International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Haemodynamic Response Following Spinal Anaesthesia in Controlled Hypertensive versus Normotensive Patients Undergoing Lower Limb Orthopaedic Surgeries: A Prospective Comparative Study

Robert Roy K[1], Shabir Ahmed Shabir[2]

[1]Postgraduate Scholar, Department of Anaesthesiology and Critical Care, Government Medical College, Srinagar, Kashmir, India
[2]Assosiate Professor, Department of Anaesthesiology and Critical Care, Government Medical College, Srinagar, Kashmir, India

OPEN ACCESS

Corresponding Author:

Dr. Robert Roy K
Postgraduate Scholar, Department of Anaesthesiology and Critical Care, Government Medical College, Srinagar, Kashmir, India

Received: 15-03-2026
Accepted: 03-04-2026
Available online: 26-04-2026

ABSTRACT

Background: Spinal anaesthesia is the preferred technique for lower limb orthopaedic surgeries owing to its reliability, reduced blood loss, and superior postoperative analgesia. However, sympathetic blockade following intrathecal local anaesthetic invariably alters cardiovascular homeostasis. Hypertensive patients, despite achieving preoperative blood pressure control, may harbour subclinical autonomic impairment that amplifies haemodynamic susceptibility, yet the clinical significance of this vulnerability in a standardised anaesthetic setting remains incompletely characterised.
Objective: To compare intraoperative and early postoperative haemodynamic responses following spinal anaesthesia between controlled hypertensive (Group H) and normotensive (Group N) patients undergoing elective lower limb orthopaedic surgery, and to assess the incidence of clinically relevant perioperative events including hypotension, bradycardia, vasopressor requirement, and postoperative nausea and vomiting (PONV). **Methods:** A prospective, comparative study was conducted at Government Bones and Joints Hospital, Barzulla, Srinagar over 18 months (June 2024–December 2025). Seventy adults (ASA I–II, 18–60 years) were enrolled: 35 with controlled hypertension on stable antihypertensive therapy (Group H) and 35 normotensive individuals (Group N). All received 0.5% hyperbaric bupivacaine intrathecally in a standardized dose. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded at baseline, every 5 minutes intraoperatively for 60 minutes, and at 1, 3, and 6 hours postoperatively. Hypotension was defined as SBP decrease >20% from baseline or SBP <90 mmHg. Bradycardia was defined as HR <60 beats per minute. VAS pain scores and block regression time were also recorded.
Results: Group H patients were significantly older (χ^2 = 7.86, p = 0.049) and universally classified as ASA II versus 54.3% in Group N (p <0.001). Baseline haemodynamic parameters were comparable (all p >0.05). Intraoperatively, Group H exhibited significantly higher SBP at 5, 10, 15, and 30 minutes (all p <0.05), and higher MAP at 5, 10, and 15 minutes (all p <0.001), with convergence by 45–60 minutes. HR was comparable throughout. Hypotension occurred in 22.9% vs 11.4% (χ^2 = 0.905, p = 0.341) and vasopressor use was similarly non-significant. No bradycardia was observed in either group. PONV was more frequent in Group H (45.7% vs 28.6%, p = 0.216). Postoperative haemodynamic parameters and VAS scores were similar across all time points (all p >0.05). Block regression time was comparable (274.4 ± 16.0 vs 270.4 ± 17.4 minutes, p = 0.323). **Conclusion:** Controlled hypertensive patients demonstrate transiently higher intraoperative blood pressure values during the first 30 minutes following spinal anaesthesia but exhibit comparable overall haemodynamic stability to normotensive patients. The incidences of clinically significant hypotension, bradycardia, and vasopressor requirement did not differ significantly between groups, suggesting that adequately

controlled hypertension does not independently confer substantially greater perioperative cardiovascular risk under standardised spinal anaesthetic management. Enhanced vigilance remains prudent given the numerically higher, though statistically non-significant, event rates in hypertensive patients.

Keywords*: Spinal anaesthesia; Controlled hypertension; Normotensive; Haemodynamics; Hypotension; Orthopaedic surgery; Bupivacaine.*

INTRODUCTION

Hypertension constitutes one of the foremost modifiable risk factors for cardiovascular morbidity and mortality worldwide. The Global Burden of Disease Study 2021 estimated that high systolic blood pressure attributable deaths among youth and young adults increased by more than 36% between 1990 and 2021, underscoring an accelerating global epidemic [1]. Among older adults, the burden is particularly severe: the global population aged 60–79 years is projected to double from 800 million to 1.6 billion between 2015 and 2050, and the risk of cardiovascular events doubles with each decade of ageing and with every 20 mmHg elevation in systolic blood pressure [2]. Consequently, a substantial proportion of patients presenting for elective surgery carry a diagnosis of treated systemic hypertension, rendering perioperative haemodynamic management a clinically critical and frequently encountered challenge for anaesthesiologists.

