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Comparison between Effects of Ephedrine and Phenylephrine on Hemodynamic Parameters of Patients going under Spinal Anesthesia

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Abstract

Hypotension is a common complication of spinal anesthesia, resulting from sympathetic blockade and decreased venous return. Vasopressors such as ephedrine and phenylephrine are frequently used to restore blood pressure, though they differ in adrenergic activity. This study aimed to compare the effects of ephedrine and phenylephrine on hemodynamic parameters in patients undergoing spinal anesthesia. A prospective randomized controlled trial was conducted at the Department of Anesthesia and Intensive Care, Erbil Training Center, Kurdistan Region, Iraq, from January 2025 to September 2026. Fifty adult patients (ASA I–II) scheduled for elective surgery under spinal anesthesia were randomly assigned to receive intravenous ephedrine (6 mg bolus) or phenylephrine (100 µg bolus) when hypotension occurred. Hemodynamic parameters including systolic, diastolic, and mean arterial pressures (MAP) and heart rate (HR) were recorded at regular intervals. Baseline characteristics were similar between groups ($p > 0.05$). Mean preoperative systolic blood pressure (SBP) was 131.9 ± 10.2 mmHg in the Ephedrine group and 129.8 ± 7.6 mmHg in the Phenylephrine group ($p = 0.409$). Heart rate was higher in the Ephedrine group (75.3 ± 7.8 bpm vs 78.4 ± 5.7 bpm; $p = 0.116$). At 30 minutes, diastolic BP was significantly lower in the Phenylephrine group (77.7 ± 6.9 mmHg) compared with the Ephedrine group (82 ± 7.3 mmHg; $p = 0.037$). Additional vasopressor doses were required in 84% of Ephedrine and 60% of Phenylephrine patients. Adverse effects were comparable: nausea occurred in 36% of each group, while bradycardia was slightly more frequent with phenylephrine (16% vs 8%). Ephedrine and phenylephrine are equally effective and safe for managing spinal anesthesia-induced hypotension. Ephedrine better preserves heart rate, whereas phenylephrine provides stronger vasoconstrictive control. Both agents maintain stable hemodynamics when appropriately titrated.

Keywords: Ephedrine, Phenylephrine, Spinal anesthesia, Hemodynamic stability, Vasopressor, Hypotension

Introduction

Spinal anesthesia is a widely used technique for surgeries involving the lower abdomen, pelvis, and lower limbs because of its simplicity, rapid onset, and reliable sensory and motor blockade. It offers excellent postoperative analgesia and avoids the risks of general anesthesia, such as airway complications and aspiration.[1] Despite its advantages, hypotension is one of its most frequent complications.[2] The mechanism involves sympathetic blockade leading to peripheral vasodilatation, decreased venous return, and a consequent fall in cardiac output.[3,12] These hemodynamic changes can result in symptoms such as nausea, vomiting, dizziness, and, in severe cases, cardiovascular collapse, posing risks especially in elderly or obstetric patients.[2]

To prevent or manage this hemodynamic instability, various strategies have been employed, including preloading with intravenous fluids, leg elevation, and the administration of vasopressors.[3] Among vasopressors, ephedrine and phenylephrine are the most commonly used agents.[1,2] Ephedrine is a mixed-acting sympathomimetic that stimulates both α- and β-adrenergic receptors, thereby increasing blood pressure by enhancing cardiac output and systemic vascular resistance. Historically, it has been the preferred vasopressor in obstetric and non-obstetric spinal anesthesia due to its ability to maintain uteroplacental blood flow.[3] However, studies have demonstrated that ephedrine readily crosses the placenta and may lead to fetal acidosis, as well as maternal tachycardia and arrhythmias.[3,4]

Phenylephrine, in contrast, is a selective α_1-adrenergic agonist that increases systemic vascular resistance via vasoconstriction, effectively restoring blood pressure but often accompanied by reflex bradycardia due to baroreceptor activation.[1,3] Several randomized clinical trials and meta-analyses have

