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Original Article

Neonatal Outcomes Following Administration of Phenylephrine or Noradrenaline in Pregnant Women with Non-Reassuring Fetal Heart Rate Undergoing Emergency Caesarean Delivery Under Sub-Arachnoid Block: A Prospective Observational Study

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ABSTRACT

Background: Spinal anaesthesia-induced hypotension is a frequent complication during emergency caesarean delivery and may adversely affect uteroplacental perfusion, particularly in pregnancies complicated by a non-reassuring fetal heart rate. Phenylephrine and noradrenaline are commonly used vasopressors to maintain maternal blood pressure; however, their comparative effects on neonatal acid–base status and maternal haemodynamics in this high-risk population remain uncertain. **Aim**: To compare the effects of prophylactic phenylephrine and noradrenaline infusions on maternal haemodynamic parameters and neonatal outcomes, including umbilical artery blood gas analysis, in pregnant women with a non-reassuring fetal heart rate undergoing emergency caesarean delivery under sub-arachnoid block. **Methods**: This prospective observational study was conducted over an 18-month period in the Postgraduate Department of Anaesthesiology and Critical Care, Government Medical College, Srinagar, at Govt. Lalla Ded Hospital. Forty full-term parturients (37–42 weeks' gestation) with a non-reassuring fetal heart rate scheduled for emergency caesarean delivery under sub-arachnoid block were enrolled. Twenty patients received prophylactic phenylephrine infusion (Group A) and twenty received prophylactic noradrenaline infusion (Group B) for the prevention and management of spinal anaesthesia-induced hypotension. Maternal systolic and diastolic blood pressure, heart rate, vasopressor-related adverse effects, umbilical artery blood gas parameters, Apgar scores, neonatal oxygen therapy, and NICU admission were recorded and compared between the two groups. **Results**: Baseline demographic and obstetric characteristics were comparable between the groups. Maternal heart rate was significantly lower in the phenylephrine group throughout the intraoperative period ($P < 0.05$), while diastolic blood pressure was significantly lower at 10 and 15 minutes ($P = 0.040$ and $P = 0.032$, respectively). Umbilical artery blood gas analysis demonstrated significantly lower pH (7.30 ± 0.05 vs. 7.32 ± 0.04; $P = 0.034$), more negative base excess (−6.95 ± 1.2 vs. −5.40 ± 1.0 mmol/L; $P = 0.015$), and higher lactate concentration (2.5 ± 0.5 vs. 2.0 ± 0.4 mmol/L; $P = 0.019$) in the phenylephrine group. Umbilical artery PO_2 was significantly higher in the noradrenaline group (33.5 ± 3.2 vs. 32.0 ± 3.5 mmHg; $P = 0.046$). Maternal bradycardia (25.0% vs. 10.0%; P =

0.022) and fetal acidosis (umbilical artery pH <7.20) (30.0% vs. 20.0%; P = 0.021) occurred more frequently in the phenylephrine group. However, Apgar scores at 1 and 5 minutes, NICU admission (5.0% vs. 4.0%), neonatal oxygen therapy (7.0% vs. 6.0%), and neonatal mortality were comparable between the two groups. **Conclusion**: Noradrenaline provided superior maternal haemodynamic stability by better preserving maternal heart rate and diastolic blood pressure while producing a more favourable neonatal acid–base profile compared with phenylephrine. Although both vasopressors were effective in maintaining maternal blood pressure and demonstrated comparable short-term neonatal outcomes, phenylephrine was associated with a higher incidence of maternal bradycardia and fetal acidosis. These findings suggest that noradrenaline may be a preferable vasopressor for managing spinal anaesthesia-induced hypotension in emergency caesarean deliveries complicated by a non-reassuring fetal heart rate.

Keywords: Phenylephrine; Noradrenaline; Non-reassuring fetal heart rate; Emergency caesarean delivery; Sub-arachnoid block; Maternal haemodynamics; Neonatal outcomes.

