Original Research

Efficacy of phenylephrine in preventing hemodynamic responses of oxytocin during caesarean section under spinal anaesthesia

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ABSTRACT

Aim: The aim of this study was to evaluate the efficacy of prophylactic phenylephrine infusion in preventing hemodynamic responses, particularly hypotension, following oxytocin administration during caesarean section performed under spinal anaesthesia.

Material and Methods: This prospective, randomized, controlled study included 80 parturients scheduled for elective lower segment caesarean section under spinal anaesthesia. Patients were randomly allocated into two groups of 40 each. Group P received a prophylactic phenylephrine infusion immediately after spinal anaesthesia, while Group C received a normal saline placebo infusion. Hemodynamic parameters including heart rate, systolic, diastolic, and mean arterial pressures were recorded at multiple time points: baseline, before oxytocin administration, and 1, 3, 5, 10, 20, and 30 minutes post-oxytocin. The incidence of hypotension, bradycardia, need for rescue vasopressors, and adverse effects such as nausea, vomiting, and chest tightness were also recorded.

Results: Baseline demographics were comparable between the two groups. Following oxytocin administration, Group P maintained significantly higher systolic, diastolic, and mean arterial pressures compared to Group C ($p < 0.001$ at all intervals). The incidence of hypotension was significantly lower in Group P (12.5%) compared to Group C (45.0%) ($p = 0.001$). Rescue phenylephrine boluses were required less frequently in Group P (10.0%) than in Group C (40.0%) ($p = 0.001$). Additionally, the incidence of adverse effects such as nausea (7.5% vs. 25.0%), vomiting (5.0% vs. 20.0%), and chest tightness (2.5% vs. 15.0%) was significantly lower in Group P.

Conclusion: Prophylactic infusion of phenylephrine effectively prevented oxytocin-induced hypotension and maintained hemodynamic stability during caesarean section under spinal anaesthesia. It also reduced the requirement for rescue vasopressors and minimized maternal side effects, confirming its safety and efficacy in obstetric anaesthesia.

Keywords: Phenylephrine, Spinal anaesthesia, Caesarean section, Oxytocin, Hypotension

Introduction

Caesarean section is one of the most commonly performed surgical procedures worldwide, with spinal anaesthesia being the preferred anaesthetic technique due to its rapid onset, dense sensory block, reduced maternal and neonatal drug exposure, and decreased risk of aspiration. Despite its advantages, spinal anaesthesia is associated with a high incidence of maternal hypotension, which poses significant risks to both the mother and the fetus. Hypotension after spinal anaesthesia results from sympathetic blockade, leading to vasodilation, decreased systemic vascular resistance, and relative hypovolemia. These physiological changes can compromise uteroplacental perfusion, thereby affecting fetal oxygenation and resulting in adverse maternal symptoms such as nausea, vomiting, dizziness, and, in severe cases, loss of consciousness.[1]

To counteract uterine atony after delivery, oxytocin is routinely administered to promote uterine contraction and reduce postpartum hemorrhage. However, oxytocin itself can exacerbate hemodynamic instability, causing marked hypotension, tachycardia, and myocardial ischemia through its direct vasodilatory effects. The hemodynamic consequences of oxytocin administration can be sudden and severe, particularly in patients who are already vulnerable due to spinal anaesthesia-induced hypotension. Consequently, preventing and managing these hemodynamic fluctuations is a critical component of anaesthetic management during caesarean section.[2]

Phenylephrine, a selective alpha-1 adrenergic receptor agonist, is widely used as a vasopressor agent to

counteract hypotension during spinal anaesthesia. By inducing vasoconstriction, phenylephrine effectively increases systemic vascular resistance and elevates arterial blood pressure without significantly affecting cardiac output when administered at appropriate doses. In the context of caesarean delivery, phenylephrine has been shown to maintain maternal blood pressure more effectively than traditional vasopressors such as ephedrine, while also resulting in better fetal acid-base status. Given its mechanism of action, phenylephrine presents a logical choice for mitigating the hemodynamic disturbances associated with both spinal anaesthesia and oxytocin administration.[3]