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shown that phenylephrine maintains systolic blood pressure more effectively and is associated with better neonatal acid–base status and lower rates of intraoperative nausea and vomiting than ephedrine.[3-5,11] Nevertheless, the potential reduction in cardiac output and heart rate caused by phenylephrine remains a concern, particularly in patients with compromised cardiac function.[5]

Despite multiple investigations, there is still no consensus on the ideal vasopressor during spinal anesthesia, as clinical responses vary depending on patient factors, surgical type, and anesthetic management. Therefore, this study aims to compare the effects of ephedrine and phenylephrine on hemodynamic parameters in patients undergoing spinal anesthesia, focusing on changes in systolic, diastolic, and mean arterial pressures and heart rate to determine the safer and more effective agent for maintaining intraoperative hemodynamic stability.

Patients and Methods

This study was a prospective randomized controlled trial conducted at the Department of Anesthesia and Intensive Care, Erbil Training Center, Kurdistan Region, Iraq, from January 2025 to September 2025. A total of 50 adult patients who underwent various surgical procedures under spinal anesthesia were included. Consecutive eligible patients were recruited from the operating rooms using a convenient sampling method and were randomly assigned into two equal groups: Group E, which received intravenous ephedrine, and Group P, which received intravenous phenylephrine, with 25 patients in each group. Randomization was performed manually. Fifty identical pieces of paper, 25 labeled “Group E” and 25 labeled “Group P”, were folded and placed in a container. A scrub nurse who was not involved in the surgery drew one paper immediately before the spinal anesthesia was administered, and the patient was assigned to the corresponding group. The primary investigator responsible for data collection was blinded to the patient allocation.

Ethical approval was obtained from Kurdistan Higher council for medical Specialties Meeting code: 1026 granted on 20/02/2025. A written informed consent was obtained from each patient prior to their participation. The aim, details and scope of the research was explained to each patient. All participants were informed that they could withdraw from the study whenever they would like to and that participation is voluntary.

Patients aged between 18 and 60 years of both genders, classified as American Society of Anesthesiologists (ASA) physical status I or II, and scheduled for elective surgery under spinal anesthesia were included in the study.[6] Exclusion criteria comprised patients younger than 18 or older than 60 years, those with severe end-organ disease or cardiovascular disorders, known hypersensitivity to ephedrine or phenylephrine, or those who declined participation.

All participants underwent a preoperative evaluation, and informed written consent was obtained from each patient and one first-degree relative. In the operating room, standard monitoring, including non-invasive blood pressure, electrocardiography, and pulse oximetry, was applied. Spinal anesthesia was performed under aseptic conditions at the L3–L4 or L4–L5 interspace using 0.5% hyperbaric bupivacaine. After confirming adequate sensory block, baseline hemodynamic parameters—systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and Heart Rate (HR) were recorded.

Blood pressure and heart rate were continuously monitored throughout the procedure. Hypotension was defined as a fall in systolic blood pressure greater than 20% from baseline or below 90 mmHg. Patients in the ephedrine group received an intravenous bolus of ephedrine, while those in the phenylephrine group received an intravenous bolus of phenylephrine whenever hypotension occurred. Additional doses were administered as needed to maintain systolic pressure within 20% of baseline values. The onset of action, duration of effect, number of doses required, and occurrence of adverse effects such as bradycardia, tachycardia, nausea, and vomiting were recorded for each patient.

The primary outcome measure was maintenance of hemodynamic stability, including changes in mean arterial pressure and heart rate. Secondary outcomes included the incidence of hypotension, frequency of

adverse events, and the dose-dependent response of both drugs.

Data were analyzed using SPSS software version 25. Continuous variables were expressed as mean ± standard deviation and compared between groups using the independent Student's t-test. Categorical variables were presented as frequencies and percentages and compared using the Chi-square test or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant, and results were presented with 95% confidence intervals.