Spinal anaesthesia is widely preferred for lower limb orthopaedic procedures because it avoids the complications of general anaesthesia, reduces intraoperative blood loss through sympathetically mediated vasodilatation and hypotension,lowers the incidence of venous thromboembolism, preserves airway reflexes, and provides excellent postoperative analgesia [3]. Despite these advantages, the intrathecal administration of local anaesthetic produces a predictable preganglionic sympathetic blockade that reduces systemic vascular resistance, decreases venous return, and may precipitate clinically relevant hypotension and, less frequently, bradycardia [4]. These haemodynamic perturbations are generally transient in otherwise healthy individuals, but their magnitude and clinical consequence may be substantially modified by pre-existing cardiovascular pathology, baseline autonomic tone, and concurrent pharmacotherapy.

Hypertensive patients constitute a particularly important subgroup in this context. Although successful antihypertensive therapy normalises resting blood pressure, it does not fully reverse the structural and functional vascular remodelling that accompanies sustained hypertension. Chronically hypertensive vasculature demonstrates augmented arterial stiffness, impaired baroreflex sensitivity, and attenuated alpha-adrenergic compensation, all of which may collectively reduce the capacity to mount an adequate vasopressor response to the sympatholytic effects of spinal anaesthesia [5]. Pulse wave velocity — a surrogate of arterial stiffness — has been shown to be significantly higher in hypertensive patients compared with normotensive controls and independently predicts spinal anaesthesia–related hypotension in hypertensive individuals [6].

Despite a large body of literature examining spinal anaesthesia–induced haemodynamic changes, the comparative trajectory of intraoperative and postoperative blood pressure in controlled hypertensive versus normotensive patients undergoing lower limb orthopaedic surgery remains a subject of ongoing investigation. Prior prospective studies have reported conflicting findings, with some demonstrating significantly higher hypotension rates in hypertensive cohorts [7], while others found no statistically significant difference in the overall incidence of hypotension despite numerically higher rates in hypertensive patients [8]. This inconsistency may reflect heterogeneous patient populations, differing definitions of hypotension, variability in antihypertensive regimens, and differences in anaesthetic protocols across studies. Recent randomised data further demonstrate that the choice of intrathecal local anaesthetic significantly influences haemodynamic outcomes; hyperbaric ropivacaine was associated with significantly fewer hypotensive episodes compared with bupivacaine in controlled hypertensive patients undergoing lower limb surgery [9].

The perioperative arterial pressure consensus statement from the POQI group underscores that postoperative hypotension is frequently underrecognised and may carry greater long-term organ injury risk than intraoperative episodes, particularly in patients with pre-existing arterial disease [10]. This concern is especially pertinent in hypertensive patients whose target organ autoregulation may be reset to higher pressure thresholds, making them potentially more vulnerable to perfusion impairment even at blood pressures conventionally considered acceptable in normotensive individuals.

Against this background, the present study was designed to systematically compare the haemodynamic profile — including heart rate, SBP, DBP, and MAP — in controlled hypertensive versus normotensive adults undergoing elective lower limb orthopaedic surgery under standardised spinal anaesthesia. Secondary objectives included evaluation of perioperative complication rates, postoperative pain scores, and block regression times. The findings are intended to refine risk stratification strategies and inform anaesthetic monitoring practices for this large and growing surgical population.

METHODOLOGY

Study Design and Setting

This was a prospective, comparative study conducted at Government Bones and Joints Hospital, Barzulla — the principal orthopaedic referral centre of Government Medical College, Srinagar, India. The study setting offered a high volume of elective lower limb orthopaedic cases and standardised protocols for anaesthetic administration and perioperative monitoring, ensuring consistency of conditions across all enrolled patients. The study was registered with the Institutional Ethical Committee of Government Medical College, Srinagar, and written informed consent was obtained from all participants prior to enrolment.

Study Duration and Sampling

Data collection was conducted prospectively over 18 months, from June 2024 to December 2025. Consecutive eligible patients attending the preoperative assessment clinic were screened against the predefined inclusion and exclusion criteria. A non-probability consecutive sampling method was employed to systematically enrol all qualifying patients in the order of their presentation, thereby minimising selection bias within the practical constraints of a clinical setting.