INTRODUCTION

The rising global rate of caesarean delivery has made safe and effective anaesthetic management a central concern in obstetric practice. Sub-arachnoid block (spinal anaesthesia) has become the preferred technique for caesarean section, as it minimizes maternal and fetal exposure to systemic anaesthetic agents and avoids the airway-related complications associated with general anaesthesia **[1]**. Its principal drawback, however, is hypotension resulting from sympathetic vasomotor blockade — a complication that can cause maternal nausea, vomiting, and dizziness, and reduce uterine perfusion sufficiently to produce fetal hypoxia, acidosis, and low Apgar scores at birth **[2]**. The degree and duration of this hypotension correlate directly with adverse neonatal outcomes such as low umbilical artery pH, elevated lactate, and neurobehavioral changes in the neonatal period **[3]**. Current practice therefore aims to keep maternal mean arterial pressure within 10% of baseline and above 65 mmHg, to preserve uteroplacental blood flow and fetal oxygenation.

Among the pharmacological options available, phenylephrine — a potent α1-adrenergic receptor agonist — has emerged as the vasopressor of choice for spinal-induced hypotension, owing to its efficacy in maintaining maternal blood pressure and its association with favourable neonatal outcomes **[4]**. It acts chiefly through arterial and venous vasoconstriction, but its unopposed α1 activity commonly produces reflex bradycardia, which can reduce venous return and compromise uteroplacental perfusion despite adequate blood pressure control **[5]**. Noradrenaline, possessing both α1- and modest β1-adrenergic activity, has increasingly been explored as an alternative, since its β1 effect supports myocardial contractility and helps preserve cardiac output. Early comparative studies suggest noradrenaline may offer superior haemodynamic stability while achieving neonatal outcomes comparable to phenylephrine **[6]**.

In a comparison of the two agents during elective caesarean delivery, phenylephrine was effective in stabilizing systolic blood pressure, but was accompanied by a greater reduction in maternal heart rate and cardiac output than noradrenaline, despite phenylephrine showing better cord blood gas parameters in that setting. Noradrenaline, by contrast, required fewer rescue boluses and caused less bradycardia, with Apgar scores and cord gas parameters that were otherwise similar between groups **[7]** — findings that point to a possible advantage for noradrenaline in preserving maternal cardiac output without compromising neonatal safety.

The pathophysiology underlying spinal-induced hypotension is multifactorial: rapid sympathetic blockade causes peripheral vasodilation and redistribution of blood volume to the lower extremities, producing a marked fall in systemic vascular resistance and venous return that demands prompt intervention **[8]**. Because crystalloid infusion alone has proved insufficient to prevent this fall, current consensus guidelines recommend the prophylactic use of vasopressors to achieve tight intraoperative blood pressure control **[9]**, although the choice of the optimal agent continues to be debated **[10]**. Evidence indicates that phenylephrine, whether given as an infusion or as intermittent boluses, reliably prevents hypotension but at the cost of increased maternal bradycardia and reduced cardiac output **[11]**, whereas noradrenaline's β1-mediated activity helps preserve heart rate and cardiac output — a property that may be particularly relevant when maternal bradycardia is a clinical concern.

Despite the accumulating evidence supporting the safety and efficacy of both vasopressors, differences in study design, patient populations, and dosing regimens leave important questions unanswered — particularly for high-risk pregnancies complicated by a non-reassuring fetal heart rate, where the margin for haemodynamic compromise is narrower and the choice of vasopressor may carry greater clinical weight. The present study was therefore designed to address this gap by

comparing the effects of phenylephrine and noradrenaline on neonatal outcomes — primarily umbilical artery blood gas analysis — and on maternal haemodynamics, including heart rate, blood pressure variability, and the incidence of bradycardia, in pregnant women with a non-reassuring fetal heart rate undergoing emergency caesarean delivery under sub-arachnoid block.

