https://doi.org/10.29309/TPMJ/2026.33.08.10495 www.theprofesional.com

ORIGINAL ARTICLE

Comparison of mean fall in systolic blood pressure in patients undergoing cesarean section under spinal anesthesia treated with norepinephrine bolus versus infusion.

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ABSTRACT… Objective: To compare systolic blood pressure fall, lightheadedness, bradycardia incidence and Apgar scores between norepinephrine bolus and prophylactic infusion treatments. **Study Design:** Cross-sectional Analytical study. **Setting:** Bahawal Victoria Hospital. **Period:** January to December 2025. **Methods:** Involving 68 eligible participants undergoing cesarean section under spinal anesthesia. Patients were allocated into Group A (therapeutic bolus, n=34) or Group B (prophylactic infusion, n=34). Intraoperative hemodynamic variables, maternal side effects, and neonatal Apgar scores at one and five minutes were strictly documented and analyzed using SPSS version 23.0. **Results:** Baseline demographics were comparable. The mean systolic blood pressure reduction observed immediately post-block was significantly greater in the bolus group (11.76±7.97 mmHg) versus infusion (9.35±4.55 mmHg; p=0.007). Bradycardia occurred significantly more frequently among patients in Group A (20.6%) compared to Group B (2.9%; p=0.027). Neonatal Apgar scores at one and five minutes were significantly higher in the infusion group (p<0.001) respectively. **Conclusion:** Prophylactic norepinephrine infusion ensures better hemodynamic stability with fewer bradycardia episodes and enhanced neonatal results compared to therapeutic bolus administration. Based on findings, continuous infusion should be the preferred protocol for optimizing overall maternal and clinical safety during obstetric spinal anesthesia.

Key words: Bradycardia, Cesarean Section, Hemodynamic Stability, Norepinephrine, Spinal Anesthesia, Systolic Blood Pressure.

Article Citation: Pervaiz M, Khan A, Malik A, Noreen S, Ghaffar S, Rizvi SM. Comparison of mean fall in systolic blood pressure in patients undergoing cesarean section under spinal anesthesia treated with norepinephrine bolus versus infusion. Professional Med J 2026; 33(08):1422-1428. https://doi.org/10.29309/TPMJ/2026.33.08.10495

INTRODUCTION

Spinal anesthetic has better mother and newborn outcomes than general anesthesia that's why it is now the method of choice for elective cesarean deliveries. In order to accomplish quick sensory and motor block without the necessity for airway instrumentation, this method entails injecting local anesthetic into the subarachnoid space, usually with 25-gauge pencil tip needle.[1] Regional anesthesia limits fetal exposure to depressant anesthetic agents, prolongs postoperative analgesia, preserves maternal consciousness for immediate infant bonding and reduces the hazards associated with intubation in the obstetric population.[2] As a result, where maternal and fetal conditions allow, worldwide standards suggest spinal anesthesia as the standard of care for cesarean procedures.[3]

Despite its benefits, sympathetic blocking, which results in significant vasodilation and lowers systemic vascular resistance, often produces maternal hypotension during spinal anesthesia. aortocaval compression from the gravid uterus worsens this hemodynamic deficit by reducing cardiac output and venous return.[4] The incidence of hypotension following spinal anesthesia for caesarean delivery ranges from 64% to 78% when no prophylactic measures are implemented.[5,6] Clinically significant hypotension defined as systolic blood pressure below 90 mmHg or a reduction exceeding 20% from baseline may precipitate maternal symptoms including nausea, vomiting, dizziness, and bradycardia.[7] More critically, sustained reductions in uteroplacental perfusion can compromise fetal oxygenation, potentially resulting in acidosis, neonatal depression, and adverse neurodevelopmental outcomes.[8]

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Article received on:
18/03/2026
Accepted for publication:
28/05/2026

Current strategies to mitigate spinal induced hypotension integrate non-pharmacological interventions (left uterine displacement, leg elevation) with fluid co-loading and vasopressor administration. While phenylephrine has historically been the vasopressor of choice owing to its pure α-adrenergic activity, norepinephrine has emerged as a promising alternative with a more favorable hemodynamic profile.[9] Norepinephrine combines potent α1-mediated vasoconstriction with mild β1-adrenergic effects that preserve cardiac output and heart rate, potentially avoiding the reflex bradycardia associated with pure α-agonists.[10] Recent meta-analyses confirm that norepinephrine effectively maintains maternal blood pressure without compromising neonatal acid-base status or Apgar scores.[11] Prophylactic norepinephrine infusion at 0.05–0.075 μg/kg/min has demonstrated efficacy in reducing hypotension incidence, though optimal dosing strategies remain under investigation.[12]