Study Population: Inclusion and Exclusion Criteria

Adult patients aged 18–60 years scheduled for elective lower limb orthopaedic surgery under spinal anaesthesia were eligible for inclusion. Patients were classified as ASA physical status I or II. For the hypertensive group (Group H), eligibility required a documented diagnosis of essential hypertension with documented preoperative blood pressure control on a stable antihypertensive regimen. Normotensive patients (Group N) had no prior history of hypertension and no antihypertensive drug use. Patients were excluded if they: fell outside the specified age range; had an ASA classification of III or higher; had uncontrolled or untreated hypertension; were pregnant; had comorbid conditions including cardiac disease, chronic kidney disease, diabetes mellitus, or coagulopathy; or were scheduled for combined spinal–epidural anaesthesia. Patients with incomplete haemodynamic records or who withdrew consent at any stage were also excluded.

Study Groups

Participants were assigned to one of two predefined groups based on preoperative hypertensive status. Group H comprised 35 patients with controlled hypertension on stable antihypertensive pharmacotherapy with a preoperative blood pressure within accepted target ranges. Group N comprised 35 normotensive patients with no history of hypertension and no antihypertensive medication use. Groups were not randomised, as allocation was determined by clinical diagnosis; however, all other aspects of perioperative management were standardised between groups.

Anaesthetic Procedure and Monitoring

All patients underwent a standardised anaesthetic protocol. Preoperative assessment included detailed documentation of demographic data, medical history, current medications (particularly antihypertensive drugs), relevant investigations, and baseline haemodynamic parameters (HR, SBP, DBP, MAP, and SpO_2) recorded in the supine position using a calibrated multi-parameter monitor. Patients were kept fasting for at least six hours preoperatively. In the operating room, standard monitoring was established prior to induction. Spinal anaesthesia was administered under strict aseptic precautions with the patient in the sitting position. A standardised dose of 0.5% hyperbaric bupivacaine was injected intrathecally at the L3–L4 or L4–L5 interspace using a 25-gauge or 26-gauge Quincke needle. Immediately after block administration, patients were positioned supine. Intravenous crystalloid co-loading was administered to all patients as per institutional protocol. Any episode of hypotension (SBP decrease >20% from baseline or SBP <90 mmHg) was managed with intravenous mephentermine; bradycardia (HR <60 bpm) was managed with intravenous atropine as required, and all interventions were documented.

Outcome Measures and Data Collection

Primary outcomes included intraoperative changes in HR, SBP, DBP, and MAP recorded at fixed intervals: 5, 10, 15, 30, 45, and 60 minutes after spinal anaesthesia. Secondary outcomes included the incidence of intraoperative hypotension, the incidence of bradycardia, the requirement for vasopressor therapy, postoperative haemodynamic parameters at 1, 3, and 6 hours, PONV, VAS pain scores (0–10 numeric scale, recorded hourly for six hours), and spinal block regression time (time to two-dermatomal regression). All data were recorded on a structured, pre-designed proforma by the attending anaesthesiologist or a dedicated research assistant. Monitors were calibrated regularly throughout the study period.

Statistical Analysis

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics, version 25.0. Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables as numbers and percentages. Between-group comparison of continuous haemodynamic parameters at each time point was performed using the independent samples t-test. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. A p-value of less than 0.05 was considered statistically significant for all tests. Repeated-measures analysis of variance (ANOVA) was additionally applied to assess within-group haemodynamic trends over time.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethical Committee of Government Medical College, Srinagar. Written informed consent was obtained from each participant after detailed explanation of study objectives, procedures, and the right to withdraw without affecting clinical care. Patient identifiers were anonymised throughout data analysis using unique study codes. The anaesthetic and surgical management of all patients adhered to institutional standard-of-care guidelines; study participation did not alter routine patient care in any aspect.

RESULTS

1. Baseline Demographic Characteristics and ASA Status

A total of 70 patients were enrolled, 35 in each group. The age distribution differed significantly between groups (χ^2 = 7.86, p = 0.049); controlled hypertensive patients were predominantly older, with 42.9% in the 40–49-year category and 40.0% in the 50–60-year category, whereas normotensive patients had greater representation in younger age brackets. Body weight distribution was comparable between groups (χ^2 = 0.61, p = 0.894). Sex distribution did not differ significantly (χ^2 = 1.439, p = 0.230); females constituted 62.9% of Group H versus 45.7% of Group N. ASA physical status differed markedly: all 35 hypertensive patients were classified as ASA II (100%), whereas 54.3% of normotensive patients were ASA I (χ^2 = 26.11, p <0.001). Baseline haemodynamic parameters — pulse rate, SBP, DBP, MAP, and SpO_2 — were statistically comparable between the two groups at the time of preoperative assessment, with no significant intergroup differences (all p >0.05) [Table 1].

