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A Comparative Study of Phenylephrine vs Mephentermine for the Treatment of Hypotension During Spinal Anaesthesia in Caesarean Section Patients

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ABSTRACT

Background: Spinal anaesthesia–induced hypotension (SAH) complicates up to 70–80% of caesarean deliveries, threatening both maternal haemodynamic stability and uteroplacental perfusion. Vasopressor therapy is the cornerstone of management, yet the comparative merits of the selective alpha-1 agonist phenylephrine and the mixed-acting sympathomimetic mephentermine remain a subject of clinical investigation, particularly in the Indian obstetric context.

Objective: To compare the efficacy and safety of intravenous bolus phenylephrine 50 µg and mephentermine 6 mg for the treatment of SAH in parturients undergoing caesarean section under spinal anaesthesia.

Methods: Seventy ASA II parturients scheduled for caesarean section were enrolled in this prospective, randomised, double-blind study (March 2024–December 2025) and allocated equally to Group P (phenylephrine 50 µg IV bolus, n = 35) or Group M (mephentermine 6 mg IV bolus, n = 35). Haemodynamic variables—systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR)—were serially recorded after each bolus. Primary endpoints included time to restoration of baseline SBP and MAP and total bolus requirements. Secondary endpoints encompassed cardiovascular adverse effects, maternal side effects, and neonatal Apgar scores.

Results: The incidence (91.4% vs 94.3%, $p = 0.64$) and severity of SAH were comparable between groups. Phenylephrine restored SBP and MAP significantly faster than mephentermine (2.6 ± 1.1 vs 4.3 ± 1.4 min, $p < 0.001$; 2.8 ± 1.2 vs 4.5 ± 1.5 min, $p < 0.001$) and required fewer bolus doses (mean 1.3 ± 0.6 vs 2.1 ± 0.8, $p < 0.001$). SBP, DBP, and MAP were significantly higher in Group P at 1–10 minutes post-bolus, converging by 20 minutes. Bradycardia was more frequent with phenylephrine (25.7% vs 5.7%, $p = 0.02$), while tachycardia predominated with

mephentermine (22.9% vs 5.7%, p = 0.04). Maternal side effects were comparable. Neonatal Apgar scores at 1 min (7.8 ± 0.6 vs 7.7 ± 0.7) and 5 min (8.9 ± 0.4 vs 8.8 ± 0.5) and birth weights were similar between groups.

Conclusion: Phenylephrine is superior to mephentermine for rapid correction and sustained maintenance of blood pressure following SAH during caesarean section, requiring fewer rescue doses. Despite a higher incidence of bradycardia—which is responsive to atropine—phenylephrine demonstrated equivalent maternal and neonatal safety. Mephentermine may be preferred when preservation of heart rate is a clinical priority. Both agents should be used with continuous haemodynamic monitoring.

Keywords: *spinal anaesthesia; caesarean section; hypotension; phenylephrine; mephentermine; vasopressor; obstetric anaesthesia; haemodynamics; Apgar score*

1. INTRODUCTION

Spinal anaesthesia has become the anaesthetic technique of choice for caesarean deliveries worldwide, valued for its rapid, dense, and reliable block, low drug requirements, and favourable safety profile for both mother and neonate when compared with general anaesthesia [1]. By eliminating the hazards of airway management, aspiration risk, and systemic neonatal drug exposure, spinal anaesthesia has substantially reduced anaesthesia-related maternal mortality in obstetric practice [2].

However, this technique carries a well-recognised haemodynamic liability: hypotension, defined as a fall in systolic arterial pressure below 80–90% of the pre-anaesthetic baseline or below an absolute threshold of 100 mmHg, occurs in 70–80% of parturients when no prophylactic vasopressor is given [3]. The physiological substrate is the sympatholysis-induced abrupt reduction in systemic vascular resistance and venous return, compounded in late pregnancy by mechanical aortocaval compression from the gravid uterus [4]. The clinical consequences range from maternal nausea, vomiting, and dizziness to—in severe or prolonged cases—impaired cerebral and uteroplacental perfusion with risk of fetal hypoxia, metabolic acidosis, and low Apgar scores [5].

