RESEARCH PAPER

Association Between Preoperative Risk Profiles and Neuraxial Anesthesia induced hypotension: A Comparative Study

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ABSTRACT

Background: Hypotension is one of the most common complications following neuraxial anesthesia and may result in significant perioperative morbidity. Patients with type 2 diabetes mellitus (T2DM) and hypertension may exhibit impaired autonomic and cardiovascular regulation, potentially predisposing them to hemodynamic instability following sympathetic blockade. The present study evaluated the occurrence and timing of hypotension following neuraxial anesthesia among patients with different baseline risk profiles.

Methods: This comparative observational study included 179 patients aged 18–60 years undergoing lower limb orthopaedic surgery under neuraxial anesthesia. Participants were categorized into four groups: normotensive non-diabetic (Group N), hypertension (Group H), type 2 diabetes mellitus (Group D), and combined diabetes mellitus with hypertension (Group DH). Baseline demographic and anthropometric characteristics were recorded. The prevalence and time to onset of hypotension following neuraxial anesthesia were compared among the study groups using appropriate statistical tests, with $p<0.05$ considered statistically significant.

Results: Baseline age, sex distribution, height, weight, and body mass index were comparable across all groups. The mean age did not differ significantly among the groups ($p=0.24$), and anthropometric parameters were also comparable ($p=0.94$). The mean time to onset of hypotension was shorter in Group DH (19.88±21.43 min) and Group D (22.89±29.82 min) than in Group N (31.66±28.32 min) and Group H (34.08±36.02 min). The prevalence of hypotension was highest in Group H (72%), followed by Group D (67.86%), Group N (66.36%), and Group DH (62.50%).

Conclusion: Patients with T2DM, either alone or in combination with hypertension, demonstrated an earlier onset of hypotension following neuraxial anesthesia. However, the prevalence of hypotension was highest among patients with hypertension alone. These findings suggest that diabetes mellitus may contribute to earlier hemodynamic instability, whereas hypertension may be associated with a greater occurrence of hypotension. Careful perioperative risk assessment, vigilant monitoring, and individualized anesthetic management are therefore important in patients with these comorbid conditions

Keywords: Neuraxial anesthesia; Hypotension; Type 2 diabetes mellitus; Hypertension; Orthopaedic surgery; Hemodynamic instability.

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INTRODUCTION

Neuraxial anesthesia is one of the most commonly employed anesthetic techniques for lower limb orthopedic surgeries because it provides excellent sensory and motor blockade, reduces perioperative blood loss, offers effective postoperative analgesia, and is associated with fewer respiratory complications than general anesthesia. Despite these advantages, hypotension remains the most frequent and clinically significant complication following neuraxial anesthesia. The sympathetic blockade produced by spinal or epidural anesthesia results in peripheral vasodilation, venous pooling, reduced systemic vascular resistance, and diminished venous return, ultimately leading to a decrease in cardiac output and arterial blood pressure. Although transient hypotension is generally well tolerated in healthy individuals, severe or prolonged hypotension may compromise tissue perfusion and increase the risk of perioperative cardiovascular and neurological complications.

The occurrence and severity of neuraxial anesthesia-induced hypotension are influenced by several patient-related factors, including age, sex, body mass index, baseline cardiovascular status, and the presence of chronic systemic diseases. Among these, hypertension and type 2 diabetes mellitus are particularly important because both conditions are associated with alterations in autonomic cardiovascular regulation. Long-standing hypertension is characterized by impaired baroreceptor sensitivity, increased arterial stiffness, and altered vascular responsiveness, whereas diabetes mellitus frequently leads to cardiovascular autonomic neuropathy, resulting in reduced sympathetic and parasympathetic control of heart rate and vascular tone. These pathophysiological changes may impair the compensatory mechanisms required to maintain blood pressure following sympathetic blockade, thereby increasing susceptibility to intraoperative hypotension.

Understanding the contribution of baseline demographic and anthropometric characteristics, together with common cardiovascular risk factors, is essential for identifying patients at increased risk of perioperative hypotension. Such information may facilitate individualized perioperative management strategies, including appropriate fluid optimization, vigilant hemodynamic monitoring, and timely administration of vasopressors, thereby reducing anesthesia-related complications.

Therefore, the present study was undertaken to compare baseline demographic and anthropometric characteristics and to evaluate the prevalence and time to onset of hypotension following neuraxial anesthesia among four groups of patients undergoing lower limb orthopedic surgery: normotensive non-diabetic individuals, patients with hypertension alone, patients with type 2 diabetes mellitus alone, and patients with coexisting type 2 diabetes mellitus and hypertension. By comparing these clinically relevant groups, the study aims to improve understanding of patient-related risk factors associated with neuraxial anesthesia-induced hypotension and provide evidence for improved perioperative risk stratification.