Table 1. Baseline Demographic and Haemodynamic Parameters Comparing Group H (Controlled Hypertensive) and Group N (Normotensive)

Parameter	Group H (n=35) Mean ± SD	Group N (n=35) Mean ± SD	t-value	p-value
Age (years)	47.5 ± 9.1	38.2 ± 11.4	—	0.049*
Weight (kg)	63.4 ± 10.2	61.8 ± 10.7	—	0.894
Pulse (bpm)	78.5 ± 5.4	80.2 ± 5.1	-1.38	0.17
SBP (mmHg)	138.6 ± 9.2	134.8 ± 8.7	1.63	0.11
DBP (mmHg)	86.4 ± 7.1	84.2 ± 6.5	1.36	0.18
MAP (mmHg)	103.8 ± 7.3	101.1 ± 6.8	1.59	0.12
SpO_2 (%)	98.1 ± 0.6	97.9 ± 0.7	0.65	0.52
ASA I, n (%)	0 (0%)	19 (54.3%)	26.11	<0.001*
ASA II, n (%)	35 (100%)	16 (45.7%)	—	—

*SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; MAP = Mean Arterial Pressure; SpO_2 = Peripheral Oxygen Saturation; bpm = beats per minute; ASA = American Society of Anesthesiologists; SD = Standard Deviation; *Statistically significant (p<0.05). Age comparison performed using Chi-square test on grouped age categories; ASA comparison by Chi-square; all haemodynamic comparisons by independent t-test.*

2. Intraoperative Blood Pressure Changes

Intraoperative SBP was significantly higher in Group H compared with Group N at 5 minutes (141.5 ± 4.5 vs 121.4 ± 4.9 mmHg; p <0.001), 10 minutes (129.3 ± 5.7 vs 113.7 ± 5.0 mmHg; p <0.001), 15 minutes (117.5 ± 9.0 vs 107.5 ± 6.3 mmHg; p <0.001), and 30 minutes (112.4 ± 10.2 vs 105.0 ± 9.2 mmHg; p = 0.003). No statistically significant difference was observed at 45 minutes (p = 0.135) or 60 minutes (p = 0.107), indicating haemodynamic convergence with time. DBP differences followed a similar pattern, with significant intergroup differences at 5, 10, and 15 minutes (all p <0.05) but not at 30, 45, or 60 minutes (p >0.05). Both groups demonstrated a gradual decline in blood pressure following spinal anaesthesia, with Group H maintaining comparatively higher absolute values throughout [Table 2].

Table 2. Intraoperative Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Mean Arterial Pressure (MAP) at Standardised Time Points

Time	SBP Group H Mean ± SD	SBP Group N Mean ± SD	DBP Group H Mean ± SD	DBP Group N Mean ± SD	MAP p†	SBP p†
5 min	141.5 ± 4.5	121.4 ± 4.9	88.3 ± 3.7	78.3 ± 2.9	<0.001	<0.001
10 min	129.3 ± 5.7	113.7 ± 5.0	80.9 ± 4.8	73.0 ± 3.6	<0.001	<0.001
15 min	117.5 ± 9.0	107.5 ± 6.3	72.6 ± 9.3	68.5 ± 5.0	<0.001	0.023
30 min	112.4 ± 10.2	105.0 ± 9.2	68.2 ± 11.4	66.7 ± 6.1	0.089	0.485
45 min	113.4 ± 9.4	107.2 ± 8.9	69.0 ± 10.4	67.3 ± 5.4	0.156	0.414
60 min	114.7 ± 8.8	109.0 ± 8.0	69.8 ± 10.0	68.0 ± 4.9	0.118	0.334

*SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; MAP = Mean Arterial Pressure; Group H = Controlled Hypertensive; Group N = Normotensive; SD = Standard Deviation; mmHg = millimetres of mercury; †Independent samples t-test p-value for DBP (left) and SBP (right). MAP p-values are separately reported in Table 3. *Statistically significant (p<0.05).*

3. Intraoperative Mean Arterial Pressure and Heart Rate

MAP was significantly higher in Group H at 5 minutes (105.7 ± 2.9 vs 92.4 ± 2.7 mmHg; p <0.001), 10 minutes (96.6 ± 3.9 vs 86.4 ± 3.1 mmHg; p <0.001), and 15 minutes (87.3 ± 8.2 vs 81.2 ± 4.4 mmHg; p <0.001). By 30 minutes (82.6 ± 9.9 vs 79.1 ± 6.5 mmHg; p = 0.089), 45 minutes (p = 0.156), and 60 minutes (p = 0.118), intergroup MAP differences were no longer statistically significant. Heart rate was comparable between the two groups at all measured intraoperative time points (all p >0.05), indicating similar chronotropic responses to spinal anaesthesia regardless of hypertensive status [Table 3].

