure were similar between the two groups, with heart rate measuring 82.3 ± 7.2 beats/min in the midazolam group and 80.9 ± 6.8 beats/min in the dexmedetomidine group (p = 0.32), and MAP measuring 92.1 ± 8.4 mmHg versus 93.4 ± 8.1 mmHg (p = 0.44). From 10 minutes onward, heart rate

remained consistently lower in the dexmedetomidine group, decreasing to 72.8 ± 6.3 at 10 minutes and further to 68.9 ± 5.4 beats/min at 90 minutes, compared with 79.6 ± 6.9 and 75.4 ± 6.0 beats/min, respectively, in the midazolam group (all $p < 0.001$). Mean arterial pressure showed a parallel trend, remaining significantly lower in the midazolam group across all intraoperative time points from 10 to 90 minutes, with values decreasing to 72.8 ± 6.7 mmHg at 90 minutes compared to 79.6 ± 7.0 mmHg in the dexmedetomidine group ($p < 0.001$).

Table 3. Time-Based Comparison of Heart Rate and Mean Arterial Pressure

Time Interval	Heart Rate (Midazolam)	Heart Rate (Dexmedetomidine)	p-value	MAP (Midazolam)	MAP (Dexmedetomidine)	p-value
Baseline	82.3 ± 7.2	80.9 ± 6.8	0.32	92.1 ± 8.4	93.4 ± 8.1	0.44
10 minutes	79.6 ± 6.9	72.8 ± 6.3	<0.001	78.2 ± 7.6	83.6 ± 7.9	<0.001
30 minutes	77.8 ± 6.5	70.6 ± 5.8	<0.001	74.9 ± 7.1	81.4 ± 7.5	<0.001
60 minutes	76.1 ± 6.2	69.4 ± 5.6	<0.001	73.6 ± 6.9	80.2 ± 7.2	<0.001
90 minutes	75.4 ± 6.0	68.9 ± 5.4	<0.001	72.8 ± 6.7	79.6 ± 7.0	<0.001

Bradycardia occurred more frequently in the dexmedetomidine group, affecting 19 patients (35.8%), compared with 9 patients (17.0%) in the midazolam group, a statistically significant difference ($p = 0.026$). Conversely, hypotension was significantly more common in the midazolam group, occurring in 46 patients (86.8%), compared with 24 patients (45.3%) receiving dexmedetomidine ($p = 0.0005$). No episodes of oxygen desaturation were observed in either group, indicating adequate respiratory safety.

Table 4. Incidence of Adverse Hemodynamic Events

Adverse Event	Midazolam Group (n = 53)	Dexmedetomidine Group (n = 53)	p-value
Bradycardia, n (%)	9 (17.0)	19 (35.8)	0.026
Hypotension, n (%)	46 (86.8)	24 (45.3)	0.0005
Oxygen desaturation, n (%)	0 (0.0)	0 (0.0)	
Need for rescue medication, n (%)	21 (39.6)	18 (34.0)	0.53

DISCUSSION

This randomized controlled trial compared the hemodynamic impact of dexmedetomidine and midazolam delivered as BIS-directed sedatives during spinal anesthesia and exhibited a different pattern of cardiovascular responses with the two agents. The baseline characteristics were well balanced, and the mean age (38.92 vs. 38.56 years) of the patients, gender distribution, body mass index, physical status of the patient (ASA), and surgery type were similar, so that the differences observed could only be ascribed to the sedative drugs and not to the confounding factors in the patient. Dexmedetomidine was also correlated with a much lower intraoperative heart rate than with midazolam. Mean heart rate in the dexmedetomidine group and midazolam group were 71.2 plus or minus 6.1 beats/ min and 78.4 plus or minus 6.9 beats/min, respectively and a statistically significant difference was observed between 10 and 90 minutes intraoperative ($p < 0.001$). In line with this, the dexmedetomidine group had more incidence of bradycardia (35.8) than the midazolam group (17.0%). This agrees with the earlier studies, which have ascribed this to the central sympatholytic and vagomimetic effects of dexmedetomidine on 62-adrenergic receptors [15] [16]. On the contrary, the blood pressure parameters were deeper influenced in those patients who took midazolam. The difference in mean arterial pressure between the midazolam group (75.8 v.s. 80.9 mmHg; $p < 0.001$) is significant. The time-based analysis showed that this difference did not go away as long as 10 minutes up to 90 minutes of surgery. The rate of hypotension was significantly high in 86.8 % of patients in the midazolam group compared to 45.3 % in the dexmedetomidine group. Other past studies have also documented an increased predisposition towards hypotension with midazolam in spinal anesthesia, probably due to its vasodilatory and the failure to oppose neuraxial sympathetic blockage [17][18]. Although there were these differences in the cardiovascular, respiratory parameters were maintained constant in both groups. There was no difference in respiratory rate between the midazolam and dexmedetomidine groups (14.6 ± 1.9 vs. 14.4 ± 2.0 breaths /min), and oxygen saturation levels were also similar (98.1 ± 1.2 vs. 98.3 ± 1.1) with no desaturation episodes in either group. There was also no difference in the necessity of rescue medication between groups (39.6% vs. 34.0%), which means that despite dissimilarity in the frequency with which hemodynamic disturbances were observed, the

overall requirement in intraoperative management was the same. These results are in line with other prior studies that have proposed that the two agents are safe with careful titration under BIS monitoring, and sedative choice is best personalized based on the cardiovascular risk profile of the patient [19][20]. Altogether, the results of the given research are consistent with other studies that indicated that dexmedetomidine is also accompanied by an increased bradycardia but a comparatively better blood pressure maintenance, whereas midazolam is accompanied by increased hypotension rates and lower-impact on the heart-rate changes. These variations are especially applicable in patients with a low cardiovascular reserve because of which the selection of the type of sedative agent can have a significant effect on the safety of perioperative period.

CONCLUSION

It is concluded that both dexmedetomidine and midazolam provide effective and safe BIS-guided sedation during spinal anesthesia with preserved respiratory stability. Dexmedetomidine is associated with a significantly lower intraoperative heart rate and a higher incidence of bradycardia, whereas midazolam is linked to a greater reduction in blood pressure and a higher frequency of hypotension. Although the overall requirement for rescue interventions was comparable between the two agents, their differing cardiovascular effects highlight the importance of individualized sedative selection. Dexmedetomidine may be preferable in patients where blood pressure preservation is critical, while midazolam may be more suitable in patients at risk of bradycardia, provided careful hemodynamic monitoring is ensured.

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