Vasopressor therapy is therefore the pharmacological cornerstone of both prophylaxis and treatment. The international consensus statement on the management of spinal anaesthesia–induced hypotension (SAH) during caesarean section recommends a target of maintaining systolic arterial pressure at or above 90% of baseline and advocates phenylephrine as the first-line agent for most parturients [6]. Phenylephrine is a selective alpha-1 adrenoceptor agonist that produces potent, rapid vasoconstriction with minimal beta-adrenergic activity; it has been favoured for its predictable haemodynamic profile and its lower association with fetal acidosis compared with mixed-acting agents [7]. Nevertheless, its

pure alpha-agonism can precipitate baroreceptor-mediated reflex bradycardia and, in some clinical scenarios, a reduction in cardiac output—effects that may be undesirable in women with pre-existing bradycardia or compromised myocardial reserve [8].

Mephentermine, an indirect sympathomimetic amine structurally related to ephedrine, promotes the release of endogenous norepinephrine from sympathetic nerve terminals, thereby engaging both alpha-1 and beta-1 adrenoceptors. Its dual mechanism augments both vascular resistance and cardiac output, and its positive chronotropic effect may better preserve heart rate in at-risk patients [9]. Mephentermine is widely available across Indian healthcare settings, including peripheral and rural institutions, and continues to be used both as a primary agent and as a rescue vasopressor in clinical practice [10]. Yet head-to-head comparisons with phenylephrine using equivalent bolus dosing regimens and systematic serial haemodynamic monitoring remain limited in the Indian literature.

The present study was therefore designed as a prospective, randomised, double-blind trial to compare phenylephrine 50 µg and mephentermine 6 mg administered as intravenous boluses for the treatment of SAH in parturients undergoing caesarean section. The primary aim was to quantify differences in the speed of blood pressure restoration and the total vasopressor consumption. Secondary aims were to characterise the differential effects on heart rate, assess the incidence of maternal adverse effects, and evaluate neonatal outcomes assessed by Apgar scores.

2. MATERIALS AND METHODS

2.1 Study Design, Setting, and Ethics

This hospital-based, prospective, randomised, double-blind, parallel-group comparative study was conducted in the Department of Anaesthesiology and Critical Care, Rama Medical College Hospital and Research Centre, Hapur, Uttar Pradesh, India, between March 2024 and December 2025. The protocol received approval from the Institutional Ethics Committee prior to commencement, and written informed consent was obtained from every participant before enrolment. The study was conducted in accordance with the Declaration of Helsinki.

2.2 Participants

Eligible participants were ASA physical status II parturients aged 18–40 years scheduled for caesarean section under spinal anaesthesia. Exclusion criteria were pregnancy-induced hypertension or any hypertensive disorder of pregnancy, ASA III or IV status, known contraindication or hypersensitivity to either study drug, baseline systolic blood pressure below 90 mmHg, and significant cardiac, renal, hepatic, or neurological disease.

2.3 Sample Size

Sample size was calculated using Cochran's formula for proportion estimation, based on a reported incidence of SAH requiring vasopressor rescue of approximately 4.5% in controlled settings from

prior literature. With a 95% confidence interval and a 5% margin of error, the minimum sample was 66; 70 participants were enrolled to provide an additional margin of safety.

2.4 Randomisation and Blinding

Participants were randomly allocated in a 1:1 ratio to Group P (phenylephrine) or Group M (mephentermine) using computer-generated random numbers. Sealed, sequentially numbered opaque envelopes maintained allocation concealment. Drug preparation was performed by a designated resident anaesthesiologist not involved in data collection or patient care. Both the treating anaesthesiologist and the patient were blinded to group allocation throughout the study period.

2.5 Drug Preparation

Phenylephrine was prepared by drawing 0.1 mL (1 mg) from a 10 mg/mL ampoule, diluting to 10 mL with 0.9% normal saline to yield 100 µg/mL, and then diluting a further 5 mL of this solution with 5 mL saline to achieve a final concentration of 50 µg/mL; each 1 mL bolus therefore delivered 50 µg. Mephentermine was prepared by drawing 1 mL (30 mg) from a 30 mg/mL ampoule and adding 4 mL of 0.9% normal saline to yield 6 mg/mL; each 1 mL bolus delivered 6 mg. Both syringes appeared identical to the treating team.

2.6 Anaesthetic Protocol

On arrival in the operation theatre, an 18-gauge intravenous cannula was sited and all patients received crystalloid preloading with Ringer's lactate 20 mL/kg. Standard monitoring—electrocardiography, pulse oximetry, and oscillometric non-invasive blood pressure—was applied. Urinary catheterisation was performed under aseptic conditions. With the patient in the supine position with a 15-degree right-hip wedge to minimise aortocaval compression, three blood pressure and heart rate readings at 3-minute intervals were obtained; the lowest systolic blood pressure and the highest heart rate were designated as the reference baseline values.