MATERIALS AND METHODS

This comparative observational study was conducted in the Departments of Physiology, Anaesthesiology, and Orthopaedics at Geetanjali Medical College and Hospital, Udaipur, after obtaining approval from the Institutional Human Research Ethics Committee. A total of 179 patients aged 18–60 years undergoing elective or emergency lower limb orthopaedic surgery under neuraxial (spinal) anaesthesia were recruited using consecutive purposive sampling after obtaining written informed consent. Based on the presence of Type 2 diabetes mellitus (T2DM) and hypertension, participants were categorized into four groups: Group N (normotensive non-diabetic), Group H (hypertension), Group D (Type 2 diabetes mellitus), and Group DH (coexisting Type 2 diabetes mellitus and hypertension). Patients with haemodynamic instability, significant blood loss (>1000 mL), pregnancy, endocrine disorders affecting autonomic function, contraindications to neuraxial anaesthesia, or those receiving medications known to alter autonomic function were excluded.

Baseline demographic characteristics, including age, sex, height, weight, and body mass index (BMI), were recorded before surgery. All patients received preloading with Ringer's lactate (10 mL/kg) followed by spinal anaesthesia using 0.5% hyperbaric bupivacaine (10–12 mg) administered at the L3–L4 or L4–L5 intervertebral space under standard aseptic precautions. Heart rate and non-invasive blood pressure were monitored throughout the intraoperative period, and the occurrence and time to onset of hypotension following neuraxial anaesthesia were documented. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons among the four groups were performed using one-way analysis of variance (ANOVA) for continuous variables and the Chi-square test for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 179 patients undergoing lower limb orthopaedic surgery under neuraxial anaesthesia were included in the study and categorized into four groups: normotensive non-diabetic (Group N), hypertension (Group H), diabetes mellitus (Group D), and diabetes mellitus with hypertension (Group DH). The mean age of the participants was comparable across all groups, with no statistically significant difference ($p = 0.24$), indicating similar baseline demographic characteristics (Table 1). The study population was predominantly male, with a comparable gender distribution among all four groups (Table 2). Similarly, anthropometric parameters including height, weight, and body mass index (BMI) did not differ significantly between the groups ($p = 0.94$), confirming baseline comparability (Table 3).

The mean time to onset of hypotension following neuraxial anaesthesia was shorter in patients with diabetes mellitus alone (Group D) and those with coexisting diabetes mellitus and hypertension (Group DH) compared with normotensive controls (Group N) and hypertensive patients (Group H), suggesting earlier haemodynamic instability in diabetic patients (Table 4). The prevalence of hypotension was lowest in Group DH (62.50%) and highest in Group H (72%) (Table 5). These findings indicate that hypertension is associated with an increased occurrence of hypotension following neuraxial anaesthesia.

Table 1: Mean age of the study participants

	Mean Age (years)	F	P-value
Group N	44 ± 14.46		
Group H	43.70 ± 13.98		
Group DH	47.15 ± 11.01		
Group D	48.39 ± 11.26	1.40	0.24

Table 2: Gender distribution of the study population

	Group N	Group H	Group DH	Group D
Males (%)	59.81	64.08	60.00	57.14
Females (%)	40.19	35.92	40.00	42.86

Table 3: Anthropometric characteristics of the study participants

Parameter	Height (cm)	Weight (kg)	BMI (kg/m²)
Group N	157.98 ± 8.08	66.44 ± 10.20	26.73 ± 4.56
Group H	160.21 ± 8.97	69.50 ± 13.01	26.96 ± 4.01
Group DH	161.73 ± 6.61	70.97 ± 10.51	27.10 ± 3.37
Group D	162.11 ± 6.19	70.22 ± 12.26	26.60 ± 3.87
F	0.13		
P-value	0.94		

Table 4: Time to onset of hypotension across all four groups

	Group N	Group H	Group DH	Group D
Mean	31.66	34.08	19.88	22.89
Standard Error	3.36	6.00	4.29	6.84
Median	20.00	20.00	10.00	10.00
Mode	60.00	10.00	4.00	5.00

Standard Deviation	28.32	36.02	21.43	29.82
Sample Variance	801.80	1297.22	459.28	889.32
Kurtosis	1.81	1.33	0.05	5.65
Skewness	1.37	1.52	1.28	2.27
Range	116.00	116.00	56.00	116.00
Minimum	4.00	4.00	4.00	4.00
Maximum	120.00	120.00	60.00	120.00
Sum	2248.00	1227.00	497.00	435.00
Count	71.00	36.00	25.00	19.00
Confidence Level (95.0%)	6.70	12.19	8.85	14.37

Table 5: Prevalence of hypotension differed across the four study groups

	Group N	Group H	Group DH	Group D
Prevalence of hypotension (%)	66.36	72	62.50	67.86

