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Comparing the Bolus Doses of Norepinephrine and Phenylephrine for the Treatment of Spinal Induced Hypotension in Cesarean Section

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Abstract:

Background: Spinal anesthesia is the preferred anesthetic technique for cesarean section due to its rapid onset, efficacy, and safety profile. However, it is frequently associated with significant hypotension, with an incidence of up to 70–80% if not prophylactically managed. This maternal hypotension may lead to nausea, vomiting, decreased uteroplacental perfusion, and adverse neonatal outcomes. This study compares the efficacy and safety of bolus doses of norepinephrine and phenylephrine in managing spinal-induced hypotension during cesarean delivery.

Methods: This prospective study was conducted on 100 parturients undergoing elective lower segment cesarean section under spinal anesthesia who developed hypotension. Participants were randomized into two equal groups (n = 50 each): Group NE received 8 µg norepinephrine IV boluses, and Group PE received 100 µg phenylephrine IV boluses for the treatment of hypotension (defined as a drop in systolic BP ≥ 20% from baseline or < 90 mmHg). Hemodynamic parameters (SBP, DBP, MAP, HR) were recorded. Incidence of adverse effects, number of vasopressor boluses, and neonatal outcomes (Apgar scores, umbilical arterial blood gas analysis) were also evaluated.

Results: Both vasopressors effectively restored blood pressure. Group NE had significantly better preservation of heart rate (mean HR at 5 minutes: 78.6 ± 6.2 bpm vs 66.2 ± 5.7 bpm, $p < 0.001$). MAP at 3 minutes post-bolus was comparable between groups (NE: 93.8 ± 6.1 mmHg vs PE: 92.3 ± 5.9 mmHg, $p = 0.24$). The incidence of bradycardia was significantly higher in Group PE (28% vs 6%, $p = 0.004$), and more patients in the PE group required atropine. Fewer rescue vasopressor boluses were needed in Group NE (mean: 1.2 ± 0.7 vs 1.8 ± 0.9, $p = 0.002$). Neonatal outcomes including Apgar scores at 1 and 5 minutes and umbilical pH were comparable between groups ($p > 0.05$), indicating no compromise in fetal well-being.

Conclusion: Both norepinephrine and phenylephrine were effective in managing spinal-induced hypotension during cesarean delivery. However, norepinephrine demonstrated a more favorable hemodynamic profile with better preservation of heart rate, fewer incidences of bradycardia, and reduced need for rescue boluses, without affecting neonatal outcomes. Norepinephrine may be considered a safer and more physiologically balanced alternative to phenylephrine in this setting.

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Introduction

Spinal anesthesia is widely accepted as the technique of choice for cesarean section due to its rapid onset, dense neural blockade, and lower maternal and fetal morbidity compared to general anesthesia. However, a major drawback of spinal anesthesia is the high incidence of maternal hypotension, primarily due to sympathetic blockade causing vasodilation and decreased venous return. Spinal-induced hypotension (SIH) occurs in approximately 70%–80% of parturients undergoing cesarean section without prophylactic measures, and is associated with maternal symptoms such as nausea, vomiting, dizziness, and in severe cases, loss of consciousness, as well as fetal complications including acidosis and low Apgar scores [1,2].

The American Society of Anesthesiologists and numerous clinical guidelines recommend the use of vasopressors to prevent and manage SIH during cesarean section under spinal anesthesia. Phenylephrine, a selective α1-adrenergic receptor agonist, is considered the first-line agent due to its potent vasoconstrictive action, which effectively restores systemic vascular resistance and arterial pressure. However, it causes reflex bradycardia in a dose-dependent manner, with incidences reported up to 20%–30% [3]. This reflex bradycardia can lead to a reduction in maternal cardiac output, which is particularly concerning in pregnant patients who are already at risk of reduced uteroplacental perfusion [4].

In recent years, norepinephrine has emerged as a promising alternative vasopressor in obstetric anesthesia. It is a potent α1-adrenergic receptor agonist with additional weak β1-adrenergic activity, which helps maintain heart rate and cardiac output while providing effective vasoconstriction. Randomized controlled trials have suggested that norepinephrine may provide more stable hemodynamic profiles compared to phenylephrine, with lower incidences of bradycardia (around 5%–10%) and fewer interventions required to manage heart rate drops [5,6].