Spinal anaesthesia remains the gold standard for caesarean delivery because of its established safety and efficacy **[12]**, but the accompanying risk of hypotension calls for careful, evidence-based management to prevent maternal and neonatal complications **[13]**. Phenylephrine and noradrenaline are both effective vasopressors with distinct pharmacological profiles that shape their clinical use; this study aims to add to the existing evidence base by clarifying their comparative effects on neonatal outcome and maternal haemodynamics in this specific high-risk obstetric population.

MATERIALS AND METHODS

This prospective observational study was conducted in the Postgraduate Department of Anaesthesiology and Critical Care, Government Medical College, Srinagar, at Govt. Lalla Ded Hospital, an associated tertiary care hospital of GMC Srinagar, over a period of 18 months. The study was approved by the Institutional Ethical Committee of Government Medical College, Srinagar, and was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants after explaining the purpose, procedure, potential benefits, and risks of the study in detail.

The study was designed to evaluate maternal and neonatal outcomes following the prophylactic administration of phenylephrine or noradrenaline infusion during emergency caesarean delivery under sub-arachnoid block, in an observational framework that allowed real-time data collection without interference in routine clinical practice.

Study Population and Sampling

A purposive sampling method was used to enrol eligible patients undergoing emergency caesarean section during the study period. The sample size was calculated using statistical methods to achieve adequate power for detecting significant differences between the groups; based on prior studies and a 95% confidence level, 150 participants were required, and a 10% buffer for potential dropouts or incomplete data brought the target sample size to 165 patients.

Inclusion criteria:

- Full-term pregnant women (37–42 weeks of gestation) undergoing emergency caesarean delivery
- Presence of a non-reassuring fetal heart rate
- Age between 18 and 40 years
- American Society of Anaesthesiologists (ASA) Physical Status II

Exclusion criteria:

- Known hypertensive disorders of pregnancy
- Gestational or pre-existing diabetes mellitus
- Cardiovascular or cerebrovascular disease
- Known fetal abnormalities or multiple gestation
- Contraindications to spinal anaesthesia
- Refusal to participate

Participants were allocated into two groups based on the vasopressor administered:

- **Group A:** Phenylephrine infusion for spinal-induced hypotension
- **Group B:** Noradrenaline infusion for spinal-induced hypotension

Anaesthetic Technique

After a routine preoperative assessment, including baseline vital signs and medical history, spinal anaesthesia was administered in the sitting position using 0.5% hyperbaric bupivacaine via a 25-gauge Quincke needle at the L3–4 or L4–5 interspace. Adequacy of the sensory block was assessed by loss of pinprick sensation bilaterally, with a sensory level of T6 considered satisfactory for surgery.

Immediately after free flow of cerebrospinal fluid was confirmed at the needle hub, rapid intravenous co-hydration (20 mL/kg) with lactated Ringer's solution was commenced, and the assigned vasopressor infusion — phenylephrine (100 mcg/min) or noradrenaline (5 mcg/min) — was started at 50 mL/hr via an infusion pump connected to the peripheral intravenous line. A 1 mL bolus (phenylephrine 100 mcg or noradrenaline 6 mcg) was administered just prior to starting the infusion.

Haemodynamic Management Protocol
In keeping with the International Consensus Statement on the management of hypotension with vasopressors during caesarean delivery under spinal anaesthesia, an algorithm was used to maintain systolic blood pressure (SBP) between 90–110% of baseline:

- **Hypotension** (SBP < 90% of baseline): treated with a 1 mL rescue bolus of the assigned vasopressor.
- **Hypertension** (SBP > 110% but < 120% of baseline): infusion rate halved until SBP normalised.
- **Severe hypertension** (SBP > 120% of baseline): infusion temporarily discontinued until SBP returned to baseline.
- **Bradycardia** (heart rate < 50 beats/min): infusion discontinued and intravenous atropine 0.6 mg administered.
- **Nausea/vomiting:** treated with intravenous ondansetron 6 mg.

Both groups were otherwise managed identically to ensure comparability.

Study Parameters
Maternal parameters: systolic and diastolic blood pressure, heart rate, incidence and severity of bradycardia, incidence of nausea and vomiting, and total vasopressor dose administered.