Table 3. Intraoperative Mean Arterial Pressure (MAP) and Heart Rate (HR) at Standardised Time Points

Time	MAP Group H Mean ± SD	MAP Group N Mean ± SD	HR Group H Mean ± SD	HR Group N Mean ± SD	MAP p†	HR p†
5 min	105.7 ± 2.9	92.4 ± 2.7	81.6 ± 5.2	82.2 ± 6.5	<0.001	0.653
10 min	96.6 ± 3.9	86.4 ± 3.1	82.0 ± 7.5	81.1 ± 6.4	<0.001	0.583
15 min	87.3 ± 8.2	81.2 ± 4.4	81.9 ± 7.5	82.1 ± 7.9	<0.001	0.914
30 min	82.6 ± 9.9	79.1 ± 6.5	78.9 ± 8.6	82.4 ± 8.2	0.089	0.097
45 min	83.8 ± 7.5	80.6 ± 5.8	79.1 ± 7.1	81.1 ± 7.5	0.156	0.230
60 min	84.8 ± 7.5	81.7 ± 5.9	79.2 ± 5.3	80.5 ± 6.2	0.118	0.343

*MAP = Mean Arterial Pressure; HR = Heart Rate; Group H = Controlled Hypertensive; Group N = Normotensive; SD = Standard Deviation; mmHg = millimetres of mercury; bpm = beats per minute. †Independent samples t-test p-value for MAP and HR respectively. *Statistically significant (p<0.05).*

4. Perioperative Adverse Events: Hypotension, Bradycardia, Vasopressor Use, and PONV

Intraoperative hypotension (SBP decrease >20% from baseline or SBP <90 mmHg) occurred in 8 of 35 patients (22.9%) in Group H compared with 4 of 35 (11.4%) in Group N; this difference was not statistically significant (χ^2 = 0.905, p = 0.341). All patients who developed hypotension responded adequately to intravenous mephentermine. Vasopressor requirement mirrored the hypotension data, occurring in 22.9% of Group H versus 11.4% of Group N (p = 0.341). Importantly, no episodes of bradycardia were recorded in either group (Fisher's exact test, p = 1.000). PONV was observed in 45.7% of Group H versus 28.6% of Group N (χ^2 = 1.53, p = 0.216). No other perioperative cardiovascular events were documented in either group [Table 4].

Table 4. Summary of Perioperative Adverse Events

Event	Group H n (%)	Group N n (%)	χ^2/Test	p-value
Intraoperative hypotension	8 (22.9%)	4 (11.4%)	0.905	0.341
Vasopressor required	8 (22.9%)	4 (11.4%)	0.905	0.341
Bradycardia (<60 bpm)	0 (0%)	0 (0%)	Fisher's	1.000
PONV	16 (45.7%)	10 (28.6%)	1.53	0.216

Group H = Controlled Hypertensive; Group N = Normotensive; PONV = Postoperative Nausea and Vomiting; χ^2 = Chi-square statistic; Fisher's = Fisher's exact test (used when expected cell counts <5). All comparisons were not statistically significant (p>0.05). Hypotension defined as SBP decrease >20% from baseline or SBP <90 mmHg; Bradycardia defined as HR <60 bpm.

5. Postoperative Haemodynamics, Block Regression, and VAS Pain Scores

Postoperative SBP, MAP, HR, and DBP remained comparable between groups at 1, 3, and 6 hours following surgery (all p >0.05). Although Group H demonstrated marginally higher absolute blood pressure values at all postoperative time points, the differences did not reach statistical significance. Spinal block regression time was comparable between groups (Group H: 274.4 ± 16.0 minutes vs Group N: 270.4 ± 17.4 minutes; t = 0.997, p = 0.323), indicating that hypertensive status did not influence local anaesthetic pharmacodynamics. VAS pain scores rose progressively in both groups from 1 to 6 hours as the block regressed, reaching 4.2 ± 1.2 in Group H and 4.3 ± 1.1 in Group N at 6 hours, with no statistically significant intergroup difference at any time point (all p >0.05) [Table 5].

Table 5. Postoperative Haemodynamics (SBP and MAP), VAS Pain Scores, and Block Regression Time

Time	SBP Group H Mean ± SD	SBP Group N Mean ± SD	MAP Group H Mean ± SD	MAP Group N Mean ± SD	VAS Group H	VAS Group N
1 hr	123.5 ± 7.7	121.1 ± 7.1	96.3 ± 5.9	94.5 ± 5.7	0.6 ± 0.7	0.7 ± 0.8
3 hr	124.3 ± 6.2	121.9 ± 6.0	97.0 ± 5.7	95.3 ± 5.5	2.0 ± 1.0	2.1 ± 0.9
6 hr	122.9 ± 5.9	120.7 ± 5.7	95.9 ± 5.4	94.3 ± 5.5	4.2 ± 1.2	4.3 ± 1.1
Block regression (min)	274.4 ± 16.0	270.4 ± 17.4	—	—	p = 0.323	—

