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PREVENTION OF MATERNAL HYPOTENSION FOLLOWING SPINAL ANESTHESIA IN EMERGENCY C-SECTIONS; PROPHYLACTIC PHENYLEPHRINE INFUSION VERSUS COLLOID COLOAD – A RANDOMIZED CONTROL TRIAL

Original Research

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ABSTRACT

Background: Spinal anesthesia is the preferred anesthetic technique for cesarean sections, but maternal hypotension remains a common complication, with incidence rates reaching up to 100% in the absence of preventive measures. Crystalloids, colloids, and vasopressors have all been employed to address this issue, with varying degrees of effectiveness. While vasopressors—particularly phenylephrine—demonstrate superior efficacy, their prophylactic use remains inconsistent across clinical settings due to a lack of consensus on optimal dosing strategies.

Objective: To compare the effectiveness of prophylactic phenylephrine infusion versus colloid infusion in preventing post-spinal maternal hypotension during emergency cesarean sections.

Methods: A prospective, randomized controlled trial was conducted at the emergency operation theater of Benazir Bhutto Hospital. Sixty ASA I–II patients undergoing cesarean section under spinal anesthesia were enrolled and randomized into two groups. Group A (n=30) received colloid infusion with 10 mL/kg of gelofusine over the first 10–15 minutes post-anesthesia. Group B (n=30) received a prophylactic phenylephrine infusion at 1.2–1.5 mcg/kg/min, titrated to maintain hemodynamic stability. Hypotension was defined as a >20% decrease in baseline mean arterial blood pressure (MABP), and bradycardia as heart rate <60 bpm.

Results: Hypotensive episodes occurred in 46.7% of patients in Group A (14/30), compared to only 3.33% in Group B (1/30), with a statistically significant difference (P = 0.0001; 95% CI = 20.35 to 62.6; Chi-Square = 14.776). All hypotensive episodes occurred within the first 10 minutes after spinal anesthesia. Bradycardia was observed in one patient in each group (3.33%).

Conclusion: Prophylactic phenylephrine infusion is significantly more effective than colloid infusion in preventing maternal hypotension following spinal anesthesia, with fewer rescue interventions required and better hemodynamic stability.

Keywords: Anesthesia, Spinal; Colloids; Fluid Therapy; Intraoperative Care; Monitoring, Intraoperative; Phenylephrine; Succinylated Gelatin.

INTRODUCTION

Various strategies have been explored to prevent maternal hypotension following spinal anesthesia, including preloading or coloading with intravenous fluids, mechanical measures such as uterine displacement and leg elevation, and pharmacologic interventions involving vasopressors like ephedrine and phenylephrine (5). Hypotension has been reported in as many as 80–100% of patients undergoing cesarean sections with spinal anesthesia in the absence of prophylactic measures (6). However, incidence rates vary significantly due to the inconsistent definitions of hypotension used across studies. These definitions range from a drop of more than 20% from baseline blood pressure to absolute thresholds such as a systolic pressure below 100 mmHg or a decrease to less than 80% of baseline readings, with at least 15 different criteria identified in literature (7). A systematic review analyzing 75 studies concluded that while crystalloids are more effective than no fluid administration, colloids are superior to crystalloids in preventing hypotension during cesarean delivery under spinal anesthesia. Nevertheless, no significant differences were observed in outcomes based on the volume, rate, or method of administration of these fluids. Vasopressors, particularly phenylephrine, have demonstrated the highest efficacy in hypotension prevention (8). Phenylephrine has gained preference over ephedrine due to better neonatal outcomes, as indicated by higher umbilical artery pH values (9). When administered in rescue boluses of 75–100 mcg, phenylephrine effectively corrects hypotension (10). Furthermore, prophylactic infusions of phenylephrine have been shown to significantly reduce the incidence of hypotension in elective cesarean deliveries. One randomized controlled trial found that none of the patients receiving a variable-rate phenylephrine infusion alongside colloid coload required rescue vasopressors, compared to 75.5% in the control group (11). However, reflex bradycardia remains a recognized dose-dependent adverse effect of both bolus and infusion routes (11,12).

