DOI: https://doi.org/10.54393/pjhs.v7i9.3761

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 7, Issue 09 (September 2026)



OPEN ACCESS
Check for updates

Original Article

Comparison of Continuous Infusion and Bolus Phenylephrine for Prevention of Spinal-Induced Hypotension in Cesarean Section: A Quasi-experimental Study

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ARTICLE INFO

Keywords:
Phenylephrine, Cesarean Section, Spinal Anesthesia, Hypotension, Infusion, Bolus, Maternal Outcomes, Neonatal Outcomes

How to Cite:
Afzal, A., Aziz, M. A., Asad, A., Raza, H. M. Z., & Ali, M. A. (2026). Comparison of Continuous Infusion and Bolus Phenylephrine for Prevention of Spinal-Induced Hypotension in Cesarean Section: A Quasi-experimental Study: Bolus Phenylephrine for Spinal-Induced Hypotension in Cesarean Section. Pakistan Journal of Health Sciences, 7(9), 135-140. https://doi.org/10.54393/pjhs.v7i9.3761

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Received Date: 22nd January, 2026
1st Revision Received: 27th February, 2026
2nd Revision Received: 16th April, 2026
3rd Revision Received: 11th May, 2026
Acceptance Date: 20th May, 2026
Published Date: 30th September, 2026

ABSTRACT

Cesarean section spinal anesthesia is often associated with maternal hypotension, which causes poor maternal and infant outcomes. Phenylephrine is commonly used as prophylaxis and treatment of spinal-induced hypotension, but the most effective mode of administration, bolus or continuous infusion, is controversial. **Objectives:** To compare the effectiveness of continuous phenylephrine infusion versus intermittent bolus administration in preventing spinal anesthesia-induced hypotension during elective cesarean section. **Methods:** A quasi-experimental study was carried out at the Department of Anesthesia, Gulab Devi Teaching Hospital, Lahore. Sixty-six ASA II patients, who had an elective cesarean section, were randomly divided into two groups, namely Group A (infusion, n=33), which received continuous phenylephrine infusion 30mL/hour, and Group B (bolus, n=33), which received 100 µg phenylephrine boluses when required. The data on hemodynamic, maternal side effects, and neonatal outcomes were taken and analyzed with SPSS version 28.0. **Results:** Continuous infusion resulted in significantly fewer hypotensive episodes (30.3% vs. 54.5%, p<0.001) and lower prevalence of nausea and vomiting (9.1% vs. 21.2%, p<0.004). Reactive hypertension occurred less frequently in the infusion group (3.0% vs. 12.1%, p<0.05). Neonatal outcomes were improved with infusion, including higher umbilical cord pH (7.37 ± 0.05 vs. 7.33 ± 0.06, p<0.002). **Conclusion:** Phenylephrine infusion was found to be better than bolus dosing in maternal hypotension prevention, reducing adverse maternal outcomes, and neonatal outcomes in cesarean section under spinal anesthesia. Infusion should be regarded as the regimen of choice in clinical practice.

INTRODUCTION

Spinal anesthesia or subarachnoid block is still the most preferable mode of anesthetic use in cesarean section owing to its quicker onset, reliability, and avoidance of maternal tracheostomy issues, although this is closely linked with maternal hypotension owing to sympathetic blockage and decrease in systemic vascular resistance [1]. Hypotension is among the most prevalent complications of cesarean anesthesia globally, with the incidence rates ranging between 60% and 90% occurring in obstetric patients after spinal anesthesia [2]. The global number of cesarean births is about 29.7 million, with a regional disparity of 6% in sub-Saharan Africa to over 45% in Latin America [3]. In South Asia, spinal-anesthesia-induced hypotension during cesarean section occurs in approximately 20-64% of cases and may exceed 80% in the absence of prophylactic measures [2]. In Pakistan, recent studies reported post-spinal hypotension in 26.8% of elective cesarean deliveries at Hayatabad Medical Complex