Results

Table (1) presents the baseline demographic and clinical characteristics of patients in the Ephedrine and Phenylephrine groups. The results show that both groups were comparable across all baseline variables. The mean age was slightly higher in the Ephedrine group (50.6 ± 12.1 years) compared to the Phenylephrine group (45.2 ± 11.8 years), but this difference was not statistically significant (p = 0.115). Gender distribution and BMI categories were similar, with most patients being overweight in both groups. ASA classification, cardiovascular disease history, hypertension, and antihypertensive medication use did not differ significantly (p > 0.05). These findings confirm that the study groups were homogenous before intervention, minimizing potential confounding factors.

Table (1): Baseline demographic and clinical characteristics of patients in the ephedrine and phenylephrine groups

Variables		Ephedrine Group n=25	Phenylephrine Group n=25	p-value
Age, mean±SD		50.6±12.1	45.2±11.8	0.115
Gender	Male	13 (52%)	11 (44%)	0.571
	Female	12 (48%)	14 (56%)	
BMI	Normal	7 (29.2%)	3 (12%)	0.287
	Overweight	16 (62.5%)	21 (84%)	
	Obese	2 (8.3%)	1 (4%)	
ASA Classification	I	8 (32%)	9 (36%)	1.000
	II	17 (68%)	16 (64%)	
History of Cardiovascular disease		8 (32%)	7 (28%)	1.000
Hypertension		11 (44%)	15 (60%)	0.258
Antihypertensive		11 (44%)	8 (32%)	0.382

Table (2) presents a comparison of the mean preoperative vital signs between the Ephedrine and Phenylephrine groups). The two groups showed no significant differences in any of these parameters (p > 0.05). Both groups had comparable baseline hemodynamic profiles before spinal anesthesia, ensuring that subsequent differences observed were due to the effect of the administered vasopressors rather than preexisting disparities.

Table (2): Comparison of mean preoperative vital signs between the ephedrine and phenylephrine group

Variables	Ephedrine Group n=25	Phenylephrine Group n=25	p-value
Heart rate	75.3±7.8	78.4±5.7	0.116
Systolic blood pressure	131.9±10.2	129.8±7.6	0.409
Diastolic blood pressure	84.3±8.2	81.3±7.7	0.190
MAP	100.3±8.4	97.6±6.4	0.209

Table (3) presents information regarding the initial and total doses of the vasopressors, the need for additional doses, and the time interval between spinal anesthesia and the administration of the vasopressor. The initial dose of Ephedrine was 9.9 ± 3.5 mg, while Phenylephrine was administered at 90.8 ± 12.1 µg, reflecting standard clinical dosing differences. A higher percentage of patients in the

Ephedrine group required additional doses (84%) compared with the Phenylephrine group (60%), indicating a more frequent need for reinforcement with Ephedrine. However, the mean time to vasopressor administration after spinal anesthesia was similar between groups (7.2 ± 4 min vs. 8.3 ± 3.4 min; p = 0.294). These findings suggest that both vasopressors were used under similar clinical conditions and timing, with Phenylephrine demonstrating a longer-lasting initial effect in some patients.

Table (3): Dose and timing characteristics of administered vasopressors among the study groups

Variables	Ephedrine Group n=25	Phenylephrine Group n=25	p-value
Initial vasopressor dose	9.9±3.5 mg	90.8±12.1 mcg	-
Need for additional vasopressor dose	21 (84%)	15 (60%)	
Total vasopressor dose	16.1±4.6 mg	149±71.3 mcg	-
Time after spinal anesthesia that vasopressor was administered	7.2±4	8.3±3.4	0.294

Table (4) presents the sequential changes in heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure at 2, 5, 10, 15, 20, and 30 minutes following spinal anesthesia. The Ephedrine group consistently showed higher heart rates than the Phenylephrine group throughout the observation period, which aligns with Ephedrine's β-adrenergic activity, though these differences were not statistically significant (Figure 1). Systolic blood pressure remained relatively stable in both groups across all time points, with no significant differences. Diastolic blood pressure values were similar until 30 minutes, where a significant reduction was observed in the Phenylephrine group (p = 0.037). Mean arterial pressure was slightly lower in the Phenylephrine group at later intervals (20 and 30 minutes), but without statistical significance (Figure 2). Overall, both vasopressors effectively maintained hemodynamic stability during the intraoperative period, with only minor variations in blood pressure trends.