Despite these findings, there is still no global consensus among anesthetists regarding the routine use of prophylactic phenylephrine infusion. At Benazir Bhutto Hospital, where this study was conducted, the standard practice in emergency cesarean sections typically involves a combination of colloid and crystalloid coloads with intermittent phenylephrine boluses administered as needed. Prophylactic infusions of phenylephrine are rarely used, and there is a notable lack of randomized controlled trials comparing prophylactic phenylephrine infusion plus crystalloid coload versus colloid plus crystalloid coload in similar clinical settings or populations. Given this gap in the literature, the objective of the current study is to evaluate and compare the efficacy of prophylactic phenylephrine infusion with crystalloid coload versus the conventional colloid plus crystalloid coload in preventing maternal hypotension following spinal anesthesia in emergency cesarean sections. The aim is to identify a more effective and cost-efficient management strategy tailored to resource-constrained settings.

METHODS

This randomized, double-blind, controlled trial was conducted in the emergency operation theater of Benazir Bhutto Hospital, affiliated with Rawalpindi Medical College. Ethical approval was obtained from the Institutional Research Forum and the Research and Ethical Committee of RMC and Allied Hospitals prior to the commencement of the study. All participants provided written informed consent before inclusion. The study aimed to compare the efficacy of prophylactic phenylephrine infusion plus crystalloid coload with colloid plus crystalloid coload in the prevention of post-spinal maternal hypotension in patients undergoing emergency lower segment cesarean section. Eligible participants were women undergoing emergency cesarean section under spinal anesthesia. Inclusion criteria required patients to be within a weight range of 60–90 kg and have baseline blood pressure between 90/60 mmHg and 140/90 mmHg. Exclusion criteria included patients classified as ASA physical status III or above, and those with pregnancy-induced hypertension, pre-eclampsia, eclampsia, antepartum hemorrhage, or baseline hypotension or hypertension. No specific preoperative fasting duration (NPO) was mandated due to the emergency nature of the procedures.

Sample size was calculated using the WHO sample size calculator with a 95% confidence level and 90% power, based on anticipated frequency of hypotensive episodes from prior studies (8,9). The minimum required sample size was 26 patients per group. To account for potential dropouts, 30 patients were included in each group, totaling 60 participants. Randomization was performed using SPSS version 22.0.0, generating a computer-based allocation sequence to assign patients into two groups: Group A (colloid plus crystalloid coload) and Group B (phenylephrine infusion plus crystalloid coload). A detailed medical and obstetric history was taken for each

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participant. Baseline blood pressure was calculated as the mean of three readings taken in the operating room before spinal anesthesia. All patients received a preload of 500 mL normal saline. Spinal anesthesia was administered using 0.2 mL/kg of 0.75% hyperbaric bupivacaine to achieve a sensory block up to the T6-T7 dermatome. Following subarachnoid block, Group A received 10 mL/kg of colloid (gelofusine), while Group B received a 100-mcg phenylephrine loading dose followed by a titrated phenylephrine infusion at a rate of 1.2–1.5 mcg/kg/min, continued until delivery. Both groups also received crystalloid infusions via a separate IV line. Intravenous access was secured using two 18-gauge cannulas.

To ensure double blinding, an independent anesthetist, unaware of group allocations or study objectives, was designated as the observer. Hemodynamic parameters—including non-invasive blood pressure, heart rate, oxygen saturation, and ECG—were monitored using the Nihon Kohden bedside monitor (BSM-3768). Measurements were recorded at one-minute intervals immediately before and after the administration of anesthesia, every three minutes until delivery, at the time of delivery, and then every 15 minutes until the end of the procedure. Hypotension was defined as a reduction in mean arterial pressure exceeding 20% from baseline, while bradycardia was defined as a heart rate below 60 beats per minute. Any hypotensive episode was managed with a 100-mcg phenylephrine bolus, while bradycardia was treated with 500 mcg atropine. All interventions and adverse events were documented, including their time of occurrence. Neonatal outcomes were evaluated using the APGAR score recorded five minutes after birth. Data were entered and analyzed using SPSS version 22.0.0. Numerical variables such as maternal age, body weight, total volume of crystalloids administered, intraoperative blood loss, NPO duration, procedure duration, and neonatal APGAR scores were expressed as means with standard deviations. For categorical variables including hypotension and bradycardia events, frequencies and percentages were calculated. Independent samples t-tests were used to compare hemodynamic variables and APGAR scores between groups at a significance level of 0.05. Chi-square tests were employed for categorical data, and 95% confidence intervals were calculated. Time-dependent variations in mean arterial pressure and heart rate were graphically represented for both groups.