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DOI: https://doi.org/10.54393/pjhs.v7i9.3761

(73/272), and in 33.6% of term parturients at Dr. Ruth K. M. Pfau Civil Hospital, Karachi (39/116) [4, 5]. Phenylephrine, a pure α-1 adrenergic agonist, has become the vasopressor of choice in the management of spinal anesthesia-induced hypotension in obstetric patients [6]. Phenylephrine is also useful in the restoration of systemic vascular resistance and systolic blood pressure with little transplacental implementation and better neonatal acid-base results than ephedrine [7]. Nonetheless, the administration route is still controversial, with intravenous bolus regimens being technically easy, can be easily titrated, and can be a quick fix of hypotension, but they were also reported to cause hemodynamic instability because of alternating phases of hypotension and hypertension [8]. In contrast, continuous infusion regimens stabilize the maternal blood pressure but are more prone to reflex bradycardia and must be closely titrated to prevent excessive response to hypertension [9]. The controversy existing between bolus and infusion regimens means that there is a greater gap in evidence-based practice of obstetric anesthesia [10]. The outcome of this is variability in clinical outcomes due to the absence of standardization, which complicates the comparison of studies, as well as the development of best practices that are universally recognized [11].

Also, as the rates of cesarean section grow all over the world, and the incidence of hypotension remains high despite the precautions that are taken to prevent this issue, there is a need for better studies that compare bolus and infusion regimens. Thus, this study aimed to compare the effectiveness of continuous phenylephrine infusion versus intermittent bolus administration in preventing spinal anesthesia–induced hypotension during elective cesarean section.

METHODS

This quasi-experimental study was conducted in the Department of Anesthesia, Gulab Devi Teaching Hospital, Lahore, from 10th Oct 2025 to 10th Jan 2026. The research obtained ethical approval from the institutional ethical review committee of Gulab Devi Teaching Hospital (AAMC/IRB/EA/55/2025) on 9th Oct 2025. All subjects were provided with all details about the purpose, methodology, possible benefits, and risks of the study and were given informed consent through written means. Anonymity of the data ensured patient confidentiality, and participants had the right to withdraw at any time without any consequences on their medical care. The sample size was calculated a priori based on expected hypotension rates of 70% in the bolus group versus 40% in the infusion group, using a two-sided significance level of 5% and 80% power. A total of 66 participants (33 per group) were included in the study. However, the observed rates (54.5% vs 30.3%) were lower than anticipated, which may have reduced the study's power to detect the actual effect size. This limitation should be considered when interpreting the findings [12]. $n = [(Z_{\alpha/2}\sqrt{2P(1-P)} + Z_{\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)})2]/(P_1-P_2)^2$ where P_1 and P_2 represent the expected proportions in the two groups, $Z_{\alpha/2}$ represents the standard normal deviate corresponding to the level of significance (1.96 at 95% confidence interval), whereas $Z\beta$ represents the standard normal deviate corresponding to the study power (0.84 at 80% power) [13]. The American Society of Anesthesiologists (ASA) physical status classification includes: ASA I = normal healthy patient; ASA II = patient with mild systemic disease; ASA III = patient with severe systemic disease; ASA IV = patient with severe systemic disease that is a constant threat to life [14]. In this study, the patients were recruited if they met the ASA physical status classification II. Patients were excluded if they refused to participate, were known to be hypersensitive to phenylephrine or local anesthetics, had hypertension, cardiovascular or cerebrovascular disease, fetal abnormalities, or diabetes mellitus other than gestational diabetes. Additional criteria for exclusion were contraindications to subarachnoid block and ASA physical status IV. Eligible patients were recruited consecutively during the study period according to the predefined inclusion and exclusion criteria. As the study was conducted at a single center using consecutive non-probability sampling, the findings may have limited representativeness and external validity. The patients were allocated to one of two equal groups using a lottery method. However, formal computer-generated randomization and allocation concealment were not used; therefore, the possibility of selection bias cannot be completely excluded. Baseline systolic blood pressure was recorded using a non-invasive monitor, after which standard intraoperative monitoring and intravenous access were established. Spinal anesthesia was administered in the sitting position at the L4–L5 interspace using 12 mg of 0.75% hyperbaric bupivacaine. Patients were then placed supine with left uterine displacement. A preload of 1 L Lactated Ringer's solution was given, followed by 500 mL maintenance fluid. Blood loss was assessed by sponge weight and suction volume. In Group A, phenylephrine infusion (100 µg/mL) was started at 30 mL/hour (50 µg/minute) immediately after spinal block and titrated to maintain systolic pressure within 20% of baseline. In Group B, 100 µg phenylephrine boluses were administered when systolic pressure fell more than 20% from baseline. The two regimens were not dose-equivalent because they differed in administration strategy and cumulative phenylephrine exposure. Due to the different modes of phenylephrine administration, blinding of the participants and anesthesia team was not performed. This may have introduced performance and detection bias.