Spinal anaesthesia was administered via a midline approach with a 25-gauge spinal needle at the L3/L4 or L4/L5 interspace under strict asepsis. Hyperbaric bupivacaine 12.5 mg (2.5 mL of 0.5% bupivacaine in 8% dextrose) was injected intrathecally at 0.2 mL/s. After spinal injection, the patient was immediately repositioned supine with the right-hip wedge maintained.

Haemodynamic parameters were recorded every 2 minutes for the first 20 minutes post-injection and every 5 minutes thereafter until wound closure. Hypotension was defined as SBP < 90% of the pre-spinal baseline or an absolute value below 100 mmHg. On detection of hypotension, 1 mL of the assigned blinded study drug (phenylephrine 50 µg or mephentermine 6 mg) was administered as an intravenous bolus. Boluses could be repeated every 2 minutes if hypotension persisted, to a maximum of 20 doses. Bradycardia (HR < 60 bpm) was treated with intravenous atropine 0.3 mg; nausea and vomiting with ondansetron 4 mg; shivering with tramadol 0.5 mg/kg. Oxytocin 10 IU in 5% dextrose was infused after cord clamping.

2.7 Outcome Measures

The primary outcomes were time to restoration of baseline SBP (minutes), time to restoration of baseline MAP (minutes), and total number of vasopressor boluses required. Secondary outcomes included serial SBP, DBP, MAP, and HR at 1, 2, 5, 10, 15, and 20 minutes post-bolus; incidence of bradycardia (HR < 60 bpm), tachycardia (HR > 100 bpm), and reactive hypertension (SBP > 140 mmHg); maternal side effects (nausea, vomiting, dizziness, dyspnoea, headache, shivering); and neonatal Apgar scores at 1 and 5 minutes with birth weight.

2.8 Statistical Analysis

Data were analysed using IBM SPSS Statistics version 26. Continuous variables were tested for normality with the Shapiro–Wilk test and expressed as mean ± standard deviation (SD). Between-group comparisons of continuous variables used the independent-samples Student t-test; repeated haemodynamic measurements were analysed with repeated-measures analysis of variance (ANOVA) with Bonferroni post-hoc correction. Categorical variables were summarised as frequencies and percentages and compared using the chi-square test or Fisher's exact test as appropriate. A two-tailed p-value < 0.05 was considered statistically significant.

3. RESULTS

3.1 Baseline Characteristics

Seventy parturients were enrolled and analysed (Group P, n = 35; Group M, n = 35). Both groups were well matched at baseline: mean age 26.8 ± 3.6 vs 27.3 ± 4.0 years (p = 0.58), mean gestational age 38.4 ± 1.2 vs 38.6 ± 1.1 weeks (p = 0.48), and mean BMI 26.2 ± 2.1 vs 26.5 ± 2.3 kg/m² (p = 0.56) (Table 1). Previous lower-segment caesarean section was the most common indication in both groups (51.4% and 57.1%), followed by cephalopelvic disproportion, breech presentation, failed induction, and fetal distress. Baseline haemodynamic parameters—SBP 120.4 ± 8.3 vs 121.2 ± 7.8 mmHg, MAP 90.7 ± 6.2 vs 91.3 ± 6.5 mmHg, HR 82.6 ± 6.8 vs 83.9 ± 6.4 bpm—were comparable (Table 2). Duration of surgery was similar between groups (36.2 ± 2.8 vs 35.8 ± 3.1 minutes, p = 0.57).

Table 1. Baseline Demographic and Clinical Characteristics

Parameter	Group P (n=35)	Group M (n=35)	p
Age (years)	26.8 ± 3.6	27.3 ± 4.0	0.58
Weight (kg)	64.1 ± 5.8	65.3 ± 6.2	0.41
Height (cm)	156.5 ± 5.2	157.8 ± 5.6	0.33
BMI (kg/m²)	26.2 ± 2.1	26.5 ± 2.3	0.56
Gestational age (weeks)	38.4 ± 1.2	38.6 ± 1.1	0.48

Duration of surgery (min)	36.2 ± 2.8	35.8 ± 3.1	0.57

Values expressed as mean ± SD. BMI = body mass index.

Table 2. Baseline Haemodynamic Parameters

Parameter	Group P	Group M	p
SBP (mmHg)	120.4 ± 8.3	121.2 ± 7.8	0.68
DBP (mmHg)	75.8 ± 6.5	76.3 ± 6.8	0.75
MAP (mmHg)	90.7 ± 6.2	91.3 ± 6.5	0.69
Heart rate (bpm)	82.6 ± 6.8	83.9 ± 6.4	0.42
SpO_2 (%)	98.8 ± 0.8	98.9 ± 0.7	0.58

SBP = systolic blood pressure; DBP = diastolic blood pressure; MAP = mean arterial pressure; SpO_2 = peripheral oxygen saturation.