RESULTS

A total of 60 patients were enrolled and equally randomized into two groups: Group A received colloid infusion, while Group B received phenylephrine infusion. Baseline demographic characteristics, including age (mean ± SD: 28.77 ± 5.01 in Group A vs. 26.93 ± 4.82 in Group B; P = 0.1528) and weight (67.20 ± 6.73 kg vs. 67.27 ± 7.37 kg; P = 0.9695), were statistically comparable. Other parameters such as NPO duration, ASA classification, anesthetic dosage, block level, total crystalloids infused, blood loss (835 ± 87.5 ml in Group A vs. 855 ± 102.51 ml in Group B; P = 0.4197), and duration of surgery (48 ± 8.35 min vs. 50 ± 6.91 min; P = 0.3164) also showed no significant difference. APGAR scores at 5 minutes were identical in both groups (mean 6.83 ± 0.46 vs. 6.83 ± 0.38; P = 1.000). The incidence of hypotension was significantly higher in Group A compared to Group B. In Group A, 46.7% (14 of 30) experienced one or more hypotensive episodes, while only 3.33% (1 of 30) did so in Group B, reflecting a difference of 43.34% (P = 0.0001, 95% CI: 20.35 to 62.6). Among the 14 patients in Group A, 11 had a single episode, and 3 had two episodes. In contrast, Group B had only one patient with a single episode. All 18 hypotensive events occurred within the first 10 minutes post-spinal anesthesia, with 61.1% (11/18) occurring within the first three minutes and 83.3% (15/18) within six minutes.

Phenylephrine rescue boluses (100 mcg) were administered to all 14 hypotensive patients in Group A, totaling 18 doses. In Group B, only one such rescue dose was required. Bradycardia was noted in one patient (3.33%) from each group. The bradycardic event in Group A followed administration of a phenylephrine rescue bolus. Mean arterial blood pressure (MABP) trends revealed significant intergroup differences at key time points. At 3 minutes, MABP was 81.2 mmHg in Group A and 90.0 mmHg in Group B (difference = 8.8 mmHg; P = 0.0016, 95% CI: 3.47 to 14.1). At 6 minutes, the difference widened to 10.7 mmHg (P < 0.0001, 95% CI: 6.58 to 14.82). At 9 minutes, MABP in Group A was 5.3 mmHg lower than Group B (P = 0.0052, 95% CI: 1.64 to 8.95). No statistically significant difference was observed at the time of baby delivery or at the conclusion of surgery (P = 0.3 and P = 0.59, respectively). Incidence of hypertensive episodes (>20% increase in baseline MABP) was 3.33% in Group A and 10% in Group B (P = 0.2755, 95% CI: -8.81 to 23.79).

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Table 1: Baseline Characteristics of Group A (Colloid) and Group B (Phenylephrine)

	Group A		Group B		Level of significance
	Mean	SD	Mean	SD	
Age	28.77	5.015	26.93	4.82	P = 0.1528
Weight (kg)	67.20	6.73	67.27	7.37	P = 0.9695
NPO (hours)	3.37	2.35	2.80	2.32	P = 0.3484
Apgar score	6.83	0.461	6.83	0.379	P = 1.0000
Total Crystalloid (ml)	2003	214.3	1916	222.96	P = 0.1288
Time (min)	48	8.35	50	6.91	P = 0.3164
ASA	2.00	0.00	2.00	0.00	P = 1.0000
Blood loss (ml)	835	87.5	855	102.51	P = 0.4197