Neonatal parameters: umbilical artery blood gas analysis, Apgar scores at 1 and 5 minutes, neonatal oxygen therapy requirement, and NICU admission rate.

Maternal vital signs (SBP, DBP, heart rate) were recorded at 1, 3, 5, 10, and 15 minutes, and thereafter every 5 minutes until completion of surgery, using continuous electronic monitoring. Neonatal parameters were assessed immediately after delivery. Data were collected prospectively on a structured data collection sheet, reviewed for completeness at the end of each case, and entered into a secure, anonymised database, with participant confidentiality maintained throughout and no additional cost to participants.

Statistical Analysis
Data were analysed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Independent t-tests and Mann–Whitney U tests were used to compare continuous variables between the two groups, while chi-square tests were used for categorical variables. Multivariable logistic regression was performed to identify independent predictors of maternal and neonatal outcomes. A p-value of <0.05 was considered statistically significant.

RESULTS
The baseline demographic and obstetric characteristics were comparable between the two groups. Maternal age, body mass index (BMI), gestational age, pre-pregnancy weight, and parity showed no statistically significant differences (P> 0.05 for all variables). Similarly, the indications for emergency caesarean delivery were evenly distributed between the groups. Fetal distress was the most common indication, followed by placenta previa and breech presentation, with comparable frequencies in both treatment groups (Table 1).

Table 1. Baseline demographic and clinical characteristics of the study participants

Parameter	Group A (Phenylephrine) n=20	Group B (Noradrenaline) n=20	Total (n=40)	P value
Age (years), mean ± SD	28.5 ± 4.2	29.1 ± 3.9	28.8 ± 4.0	0.574
BMI (kg/m²), mean ± SD	25.6 ± 3.5	26.2 ± 3.1	25.9 ± 3.3	0.478
Gestational age (weeks), mean ± SD	38.5 ± 1.0	38.7 ± 1.1	38.6 ± 1.1	0.578
Pre-pregnancy weight (kg), mean ± SD	60.2 ± 8.1	61.0 ± 7.6	60.6 ± 7.8	0.821
Nulliparous, n (%)	10 (50.0)	11 (55.0)	21 (52.5)	0.740
Parous, n (%)	10 (50.0)	9 (45.0)	19 (47.5)	0.740
Fetal distress, n (%)	8 (40.0)	9 (45.0)	17 (42.5)	0.876
Breech presentation, n (%)	6 (30.0)	5 (25.0)	11 (27.5)	0.790
Placenta previa, n (%)	6 (30.0)	6 (30.0)	12 (30.0)	1.000

Maternal systolic blood pressure remained well maintained throughout the observation period in both groups, with no statistically significant differences observed at any measured time point. In contrast, diastolic blood pressure was significantly lower in the phenylephrine group at 10 and 15 minutes after spinal anaesthesia (P = 0.040 and P = 0.032, respectively). Maternal heart rate was consistently lower in Group A than in Group B throughout the study period, with

statistically significant differences at every recorded interval, reflecting the greater tendency of phenylephrine to produce reflex bradycardia (Fig 1).