3.2 Hypotension Characteristics

SAH occurred with high frequency in both groups: 91.4% (32/35) in Group P and 94.3% (33/35) in Group M (p = 0.64). The time to onset of hypotension was similar (4.2 ± 1.5 vs 4.5 ± 1.6 minutes, p = 0.43), as were the lowest recorded SBP (86.3 ± 8.4 vs 84.8 ± 9.2 mmHg, p = 0.47) and the nadir MAP (61.5 ± 7.2 vs 60.8 ± 7.8 mmHg, p = 0.69), confirming equivalent hypotensive burden prior to vasopressor intervention.

3.3 Time to Blood Pressure Restoration and Bolus Requirements (Primary Outcomes)

Among patients who developed hypotension (Group P n=32, Group M n=33), phenylephrine achieved significantly faster restoration of SBP to baseline compared with mephentermine (2.6 ± 1.1 vs 4.3 ± 1.4 minutes, p < 0.001) and faster MAP restoration (2.8 ± 1.2 vs 4.5 ± 1.5 minutes, p < 0.001) (Table 3). The mean total bolus requirement was significantly lower in Group P (1.3 ± 0.6 vs 2.1 ± 0.8, p < 0.001). In Group P, 75.0% of patients required only a single bolus, versus 45.5% in Group M; three or more boluses were needed in 6.2% vs 21.2% of patients respectively (p < 0.01) (Table 4).

Table 3. Time to Restoration of Baseline Blood Pressure (Hypotensive Patients Only)

Parameter	Group P (n=32)	Group M (n=33)	p
Time to restore SBP (min)	2.6 ± 1.1	4.3 ± 1.4	**<0.001 ***
Time to restore MAP (min)	2.8 ± 1.2	4.5 ± 1.5	**<0.001 ***

**Statistically significant (p < 0.05). Independent-samples t-test.*

Table 4. Number of Vasopressor Boluses Required

Bolus doses	Group P (n=32)	Group M (n=33)	p
1 dose, n (%)	24 (75.0%)	15 (45.5%)	
2 doses, n (%)	6 (18.8%)	11 (33.3%)	**<0.01***
3 doses, n (%)	2 (6.2%)	7 (21.2%)	
Mean ± SD	**1.3 ± 0.6**	**2.1 ± 0.8**	**<0.001 ***

p for overall group comparison (chi-square test for distribution; t-test for means).

3.4 Serial Haemodynamic Responses

Serial SBP following vasopressor administration was significantly higher in Group P at 1 minute (118.5 ± 7.2 vs 98.4 ± 8.5 mmHg), 2 minutes (122.8 ± 6.8 vs 105.2 ± 7.9 mmHg), and 5 minutes (119.6 ± 7.1 vs 111.5 ± 7.4 mmHg) post-bolus (all $p < 0.001$). Significant but attenuating differences persisted at 10 and 15 minutes ($p = 0.03$ each); by 20 minutes, SBP values were comparable (114.2 ± 5.8 vs 111.8 ± 6.2 mmHg, $p = 0.11$) (Table 5). An identical temporal pattern was observed for DBP and MAP: Group P achieved markedly higher values at 1–5 minutes post-bolus (all $p < 0.001$), with convergence occurring at 15–20 minutes. Heart rate was consistently and significantly lower in Group P across all post-bolus time points from 1 to 20 minutes (range $p < 0.001$ to 0.01), reflecting phenylephrine's baroreceptor-mediated reflex bradycardic effect (Table 5).

Table 5. Serial Haemodynamic Parameters Post-Bolus (Selected Time Points)

Time point	SBP-P	SBP-M	HR-P	HR-M	p*
Baseline	120.4 ± 8.3	121.2 ± 7.8	82.6 ± 6.8	83.9 ± 6.4	NS
At hypotension	86.3 ± 8.4	84.8 ± 9.2	94.2 ± 8.5	95.8 ± 8.2	NS
1 min post-bolus	118.5 ± 7.2	98.4 ± 8.5	72.4 ± 7.2	88.5 ± 7.8	**<0.001**
5 min post-bolus	119.6 ± 7.1	111.5 ± 7.4	68.5 ± 6.5	84.8 ± 7.2	**<0.001**
10 min post-bolus	117.4 ± 6.5	113.8 ± 6.9	72.2 ± 6.8	82.4 ± 7.0	**0.03**
20 min post-bolus	114.2 ± 5.8	111.8 ± 6.2	76.4 ± 6.2	80.5 ± 6.5	0.11 / 0.01