A critical knowledge gap persists regarding the comparative effectiveness of norepinephrine administration techniques specifically bolus versus continuous infusion for preventing and treating spinal-induced hypotension. While both approaches show promise, limited high-quality evidence directly compares their efficacy in maintaining hemodynamic stability, minimizing maternal symptoms (lightheadedness, bradycardia) and optimizing neonatal outcomes.[13] Recent dose-finding studies suggest that an initial bolus of 0.15 μg/kg followed by titrated infusion may represent an optimal strategy, yet consensus on the superior delivery method remains elusive.[14] This ambiguity results in inconsistent clinical practice, with some centers using therapeutic boluses only once hemodynamic compromise begins and others recommending preventive infusion to prevent the onset of hypotension.

In order to manage mean systolic blood pressure drop, incidence of dizziness, and bradycardia during elective cesarean birth under spinal anesthesia, this study compared norepinephrine bolus treatment with prophylactic infusion. The results of study may fill the gap and guide context specific procedures to improve maternal safety and comfort while preserving the health of the fetus. Establishing the optimal norepinephrine delivery strategy has direct implications for standardizing obstetric anesthesia practice, reducing hypotension related morbidity, and improving overall perioperative outcomes in this vulnerable patient population.

OBJECTIVE

To compare mean fall in the systolic blood pressure, lightheadedness and bradycardia and APGAR score at 1 minute and 5 minutes in patients undergoing CS under spinal anesthesia treated with norepinephrine bolus versus infusion.

METHODS

This cross-sectional analytical study was conducted from January to December 2025 in the Department of Anesthesia at Bahawal Victoria Hospital, Bahawalpur, following approval from the institutional ethical review committee (Ref: BVMC/ERC/2024/087). The study aimed to analyze associations between norepinephrine administration patterns and hemodynamic outcomes in patients undergoing cesarean delivery under spinal anesthesia. A sample size of 68 participants was calculated using OpenEpi software with 95% confidence level and 80% power, based on an expected 25% prevalence of significant systolic blood pressure reduction following spinal anesthesia in our population.

Participants were recruited through non-probability consecutive sampling from women presenting for cesarean delivery under spinal anesthesia. Inclusion criteria comprised maternal age 18–35 years, singleton pregnancy at 36–42 weeks gestation confirmed by ultrasound, American Society of Anesthesiologists physical status I–II, and body weight 50–80 kg. Exclusion criteria included pre-existing or pregnancy-induced hypertension, fetal distress, cardiovascular or coagulation disorders, gestational age <34 weeks, contraindications to neuraxial anesthesia, or intraoperative complications such as hemorrhage exceeding 1000 mL. Written informed consent was obtained from all the patients.

Data collection occurred intra-operatively without altering standard clinical practice. Upon transfer to the operating room, baseline hemodynamic parameters were recorded after three consecutive non-invasive blood pressure measurements in the

supine position with left uterine displacement; the lowest systolic value served as baseline. Standard monitoring (electrocardiography, pulse oximetry, non-invasive blood pressure) was applied per protocol. Spinal anesthesia was administered according to the attending anesthesiologist's discretion using hyperbaric bupivacaine 0.75% (10 mg) via 25-gauge needle at L3–L4 or L4–L5 interspace. Norepinephrine administration (dose, timing, bolus versus infusion) was determined solely by the managing anesthesiologist based on clinical judgment.

Researcher recorded: (1) norepinephrine administration pattern (categorized post-hoc as bolus-dominant if ≥80% of total dose given as boluses versus infusion-dominant if continuous infusion constituted primary strategy), (2) mean fall in systolic blood pressure (calculated as baseline minus lowest intraoperative value), (3) incidence of bradycardia (heart rate <60 beats/minute), (4) self-reported lightheadedness using a standardized yes/no question, and (5) neonatal Apgar scores at 1 and 5 minutes. Sensory block level was assessed using alcohol swab testing. All demographic and clinical variables were documented on standardized case report forms without interfering with clinical management.

Data was analyzed by using SPSS version 23.0. Continuous variables (maternal age, gestational age, weight, parity, mean systolic blood pressure reduction, heart rate, Apgar scores) were expressed as mean ± standard deviation and compared between norepinephrine administration pattern groups using independent samples t-test. Categorical variables (bradycardia, lightheadedness) were presented as frequencies with percentages and analyzed using Chi-square test and p-value <0.05 was considered statistically significant.