SBP = Systolic Blood Pressure; MAP = Mean Arterial Pressure; VAS = Visual Analogue Scale (0 = no pain, 10 = worst imaginable pain); Group H = Controlled Hypertensive; Group N = Normotensive; SD = Standard Deviation; mmHg = millimetres of mercury. Block regression time expressed as mean ± SD in minutes. All postoperative intergroup comparisons non-significant (p>0.05 by independent t-test). DBP data not shown; intergroup differences non-significant at all postoperative time points (p = 0.279–0.326).

DISCUSSION

This prospective comparative study evaluated haemodynamic responses to spinal anaesthesia in 70 patients undergoing elective lower limb orthopaedic surgery. The principal findings were: (1) controlled hypertensive patients exhibited significantly higher intraoperative SBP and MAP during the first 15–30 minutes following spinal anaesthesia compared with normotensive patients; (2) despite these early absolute differences, both groups demonstrated comparable haemodynamic stability by 45–60 minutes; (3) the incidence of clinically significant hypotension, vasopressor requirement, bradycardia, PONV, and postoperative haemodynamic derangements did not differ significantly between groups. These results suggest that adequate preoperative control of hypertension, when paired with standardised anaesthetic management, substantially mitigates perioperative cardiovascular risk in this surgical population.

The significantly older age and uniformly higher ASA classification (ASA II) observed in Group H are consistent with the well-established epidemiological relationship between advancing age and hypertension prevalence. Egan et al. [2] documented that systolic blood pressure and prevalent hypertension increase disproportionately with ageing, particularly in women, and that cardiovascular risk doubles with each decade of life. In our cohort, the higher ASA grading among hypertensive patients reflects not merely elevated blood pressure but also the cumulative systemic burden of end-organ exposure, which may independently modulate haemodynamic reserve. This age and ASA disparity must be considered a potential confounder when interpreting our results: the numerically higher but non-significant hypotension rate in Group H (22.9% vs 11.4%) may partly reflect age-related autonomic attenuation rather than hypertension per se. This interpretation is supported by previous data from Singla et al. [11], who in a large prospective cohort identified advancing age, alongside hypertension, obesity, and female sex, as independent risk factors for early post-spinal hypotension.

The primary outcome of this study — the intraoperative blood pressure trajectory — revealed consistently higher SBP, DBP, and MAP values in Group H during the early intraoperative period (5–30 minutes), after which both groups converged. This pattern aligns with pathophysiological principles: hypertensive patients with established arterial remodelling maintain higher ambient vascular tone, and while spinal sympathectomy abruptly reduces this tone, the residual vascular autoregulatory reserve sustains relatively higher absolute pressures before equilibrium is reached. Leake Gebrargs et al. [7], studying a similar comparative design in patients aged ≥40 years, also reported significantly higher mean SBP and MAP in controlled hypertensive patients at multiple intraoperative intervals, with a higher hypotension incidence (23.6%) compared with normotensives (7.3%, p = 0.018). Our findings of higher early absolute pressures mirror their results, although we did not observe a statistically significant hypotension rate difference, likely reflecting differences in sample age profile and baseline risk distribution. Dohare et al. [8] similarly reported that hypertensive patients on calcium channel blockers experienced significantly more frequent hypotension following spinal anaesthesia, with a mechanism attributable to additive vasodilatory effects of both the drug class and sympathetic blockade.

The predominant antihypertensive agent in Group H was amlodipine, used in 51.4% of patients either as monotherapy or as a component of combination regimens. Calcium channel blockers reduce systemic vascular resistance through peripheral arterial vasodilatation; when superimposed upon sympatholytic vasodilatation from spinal anaesthesia, a compounded vasodilatory response becomes mechanistically plausible. Panda et al. [12] corroborated this risk pattern, demonstrating significantly higher hypotension rates in hypertensive patients managed with calcium channel blockers as monotherapy compared with those on combined calcium channel blocker plus beta-blocker regimens or normotensive controls. Beta-blockers, by contrast, may attenuate reflex tachycardia without substantially worsening hypotension, whereas ACE inhibitors have been associated with augmented hypotensive responses through renin–angiotensin system blockade that is unmasked under sympathectomy conditions. The absence of bradycardia in both our groups likely reflects the moderate block heights achieved with standardised dosing and the absence of high thoracic sympathetic blockade that would impair cardioaccelerator fibres (T1–T4).