Table (4): Comparison of hemodynamic parameters between Ephedrine and Phenylephrine groups at different time intervals following spinal anesthesia

Variables		Ephedrine Group n=25	Phenylephrine Group n=25	P-Value
Heart rate	2 minutes	81.8±10.8	76.7±9.6	0.136
	5 minutes	80.6±7.9	76.2±8.6	0.063
	10 minutes	79.9±9.9	75.6±8.9	0.113
	15 minutes	79.7±10.7	76.1±9	0.195
	20 minutes	78.9±8.8	74.9±11	0.167
	30 minutes	76.8±76.8	74.4±10.8	0.408
SBP	2 minutes	132±18.9	136.4±8.6	0.299
	5 minutes	133.4±9.9	130.9±9.4	0.360
	10 minutes	131.7±8.1	130.9±10.5	0.675
	15 minutes	128.8±9.6	129.1±8.8	0.915
	20 minutes	130.7±9.3	122.9±20.1	0.084
	30 minutes	128.6±11.7	126±8.6	0.384
DBP	2 minutes	86.5±7.9	84.9±5.3	0.433
	5 minutes	84.6±7.7	83.6±6.8	0.617
	10 minutes	84.1±7	83±7.1	0.591
	15 minutes	84.1±7.3	80.8±8.3	0.147
	20 minutes	82.6±7.1	79.4±8.4	0.160
	30 minutes	82±7.3	77.7±6.9	0.037

MAP	2 minutes	102.7±9	101.9±4.2	0.705
	5 minutes	100.4±8	99.5±6.2	0.637
	10 minutes	99.6±6.6	98.5±6.7	0.541
	15 minutes	98.4±7.1	96.4±5.7	0.330
	20 minutes	98.4±7.1	95±6.3	0.082
	30 minutes	97.7±8.1	93.8±5.8	0.060

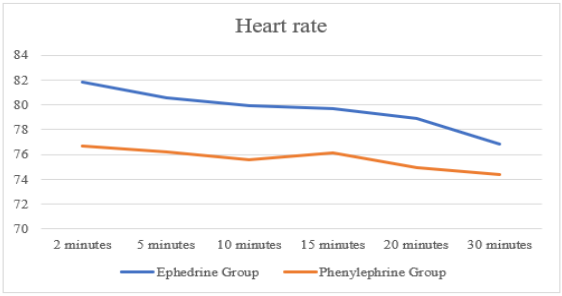

Figure (1): Pattern of heart rate changes in ephedrine group and the phenylephrine group

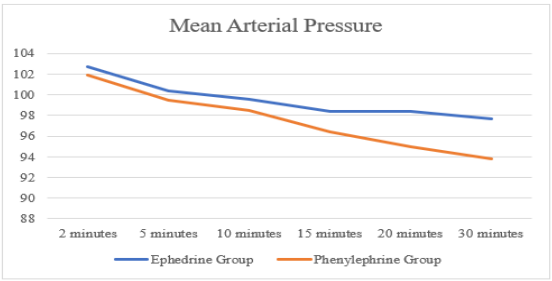

Figure (2): Pattern of mean arterial pressure changes in ephedrine group and the phenylephrine group

Table (5) presents data on the duration of spinal anesthesia effect, intraoperative adverse events, and postoperative outcomes for both groups. The mean duration of spinal anesthesia effect was longer in the Ephedrine group (99.9 ± 28.1 minutes) than in the Phenylephrine group (90 ± 18.3 minutes), although this was not statistically significant (p = 0.156). The frequency of adverse effects was comparable between groups. Nausea occurred in 36% of patients in each group, while vomiting, bradycardia, and hypotension were slightly more common with Phenylephrine. Tachycardia and arrhythmia appeared only in patients receiving Ephedrine, but none of these differences reached statistical significance. No participants required additional intraoperative intervention in either group. The majority of patients remained stable postoperatively, with only a few requiring ICU admission or additional postoperative support, and no significant differences between groups. These results indicate that both agents were well tolerated and provided safe hemodynamic control during spinal anesthesia.