DISCUSSION

The present study evaluated the occurrence and timing of hypotension following neuraxial anaesthesia among patients with hypertension, type 2 diabetes mellitus (T2DM), coexisting diabetes and hypertension, and normotensive non-diabetic controls undergoing lower limb orthopaedic surgery. Age, sex distribution, height, weight, and body mass index (BMI) were comparable among the four study groups, suggesting that these baseline demographic and anthropometric characteristics were unlikely to confound the observed differences in hypotension. The prevalence of hypotension was highest among patients with hypertension, followed by those with T2DM, normotensive non-diabetic controls, and patients with coexisting diabetes and hypertension. In contrast, the onset of hypotension occurred earlier in the diabetic groups, particularly among patients with coexisting diabetes and hypertension. These findings suggest that while hypertension may be associated with a higher prevalence of neuraxial anaesthesia-induced hypotension, diabetes mellitus may contribute to its earlier onset, potentially reflecting underlying alterations in autonomic cardiovascular regulation.

Age is a well-recognized determinant of cardiovascular responses to spinal anaesthesia, as advancing age is associated with reduced baroreceptor sensitivity, diminished vascular compliance, and impaired autonomic regulation. However, the absence of significant differences in mean age among the study groups indicates that age was unlikely to influence the observed outcomes. Likewise, the comparable gender distribution across the groups minimized the possibility of sex-related bias. Similar observations have been reported by Kweon et al., who found that demographic characteristics were comparable between hypertensive patients with and without spinal anaesthesia-induced hypotension, emphasizing that underlying autonomic dysfunction rather than baseline demographic variables is more closely associated with perioperative haemodynamic instability.

Anthropometric characteristics, including height, weight, and BMI, were also similar among the study groups. Obesity and increased BMI have been reported to influence the cephalad spread of intrathecal local anaesthetics and alter cardiovascular responses following neuraxial blockade. However, because anthropometric variables were well matched in the present study, they were unlikely to account for the differences in hypotension observed. These findings suggest that the observed differences in the occurrence and timing of hypotension across the study groups are more likely related to disease-associated alterations in autonomic and vascular function than to differences in body habitus.

One of the most important observations of the present study was the earlier onset of hypotension among patients with diabetes mellitus, either alone or in combination with hypertension. The median onset time of hypotension was approximately 10 minutes in Groups D and DH compared with 20 minutes in Groups N and H, indicating that diabetic patients experienced more rapid haemodynamic deterioration following neuraxial anaesthesia. This finding is biologically plausible because chronic hyperglycaemia results in cardiovascular autonomic neuropathy, characterized by impaired sympathetic vasoconstriction, reduced baroreflex sensitivity, and diminished cardiac autonomic responsiveness. Similar findings were reported by Lee et al., who demonstrated significantly altered autonomic cardiovascular responses during spinal anaesthesia in patients with type 2 diabetes mellitus, suggesting that impaired autonomic compensation contributes to haemodynamic instability during sympathetic blockade. Likewise, Benichou et al., in their systematic review and meta-analysis, confirmed that patients with type 2 diabetes exhibit significantly reduced heart rate variability across multiple time- and frequency-domain parameters, reflecting widespread autonomic dysfunction that may increase susceptibility to perioperative hypotension.

The prevalence of hypotension varied across the four study groups, with the highest prevalence observed among hypertensive patients (72%), followed by patients with T2DM (67.86%), normotensive non-diabetic controls (66.36%), and patients with coexisting diabetes and hypertension (62.50%). Thus, a progressive increase in the prevalence of hypotension across the study groups was not observed. These findings are consistent with those of Vinayagam et al., who reported that approximately 69% of diabetic patients undergoing spinal anaesthesia developed hypotension and demonstrated significantly lower SDNN and RMSSD values among patients who experienced hypotension, indicating impaired autonomic regulation. Although their study concluded that heart rate variability alone had limited predictive accuracy, it highlighted the important contribution of diabetic autonomic neuropathy to haemodynamic instability. In contrast, Kweon et al. observed that although hypertensive patients frequently developed hypotension after spinal anaesthesia, conventional heart rate variability indices were not sufficiently sensitive to predict its occurrence, suggesting that hypertension-related vascular changes and antihypertensive therapy may also influence perioperative blood pressure responses.

The pathophysiological basis of neuraxial anaesthesia-induced hypotension is the abrupt blockade of sympathetic outflow, resulting in peripheral vasodilation, venous pooling, decreased venous return, and reduced cardiac output. In individuals with intact autonomic function, compensatory sympathetic activation and baroreceptor reflexes help maintain arterial pressure. However, these compensatory mechanisms are substantially impaired in diabetes mellitus and, to a lesser extent, hypertension. Hanss et al. demonstrated that alterations in sympathovagal balance, particularly changes in the low-frequency/high-frequency (LF/HF) ratio, were associated with severe hypotension after spinal anaesthesia, supporting the concept that autonomic imbalance plays a central role in perioperative haemodynamic instability. Although heart rate variability was not analysed in the present study, the earlier onset of hypotension among diabetic patients is consistent with the physiological consequences of impaired autonomic cardiovascular regulation.