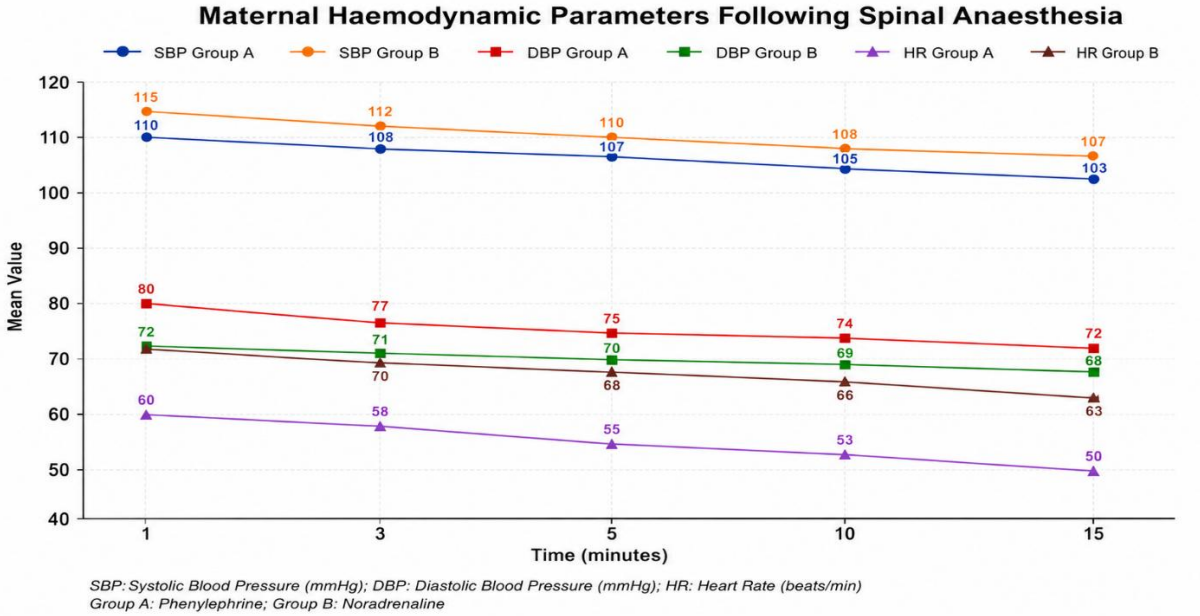

Figure 1. Maternal systolic blood pressure, diastolic blood pressure, and heart rate at different time intervals

Neonatal Apgar scores at both 1 and 5 minutes were comparable between the two groups. At 1 minute, 60% of neonates in each group achieved Apgar scores between 7 and 10. By 5 minutes, most newborns had improved to this category, accounting for 85% in the phenylephrine group and 75% in the noradrenaline group. No statistically significant differences were observed at either assessment time ($P = 0.212$ and $P = 0.180$, respectively), indicating that both vasopressors were associated with similar early neonatal adaptation (Fig 2).