*SBP = systolic blood pressure (mmHg); HR = heart rate (bpm); P = Group P (phenylephrine); M = Group M (mephentermine); NS = not significant. *p-values shown for SBP comparison; HR comparisons were all significant (p < 0.001 to 0.01) throughout the 20-min observation period.*

3.5 Cardiovascular Adverse Effects

Bradycardia (HR < 60 bpm) was significantly more prevalent in Group P than Group M (25.7% vs 5.7%, p = 0.02), while tachycardia (HR > 100 bpm) was significantly more common in Group M (22.9% vs 5.7%, p = 0.04). Reactive hypertension (SBP > 140 mmHg) showed a numerical trend toward higher frequency with phenylephrine (14.3% vs 2.9%), though this difference did not achieve statistical significance (p = 0.09). No arrhythmias were recorded in either group (Table 6).

Table 6. Cardiovascular Adverse Effects and Maternal Side Effects

Adverse Effect	Group P n (%)	Group M n (%)	p-value
CARDIOVASCULAR			
Bradycardia (HR < 60 bpm)	9 (25.7%)	2 (5.7%)	**0.02***
Tachycardia (HR > 100 bpm)	2 (5.7%)	8 (22.9%)	**0.04***
Reactive hypertension (SBP > 140 mmHg)	5 (14.3%)	1 (2.9%)	0.09
Arrhythmia	0 (0%)	0 (0%)	—
MATERNAL SIDE EFFECTS			
Nausea	6 (17.1%)	8 (22.9%)	0.54
Vomiting	2 (5.7%)	4 (11.4%)	0.39
Dizziness	3 (8.6%)	5 (14.3%)	0.45
Shivering	4 (11.4%)	6 (17.1%)	0.49
Headache	2 (5.7%)	3 (8.6%)	0.64
Dyspnoea	1 (2.9%)	3 (8.6%)	0.30

**Statistically significant (p < 0.05). Chi-square test or Fisher's exact test as applicable.*

3.6 Maternal Side Effects

No statistically significant intergroup differences were observed for any maternal side effect (Table 6). Nausea occurred in 17.1% vs 22.9% (p = 0.54), vomiting in 5.7% vs 11.4% (p = 0.39), dizziness in 8.6% vs 14.3% (p = 0.45), and shivering in 11.4% vs 17.1% (p = 0.49) in Groups P and M

respectively. Numeric trends towards lower side-effect rates in Group P were consistent across all parameters but did not reach significance.

3.7 Neonatal Outcomes

Neonatal outcomes were reassuring and comparable between groups (Table 7). Mean 1-minute Apgar scores were 7.8 ± 0.6 in Group P and 7.7 ± 0.7 in Group M (p = 0.52); 5-minute scores were 8.9 ± 0.4 and 8.8 ± 0.5 respectively (p = 0.38). No neonate in either group had a 5-minute Apgar score below 7. Mean birth weight was 2.92 ± 0.28 kg vs 2.96 ± 0.31 kg (p = 0.58), indicating appropriately grown term neonates in both cohorts.

Table 7. Neonatal Outcomes

Parameter	Group P (n=35)	Group M (n=35)	p
Apgar score at 1 min	7.8 ± 0.6	7.7 ± 0.7	0.52
Apgar < 7 at 1 min, n (%)	3 (8.6%)	4 (11.4%)	0.69
Apgar score at 5 min	8.9 ± 0.4	8.8 ± 0.5	0.38
Apgar < 7 at 5 min, n (%)	0 (0%)	0 (0%)	—
Birth weight (kg)	2.92 ± 0.28	2.96 ± 0.31	0.58

Values expressed as mean ± SD or n (%). Independent-samples t-test / Fisher's exact test.

4. DISCUSSION

The central finding of this double-blind randomised trial is that intravenous bolus phenylephrine 50 µg achieves faster and more complete restoration of blood pressure after SAH during caesarean section than mephentermine 6 mg, and does so with a substantially lower bolus burden—attributes that have direct clinical relevance for the safety and efficiency of obstetric anaesthesia. These advantages were achieved without any detriment to maternal symptom burden or neonatal wellbeing, confirming an acceptable overall safety profile for phenylephrine in this setting.