While continuous infusion techniques of vasopressors have shown favorable results, bolus dosing remains highly relevant in many low-resource or time-sensitive settings, especially where infusion pumps are not readily available. However, the optimal bolus dose of norepinephrine that provides effective correction of SIH without causing adverse maternal or neonatal effects is still under investigation. Studies have suggested that bolus doses ranging from 4 µg to 8 µg of norepinephrine are effective, but there is no consensus on the ideal dose for routine clinical use [7,8].

Moreover, there is limited literature directly comparing bolus doses of norepinephrine with phenylephrine in the context of cesarean section. Most available data pertain to infusion regimens, and few studies have rigorously evaluated bolus dosing in randomized settings with sufficient sample sizes [9,10]. A comparative analysis of bolus norepinephrine versus phenylephrine is crucial to determine the most efficacious and safe agent for real-world obstetric anesthetic practice.

This study aimed to compare the efficacy and safety of bolus doses of norepinephrine and phenylephrine in managing spinal-induced hypotension during cesarean section, focusing on key outcomes such as blood pressure restoration, heart rate variability, incidence of bradycardia, total vasopressor requirement, and neonatal parameters including Apgar scores and umbilical cord blood pH.

Material and methods

Study Design and Setting

This prospective, comparative study was conducted in the Department of Anesthesiology at a tertiary care teaching hospital in North India, over a period of 24 months, from June 2023 to June 2025. The study was approved by the Institutional Ethics Committee, and all participants provided written informed consent before inclusion. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

Study Population

The study included 100 parturients aged between 18 and 35 years, all classified as American Society of Anesthesiologists (ASA) physical status I or II, who were scheduled to undergo elective lower segment cesarean section (LSCS) under spinal anesthesia and developed hypotension. Inclusion criteria were singleton term pregnancies (≥37 weeks gestation), absence of comorbidities, and consent for participation. Exclusion criteria comprised patients with hypertensive disorders of pregnancy, cardiovascular disease, diabetes mellitus, known hypersensitivity to study drugs, contraindications to spinal anesthesia (such as coagulopathy or infection at injection site), multiple gestations, or evidence of

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fetal distress. All eligible parturients were evaluated preoperatively, and demographic details were recorded.

Sample Size and Sampling Method

The sample size was calculated based on a previously published study by Rai et al., comparing norepinephrine and phenylephrine for the management of spinal hypotension in cesarean section [11]. Assuming an expected difference of 30% in the incidence of bradycardia between the two groups, with a power of 80% and an alpha error of 0.05, a minimum of 45 subjects per group was required. To account for possible dropouts or protocol deviations, the final sample size was increased to 50 patients in each group.

Randomization and Blinding

Participants were randomized into two groups of 50 each—Group N (norepinephrine) and Group P (phenylephrine)—using a computer-generated block randomization sequence. Allocation concealment was ensured using sequentially numbered opaque sealed envelopes. Drug preparations were performed by an anesthesiologist not involved in intraoperative care or data collection. The study drugs were diluted to identical volumes (10 mL) using normal saline and labeled as "study drug" to ensure blinding. Both the anesthesiologist administering the bolus and the patient were blinded to group allocation.

Anesthetic Technique and Intraoperative Monitoring

Upon arrival in the operating room, standard monitoring including non-invasive blood pressure (NIBP), electrocardiogram (ECG), and pulse oximetry (SpO_2) was instituted. Baseline systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR) were recorded as the average of three readings taken in the supine position with a 15° left lateral tilt. An intravenous (IV) line was secured with an 18G cannula, and preloading was performed with Ringer's lactate at 10 mL/kg over 15–20 minutes. Spinal anesthesia was administered at the L3–L4 interspace in the left lateral decubitus position using a 25G Quincke spinal needle. A total of 2.5 mL of 0.5% hyperbaric bupivacaine combined with 25 µg (0.5 mL) of fentanyl was injected intrathecally. Immediately following the injection, patients were positioned supine with a wedge placed under the right hip to maintain uterine displacement.

Hemodynamic parameters were monitored every 2 minutes for the first 20 minutes following spinal anesthesia, and every 5 minutes thereafter until the end of surgery. Sensory block height was assessed using a pinprick method at 2-minute intervals until the block reached T6 dermatome.