Regarding the secondary outcomes, the absence of statistically significant differences in hypotension incidence (22.9% vs 11.4%, p = 0.341) between our groups is consistent with observations by Panda et al. [12] and Dohare et al. [8]. However, the relatively wide numerical gap between groups — with nearly double the rate in hypertensive patients — warrants clinical attention and may reflect a type II error attributable to the modest sample size. Balta and Yilmaz [6] provided compelling mechanistic evidence that elevated preoperative pulse wave velocity — a marker of arterial stiffness that is higher in hypertensive patients — is independently associated with spinal anaesthesia–related hypotension at multiple time points after block administration. Their data suggest that arterial stiffness, rather than blood pressure status alone, may be the critical determinant of haemodynamic vulnerability, offering a potential target for preoperative risk stratification beyond conventional blood pressure measurement. Similarly, KavakAkelma et al. [13], studying lower limb orthopaedic patients, identified elevated ASA score as an independent predictor of spinal anaesthesia-induced hypotension, consistent with the higher ASA II prevalence in our hypertensive cohort.

The POQI consensus statement on perioperative arterial pressure management [10] highlights that postoperative hypotension is both underrecognised and clinically consequential, potentially driving myocardial injury, acute kidney injury, and delirium in susceptible patients. In our study, postoperative SBP, DBP, MAP, and HR were statistically comparable between groups at 1, 3, and 6 hours, suggesting that the early intraoperative blood pressure differential does not persist into the recovery phase under standardised management. Jeandin et al. [14] in a large retrospective analysis further demonstrated that spinal anaesthesia results in significantly lower rates of intraoperative haemodynamic instability requiring vasopressors compared with general anaesthesia for total knee arthroplasty, reinforcing the intrinsic haemodynamic advantage of neuraxial techniques in the orthopaedic population.

PONV was numerically more frequent in Group H (45.7% vs 28.6%, p = 0.216), though statistically non-significant. PONV following spinal anaesthesia is pathophysiologically linked to hypotension-induced cerebral ischaemia, vagal predominance, and serotonergic activation, all of which may be slightly more pronounced in older patients with higher baseline sympathetic tone [15]. Chen et al. [15] in a large retrospective cohort identified female sex and lower BMI as significant predictors of PONV after total knee arthroplasty under spinal anaesthesia, demographic features partially reflected in our hypertensive group (62.9% female). Block regression time was similar between groups (p = 0.323), confirming that the intrathecal pharmacodynamics of hyperbaric bupivacaine are unaffected by hypertensive status, as the local anaesthetic mechanism is fundamentally physicochemical and not substantially modulated by systemic cardiovascular disease.

From a clinical implication perspective, this study provides reassurance that controlled hypertension, when optimally managed preoperatively with continued antihypertensive therapy and paired with standardised spinal anaesthesia protocols, does not substantially increase the incidence of clinically significant haemodynamic complications compared with normotensive patients undergoing comparable surgery. Nonetheless, the transiently higher early intraoperative blood pressure values and numerically greater — even if statistically non-significant — hypotension and vasopressor rates in hypertensive patients argue for heightened vigilance during the first 30 minutes following spinal block induction, when sympathetic blockade is maximal. Enhanced intraoperative monitoring frequency, readiness of vasopressor agents, and attention to volume status are prudent in this patient population.

This study has several limitations that must be acknowledged. The relatively modest sample size of 35 patients per group may have insufficient statistical power to detect moderate-sized differences in hypotension rates, and a larger multicentre trial would be required to draw definitive conclusions on this endpoint. The non-randomised comparative design, with group allocation determined by clinical diagnosis, introduced inherent baseline differences — particularly in age and ASA status — that may confound haemodynamic comparisons. Although body weight and sex were comparable, the significantly older hypertensive cohort represents an important effect modifier. The study was conducted at a single tertiary centre, which may limit generalisability to different clinical settings. Additionally, haemodynamic recordings were limited to non-invasive measurements, and intraoperative variables such as block height, dose of local anaesthetic in specific cases, and exact volume of co-loading fluids were not individually reported. Future studies should incorporate arterial stiffness measures, standardise antihypertensive regimen subgroups, and use larger sample sizes with multivariate adjustment to better isolate the independent effect of hypertensive status on post-spinal haemodynamics.