The high incidence of SAH—above 90% in both arms—aligns with the extensively reported vulnerability of parturients to sympatholysis-induced hypotension. The pregnant uterus imposes significant inferior vena caval and aortic compression in the supine position, reducing venous return at baseline, and the neuraxial sympathectomy from spinal bupivacaine then strips away compensatory vasoconstrictor tone abruptly [4,5]. The comparable incidence, onset time, and severity of hypotension between groups confirms that neither pre-existing differences in patient physiology nor group allocation influenced the haemodynamic nadir, thereby validating the reliability of between-group treatment comparisons.

Phenylephrine restored SBP and MAP to baseline approximately 1.7 minutes faster than mephentermine—a clinically meaningful difference when considering that the critical window for uteroplacental hypoperfusion is measured in minutes. Animal and clinical data indicate that maternal hypotension lasting less than 2 minutes generally spares neonatal neurobehaviour, whereas durations exceeding 4 minutes risk transient neonatal compromise [5,11]. On average, mephentermine group patients reached that 4-minute threshold before pressure was restored, whereas phenylephrine group patients achieved restoration well within the safe window. This interpretation is further supported by the significantly lower bolus requirement in Group P: 75% of phenylephrine patients required only a single dose, compared to less than half in the mephentermine group.

These findings are mechanistically coherent. Phenylephrine's direct, receptor-mediated alpha-1 agonism at vascular smooth muscle produces instantaneous vasoconstriction, bypassing the intermediate steps of synaptic norepinephrine release on which mephentermine depends [8,9]. The indirect mechanism of mephentermine introduces pharmacokinetic latency, is subject to depletion of neuronal norepinephrine stores with repeated dosing (tachyphylaxis), and produces a more gradual—and in acute hypotension, insufficient—vasopressor ramp [10,12]. This explains both the slower onset and the larger number of rescue boluses observed in the mephentermine arm.

The serial haemodynamic profiles corroborate these mechanistic differences with temporal precision. Post-bolus SBP, DBP, and MAP diverged maximally within the first 1–5 minutes, a window in which phenylephrine maintained pressures well above the hypotension threshold while mephentermine lagged by 15–20 mmHg on average. The two groups converged by 15–20 minutes, indicating that while the onset characteristics differ substantially, the duration of effect, once fully established, is broadly comparable.

The divergent heart rate responses are an expected pharmacodynamic signature. Phenylephrine's potent alpha-1 vasoconstriction elevates afterload, triggering baroreceptor-mediated reflex vagal activation and sinus slowing—a response well described in both the phenylephrine literature and confirmed by the 25.7% bradycardia incidence in our cohort [6,7,13]. Mephentermine's beta-1 agonist component, conversely, exerts positive chronotropy, explaining the 22.9% tachycardia rate in Group M. An important clinical nuance is that phenylephrine-associated bradycardia, while more frequent, is predictable, easily detected by continuous ECG, and promptly reversible with a small dose of atropine [6]. Uncorrected tachycardia, conversely, carries the theoretical risk of increased myocardial oxygen demand and may worsen cardiac output in parturients with pre-existing cardiac disease.

Maternal side effects—including nausea, vomiting, dizziness, shivering, headache, and dyspnoea—were numerically lower across all parameters in the phenylephrine arm, though the study was not powered to detect small differences in these secondary endpoints. The trend is physiologically plausible: faster and more complete restoration of MAP reduces the duration of cerebral hypoperfusion, which is a recognised driver of nausea and dizziness during neuraxial anaesthesia [14].

Larger studies with side-effect-specific endpoints may clarify whether phenylephrine's haemodynamic advantage translates into a statistically significant reduction in emetic morbidity.

Neonatal outcomes were excellent and indistinguishable between groups. Mean 5-minute Apgar scores exceeded 8.8 in both arms, and no neonate in either cohort had a 5-minute score below 7—a benchmark generally regarded as indicating satisfactory neonatal transition [15]. These results are consistent with contemporary evidence that both alpha-agonist and mixed-acting vasopressors, when titrated to achieve adequate maternal MAP, preserve uteroplacental perfusion sufficiently to protect neonatal acid-base status [6,16]. The absence of fetal compromise with phenylephrine is reassuring and challenges earlier concerns that pure alpha-agonism might redirect uteroplacental blood flow; these concerns appear more relevant to contexts of maternal hypertension rather than treatment of acute hypotension [7].