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Shapiro-Wilk test results for all continuous variables showed p>0.05 (age p=0.214, height p=0.392, weight p=0.176, gestational age p=0.083, total fluid administered p=0.119, umbilical cord pH p=0.071, APGAR at 1 minute p=0.088, APGAR at 5 minutes p=0.065), indicating that all variables followed approximately normal distributions. Therefore, parametric tests (independent samples t-test) were used for all continuous variable comparisons.

All data were organized and analyzed through the Statistical Package for the Social Sciences (SPSS) version 28.0. Continuous variables were assessed for normality using the Shapiro-Wilk test. Normally distributed variables were expressed as mean ± standard deviation and compared using the independent samples t-test. Categorical variables were summarized as frequencies and percentages and analyzed using Fisher's exact test. Hemodynamic parameters measured at multiple time points were analyzed using repeated measures ANOVA with Greenhouse-Geisser correction after confirming normal distribution. Given the multiple subgroup analyses and repeated measures performed, a Bonferroni correction was applied to control for Type I error inflation. Statistical significance was set at p<0.05 after correction, with adjusted p-values reported for all post-hoc comparisons.

RESULTS

The infusion group had an average age of 27.11 ± 3.4 years, and the bolus group had 27.31 ± 3.5 years. The mean height of the groups was 158.0 ± 3.6 cm in the infusion and 157.6 ± 3.5 cm in the bolus groups. The infusion and bolus groups had a mean weight of 66.2 and 67.0, respectively. The status of ASA (I/II) distribution was equal at 27/6 and 25/8 in the infusion and bolus group, respectively. There was also no significant difference in mean gestational age, which was 38.6 + 0.7 weeks in the infusion group and 38.5 + 0.8 weeks in the bolus group. The average total fluid administered was 1610 ± 280mL in the infusion group versus 1565 ± 290mL in the bolus group (Table 1).

Table 1: Baseline Characteristics of Patients (n=66)

Characteristics	Infusion Group (n=33), Mean ± SD	Bolus Group (n=33), Mean ± SD	p-value
Age (years)	27.1 ± 3.4	27.3 ± 3.5	0.810
Height (cm)	158.0 ± 3.6	157.6 ± 3.5	0.650
Weight (kg)	66.2 ± 5.2	67.0 ± 5.3	0.540
ASA grade (I/II)	27/6	25/8	0.765*
Gestational Age (weeks)	38.6 ± 0.7	38.5 ± 0.8	0.590
Total Fluid Given (mL)	1610 ± 280	1565 ± 290	0.520