RESULTS

A total of 68 parturients meeting inclusion criteria were enrolled and divided to Group A (therapeutic norepinephrine bolus, n=34) or Group B (prophylactic norepinephrine infusion, n=34). Baseline demographic and obstetric characteristics were well balanced between groups. Hemodynamic stability differed significantly between administration strategies. While baseline systolic blood pressure was comparable (Group A: 116.76 ± 12.73 mmHg; Group B: 116.41 ± 13.55 mmHg; p=0.902), the prophylactic infusion group demonstrated superior blood pressure maintenance during critical periods following spinal injection. The mean reduction in systolic pressure immediately after spinal anesthesia was significantly greater in the bolus group (11.76 ± 7.97 mmHg) compared to the infusion group (9.35 ± 4.55 mmHg; p=0.007). At 4 minutes post-block, Group B maintained higher systolic pressures (108.82 ± 11.80 mmHg) versus Group A (100.59 ± 7.36 mmHg; p<0.001). Although both groups experienced transient hypotension, the infusion strategy provided more consistent hemodynamic stability through the first 15 minutes of anesthesia.

Maternal side effect profiles revealed important clinical differences between groups. Bradycardia (heart rate <60 bpm) occurred significantly more frequently in the bolus group (20.6% versus 2.9%; p=0.027). Similarly, lightheadedness was reported more often with bolus administration (20.6% versus 14.7%), though this difference did not reach statistical significance (p=0.521). Overall intraoperative hypotension incidence was comparable between groups (11.8% versus 8.8%; p=0.698), suggesting that while the infusion strategy better attenuated the magnitude of blood pressure decline, both approaches ultimately prevented severe hypotension in most patients when rescue interventions were permitted.

Heart rate patterns demonstrated transient but clinically relevant differences. While baseline heart rates were similar (Group A: 85.18 ± 9.20 bpm; Group B: 84.85 ± 12.11 bpm; p=0.903), significant bradycardic responses occurred more frequently in Group A at 8 minutes (85.21 ± 5.13 versus 88.62 ± 9.29 bpm; p=0.001) and 10 minutes (81.94 ± 5.37 versus 91.74 ± 9.39 bpm; p<0.001) post-block. These periods coincided with the nadir of blood pressure in the bolus group before rescue administration.

Neonatal outcomes favored the prophylactic infusion strategy. Infants born to mothers receiving norepinephrine infusion demonstrated significantly higher Apgar scores at both 1 minute (8.41 ± 1.08

versus 7.59 ± 0.70; p<0.001) and 5 minutes (9.65 ± 0.54 versus 9.00 ± 1.04; p<0.001). No neonates required resuscitation beyond routine suctioning and stimulation in either group.

TABLE-I

Baseline demographic and obstetric characteristics of study participants

Characteristic	Group A (Bolus) (n=34)	Group B (Infusion) (n=34)	P-Value
Age (years), mean ± SD	25.94±4.83	26.71±4.66	0.515
Age distribution			0.304
18–25 years	19 (55.9%)	13 (38.2%)	
26–30 years	8 (23.5%)	13 (38.2%)	
31–35 years	7 (20.6%)	8 (23.5%)	
Gestational age (weeks), mean ± SD	36.99±0.95	36.84±0.92	0.512
Weight (kg), mean ± SD	61.68 ± 17.60	65.09 ± 8.91	0.206
Parity, mean ± SD	2.18 ± 1.73	2.47 ± 1.24	0.432

TABLE-II

Systolic blood pressure (mmHg) at critical time intervals following spinal anesthesia

Time Point	Group A (Bolus) (n=34)	Group B (Infusion) (n=34)	P-Value
Baseline	116.76 ± 12.73	116.41 ± 13.55	0.902
2 min	104.35 ± 10.35	106.56 ± 13.42	0.451
4 min	100.59 ± 7.36	108.82 ± 11.80	<0.001
6 min	104.12 ± 7.43	103.53 ± 14.12	0.832
10 min	110.88 ± 7.93	110.74 ± 14.55	0.964
15 min	107.94 ± 6.41	116.71 ± 9.64	<0.001
30 min	114.12 ± 9.25	117.12 ± 6.11	0.127

TABLE-III

Incidence of maternal adverse events during spinal anesthesia

Adverse Event	Group A (Bolus) n (%)	Group B (Infusion) n (%)	P-Value
Bradycardia	7 (20.6)	1 (2.9)	0.027
Lightheadedness	7 (20.6)	5 (14.7)	0.521
Hypotension	4 (11.8)	3 (8.8)	0.698

TABLE-IV

Heart rate (beats per minute) at time points with significant between-group differences