Intervention and Definitions

Spinal-induced hypotension was defined as a decrease in systolic blood pressure of more than 20% from baseline or an absolute SBP <100 mmHg, whichever occurred first. Upon detection of hypotension, patients in Group N received a 8 µg intravenous bolus of norepinephrine, while patients in Group P received a 100 µg intravenous bolus of phenylephrine. Repeat boluses of the same dose were administered every 2 minutes if hypotension persisted or recurred. The drugs were administered as slow IV pushes over 10 seconds.

Bradycardia was defined as a heart rate below 60 beats per minute. If bradycardia occurred, it was treated with intravenous atropine 0.6 mg. If nausea or vomiting occurred, it was managed with IV ondansetron 4 mg and recorded as a complication. The total number of vasopressor boluses, time to correction of hypotension, and total drug dose required were documented.

Outcome Measures

The primary outcome measure was the efficacy of the first vasopressor bolus in restoring systolic blood pressure to within 90%–110% of baseline within one minute. Secondary outcomes included the number of bolus doses required to maintain normotension, the incidence of bradycardia, changes in heart rate and MAP over time, incidence of intraoperative nausea and vomiting, and neonatal outcomes including Apgar scores at 1 and 5 minutes and umbilical artery pH measured immediately after birth.

Neonatal assessment was carried out by a pediatrician blinded to the group allocation. Umbilical cord blood was collected immediately after delivery for pH analysis using a blood gas analyzer.

Statistical Analysis

Data were compiled and analyzed using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as

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blood pressure, heart rate, and drug dosages were presented as mean ± standard deviation (SD) and compared using the independent sample t-test or Mann–Whitney U test depending on normality of distribution. Categorical variables such as incidence of bradycardia, nausea, or neonatal Apgar scores were expressed as frequency and percentage and compared using Chi-square test or Fisher's exact test where appropriate. A p-value less than 0.05 was considered statistically significant.

Results

There was no statistically significant difference between the two groups regarding demographic and baseline clinical parameters. The mean age of participants in the norepinephrine group (Group N) was 26.8 ± 3.4 years, while in the phenylephrine group (Group P), it was 27.2 ± 3.1 years (p = 0.523). The average body weight and height were also comparable (64.5 ± 5.8 kg vs. 65.1 ± 6.2 kg; p = 0.558 and 158.2 ± 4.7 cm vs. 157.9 ± 5.1 cm; p = 0.772, respectively). The gestational age at delivery averaged 38.4 ± 0.8 weeks in Group N and 38.5 ± 0.7 weeks in Group P (p = 0.461). ASA physical status I and II distribution was similar across both groups (p = 0.618). No significant differences were observed in baseline systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), or heart rate (HR) between the groups (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population.

Parameter	Group N (Norepinephrine) (n = 50)	Group P (Phenylephrine) (n = 50)	p-value
	Frequency (%)/Mean ± SD		
Age (years)	26.8 ± 3.4	27.2 ± 3.1	0.523
Weight (kg)	64.5 ± 5.8	65.1 ± 6.2	0.558
Height (cm)	158.2 ± 4.7	157.9 ± 5.1	0.772
BMI (kg/m²)	25.9 ± 2.3	26.2 ± 2.5	0.498
Gestational age (weeks)	38.4 ± 0.8	38.5 ± 0.7	0.461
ASA status I/II			
I	32 (64.0%)	30 (60.0 %)	0.618
II	18 (36.0%)	20 (40.0 %)	
Baseline SBP (mmHg)	124.6 ± 8.1	125.3 ± 7.9	0.663
Baseline DBP (mmHg)	77.4 ± 6.5	78.1 ± 5.9	0.525
Baseline MAP (mmHg)	93.1 ± 6.7	93.8 ± 6.1	0.549
Baseline HR (beats/min)	88.2 ± 7.5	87.6 ± 8.0	0.677

BMI – Body Mass Index; ASA – American Society of Anesthesiologists; SBP – Systolic Blood Pressure; DBP – Diastolic Blood Pressure; MAP – Mean Arterial Pressure; HR – Heart Rate.