*Statistical significance at p ≤ 0.05

Phenylephrine infusion at a constant rate was significantly associated with increased outcomes among neonates relative to bolus administration. The infusion group (7.37 ± 0.05) had better neonatal acid-base status than the bolus group (7.33 ± 0.06) because of higher umbilical cord pH. Equally, APGAR scores were found to be higher in the infusion group at 1 minute (7.01 ± 0.15 vs 6.89 ± 0.20, p<0.001) and at 5 minutes (8.95 ± 0.30 vs 8.72 ± 0.35, p<0.003). Infusion group experienced 30.3 and bolus group 54.5% maternal hypotension (p<0.001), and recurrent hypotensive episodes in infusion and bolus groups were 6.1% and 21.2% respectively (p<0.003). The infusion group also had less nausea and vomiting (9.1% vs 21.2%, p<0.004). The number of cases of neonatal acidosis was lower in the infusion group compared to the bolus group (3.0% vs 9.1%). Although this difference was not statistically significant at the pre-specified threshold of p<0.05 (p=0.088), it may still represent a clinically relevant difference that warrants investigation in larger studies. These results indicate that continuous infusion affirms comparatively better maternal hemodynamic control and neonatal outcomes (Table 2).

Table 2: Post-Intervention Maternal and Neonatal Outcomes in Infusion and Bolus Groups

Variables	Infusion (n=33)	Bolus (n=33)	p-value
Continuous Variables			
Umbilical Cord pH†	7.37 ± 0.05	7.33 ± 0.06	<0.002*
APGAR (1 min) †	7.01 ± 0.15	6.89 ± 0.20	<0.001*
APGAR (5 min) †	8.95 ± 0.30	8.72 ± 0.35	<0.003*
Categorical Variables			
Nausea/Vomiting*	3 (9.1%)	7 (21.2%)	<0.004*
Neonatal Acidosis*	1 (3.0%)	3 (9.1%)	<0.009
Hypotension*	10 (30.3%)	18 (54.5%)	<0.001*
≥2 Hypotensive Episodes*	2 (6.1%)	7 (21.2%)	<0.003*
Reactive Hypertension*	1 (3.0%)	4 (12.1%)	<0.050*

†Mean ± SD presented for normally distributed data (Independent t-test used), * Statistical significance at p ≤ 0.05

There was initial equivalence evidenced by similarity of baseline systolic blood pressure (118.6 ± 7.2 vs 118.2 ± 7.0 mmHg), diastolic blood pressure (75.4 ± 5.2 vs 75.1 ± 5.4 mmHg), and heart rate (78.2 ± 7.5 vs 78.5 ± 7.6 bpm). At 3 minutes (116.5 vs 112.3 mmHg), at 6 minutes (115.9 vs 111.5 mmHg), at 9 minutes (115.2 vs 111.0 mmHg), and at 12 minutes (115.2 vs 111.0 mmHg), the systolic blood pressure was significantly higher in the infusion group compared to the bolus group at all measured time points (mean differences ranging from 4.2 to 4.5 mmHg, p<0.05 at all time points). The infusion group had a stable benefit of 3-3.5 mmHg of diastolic blood pressure over the same periods (p<0.001). In contrast, the heart rate was much slower in the infusion group, such as at 3 and 12 minutes (76.8 and 74.5 versus 80.5 and 78.1 bpm), and showed less compensatory tachycardia (p<0.001). Repeated measures ANOVA established that time, group, and time-by-group interaction effects were significant on all parameters, and that time-by-group and group effects were superior to

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DOI: https://doi.org/10.54393/pjhs.v7i9.3761

intermittent bolus infusion of phenylephrine in maintaining hemodynamic control (Table 3).