The combined hemodynamic effects of spinal anaesthesia and oxytocin administration present a unique challenge in obstetric anaesthesia. The administration of oxytocin shortly after delivery often triggers a secondary wave of hypotension, superimposed on the sympathetic blockade caused by spinal anaesthesia. This dual impact underscores the necessity of a proactive approach in maintaining maternal hemodynamic stability throughout the surgical procedure. Although oxytocin remains indispensable for obstetric care, its side effects must be anticipated and effectively managed to ensure optimal maternal and fetal outcomes.Traditional strategies to prevent and treat spinal-induced hypotension have included preloading or coloading with intravenous fluids, left lateral uterine displacement, and the use of vasopressors. While fluid loading helps to some extent, it is often insufficient alone to prevent significant drops in blood pressure, particularly in response to the potent vasodilatory effects of oxytocin. Therefore, vasopressor support is often required, with phenylephrine emerging as the vasopressor of choice in many modern obstetric anaesthesia practices.[4]

Prophylactic infusion of phenylephrine has been suggested as a more effective method than bolus administration to maintain continuous blood pressure control during caesarean section. Continuous infusion ensures a stable plasma concentration of the drug, minimizing the fluctuations in blood pressure that are commonly seen with intermittent boluses. Furthermore, the infusion can be titrated according to maternal blood pressure readings, allowing individualized management tailored to the patient's hemodynamic needs.[5]

While phenylephrine infusion has been well-studied for preventing spinal anaesthesia-induced hypotension, its role in attenuating the additional hemodynamic insults following oxytocin administration is an area of ongoing interest. Effective prevention of oxytocin-induced hypotension with phenylephrine could result in a smoother intraoperative course, reduced maternal discomfort, fewer interventions, and better fetal outcomes. In particular, the maintenance of systolic and mean arterial pressures within a narrow, safe range is crucial for ensuring adequate uteroplacental perfusion and preventing fetal hypoxia.The challenge lies in balancing the vasoconstrictive effects of phenylephrine against potential side effects such as reflex bradycardia and decreased cardiac output. Excessive vasoconstriction can lead to reduced uteroplacental blood flow, negating the benefits of maintaining systemic blood pressure. Therefore, careful dosing and vigilant monitoring are paramount to maximizing the benefits of phenylephrine while minimizing potential risks.[6]

In clinical practice, the optimal management strategy involves a combination of measures, including left uterine displacement, appropriate fluid therapy, timely administration of oxytocin, and tailored phenylephrine infusion. Individual patient variability in response to both spinal anaesthesia and oxytocin highlights the importance of dynamic anaesthetic management and the need for vigilance throughout the perioperative period.Understanding the efficacy of phenylephrine in preventing hemodynamic responses associated with oxytocin administration during caesarean section under spinal anaesthesia is critical for improving maternal safety and comfort. It also impacts neonatal outcomes by preserving uteroplacental blood flow during a period of heightened vulnerability. As caesarean delivery rates continue to rise globally, optimizing anaesthetic protocols for hemodynamic stability becomes increasingly relevant in ensuring quality obstetric care.[7,8]

Material and Methods

This prospective, randomized, controlled study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital. Written informed consent was obtained from all participants before enrollment.A total of 80 parturients scheduled for elective lower segment caesarean section (LSCS) under spinal anaesthesia were enrolled. Participants were randomly allocated into two groups (n=40 each) using a computer-generated randomization table:

- **Group P (Phenylephrine Group):** Received prophylactic phenylephrine infusion immediately after spinal anaesthesia until the end of oxytocin administration.
- **Group C (Control Group):** Received normal saline infusion as placebo.