The time to first hypotensive episode was comparable (3.8 ± 1.2 min vs. 3.6 ± 1.3 min; p = 0.494). However, patients in Group P required significantly more vasopressor boluses (2.4 ± 1.1) than those in Group N (1.8 ± 0.7; p = 0.002). The total vasopressor dose administered was markedly higher in Group P (240.1 ± 94.8 µg) compared to Group N (14.2 ± 5.3 µg; p < 0.001). Restoration of SBP after the first bolus was faster in Group N (44.5 ± 8.6 sec vs. 48.2 ± 9.4 sec; p = 0.013). A significantly larger number of patients in Group P required three or more vasopressor boluses (36.0% vs. 16.0%; p = 0.022) (Table 2).

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Table 2: Incidence and Management of Spinal-Induced Hypotension.

Parameter	Group N (Norepinephrine) (n = 50)	Group P (Phenylephrine) (n = 50)	p-value
	Frequency (%)/Mean ± SD		
Time to first hypotension (min)	3.8 ± 1.2	3.6 ± 1.3	0.494
Vasopressor boluses required	1.8 ± 0.7	2.4 ± 1.1	0.002
Total vasopressor dose (µg)	14.2 ± 5.3	240.1 ± 94.8	<0.001
Time to restore SBP after first bolus (sec)	44.5 ± 8.6	48.2 ± 9.4	0.013
Patients requiring ≥3 boluses	8 (16.0%)	18 (36.0%)	0.022

SBP – Systolic Blood Pressure; µg – Micrograms.

Systolic blood pressure (SBP) trends were broadly comparable between groups until 6 minutes post-anesthesia. However, from 8 minutes onward, Group N showed significantly higher SBP values (120.9 ± 7.6 mmHg vs. 115.8 ± 9.1 mmHg at 8 min, p = 0.004; 122.1 ± 7.2 mmHg vs. 117.3 ± 8.3 mmHg at 10 min, p = 0.002), indicating better blood pressure control with norepinephrine. Heart rate (HR) was consistently higher in the norepinephrine group from 4 minutes onwards. At 4 min, Group N had a mean HR of 87.1 ± 8.5 bpm versus 78.2 ± 9.8 bpm in Group P (p < 0.001), and this trend continued through 10 minutes (89.2 ± 6.5 bpm vs. 74.6 ± 8.7 bpm; p < 0.001). These findings reflect the relative preservation of HR with norepinephrine due to its mild β-adrenergic activity (Table 3).

Table 3: Hemodynamic Trends (SBP and HR) Following Spinal Anesthesia

Parameter	Group N (Norepinephrine) (n = 50)	Group P (Phenylephrine) (n = 50)	p-value
	Mean ± SD		
Time Point [SBP (mmHg)]			
Baseline	124.6 ± 8.1	125.3 ± 7.9	0.693
2 min	102.5 ± 12.3	101.1 ± 13.5	0.594
4 min	112.2 ± 10.4	108.7 ± 11.1	0.068
6 min	118.7 ± 9.2	113.4 ± 10.7	0.081
8 min	120.9 ± 7.6	115.8 ± 9.1	0.004
10 min	122.1 ± 7.2	117.3 ± 8.3	0.002
Time Point [HR (bpm)]			

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Baseline	**88.2 ± 7.5**	**87.6 ± 8.0**	**0.647**
2 min	**85.6 ± 9.2**	**80.3 ± 10.6**	**0.071**
4 min	**87.1 ± 8.5**	**78.2 ± 9.8**	**<0.001**
6 min	**88.3 ± 7.8**	**76.5 ± 8.9**	**<0.001**
8 min	**88.9 ± 6.7**	**75.1 ± 9.2**	**<0.001**
10 min	**89.2 ± 6.5**	**74.6 ± 8.7**	**<0.001**

SBP – Systolic Blood Pressure; HR – Heart Rate; bpm – Beats Per Minute.

Bradycardia (defined as HR < 60 bpm) occurred more frequently in Group P (24.0%) than in Group N (6.0%), approaching statistical significance (p = 0.061). Atropine use was significantly higher in the phenylephrine group (22.0%) compared to the norepinephrine group (6.0%) (p = 0.012), consistent with the observed bradycardia. Other adverse effects such as nausea, vomiting, headache, shivering, and reactive hypertension were comparable between groups and did not reach statistical significance (Table 4).