Comparing our results with the existing literature, Sunitha S et al. (2025) in a similarly designed double-blind RCT observed that phenylephrine 50 µg achieved faster SBP restoration and required fewer boluses than mephentermine 6 mg, with comparable Apgar scores—findings that mirror ours with high fidelity [17]. Karkala SR et al. (2024) reported superior haemodynamic stabilisation with phenylephrine versus mephentermine boluses in parturients undergoing elective caesarean section, noting that while both agents were effective, phenylephrine produced more sustained blood pressure improvement [18]. Garg A et al. (2025), in a comparison focused on oxytocin-induced haemodynamic instability, found phenylephrine more effective for blood pressure maintenance while mephentermine better preserved heart rate, highlighting the complementary profiles of the two agents [19]. Chaturvedi et al. (2020) observed higher reactive hypertension and bradycardia rates with phenylephrine infusions, while tachycardia was more common with mephentermine—a pattern consistent with our bolus study [20]. Mohta et al. (2010) found both agents equally effective when delivered as infusions at calibrated rates, suggesting that the superiority of phenylephrine may be more pronounced with bolus administration, where the rapid concentration peak amplifies its immediate alpha-agonist effect [21].

The practical implications extend beyond hospital pharmacies. In resource-limited Indian healthcare settings where continuous phenylephrine infusion pumps may not be universally available, the demonstration that bolus phenylephrine achieves superior and faster haemodynamic control than bolus mephentermine provides evidence-based support for its adoption as first-line rescue therapy even in facilities without infusion infrastructure. Conversely, mephentermine's widespread availability in prefilled ampoules, its lower cost, and its favourable chronotropic profile justify its continued use as a reasonable second-line or alternative agent when phenylephrine is unavailable or when heart rate preservation is a priority.

This study has several limitations that should be considered when interpreting the findings. The sample size, although adequate for the primary endpoints, was relatively small and may have underpowered

secondary side-effect analyses. The single-centre design limits generalisability across diverse populations and institutional settings. Only bolus dosing was evaluated; given that continuous infusion strategies, particularly variable-rate phenylephrine infusions, are increasingly considered the standard of care in high-resource settings, comparisons incorporating infusion protocols would be valuable. Umbilical cord pH, the most sensitive marker of neonatal acid-base status, was not measured, which limits the granularity of neonatal outcome assessment. Finally, the study period extended over 21 months, during which evolving clinical practices could theoretically have influenced management beyond the study protocol.

5. CONCLUSIONS

In ASA II parturients undergoing caesarean section under spinal anaesthesia, intravenous bolus phenylephrine 50 µg is superior to mephentermine 6 mg for the treatment of spinal anaesthesia–induced hypotension, providing faster restoration of systolic and mean arterial pressure and requiring fewer rescue doses. Despite a higher incidence of baroreceptor-mediated bradycardia—readily managed with atropine—phenylephrine demonstrated equivalent maternal comfort and neonatal Apgar scores. Mephentermine remains a reasonable alternative when heart rate preservation is clinically important or when phenylephrine is unavailable. Both agents require close continuous haemodynamic monitoring. Larger multicentre trials incorporating umbilical cord blood gas analysis and infusion-based protocols are warranted to further refine vasopressor guidelines in obstetric anaesthesia.

Ethical Approval:

Approved by the Institutional Ethics Committee, Rama Medical College Hospital and Research Centre, Hapur, prior to enrolment. All participants provided written informed consent.

Conflicts of Interest: None declared.

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REFERENCES

1. Mercier FJ, Augè M, Hoffmann C, Fischer C, Le Gouez A. Maternal hypotension during spinal anesthesia for caesarean delivery. Minerva Anestesiol. 2013;79(1):62–73.
2. Guay J, Choi P, Suresh S, Albert N, Kopp S, Pace NL. Neuraxial blockade for the prevention of postoperative mortality and major morbidity: an overview of Cochrane systematic reviews. Cochrane Database Syst Rev. 2014;(1):CD010108.
3. Klohr S, Roth R, Hofmann T, Rossaint R, Heesen M. Definitions of hypotension after spinal anaesthesia for caesarean section: literature search and application to parturients. Acta Anaesthesiol Scand. 2010;54(8):909–921.
4. Kinsella SM, Lohmann G. Supine hypotensive syndrome. Obstet Gynecol. 1994;83(5 Pt 1):774–788.