Inclusion Criteria

- Age between 18 to 40 years
- American Society of Anesthesiologists (ASA) physical status I or II
- Singleton term pregnancy (>37 weeks gestation)
- Scheduled for elective caesarean section under spinal anaesthesia

Exclusion Criteria

- Contraindications to spinal anaesthesia
- Pre-existing hypertension or cardiovascular diseases
- Preeclampsia or other hypertensive disorders of pregnancy
- Multiple gestation
- Allergy to phenylephrine or oxytocin

- Known fetal anomalies
- Patients on medications affecting autonomic responses

Anaesthetic Technique

Upon arrival in the operating room, standard monitors including electrocardiogram (ECG), non-invasive blood pressure (NIBP), and pulse oximetry (SpO_2) were attached. Baseline heart rate (HR) and blood pressure (systolic, diastolic, and mean arterial pressure) were recorded.

All patients received preloading with 10 mL/kg of Ringer's lactate over 15–20 minutes before the administration of spinal anaesthesia.

Spinal anaesthesia was performed at the L3–L4 interspace in the sitting position using a 25G Quincke spinal needle. 2.0 mL of 0.5% hyperbaric bupivacaine combined with 20 µg fentanyl was injected intrathecally.

Immediately after the spinal block:

- **Group P** patients received a prophylactic phenylephrine infusion at 50 µg/min, titrated according to blood pressure response.
- **Group C** patients received an equivalent volume of normal saline as placebo.

Following delivery of the baby and clamping of the umbilical cord, all patients received oxytocin 5 IU as an intravenous bolus over 30 seconds, followed by an infusion of 10 IU/hour.

Hemodynamic parameters, including heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure, were recorded at multiple predefined time points throughout the study. Baseline measurements were taken before the administration of spinal anaesthesia. Following spinal anaesthesia, hemodynamic readings were recorded every 2 minutes until delivery of the baby. Further measurements were documented immediately before oxytocin administration, and subsequently at 1, 3, 5, 10, 20, and 30 minutes after oxytocin administration, as well as at the end of the surgical procedure.

The incidence of hypotension, defined as a decrease in systolic blood pressure greater than 20% from baseline or a fall below 90 mmHg, was carefully monitored and recorded. Similarly, episodes of bradycardia, defined as a heart rate of less than 50 beats per minute, were documented. Hypotension was managed with rescue boluses of phenylephrine in doses ranging from 50 to 100 micrograms, while bradycardia was treated with intravenous administration of atropine 0.6 mg as needed. Additionally, the occurrence of side effects such as nausea, vomiting, and chest tightness during the intraoperative period was noted.

The primary outcome of the study was the incidence of hypotension following oxytocin administration. Secondary outcomes included evaluation of changes in heart rate and mean arterial pressure, the requirement for rescue phenylephrine boluses, and the incidence of bradycardia and other adverse effects.

Statistical Analysis

Data were analyzed using SPSS version 16.0. Continuous variables were expressed as mean ± standard deviation (SD) and compared using Student's t-test. Categorical variables were analyzed using Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Table 1: Demographic Characteristics of Participants

The demographic characteristics of the two groups were comparable with no statistically significant differences, indicating successful randomization. The mean age of participants was 28.5 ± 4.2 years in Group P and 29.1 ± 3.9 years in Group C ($p = 0.42$). Similarly, the mean weight was 68.2 ± 7.1 kg in Group P and 67.5 ± 6.8 kg in Group C ($p = 0.56$), while the mean height was 158.4 ± 5.5 cm and 157.6 ± 6.0 cm, respectively ($p = 0.48$). Regarding ASA physical status, the distribution of ASA I and II patients was also similar between the two groups (30/10 in Group P versus 28/12 in Group C; $p = 0.61$). These findings suggest that the baseline demographic profile of the study participants was well-matched and any differences observed later in hemodynamic outcomes could be attributed to the intervention rather than baseline disparities.

Table 2: Comparison of Hemodynamic Parameters Between Group P and Group C at Different Time Points

At baseline and before oxytocin administration, no significant differences were observed between Group P and Group C in heart rate, systolic blood pressure, diastolic blood pressure, or mean arterial pressure, indicating that both groups had similar hemodynamic statuses initially.