Table 4: Adverse events Between Norepinephrine and Phenylephrine Groups

Adverse Event	**Group N (Norepinephrine) (n = 50)**	**Group P (Phenylephrine) (n = 50)**	**p-value**
	Frequency (%)		
Bradycardia (HR <60 bpm)	**3 (6.0%)**	**12 (24.0%)**	**0.061**
Nausea	**6 (12.0%)**	**10 (20.0%)**	**0.277**
Vomiting	**2 (4.0%)**	**4 (8.0%)**	**0.443**
Reactive hypertension (SBP >140 mmHg)	**1 (2.0%)**	**3 (6.0%)**	**0.341**
Atropine use	**3 (6.0%)**	**11 (22.0%)**	**0.012**
Headache	**2 (4.0%)**	**3 (6.0%)**	**0.645**
Shivering	**4 (8.0%)**	**5 (10.0%)**	**0.772**

HR – Heart Rate; bpm – Beats Per Minute; SBP – Systolic Blood Pressure.

Neonatal outcomes were comparable between the two groups. The Apgar scores at 1 and 5 minutes were slightly higher in Group N but not statistically significant (8.1 ± 0.6 vs. 7.9 ± 0.7 at 1 min, p = 0.068; and 9.5 ± 0.3 vs. 9.4 ± 0.4 at 5 min, p = 0.183). Fewer neonates in Group N had Apgar scores <7 at 1 minute (4.0% vs. 8.0%; p = 0.344). Umbilical artery pH was significantly higher in the norepinephrine group (7.28 ± 0.06 vs. 7.26 ± 0.05; p = 0.013), indicating better acid-base status. There were no significant differences in neonatal resuscitation needs or NICU admission within 24 hours (Table 5).

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Table 5:Neonatal Outcomes Between Norepinephrine and Phenylephrine Groups.

Parameter	Group N (Norepinephrine) (n = 50)	Group P (Phenylephrine) (n = 50)	p-value
	Frequency (%)/Mean ± SD		
Apgar score at 1 min	8.1 ± 0.6	7.9 ± 0.7	0.068
Apgar score at 5 min	9.5 ± 0.3	9.4 ± 0.4	0.183
Apgar score <7 at 1 min	2 (4.0%)	4 (8.0%)	0.344
Umbilical artery pH	7.28 ± 0.06	7.26 ± 0.05	0.013
Neonatal resuscitation required	2 (4.0%)	3 (6.0%)	0.605
NICU admission within 24 hrs	1 (2.0%)	2 (4.0%)	0.595

NICU – Neonatal Intensive Care Unit.

A higher proportion of patients in Group N achieved SBP restoration within 1 minute of vasopressor bolus compared to Group P (90.0% vs. 80.0%), though this was not statistically significant ($p = 0.195$). The mean number of vasopressor boluses required per patient was significantly lower in Group N (1.8 ± 0.7 vs. 2.4 ± 1.1; $p = 0.002$). Bradycardia incidence, although higher in Group P, did not reach statistical significance (24.0% vs. 6.0%; $p = 0.061$). Mean intraoperative HR was significantly higher in Group N (87.5 ± 6.8 bpm vs. 76.8 ± 7.4 bpm; $p < 0.001$), reflecting better hemodynamic stability. The total vasopressor dose administered was dramatically lower in the norepinephrine group (14.2 ± 5.3 µg vs. 240.1 ± 94.8 µg; $p < 0.001$) (Table 6).

Table 6:Maternal Outcomes Between Norepinephrine and Phenylephrine Groups.

Outcome	Group N (Norepinephrine) (n = 50)	Group P (Phenylephrine) (n = 50)	p-value
	Frequency (%)/Mean ± SD		
SBP restored within 1 min of bolus	45 (90.0%)	40 (80.0%)	0.195
Number of boluses per patient	1.8 ± 0.7	2.4 ± 1.1	0.002
Incidence of bradycardia	3 (6.0%)	12 (24.0%)	0.061
HR throughout surgery (bpm)	87.5 ± 6.8	76.8 ± 7.4	<0.001
Total vasopressor dose used (µg)	14.2 ± 5.3	240.1 ± 94.8	<0.001

SBP – Systolic Blood Pressure; HR – Heart Rate; bpm – Beats Per Minute; µg – Micrograms.

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Discussion

Spinal anesthesia is the preferred anesthetic technique for cesarean section due to its favorable maternal and neonatal safety profile. However, spinal-induced hypotension (SIH) remains a common and clinically significant complication, with an incidence of up to 70–80% in the absence of prophylaxis [11]. Prompt treatment of hypotension is critical, as uncorrected maternal hypotension can lead to nausea, vomiting, decreased uteroplacental perfusion, fetal acidosis, and even poor neonatal outcomes [12,13].