Table (5): Duration of vasopressor effect, adverse events, and postoperative outcomes in both groups

Variables		**Ephedrine Group n=25**	**Phenylephrine Group n=25**	**p-value**
Duration of spinal anesthesia effect in minutes		99.9±28.1	90±18.3	0.156
Adverse effects	Nausea	9 (36%)	9 (36%)	1.000
	Vomiting	1 (4%)	4 (16%)	0.349
	Bradycardia	2 (8%)	4 (16%)	0.667
	Tachycardia	2 (8%)	0 (0%)	0.490
	Hypertension	2 (8%)	2 (8%)	1.000
	Hypotension	2 (8%)	4 (16%)	0.667
	Arrhythmia	3 (12%)	0 (0%)	0.235
Additional intervention needed		0 (0%)	0 (0%)	NA
Final outcome	Stable	15 (60%)	1 (56%)	0.842
	ICU admission	3 (12%)	2 (8%)	
	Additional post-op support	7 (28%)	9 (36%)	

Discussion

The present study compared the effects of ephedrine and phenylephrine on hemodynamic parameters in patients undergoing spinal anesthesia. Both vasopressors effectively maintained blood pressure

and cardiovascular stability throughout the procedure, with no statistically significant differences in systolic blood pressure, diastolic blood pressure, or mean arterial pressure (MAP) between the groups. Ephedrine tended to sustain a higher heart rate, consistent with its mixed α- and β-adrenergic effects, whereas phenylephrine caused a slight reduction in heart rate due to its selective α-adrenergic stimulation and reflex bradycardia. Adverse effects such as nausea, vomiting, bradycardia, and hypotension were comparable between the groups, indicating that both agents were safe and clinically effective when titrated properly.

The current results are in close agreement with those reported by Nazir et al.,[7] who investigated the preventive and therapeutic effects of phenylephrine and ephedrine on hypotension during spinal anesthesia for cesarean delivery. Their study found no significant difference in maintaining systolic, diastolic, or mean blood pressure between the two groups, which supports our observation of comparable blood pressure control. However, Nazir et al.[7] noted a significantly higher incidence of bradycardia in the phenylephrine group, an expected outcome due to reflex parasympathetic activation following an increase in vascular resistance. This aligns precisely with our data, where the phenylephrine group exhibited lower mean heart rates at most time intervals. Moreover, Nazir et al.[7] found no significant difference in neonatal outcomes (Apgar score and umbilical cord pH), suggesting that both agents are safe for maternal and fetal use, which corresponds with our finding of favorable intraoperative and postoperative stability without complications.

Similarly, Hama et al. compared the effect of intravenous ephedrine and phenylephrine in treating post-spinal hypotension and reported that both drugs effectively restored blood pressure, though ephedrine produced a significantly higher pulse rate.[1] This agrees with our finding that heart rate was consistently higher in the Ephedrine group across all time points, reflecting its β-adrenergic activity and its ability to increase cardiac output. Hama et al.,[1] concluded that while both agents are effective in treating hypotension, their mechanisms differ, ephedrine acting as a mixed α/β agonist and phenylephrine as a pure α agonist, which mirrors our interpretation of the differential heart rate responses observed between groups.