However, significant differences emerged following oxytocin administration. At 1 minute post-oxytocin, Group C exhibited a significantly higher heart rate (90.8 ± 9.1 bpm vs. 86.5 ± 8.5 bpm, $p = 0.02$) and significantly lower systolic (105.5 ± 10.5 mmHg vs. 115.0 ± 9.8 mmHg, $p < 0.001$), diastolic (68.0 ± 6.7 mmHg vs. 74.2 ± 6.4 mmHg, $p < 0.001$), and mean arterial pressures (76.5 ± 9.5 mmHg vs. 86.7 ± 8.2 mmHg, $p < 0.001$) compared to Group P.

This pattern continued consistently at 3, 5, and 10 minutes post-oxytocin, with Group C showing significantly lower blood pressures and higher heart rates compared to Group P (all p-values < 0.001 for blood pressure measurements). At 20 and 30 minutes post-oxytocin and at the end of surgery, systolic, diastolic, and mean arterial pressures remained significantly lower in Group C compared to Group P, although heart rates became comparable ($p > 0.05$ at 20 min, 30 min, and end of surgery). These results clearly indicate that phenylephrine infusion effectively stabilized blood pressure and mitigated tachycardic responses after oxytocin administration.

Table 3: Incidence of Hypotension and Bradycardia

The incidence of hypotension was significantly lower in Group P compared to Group C. Only 5 patients (12.5%) in Group P experienced hypotension, whereas 18 patients (45.0%) in Group C had hypotensive episodes ($p = 0.001$), demonstrating the efficacy of prophylactic phenylephrine in preventing oxytocin-induced hypotension.

Regarding bradycardia, although fewer patients developed bradycardia in Group P (2 patients, 5.0%) compared to Group C (5 patients, 12.5%), the difference was not statistically significant ($p = 0.23$). Additionally, the need for rescue phenylephrine boluses was significantly less in Group P (10.0%) than in Group C (40.0%) with a p-value of 0.001, further supporting the prophylactic benefit of phenylephrine infusion.

Table 4: Adverse Effects

The occurrence of adverse effects was markedly lower in Group P compared to Group C. Nausea was reported in 7.5% of patients in Group P and 25.0% of patients in Group C, a statistically significant difference ($p = 0.03$). Similarly, vomiting occurred less frequently in Group P (5.0%) compared to Group C (20.0%), with a significant p-value ($p = 0.04$). Chest tightness was experienced by only 2.5% of patients in Group P versus 15.0% in Group C ($p = 0.05$). These results suggest that maintaining hemodynamic stability with phenylephrine not only reduces hypotension but also minimizes oxytocin-related side effects such as nausea, vomiting, and chest discomfort.

Table 1: Demographic Characteristics of Participants

Parameter	Group P (n = 40)	Group C (n = 40)	p-value
Age (years), mean ± SD	28.5 ± 4.2	29.1 ± 3.9	0.42
Weight (kg), mean ± SD	68.2 ± 7.1	67.5 ± 6.8	0.56
Height (cm), mean ± SD	158.4 ± 5.5	157.6 ± 6.0	0.48
ASA Physical Status (I/II)	30/10	28/12	0.61

Table 2: Comparison of Hemodynamic Parameters Between Group P and Group C at Different Time Points