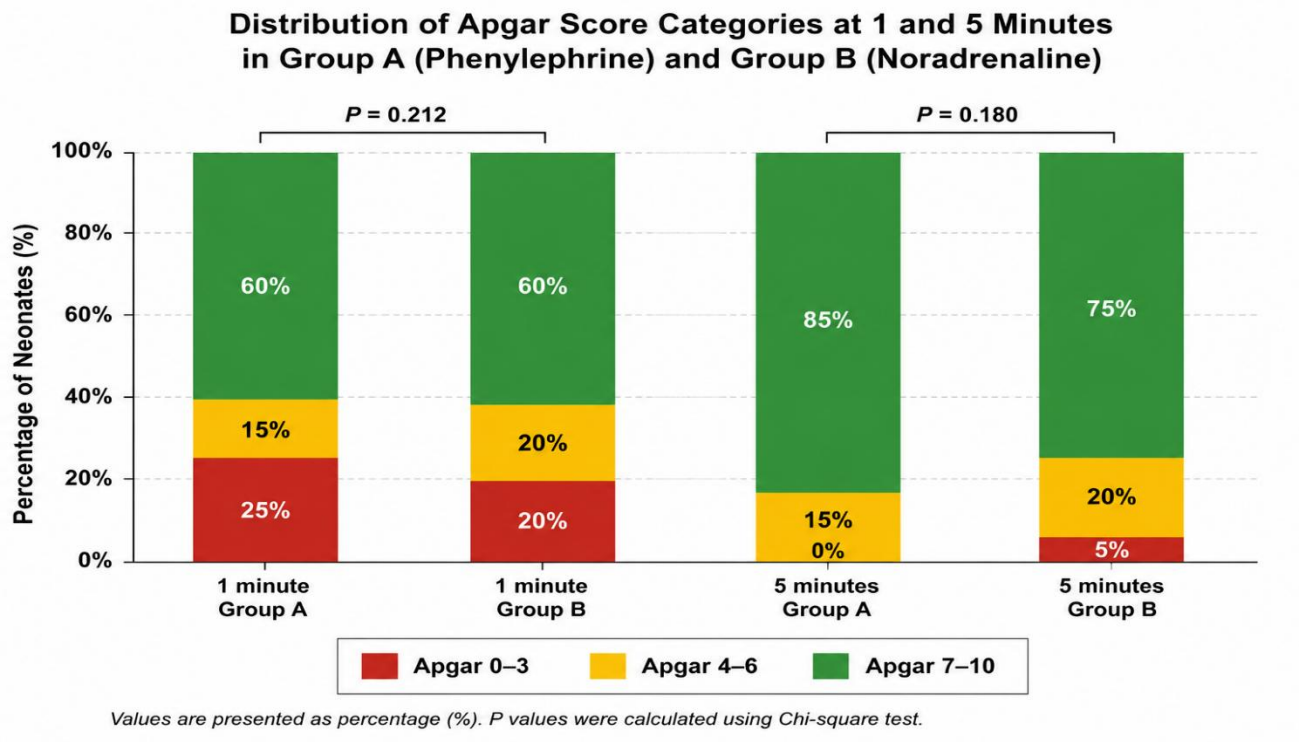

Figure 2. Distribution of neonatal Apgar scores at 1 and 5 minutes

Analysis of umbilical artery blood gas parameters demonstrated modest but significant differences between the two groups. Neonates in the phenylephrine group had a lower mean umbilical artery pH compared with those in the noradrenaline group (7.30 ± 0.05 vs. 7.32 ± 0.04; $P = 0.034$). Base excess was more negative in Group A, while bicarbonate concentration was

also lower, indicating a greater degree of metabolic acidosis. Umbilical artery PO2 was significantly higher in the noradrenaline group, whereas PCO2 values were comparable between the groups. Lactate concentration was significantly higher in the phenylephrine group, suggesting increased neonatal metabolic stress (Table 2).

Table 2. Umbilical artery blood gas and metabolic parameters

Parameter	Group A (Phenylephrine)	Group B (Noradrenaline)	P value
pH	7.30 ± 0.05	7.32 ± 0.04	0.034
Base excess (mmol/L)	−6.95 ± 1.2	−5.40 ± 1.0	0.015
HCO_3^- (mmol/L)	18.5 ± 2.0	19.0 ± 1.8	0.040
PCO2 (mmHg)	47.8 ± 5.0	46.3 ± 4.8	0.075
PO2 (mmHg)	32.0 ± 3.5	33.5 ± 3.2	0.046
Lactate (mmol/L)	2.5 ± 0.5	2.0 ± 0.4	0.019

Maternal adverse events were generally infrequent in both groups. Bradycardia occurred more frequently in women receiving phenylephrine than in those receiving noradrenaline. Episodes of hypotension were also slightly more common in the phenylephrine group. Although nausea and vomiting were reported more frequently among women receiving phenylephrine, these differences were not statistically significant (Table 3).

Table 3. Maternal adverse effects

Adverse effect	Group A n (%)	Group B n (%)	P value
Bradycardia	5 (25.0)	2 (10.0)	0.022
Hypotension	3 (15.0)	2 (12.0)	0.037
Nausea	4 (18.0)	3 (12.0)	0.071
Vomiting	4 (16.0)	2 (11.0)	0.077

Neonatal outcomes were favourable in both study groups. However, fetal acidosis, defined as an umbilical artery pH below 7.20, occurred more frequently in the phenylephrine group than in the noradrenaline group. Rates of NICU admission and neonatal oxygen therapy were low and comparable between groups, with no neonatal deaths recorded during the study period (Fig 3).