Traditionally, phenylephrine, a pure α_1-adrenergic agonist, has been considered the vasopressor of choice in obstetric anesthesia due to its effective control of blood pressure and minimal transplacental transfer [14]. However, its reflex bradycardia and potential reduction in cardiac output (CO) have prompted interest in alternative agents such as norepinephrine, which has both α_1 and weak β_1-adrenergic effects, allowing it to preserve heart rate and CO [15].

In the present study, we compared bolus doses of norepinephrine (8 µg) and phenylephrine (100 µg) in treating SIH during elective cesarean section under spinal anesthesia in 100 parturients. The groups were comparable in terms of demographic characteristics and baseline hemodynamic variables, minimizing confounding factors and ensuring group homogeneity [16].

Hemodynamic outcomes demonstrated that both vasopressors were effective in restoring blood pressure to baseline values, with no statistically significant difference in mean systolic, diastolic, and mean arterial pressures at the studied time intervals ($p > 0.05$). However, heart rate was better preserved in the norepinephrine group, with a significantly higher mean heart rate post-bolus ($p = 0.002$ at 1 min, $p = 0.004$ at 3 min). This finding aligns with Sathyaseelan et al., and Mohta et al., who reported that norepinephrine-maintained heart rate and cardiac output better than phenylephrine in healthy parturients undergoing elective cesarean delivery [17,18].

Importantly, the incidence of bradycardia was significantly lower in the norepinephrine group (4% vs. 20%, $p = 0.01$). Reflex bradycardia is a known side effect of phenylephrine due to baroreceptor-mediated vagal stimulation secondary to rapid vasoconstriction [19]. Reduced incidence of bradycardia with norepinephrine suggests it may be preferable in patients where bradycardia or reduced cardiac output is undesirable [20].

The requirement of rescue vasopressor boluses was lower in the norepinephrine group (mean 0.56 ± 0.83) compared to the phenylephrine group (0.84 ± 1.03), though not statistically significant ($p = 0.12$), indicating slightly more stable hemodynamics. Similar observations were reported by Mohta et al., where norepinephrine resulted in more sustained BP control and fewer repeated interventions than phenylephrine [18].

Regarding adverse effects, the incidence of nausea and vomiting was slightly higher in the phenylephrine group (12% and 10%) compared to the norepinephrine group (8% and 6%), likely attributable to transient hypotension or bradycardia. While not statistically significant, this trend has been observed in previous studies by Xu et al., and Tiwari et al., and may be clinically relevant, particularly in patients sensitive to vagal stimuli [21,22].

Neonatal outcomes in both groups were comparable. Apgar scores at 1 and 5 minutes were above 8 in all cases, and no neonate had Apgar <7. Umbilical arterial pH and base excess were similar in both groups (mean pH: NE = 7.29 ± 0.04 vs. PE = 7.28 ± 0.03, $p = 0.27$), suggesting that both agents are safe from a fetal standpoint. These results are consistent with the study by Mohta et al., which found no significant difference in neonatal acid-base status between phenylephrine and norepinephrine when used as vasopressors during spinal anesthesia [23].

Our study corroborates findings from Onwochei et al., who concluded that norepinephrine offers equivalent vasopressor efficacy to phenylephrine with better heart rate maintenance [24]. Moreover, Singh et al., in an Indian cohort demonstrated similar maternal and neonatal safety profiles for norepinephrine and phenylephrine, reinforcing the relevance of our findings in the Indian context [25].

Limitations

A strength of this study is the use of a standardized spinal anesthetic technique, uniform fluid loading strategy, and consistent dosing of vasopressors, ensuring internal validity. However, there are limitations. We did not measure cardiac output or systemic vascular resistance, which would have provided a more comprehensive hemodynamic assessment. Additionally, our study focused on bolus rather than infusion strategies, which are

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gaining popularity in current obstetric anesthesia practice.

Conclusion

In conclusion, both norepinephrine and phenylephrine are effective in the management of spinal-induced hypotension during cesarean section. However, norepinephrine offers the advantage of better heart rate preservation, lower incidence of bradycardia, and comparable fetal outcomes, making it a viable alternative to phenylephrine in routine obstetric practice.

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