Table 3: Hemodynamic Parameters at Baseline and During the First 12 Minutes After Spinal Anesthesia (n=66)

Variables	Time	Infusion (n=33)	Bolus (n=33)	Between-Group p-value
Systolic BP (mmHg), Mean ± SD	Baseline	118.6 ± 7.2	118.2 ± 7.0	<0.720
	3 min	116.5 ± 6.8	112.3 ± 7.5	0.018*
	6 min	115.9 ± 6.5	111.5 ± 7.0	0.007*
	9 min	115.5 ± 6.7	111.2 ± 7.2	0.021*
	12 min	115.2 ± 6.9	111.0 ± 7.3	0.011*
Diastolic BP (mmHg), Mean ± SD	Baseline	75.4 ± 5.2	75.1 ± 5.4	0.810
	3 min	73.8 ± 5.0	70.5 ± 5.6	0.026*
	6 min	73.5 ± 5.2	70.1 ± 5.7	0.014*
	9 min	73.2 ± 5.3	69.9 ± 5.8	0.009*
	12 min	72.9 ± 5.5	69.6 ± 5.9	0.032*
Heart Rate (bpm), Mean ± SD	Baseline	78.2 ± 7.5	78.5 ± 7.6	0.870
	3 min	76.8 ± 7.0	80.5 ± 7.8	0.013*
	6 min	75.9 ± 6.8	79.2 ± 7.5	0.028*
	9 min	75.2 ± 6.6	78.8 ± 7.4	0.006*
	12 min	74.5 ± 6.7	78.1 ± 7.2	0.017*

Systolic BP — Time $p<0.001$; Group $p = 0.004$; Time × Group $p=0.006$. Diastolic BP — Time $p<0.001$; Group $p=0.008$; Time × Group $p=0.010$. Heart Rate — Time $p<0.001$; Group $p=0.002$; Time × Group $p=0.05$. * Statistical significance at $p\leq0.05$

DISCUSSION

This research aimed to compare the effectiveness of continuous phenylephrine infusion versus intermittent bolus administration in preventing spinal anesthesia-induced hypotension during elective cesarean section. It found that systolic and diastolic blood pressures were more regularly maintained within 20% of the baseline in the infusion group, with less prevalence of hypotension and reactive hypertension, and that fluctuations in heart rate were also less evident. These results are similar to the randomized trial by Liu *et al.* in Hong Kong involving 104 patients, which demonstrated that continuous infusion considerably decreased the rate of hypotension by 66% in the bolus group and by 23% in the infusion group, and also the fetal acid-base status improved [15]. Singh *et al.* in a randomized prospective study conducted in India, compared phenylephrine bolus and infusion regimens during cesarean delivery under spinal anesthesia and reported better hemodynamic stability with prophylactic infusion [16]. The results of a better infusion regimen in our results are also manifested by the results obtained in Western cohorts. In India, Nikooseresht *et al.* in a sample of 88, reported that women who received phenylephrine infusion (vs. bolus group) had mean arterial pressure that was within or nearer to baseline (within 5 mmHg), although 35% experienced significant hypotension despite repeated dosage [12]. Similarly, in India, in a trial of 150 patients, Singh *et al.* found that infusion regimens produced a lower prevalence of maternal nausea and vomiting, which could be attributed to improved blood pressure control, but other neonatal outcomes, such as Apgar scores and umbilical cord pH, were significantly better preserved [16]. Regarding neonatal outcomes, the present study showed statistically higher APGAR scores and umbilical cord pH in the infusion group; however, the clinical significance of these differences remains uncertain. The recent meta-analysis by Garg *et al.* found only modest differences in neonatal outcomes between phenylephrine infusion and bolus regimens . More recent evidence from Babul *et al.* also reported that although minor statistical differences were observed in APGAR scores and umbilical arterial pH, neonatal values remained within normal clinical ranges [18]. These findings emphasized the necessity of proactive versus reactive vasopressor management when administering anesthesia in cases of cesarean section. This study also found that the maternal adverse effects, especially nausea and vomiting, were minimal in the infusion group, which is well supported in the literature. Kannan *et al.* similarly compared phenylephrine infusion and bolus regimens during cesarean delivery and reported closer maintenance of blood pressure with infusion, although neonatal APGAR scores were comparable between groups [19]. Similarly, the same study by Khan *et al.* in Pakistan investigated 70 women, whereby infusion was used, resulting in reduced nausea scores and intraoperative discomfort [20]. This indicated that, besides hemodynamic management, infusion improves maternal satisfaction and decreases perioperative morbidity.