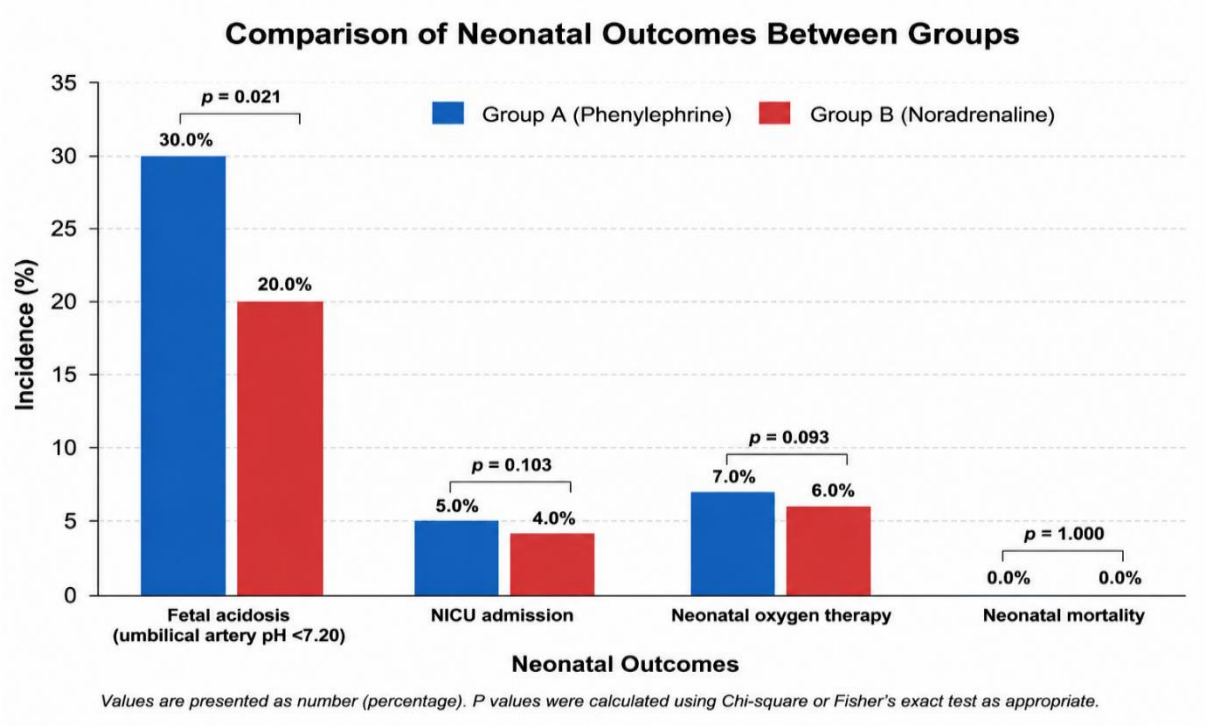

Figure 3. Neonatal outcomes

DISCUSSION

This study compared the maternal and neonatal effects of prophylactic phenylephrine and noradrenaline infusion in parturients with a non-reassuring fetal heart rate undergoing emergency caesarean delivery under sub-arachnoid block.

The two groups were comparable in age, BMI, gestational age, parity, pre-pregnancy weight, and indication for caesarean delivery, minimising the likelihood that baseline differences confounded the outcome comparisons. **Mohta et al. [14]**

similarly reported comparable baseline demographics between phenylephrine and noradrenaline groups in a randomised controlled study, supporting the reliability of between-group comparisons in the present study.

Systolic blood pressure did not differ significantly between groups at any time point, consistent with **Chen et al. [15]**, who found similar SBP maintenance with these two agents in twin pregnancies, suggesting comparable efficacy in preventing spinal-induced hypotension. Diastolic blood pressure, however, was significantly lower in the phenylephrine group at 10 and 15 minutes, a finding also reported by **Shrieaswari and Sujatha [16]**, who attributed this to phenylephrine's selective α-adrenergic action increasing afterload while reducing heart rate. Maternal heart rate was significantly lower in the phenylephrine group throughout, in agreement with **Liu et al. [17]**, who described phenylephrine-induced reflex bradycardia as a consistent finding, with potential implications for maternal cardiac output and fetal oxygen delivery.