5. Corke BC, Datta S, Ostheimer GW, Weiss JB, Alper MH. Spinal anaesthesia for caesarean section: the influence of hypotension on neonatal outcome. Anaesthesia. 1982;37(6):658–662.
6. Kinsella SM, Carvalho B, Dyer RA, Fernando R, McDonnell N, Mercier FJ, et al. International consensus statement on the management of hypotension with vasopressors during caesarean section under spinal anaesthesia. Anaesthesia. 2018;73(1):71–92.
7. Doherty A, Ohashi Y, Downey K, Carvalho JC. Phenylephrine infusion versus bolus regimens during cesarean delivery under spinal anesthesia: a double-blind randomized clinical trial to assess hemodynamic changes. Anesth Analg. 2012;115(6):1343–1350.
8. Bhattarai B, Bhat SY, Upadya M. Comparison of bolus phenylephrine, ephedrine and mephentermine for maintenance of arterial pressure during spinal anesthesia in cesarean section. J Nepal Med Assoc. 2010;49(177):23–28.
9. Basnet RB. Comparative analytical study of intravenous bolus dose of mephentermine and phenylephrine for hemodynamic stability during elective cesarean section under spinal anesthesia [dissertation]. 2023.
10. Šklebar I, Bujas T, Habek D. Spinal anaesthesia-induced hypotension in obstetrics: prevention and therapy. Acta Clin Croat. 2019;58(Suppl 1):90–95.
11. Lanni SM, Tillinghast J, Silver HM. Hemodynamic changes and baroreflex gain in the supine hypotensive syndrome. Am J Obstet Gynecol. 2002;187(6):1636–1641.
12. Srinivasan D, Devi SN, Kay JP, Nongthombam R, Devanathan B, Sowrirajan L, et al. Mephentermine versus phenylephrine for prevention and management of maternal hypotension during caesarean section under spinal anaesthesia and their effects on foetal outcome: a randomized controlled trial. J Clin Diagn Res. 2022;16(8):UC09–UC13.
13. Kaur D, Khan AL, Pathak A. A comparative study of three vasopressors for maintenance of blood pressure during spinal anesthesia in lower abdominal surgeries. Anesth Essays Res. 2018;12(2):333–337.
14. Savanth Kumar P, Doshi V, Mehta S. Comparison of phenylephrine and mephentermine for management of hypotension during spinal anaesthesia for caesarean section. Int J Anesth Crit Care. 2020;10(2):15–22.
15. American Academy of Pediatrics, American Heart Association. Textbook of Neonatal Resuscitation. 8th ed. Elk Grove Village, IL: AAP; 2021.
16. Ngan Kee WD, Khaw KS, Tan PE, Ng FF, Karmakar MK. Placental transfer and fetal metabolic effects of phenylephrine and ephedrine during spinal anesthesia for cesarean delivery. Anesthesiology. 2009;111(3):506–512.
17. Sunitha S, Joshi N, Ramana PV, Kalyanasundaram S. Comparative efficacy of intravenous bolus phenylephrine versus mephentermine for spinal anaesthesia–induced hypotension during elective caesarean section: a randomised double-blind trial. Indian J Anaesth. 2025;69(1):42–49.
18. Karkala SR, Rao MV, Sridevi A. Randomized clinical comparison of bolus phenylephrine and mephentermine for correction of hypotension during elective caesarean section under spinal anaesthesia. J Obstet Anaesth Crit Care. 2024;14(2):88–95.
19. Garg A, Verma A, Singh P, Mehta S. Phenylephrine versus mephentermine for prevention of oxytocin-induced hemodynamic instability during caesarean section under spinal anesthesia: a prospective randomized study. Anaesthesiol Intensive Ther. 2025;57(1):22–29.

20. Chaturvedi NK, Gupta S, Shukla U, Agarwal A. Randomized comparative study of phenylephrine and mephentermine infusions for prevention of spinal-induced hypotension in parturients. J Anaesthesiol Clin Pharmacol. 2020;36(3):355–361.
21. Mohta M, Janani SS, Sethi AK, Agarwal D, Tyagi A. Comparison of phenylephrine hydrochloride and mephentermine sulphate for prevention of post-spinal hypotension. Anaesthesia. 2010;65(12):1200–1205.
22. Aruna V, Prasad GV, Ramana PV, Rao MN. Randomized controlled trial comparing phenylephrine, ephedrine, and mephentermine for prevention and treatment of spinal anaesthesia-induced hypotension in elective caesarean section. Anesth Essays Res. 2021;15(1):43–49.
23. Khan F, Hamid MA, Shaheen B, Iqbal A. Comparative study of phenylephrine, ephedrine, and mephentermine as bolus or infusion for blood pressure maintenance during spinal anaesthesia in parturients. J Pak Med Assoc. 2022;72(5):903–908.