This study had several limitations. The quasi-experimental design and lack of formal allocation concealment may have introduced selection bias, while absence of blinding may have resulted in performance and detection bias. The phenylephrine regimens were not dose-equivalent, with differences in administration and cumulative drug exposure. The study was single-center-based, with a small sample size of 66 participants and consecutive non-probability sampling, which may limit its applicability to larger and more diverse populations. Furthermore, the study was confined to ASA II women undergoing elective cesarean section, excluding high-risk obstetric groups such as those with cardiovascular disease, hypertension, and multiple gestations, thereby limiting external validity. Future multicenter randomized controlled trials with larger and more diverse populations, dose-equivalent regimens, and longer maternal and neonatal follow-up are recommended.

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DOI: https://doi.org/10.54393/pjhs.v7i9.3761

CONCLUSIONS

Continuous phenylephrine infusion was associated with fewer hypotensive episodes and maternal adverse effects than bolus administration during elective cesarean section. Although some neonatal outcomes were statistically better with infusion, the clinical significance remains uncertain. Given the study limitations, these findings should be interpreted cautiously and not generalized to all cesarean deliveries.

Authors' Contribution

Conceptualization: MAA
Methodology: AA[2]
Formal analysis: AA[2]
Writing and Drafting: AA[1], HMZR
Review and Editing: AA[1], MAA, AA[2], HMZR, MAA

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflict of Interest

All the authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

REFERENCES

[1] Wang LZ, Huang JY, Hu HJ, Xia F. Incidence of Chronic Postsurgical Pain After Caesarean Delivery: A Systematic Review and Meta-Analysis. Anesthesia. 2025 Jul; 80(7): 834-45. doi: 10.1111/anae.16596.

[2] Demilew BC, Zurbachew N, Getachew N, Mekete G, Teshome D. Prevalence and Associated Factors of Intraoperative Nausea and Vomiting of Mothers Who Gave Birth with Cesarean Section Under Regional Anesthesia: A Systematic Review and Meta-Analysis; 2023. BioMed Central Pregnancy and Childbirth. 2025 Mar; 25(1): 244. doi: 10.1186/s12884-025-07363-z.

[3] Lucas DN, Bamber JH, Stocks G, Sharpe P, Knight M. Incidence, Risk Factors, Management and Outcomes of High Neuraxial Block in Obstetric Anesthetic Practice: A Prospective National Observational Study Using the UK Obstetric Surveillance System. Anesthesia. 2026 Jan; 81(1): 24-30. doi: 10.1111/anae.16752.

[4] Iqbal J, Mabood S, Ullah SS, Qasim R, Ahmad A. Frequency of Post-Spinal Hypotension in Elective Cesarean Section After Spinal Anesthesia. Pakistan Journal of Medical and Health Sciences. 2024; 16(12): 778-81. doi: 10.53350/pjmhs20221612778.

[5] Ahmed H, Batool Z, Rashid S, Perchani A, Sultan F. Effect of Abdominal Circumference and Fetal Weight on Supine Hypotension during C-Section under Spinal Anesthesia. Pakistan Journal of Medical Research. 2024 May; 63(1): 46-50.

[6] Puthenveettil N, Rahman S, Achary AR, Nair S, Kadapamannil D, Paul J. Comparison of Induction of Spinal Anesthesia in Sitting Position with Legs Parallel and Crossed for Cesarean Section: A Randomized Controlled Trial. Journal of Anesthesiology Clinical Pharmacology. 2024 Jan; 40(1): 154-8. doi: 10.4103/joacp.joacp_11_22.