No significant between-group difference was seen in Apgar scores at 1 or 5 minutes, mirroring the findings of **Bedi et al. [18]**, who reported that Apgar scores remained unaffected by vasopressor choice provided hypotension was managed effectively — indicating that both agents supported adequate neonatal transition.

Umbilical artery pH was significantly lower in the phenylephrine group, consistent with **Negm et al. [19]**, who reported a similar reduction attributable to phenylephrine's vasoconstrictive effect on placental blood flow. Base excess and bicarbonate were correspondingly higher in the noradrenaline group, in line with **Riveros-Perez et al. [20]**, supporting better fetal acid–base status with noradrenaline. PCO_2 did not differ between groups, but PO_2 was significantly higher with noradrenaline, an observation also made by **Baljon et al. [21]**, suggesting improved fetal oxygenation. Neonatal lactate was significantly higher in the phenylephrine group, and **Sasanelli et al. [22]** similarly linked elevated lactate to fetal hypoxia and acidosis, reinforcing the metabolic-stress signal seen with phenylephrine in this study.

Bradycardia and hypotension were both significantly more frequent with phenylephrine, consistent with **Mahfouz et al. [23]**, who reported that noradrenaline better preserves maternal haemodynamics through its vascular-tone–sparing effect. Nausea was more common with phenylephrine, though not significantly so, in keeping with **Simpson et al. [24]**, who linked haemodynamic instability to these symptoms; vomiting showed a similar non-significant trend, consistent with **Salimi and Fardelmann [25]**, who likewise found no significant between-vasopressor difference in vomiting incidence.

Fetal acidosis (umbilical artery pH <7.2) was significantly more common with phenylephrine, matching **Giorgetti et al. [26]**, who reported a similar increased risk with phenylephrine use. NICU admission rates did not differ significantly, and **Ituk et al. [27]** similarly concluded that stable maternal haemodynamics, rather than vasopressor choice, was the key determinant of NICU admission. Oxygen therapy requirement was marginally higher with phenylephrine but not significantly so, consistent with **Mahfouz et al. [23]**, who found oxygen therapy needs largely unaffected despite mild phenylephrine-associated acidosis. There were no neonatal deaths in either group, in agreement with **Skoog et al. [28]**, who concluded that both vasopressors are equally safe with respect to neonatal survival.

Taken together, these findings suggest that noradrenaline offers greater maternal haemodynamic stability and a more favourable neonatal acid–base profile, while phenylephrine remains an effective, though comparatively less stable, alternative for managing spinal-induced hypotension in this high-risk group.

CONCLUSION

This study demonstrates that both phenylephrine and noradrenaline are effective vasopressors for managing spinal-induced hypotension in pregnant women with a non-reassuring fetal heart rate undergoing emergency caesarean delivery under sub-arachnoid block. However, noradrenaline offered superior maternal haemodynamic stability, with a significantly lower incidence of bradycardia and hypotension, and was associated with a more favourable neonatal acid–base profile, reflected in higher umbilical artery pH, base excess, bicarbonate, and PO2, along with lower lactate levels and a reduced incidence of fetal acidosis compared with phenylephrine.

Phenylephrine, while effective in maintaining maternal blood pressure, was associated with a greater risk of maternal bradycardia and neonatal metabolic acidosis. Importantly, these differences did not translate into significant disparities in immediate neonatal well-being — Apgar scores at 1 and 5 minutes, NICU admission rates, and neonatal oxygen therapy requirements were comparable between groups, and no neonatal deaths occurred in either group.

These findings suggest that noradrenaline may be a preferable first-line vasopressor in this high-risk obstetric population, offering better maternal cardiovascular stability without compromising neonatal safety, while phenylephrine remains a safe and effective alternative. Larger, multicentric studies are warranted to further validate these findings and guide vasopressor selection in emergency caesarean deliveries complicated by fetal compromise.

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