The clinical implications of these findings are significant. Patients with diabetes mellitus, particularly those with concomitant hypertension, should be considered at increased risk for hypotension during neuraxial anaesthesia. Careful preoperative assessment, adequate intravascular volume optimization, continuous haemodynamic monitoring, and early administration of vasopressors may reduce the incidence and severity of hypotensive episodes in these patients. Furthermore, recent evidence summarized by Frandsen et al. suggests that preoperative assessment of autonomic function, including heart rate variability, may contribute to perioperative risk stratification, although additional large-scale prospective studies are required before its routine implementation in clinical practice.

CONCLUSION

Overall, the present study demonstrates that, while demographic and anthropometric characteristics were comparable among the study groups, patients with type 2 diabetes mellitus, either alone or in combination with hypertension, exhibited an earlier onset of hypotension following neuraxial anaesthesia. However, the prevalence of hypotension was highest among patients with hypertension alone, followed by those with T2DM, normotensive non-diabetic controls, and patients with coexisting diabetes and hypertension. These findings suggest that diabetes mellitus may be associated with earlier haemodynamic instability, whereas hypertension may be associated with a higher prevalence of hypotension following neuraxial anaesthesia. The results highlight the importance of careful perioperative risk assessment and individualized anaesthetic management strategies in patients with these comorbid conditions.

REFERENCES

1. Kamel I, Ahmed MF, Sethi A. Regional anesthesia for orthopedic procedures: What orthopedic surgeons need to know. World J Orthop. 2022 Jan 18;13(1):11–35. doi:10.5312/wjo.v13.i1.11

2. Bower JR, Kinsella SM. Preventing and treating hypotension during spinal anaesthesia for caesarean

section. BJA Educ. 2020 Nov;20(11):360–1. doi:10.1016/j.bjae.2020.08.001

3. Guarracino F, Bertini P. Perioperative hypotension: causes and remedies. Journal of Anesthesia, Analgesia and Critical Care. 2022 Dec 14;2(1):17. doi:10.1186/s44158-022-00045-8

4. Suh DC, Kim JL, Kim EH, Kim JK, Shin JH, Hyun DH, et al. Carotid Baroreceptor Reaction after Stenting in 2 Locations of Carotid Bulb Lesions of Different Embryologic Origin. American Journal of Neuroradiology. 2012 May;33(5):977–81. doi:10.3174/ajnr.A2891

5. Kweon TD, Kim SY, Cho SA, Kim JH, Kang YR, Shin YS. Heart rate variability as a predictor of hypotension after spinal anesthesia in hypertensive patients. Korean J Anesthesiol. 2013;65(4):317. doi:10.4097/kjae.2013.65.4.317

6. Lee SH, Lee DH, Ha DH, Oh YJ. Dynamics of heart rate variability in patients with type 2 diabetes mellitus during spinal anaesthesia: prospective observational study. BMC Anesthesiol. 2015 Dec 8;15(1):141–5. doi:10.1186/s12871-015-0125-6

7. Benichou T, Pereira B, Mermillod M, Tauveron I, Pfabigan D, Maqdasy S, et al. Heart rate variability in type 2 diabetes mellitus: A systematic review and meta–analysis. PLoS One. 2018 Apr 2;13(4):e0195166. doi:10.1371/journal.pone.0195166

8. Vinayagam S, Panta S, Badhe A, Sharma V. Heart rate variability as a predictor of hypotension after spinal anaesthesia in patients with diabetes mellitus. Indian J Anaesth. 2019;63(8):671–7. doi:10.4103/ija.IJA_13_19

9. Kweon TD, Kim SY, Cho SA, Kim JH, Kang YR, Shin YS. Heart rate variability as a predictor of hypotension after spinal anesthesia in hypertensive patients. Korean J Anesthesiol. 2013;65(4):317–22. doi:10.4097/kjae.2013.65.4.317

10. Hanss R, Bein B, Ledowski T, Lehmkuhl M, Ohnesorge H, Scherkl W, et al. Heart Rate Variability Predicts Severe Hypotension after Spinal Anesthesia for Elective Cesarean Delivery. Anesthesiology. 2005 Jun 1;102(6):1086–93. doi:10.1097/00000542-200506000-00005

11. Frandsen MN, Mehlsen J, Foss NB, Kehlet H. Preoperative heart rate variability as a predictor of perioperative outcomes: a systematic review without meta-analysis. J Clin Monit Comput. 2022 Aug 29;36(4):947–60. doi:10.1007/s10877-022-00819-z