Time Point	Parameter	Group P (Mean ± SD)	Group C (Mean ± SD)	p-value
Baseline	Heart Rate (bpm)	84.3 ± 8.6	85.2 ± 7.9	0.63
	Systolic BP (mmHg)	118.5 ± 10.3	117.9 ± 9.8	0.74
	Diastolic BP (mmHg)	75.8 ± 6.2	76.5 ± 5.9	0.58
	Mean Arterial Pressure (mmHg)	90.0 ± 7.4	89.5 ± 6.9	0.67
Before Oxytocin	Heart Rate (bpm)	85.0 ± 8.2	86.0 ± 7.7	0.57
	Systolic BP (mmHg)	117.5 ± 9.5	116.8 ± 9.2	0.69
	Diastolic BP (mmHg)	75.5 ± 6.0	75.0 ± 6.1	0.64
	Mean Arterial Pressure (mmHg)	88.5 ± 7.1	88.2 ± 6.7	0.85
1 min Post-Oxytocin	Heart Rate (bpm)	86.5 ± 8.5	90.8 ± 9.1	0.02
	Systolic BP (mmHg)	115.0 ± 9.8	105.5 ± 10.5	<0.001
	Diastolic BP (mmHg)	74.2 ± 6.4	68.0 ± 6.7	<0.001
	Mean Arterial Pressure (mmHg)	86.7 ± 8.2	76.5 ± 9.5	<0.001
3 min Post-Oxytocin	Heart Rate (bpm)	85.7 ± 8.0	89.5 ± 8.5	0.04
	Systolic BP (mmHg)	116.0 ± 9.2	107.0 ± 10.2	<0.001
	Diastolic BP (mmHg)	74.5 ± 6.5	68.5 ± 7.0	<0.001
	Mean Arterial Pressure (mmHg)	87.4 ± 7.9	77.2 ± 9.0	<0.001
5 min Post-Oxytocin	Heart Rate (bpm)	85.0 ± 7.9	88.5 ± 8.8	0.05
	Systolic BP (mmHg)	117.0 ± 9.0	108.5 ± 9.8	<0.001
	Diastolic BP (mmHg)	75.0 ± 6.3	69.0 ± 6.8	<0.001
	Mean Arterial Pressure (mmHg)	88.1 ± 8.0	78.5 ± 9.2	<0.001
10 min Post-Oxytocin	Heart Rate (bpm)	84.2 ± 7.5	87.0 ± 8.2	0.08
	Systolic BP (mmHg)	118.0 ± 8.8	110.0 ± 9.0	<0.001

	Diastolic BP (mmHg)	76.0 ± 6.1	70.5 ± 6.5	<0.001
	Mean Arterial Pressure (mmHg)	89.0 ± 7.7	80.0 ± 8.8	<0.001
20 min Post-Oxytocin	Heart Rate (bpm)	83.5 ± 7.2	85.5 ± 7.8	0.22
	Systolic BP (mmHg)	119.0 ± 8.5	112.0 ± 8.9	<0.001
	Diastolic BP (mmHg)	76.5 ± 5.9	72.0 ± 6.2	0.001
	Mean Arterial Pressure (mmHg)	90.2 ± 7.3	82.5 ± 8.3	<0.001
30 min Post-Oxytocin	Heart Rate (bpm)	83.0 ± 7.0	84.5 ± 7.5	0.35
	Systolic BP (mmHg)	120.0 ± 8.2	114.0 ± 8.6	0.001
	Diastolic BP (mmHg)	77.0 ± 5.8	73.0 ± 6.1	0.002
	Mean Arterial Pressure (mmHg)	91.0 ± 7.0	84.0 ± 7.9	0.001
End of Surgery	Heart Rate (bpm)	82.5 ± 6.8	83.5 ± 7.2	0.51
	Systolic BP (mmHg)	121.0 ± 8.0	115.5 ± 8.2	0.001
	Diastolic BP (mmHg)	78.0 ± 5.7	74.0 ± 6.0	0.002
	Mean Arterial Pressure (mmHg)	91.5 ± 6.8	85.5 ± 7.5	0.001

Table 3: Incidence of Hypotension and Bradycardia

Event	Group P (n = 40)	Group C (n = 40)	p-value
Hypotension (%)	5 (12.5%)	18 (45.0%)	0.001
Bradycardia (%)	2 (5.0%)	5 (12.5%)	0.23
Rescue Phenylephrine Required (%)	4 (10.0%)	16 (40.0%)	0.001

Table 4: Adverse Effects

Side Effect	Group P (n = 40)	Group C (n = 40)	p-value
Nausea (%)	3 (7.5%)	10 (25.0%)	0.03
Vomiting (%)	2 (5.0%)	8 (20.0%)	0.04
Chest Tightness (%)	1 (2.5%)	6 (15.0%)	0.05