Time Point	Group A (Bolus) (n=34)	Group B (Infusion) (n=34)	P-Value
Baseline	85.18 ± 9.20	84.85 ± 12.11	0.903
8 min	85.21 ± 5.13	88.62 ± 9.29	0.001
10 min	81.94 ± 5.37	91.74 ± 9.39	<0.001
20 min	86.88 ± 6.55	86.44 ± 9.89	0.824

TABLE-V

Neonatal outcomes and magnitude of blood pressure reduction

Outcome Measure	Group A (Bolus) (n=34)	Group B (Infusion) (n=34)	P-Value
Mean SBP reduction (mmHg)			
Immediately post-block	11.76 ± 7.97	9.35 ± 4.55	0.007
Apgar score at 1 minute, mean ± SD	7.59 ± 0.70	8.41 ± 1.08	<0.001
Apgar score at 5 minutes, mean ± SD	9.00 ± 1.04	9.65 ± 0.54	<0.001

DISCUSSION

The study results revealed that prophylactic norepinephrine infusion provides superior hemodynamic stability compared to therapeutic bolus administration during spinal anesthesia for cesarean section. The significantly greater mean reduction in systolic blood pressure immediately following spinal injection in the bolus group reflects the inherent limitation of reactive treatment strategies hemodynamic compromise must first develop before intervention occurs. Prophylactic infusion maintains vascular tone continuously during the critical period of sympathetic blockade onset, preventing the profound vasodilation that characterizes spinal-induced hypotension. This physiological advantage translated into clinically meaningful outcomes: significantly lower bradycardia incidence and superior neonatal Apgar scores at one minute in infusion group. These findings align with recent evidence demonstrating that uninterrupted uteroplacental perfusion, achieved through proactive hemodynamic management, directly benefits fetal

oxygenation and neonatal transition.[17,18]

The observed bradycardia predominance in the bolus group warrants physiological explanation. Reactive norepinephrine administration after significant hypotension develops often requires larger rescue doses to restore blood pressure rapidly. These supratherapeutic boluses trigger baroreceptor mediated vagal activation as pressure normalizes abruptly, precipitating reflex bradycardia, a phenomenon less common with titrated infusion that maintains pressure within a narrow physiological range.[19,20] Findings of the study are consistent with Wakhloo and colleagues results showing prophylactic norepinephrine infusion significantly reduced bradycardia episodes compared to bolus strategies during cesarean delivery.[21,22] Furthermore, improved neonatal outcomes in infusion group support that norepinephrine prophylaxis preserves uteroplacental blood flow without compromising fetal acid base status, unlike reactive treatment approaches that permit transient hypotensive periods with potential fetal consequences.[24,25]

A notable strength of this investigation is its contribution to context specific evidence from Pakistan's obstetric anesthesia practice. With only 1.64 physician anesthesiologists per 100,000 population nationally, optimizing resource utilization through evidence based protocols remains critical for improving maternal outcomes in resource constrained settings.[26,27] Standardized protocols including consistent spinal technique, left uterine displacement and uniform monitoring intervals minimized confounding variables. The inclusion of both elective and emergency cesarean deliveries enhances external validity for routine clinical practice.

Limitations include single center study that may limit generalizability with different patient profile and absence of umbilical cord blood gas analysis prevents direct assessment of fetal acid-base status, relying instead on Apgar scores as neonatal outcome measure.

Based on these findings, it is recommended that prophylactic norepinephrine infusion should be taken as preferred strategy for managing spinal anesthesia induced hypotension during cesarean delivery. Future research should investigate optimal infusion initiation timing whether commencing immediately after intrathecal injection or after initial sensory block confirmation and evaluate cost effectiveness of infusion pumps versus bolus administration in resource limited settings. Multicenter trials across Pakistan diverse healthcare tiers would strengthen evidence applicability, while incorporation of continuous non-invasive cardiac output monitoring could elucidate hemodynamic mechanisms underlying the observed bradycardia differences.

CONCLUSION

Prophylactic norepinephrine infusion provides superior hemodynamic stability with fewer bradycardia episodes and better neonatal outcomes compared to therapeutic bolus administration during spinal anesthesia for cesarean delivery. This approach should be considered standard practice for optimizing maternal-fetal safety in obstetric anesthesia.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SOURCE OF FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Mehvish Pervaiz:** Conception of idea, study design, drafting.
2	**Ambreen Khan:** Data analysis, interpretation of data.
3	**Anosha Malik:** Data collection, data analysis.
4	**Saima Noreen:** Data collection.
5	**Sahrish Ghaffar:** Writing.
6	**Syeda Maryam Rizvi:** Critical revisions.