CONCLUSION

This prospective comparative study demonstrates that controlled hypertensive patients undergoing lower limb orthopaedic surgery under spinal anaesthesia exhibit transiently elevated intraoperative systolic and mean arterial pressures during the first 30 minutes following block induction compared with normotensive peers. However, these early absolute differences converge by 45–60 minutes, and the overall incidences of clinically significant hypotension, bradycardia, vasopressor requirement, PONV, and postoperative haemodynamic derangements do not differ significantly between groups. Spinal block regression time and postoperative pain profiles are likewise comparable. These findings suggest that well-controlled hypertension, managed with continued antihypertensive therapy and a standardised anaesthetic protocol, does not independently confer a markedly greater perioperative haemodynamic risk. Nevertheless, the numerically higher complication rates in hypertensive patients — particularly during the early intraoperative period — warrant sustained clinical vigilance, reinforcing the need for individualised monitoring strategies that account for patient age, ASA status, antihypertensive regimen class, and arterial stiffness. Larger, multicentre randomised studies with multivariate haemodynamic modelling are needed to fully characterise the independent contribution of controlled hypertension to post-spinal haemodynamic instability.

DECLARATIONS

Conflict of Interest: The authors declare no conflicts of interest.

Funding: This study received no external funding.

Ethical Approval: Ethical approval was obtained from the Institutional Ethical Committee of Government Medical College, Srinagar. All procedures conformed to the ethical standards of the institutional and national research committees, and to the 1964 Declaration of Helsinki and its later amendments.

Informed Consent: Written informed consent was obtained from all individual participants included in the study.

BIBLIOGRAPHY

1. He C, Lu S, Yu H, Sun Y, Zhang X. Global, regional, and national disease burden attributable to high systolic blood pressure in youth and young adults: 2021 Global Burden of Disease Study analysis. BMC Med. 2025;23(1):74. doi:10.1186/s12916-025-03918-1
2. Egan BM, Mattix-Kramer HJ, Basile JN, Sutherland SE. Managing hypertension in older adults. CurrHypertens Rep. 2023;26(4):157–167. doi:10.1007/s11906-023-01289-7
3. LeakeGebrargs et al. Comparison of haemodynamic responses following spinal anesthesia in controlled hypertensive and normotensive patients undergoing surgery below umbilicus: a prospective cohort study. [Published 2021]. [Internal reference from thesis]
4. Saugel B, Fletcher N, Gan TJ, et al. PeriOperative Quality Initiative (POQI) international consensus statement on perioperative arterial pressure management. Br J Anaesth. 2024;133(2):264–276. doi:10.1016/j.bja.2024.04.046
5. Messina A, La Via L, Milani A, et al. Spinal anesthesia and hypotensive events in hip fracture surgery in elderly patients: a meta-analysis. J AnesthAnalgCrit Care. 2022;2(1):19.
6. Balta E, Yilmaz S. Increased pulse wave velocity as a predictor of intraoperative hypotension in hypertensive patients undergoing spinal anaesthesia. J Coll Physicians Surg Pak. 2024;34(12):1419–1424. doi:10.29271/jcpsp.2024.12.1419
7. Gebrargs L, et al. Haemodynamic response following spinal anaesthesia in controlled hypertensive and normotensive patients. [Ethiopian study 2021; referenced as [3] in thesis]
8. Dohare S, Vatsalya T, Mehrotra S. An observational study to compare spinal anaesthesia-induced haemodynamic changes in normotensive and hypertensive patients on antihypertensive medications. Asian J Pharm Clin Res. 2024;17(2):26–30.
9. Singh A, De RR, Kumar N, Akhileshwar, Shekhar S. A comparative study of spinal anaesthesia with hyperbaric ropivacaine 0.75% and hyperbaric bupivacaine 0.5% in hypertensive patients undergoing lower abdominal and lower limb surgery. Cureus. 2025;17(12):e98437. doi:10.7759/cureus.98437
10. Saugel B, Fletcher N, Gan TJ, et al. POQI consensus statement on perioperative arterial pressure management. Br J Anaesth. 2024;133(2):264–276. doi:10.1016/j.bja.2024.04.046
11. Singla D, Kathuria S, Singh A, et al. Risk factors for development of early hypotension during spinal anaesthesia. J AnaesthesiolClinPharmacol. 2006;22:387–393.
12. Panda A, Muni MK, Nanda A. A comparative study of haemodynamic parameters following subarachnoid block in patients with and without hypertension. Cureus. 2022;14(1):e20948.
13. KavakAkelma F, Mafizer M, Nalbant B. Perfusion index as a predictor of hypotension after spinal anesthesia in lower extremity orthopedic surgery: a prospective observational trial. BMC Surg. 2025;25(1):348.
14. Jeandin T, Albrecht E, Rossel JB, Wegrzyn J, Cachemaille M. Haemodynamic stability between spinal and general anaesthesia in patients undergoing primary total knee arthroplasty: a retrospective study. Anesthesiol Res Pract. 2025;2025:9045822.
15. Chen TH, Wu CC, Chen JP. Factors associated with postoperative pain trajectory, nausea, and vomiting after total knee arthroplasty: a retrospective study. Clin J Pain. 2025;41(3). doi:10.1097/AJP.0000000000001270