Discussion

In the present study, the demographic characteristics, including mean age (28.5 ± 4.2 years in Group P vs. 29.1 ± 3.9 years in Group C, p = 0.42), mean weight (68.2 ± 7.1 kg vs. 67.5 ± 6.8 kg, p = 0.56), and mean height (158.4 ± 5.5 cm vs. 157.6 ± 6.0 cm, p = 0.48), were comparable between the two groups. Similarly, ASA physical status distribution was not significantly different (p = 0.61). These findings ensured that subsequent hemodynamic differences were attributable to the intervention. Comparable demographic matching was observed by Ngan Kee et al (2014), who, in their randomized study of vasopressor management during caesarean section, reported no significant difference in baseline parameters, allowing for unbiased assessment of vasopressor efficacy.[9]

Following oxytocin administration, significant hemodynamic differences were observed. At 1 minute post-oxytocin, Group C had a mean systolic BP of 105.5 ± 10.5 mmHg compared to 115.0 ± 9.8 mmHg in Group P (p < 0.001), with similar trends for diastolic BP and MAP. This trend persisted up to 30 minutes post-oxytocin. Our findings are consistent with Mercier et al (2013), who demonstrated that phenylephrine infusion better preserved systolic blood pressure after spinal anaesthesia, maintaining MAP closer to baseline compared to placebo. In our study, mean arterial pressure was significantly higher in Group P at all post-oxytocin intervals, with MAP at 1 minute being 86.7 ± 8.2 mmHg in Group P versus 76.5 ± 9.5 mmHg in Group C (p < 0.001).[10]

The incidence of hypotension in our study was significantly lower in the phenylephrine group, occurring in only 5 patients (12.5%) compared to 18 patients (45.0%) in the control group (p = 0.001). This reflects a strong preventive effect of phenylephrine infusion against oxytocin-induced hypotension. A similar protective effect was reported by Cooper et al (2010), who found that prophylactic phenylephrine reduced the incidence of spinal-induced hypotension from 64% to 18% in women undergoing elective caesarean section, supporting the current findings of a threefold reduction in hypotension incidence with prophylactic vasopressor use.[11]

Regarding heart rate variations, although Group C experienced a significantly higher heart rate at 1 and 3 minutes post-oxytocin (90.8 ± 9.1 bpm vs. 86.5 ± 8.5 bpm at 1 minute, p = 0.02), the difference in bradycardia incidence was not statistically significant (5.0% in Group P vs. 12.5% in Group C, p = 0.23). This is similar to findings reported by Allen et al

(2010), who described that although phenylephrine can cause reflex bradycardia, it rarely results in clinically significant events requiring intervention, thus affirming the hemodynamic safety of phenylephrine infusion.[12]

Our study also observed that the requirement for rescue boluses of phenylephrine was significantly reduced in Group P, with only 4 patients (10.0%) requiring boluses compared to 16 patients (40.0%) in Group C (p = 0.001). This lower vasopressor requirement not only confirms the preventive role of continuous infusion but also minimizes intraoperative fluctuations, as similarly reported by Sharwood-Smith et al (2008), who noted decreased vasopressor use and more stable intraoperative courses in patients receiving phenylephrine infusions during elective caesarean deliveries.[13]

Finally, the incidence of side effects was significantly lower in Group P. Nausea occurred in 7.5% of Group P patients compared to 25.0% in Group C (p = 0.03), vomiting in 5.0% versus 20.0% (p = 0.04), and chest tightness in 2.5% versus 15.0% (p = 0.05). These results mirror the findings of Dyer et al (2009), who emphasized that improved blood pressure control with prophylactic vasopressors substantially reduces the incidence of nausea, vomiting, and other hemodynamic-related discomforts during spinal anaesthesia for caesarean section.[14]

Conclusion

Prophylactic infusion of phenylephrine effectively prevented oxytocin-induced hemodynamic instability during caesarean section under spinal anaesthesia. It significantly reduced the incidence of hypotension, minimized the need for rescue vasopressors, and decreased maternal side effects such as nausea and vomiting. Phenylephrine proved to be a safe and reliable agent for maintaining maternal hemodynamic stability and ensuring better perioperative outcomes.

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