Table 2: Incidence of Hypotension, Bradycardia, and Hypertension

Event	Group A (n=30)	Group B (n=30)	P-value	95% CI
Hypotension (≥1 episode)	14 (46.7%)	1 (3.33%)	0.0001	20.35 to 62.6
Bradycardia	1 (3.33%)	1 (3.33%)	NS	N/A
Hypertension (>20% baseline MABP)	1 (3.33%)	3 (10%)	0.2755	-8.81 to 23.79

Table 3: Timing and Frequency of Hypotensive Episodes

Parameter	Frequency	Percentage (%)
Total Hypotensive Episodes	18	100
Episodes in First 3 min	11	61.1
Episodes in First 6 min	15	83.3
Episodes in First 10 min	18	100

Table 4: Mean Arterial Blood Pressure (MABP) Comparison of Key Time Points

Time Point	Group A (mmHg)	Group B (mmHg)	Difference (mmHg)	P-value	95% CI
0 min	88	90	2	0.4064	N/S
3 min	81.2	90	8.8	0.0016	3.47 to 14.1
6 min	79.3	90	10.7	<0.0001	6.58 to 14.82
9 min	82.1	87.4	5.3	0.0052	1.64 to 8.95
At Delivery	85.6	88	2.4	0.3	N/S
End of Procedure	84.2	85.2	1	0.59	N/S

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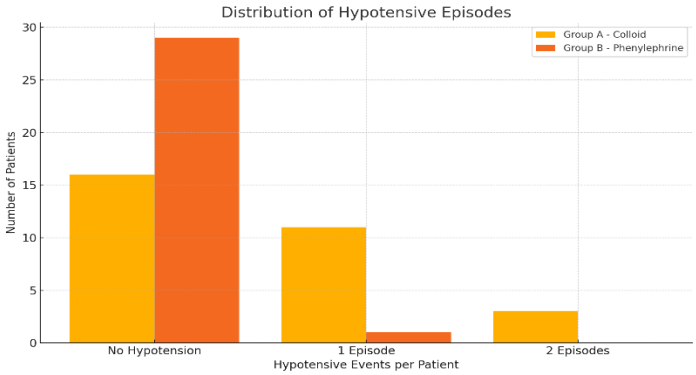