A comparable pattern was demonstrated by Dusitkasem et al.,[8] who reviewed vasopressor use in high-risk pregnancies and emphasized that both agents are safe and effective for treating spinal anesthesia–induced hypotension. They noted that phenylephrine was more effective in maintaining maternal blood pressure and was associated with fewer maternal side effects such as nausea and vomiting, though bradycardia was more common. This observation closely parallels our results: both groups maintained stable blood pressure, but phenylephrine demonstrated a mild trend toward lower heart rates, while adverse events like nausea and vomiting occurred at similar rates and were statistically insignificant. The consistency across these findings strengthens the evidence for the equivalent efficacy of both agents under spinal anesthesia.

In another study, Sonsale and Kuttarmare,[3] compared the effects of phenylephrine and ephedrine in managing maternal hypotension during cesarean delivery. They reported that phenylephrine was superior in maintaining systolic blood pressure within the desired range and in reducing the incidence of intraoperative nausea. However, they also found that bradycardia occurred more frequently in the phenylephrine group. Our findings are in partial agreement with theirs—while both agents in our study maintained systolic pressure effectively, ephedrine's β-stimulatory property contributed to a relatively higher heart rate and lower risk of bradycardia. The absence of significant nausea or vomiting in our cohort further indicates adequate hemodynamic stability with both drugs when administered in clinically appropriate doses.

Additionally, Koch et al.,[9] evaluated cerebral perfusion changes using magnetic resonance imaging in patients treated with ephedrine or phenylephrine. They reported that both agents maintained adequate cerebral macro- and microcirculation through distinct mechanisms—ephedrine by augmenting cardiac output and phenylephrine by increasing systemic vascular resistance. This mechanistic distinction supports our physiological interpretation of the results: in our study, both groups maintained

comparable mean arterial pressures despite differing adrenergic pathways, suggesting that the net effect on perfusion pressure and oxygen delivery was similar. Thus, our results confirm that both vasopressors can effectively preserve tissue perfusion during spinal anesthesia without compromising hemodynamic equilibrium.

Taken together, these comparisons consistently support the conclusion that both ephedrine and phenylephrine are effective and safe in maintaining cardiovascular stability during spinal anesthesia. Ephedrine's combined α- and β-adrenergic effects help sustain cardiac output and heart rate, explaining the higher mean heart rates observed in our Ephedrine group. Conversely, phenylephrine's pure α-agonist activity induces peripheral vasoconstriction, elevating systemic vascular resistance and maintaining blood pressure, though occasionally causing reflex bradycardia. Despite these pharmacologic differences, the hemodynamic outcomes and safety profiles remained similar across studies, indicating clinical equivalence when appropriately dosed and titrated.[10]

From a practical perspective, the choice between these agents should be individualized based on patient characteristics and clinical priorities. Phenylephrine may be preferable in cases where tachycardia or arrhythmia is a concern, whereas ephedrine may be more suitable for patients with a tendency toward bradycardia or reduced cardiac output. The overall similarity in blood pressure control and safety outcomes in our study and the supporting literature confirms that both vasopressors are reliable first-line choices for managing spinal anesthesia–induced hypotension.

This study has several limitations. The sample size was relatively small, which may reduce the power to detect subtle differences between ephedrine and phenylephrine. Convenience sampling may introduce selection bias, limiting the generalizability of the findings. Hemodynamic variables were measured at fixed intervals rather than continuously, so brief fluctuations may have been missed. Only bolus dosing was evaluated, which may not reflect practices where continuous infusions are used. Potential confounders such as hydration status, anxiety level, and variations in block height were not fully controlled. Finally, the single-center design restricts broader applicability to other populations and clinical settings.

Conclusion

The findings of this study indicate that both ephedrine and phenylephrine are effective vasopressors for maintaining hemodynamic stability during spinal anesthesia. Ephedrine tends to sustain heart rate due to β-adrenergic effects, whereas phenylephrine provides stronger vasoconstrictive control with a mild bradycardic tendency. Both agents demonstrated comparable safety profiles, reinforcing their suitability as first-line options in anesthesia practice.

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