Figure 1 Distribution of Hypotensive Episodes

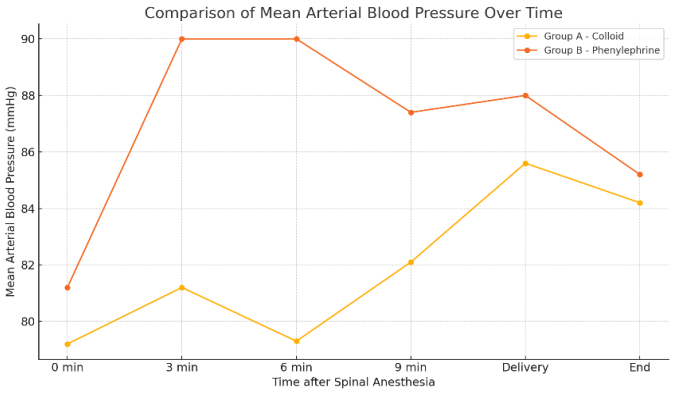
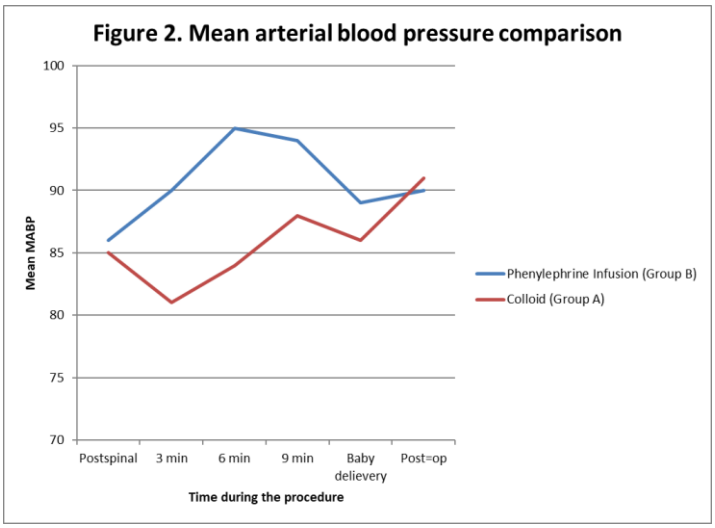
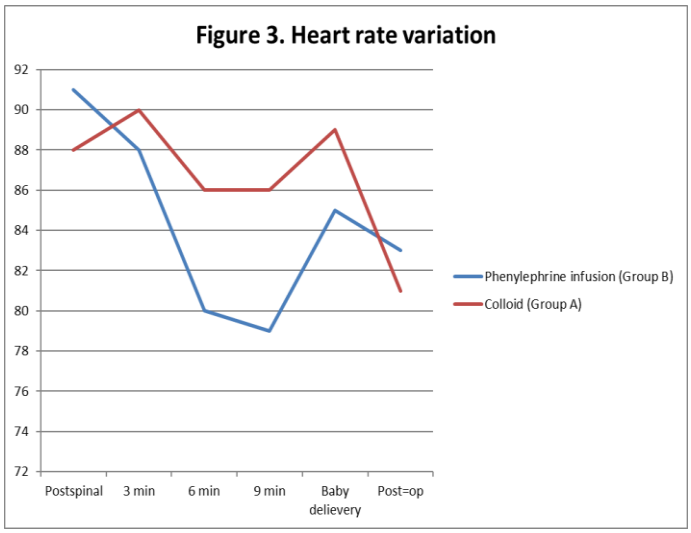
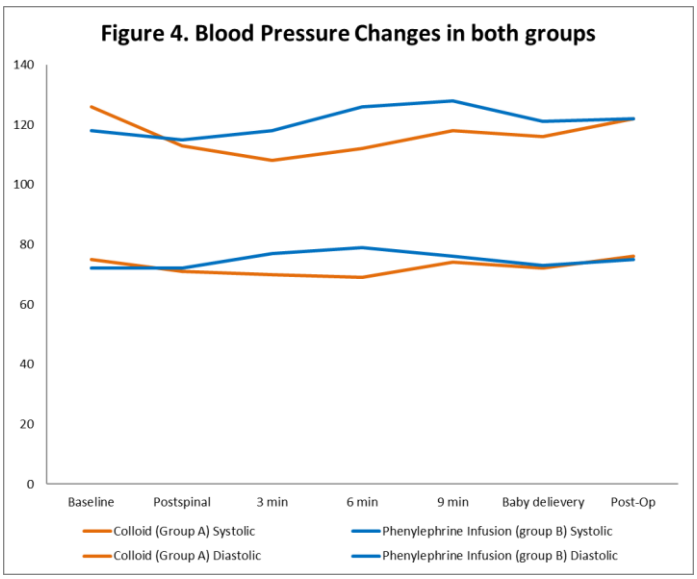


Figure 2 Comparison of Mean Arterial Blood Pressure Over Time







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DISCUSSION

Hemodynamic instability following spinal anesthesia remains a well-documented challenge during cesarean sections, despite standard measures such as crystalloid coloading and the use of rescue vasopressor boluses (13,14). When no prophylactic strategy is employed, the incidence of maternal hypotension ranges widely from 55% to 100%, as demonstrated across multiple studies (15). In an effort to mitigate this complication, various interventions—administered alone or in combination—have been evaluated, including fluid therapy with crystalloids or colloids and pharmacologic support through vasopressors. Although crystalloid preload and coload have been widely practiced, their effectiveness in preventing hypotension has been limited. Comparatively, colloid administration offers better hemodynamic stability, yet the most consistent results have been achieved through the use of vasopressors (16). The current study investigated the comparative effectiveness of colloid infusion versus prophylactic phenylephrine infusion in minimizing the incidence of post-spinal maternal hypotension. Both study groups received equivalent volumes of crystalloid preload and coload to eliminate confounding related to fluid administration. The findings clearly indicated that phenylephrine infusion was more effective than colloid infusion in preventing hypotensive episodes following spinal anesthesia. Not only was the frequency of hypotension significantly lower in the phenylephrine group, but the mean systolic, diastolic, and mean arterial pressures also remained closer to baseline values throughout the perioperative period (17). Furthermore, the requirement for rescue phenylephrine boluses was markedly reduced in the phenylephrine infusion group, supporting the effectiveness of continuous vasopressor support in maintaining hemodynamic stability.

Heart rate trends were less consistent, with substantial inter-individual variation. Although the phenylephrine group exhibited a trend toward lower, more stable heart rates, the differences did not reach statistical significance. Bradycardic episodes were infrequent and occurred with equal frequency in both groups, typically in association with vasopressor administration. This aligns with previous studies where phenylephrine-induced reflex bradycardia was recognized as a dose-dependent effect (18). Hypertension following phenylephrine infusion, reported in earlier literature with incidence rates ranging from 15% to 68% depending on the dose and infusion rate, was less pronounced in this study. With a controlled infusion rate of 1.2 mcg/kg/min, only 10% of patients experienced hypertensive episodes in the phenylephrine group compared to 3.33% in the colloid group, a difference that was not statistically significant. This suggests that careful titration of phenylephrine can optimize maternal blood pressure without inducing excessive hypertensive responses (19).

A critical observation was that all hypotensive episodes occurred within the first 10 minutes of spinal anesthesia, with the majority clustering within the first six minutes. This temporal pattern underscores a highly vulnerable window for hemodynamic instability. Given that uteroplacental perfusion is directly dependent on maternal blood pressure, the early onset of hypotension carries clinical significance. Although previous studies have reported transient maternal hypotension without marked adverse neonatal outcomes, the potential for fetal acidosis and impaired maternal well-being cannot be disregarded (20). Rapid and effective management, therefore, remains essential to improving both maternal and fetal outcomes. One of the strengths of this study is its randomized double-blind design, which minimized observer bias and ensured the reliability of hemodynamic assessments. The use of uniform anesthetic techniques, dosages, and monitoring further enhanced the study's internal validity. However, limitations include the relatively small sample size and the single-center setting, which may affect generalizability. Additionally, neonatal outcomes were limited to APGAR scores, and more sensitive indicators such as umbilical cord blood gas analysis were not evaluated. A larger multicenter trial incorporating these parameters would provide a more comprehensive understanding of fetal safety in relation to maternal hemodynamic control. Future research should also examine the role of individualized dosing strategies for vasopressors based on patient-specific factors such as baseline vascular tone or comorbidities. Additionally, comparative evaluation of phenylephrine with newer agents such as norepinephrine, which may offer a more balanced hemodynamic profile, could further refine anesthetic practice in cesarean deliveries. Overall, this study supports the superiority of prophylactic phenylephrine infusion over colloid administration in preventing post-spinal maternal hypotension and highlights the importance of early intervention within the first minutes following spinal anesthesia.

CONCLUSION

This study concludes that the use of prophylactic phenylephrine infusion during cesarean sections under spinal anesthesia offers a more effective approach for maintaining maternal hemodynamic stability compared to colloid infusion. By minimizing the occurrence of hypotensive episodes, phenylephrine infusion contributes to safer intraoperative conditions for both mother and baby. These findings support the consideration of phenylephrine infusion as a practical and superior strategy in routine obstetric anesthesia protocols, particularly during the critical initial period following spinal anesthesia.

AUTHOR CONTRIBUTION

Author	Contribution
Ahmed Zain Subhani	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Ahmed Abdullah Subhani*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Alina Hasan	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Valeed Bin Mansoor	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Humzah Abbas	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Haider Rashid	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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