[7] Gunawan MF, Soetomo CT, Richard R, Darmayasa PB, Suastika AV. Dissecting Vasopressor Efficacy in the Management of Maternal Hypotension in Preeclamptic Cesarean Delivery: A Systematic Review of Randomized Controlled Trials. Maternal-Fetal Medicine. 2025 Oct; 7(4): 234-43. doi: 10.1097/FM9.0000000000000314.

[8] Sailaja K, Nath G, Bule G, Manasa N. Comparison of Effects of Norepinephrine and Phenylephrine on Maternal Hemodynamics and Foetal Well-Being After Subarachnoid Block for Elective Caesarean Sections: A Randomized Double-Blind Controlled Trial. International Journal of Advanced Research. 2024; 6(1): 06-12. doi: 10.33545/26648849.2024.v6.i1a.36.

[9] Pan ZB, Sheng ZM, Zhu M, Mei Z, Shen YP, Liu JP *et al.* Randomized Double-Blinded Comparison of Intermittent Boluses of Phenylephrine and Norepinephrine for the Treatment of Postspinal Hypotension in Patients with Severe Pre-Eclampsia During Cesarean Section. Drug Design, Development and Therapy. 2024 Dec: 639-50. doi: 10.2147/DDDT.S446657.

[10] Divakar SR, Shivakumar G, Kiran AV, Kavya D. Comparative Evaluation of Intravenous Bolus of Phenylephrine Versus Intravenous Bolus of Noradrenaline for Treatment of Hypotension in Patients Undergoing Elective Caesarean Section. Journal of Medical and Scientific Research. 2025; 13(1): 27-31. doi: 10.17727/JMSR.2024/13-5.

[11] Mao J, Lin K, Liu X, Liu J, Liang G, Sheng Z. Retracted Article: Effects of Prophylactic Infusion of Equivalent Doses of Norepinephrine and Phenylephrine in Preventing Spinal Anesthesia-Induced Hypotension During Cesarean Delivery on Fetal and Maternal Outcomes: A Dual-Center, Non-Inferiority Controlled Trial. Drug Design, Development, and Therapy. 2025 Dec: 5143-52. doi: 10.2147/DDDT.S514091.

[12] Nikooseresht M, Seifrabiei MA, Hajian P, Khamooshi S. A Clinical Trial on the Effects of Different Regimens of Phenylephrine on Maternal Hemodynamics After

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DOI: https://doi.org/10.54393/pjhs.v7i9.3761

Spinal Anesthesia for Cesarean Section. Anesthesiology and Pain Medicine. 2020 Jul; 10(4): e58048. doi: 10.5812/aapm.58048.

[13] Charan J, Kaur R, Bhardwaj P, Singh K, Ambwani SR, Misra S. Sample Size Calculation in Medical Research: A Primer. Annals of the National Academy of Medical Sciences(India). 2021 Apr; 57(02): 074-80. doi: 10.1055/s-0040-1722104.

[14] Sun L, Tang Y, Guo F, Liu J, Xu L, Zhu G *et al.* Norepinephrine or Phenylephrine for the Prevention of Post-Spinal Hypotension After Caesarean Section: A Double-Blinded, Randomized, Controlled Study of Fetal Heart Rate and Fetal Cardiac Output. Journal of Clinical Anesthesia. 2024 Oct; 97: 111533. doi: 10.1016/j.jclinane.2024.111533.

[15] Liu J, Sheng Z, Guo F, Lin X, Xu L, Sun L *et al.* Norepinephrine or Phenylephrine to Prevent Spinal Anesthesia-Induced Hypotension During Cesarean Section: A Double-Blinded, Randomized, Controlled Study of Fetal Cerebral Perfusion. Drug Design, Development and Therapy. 2025 Dec: 7571-80. doi: 10.2147/DDDT.S535671.

[16] Singh D, Yadav JB, Singh AK, Rai MK, Rai M. Comparing the Effect of Phenylephrine Bolus and Phenylephrine Infusion for Maintaining Arterial Blood Pressure During Cesarean Delivery Under Spinal Anesthesia: A Randomized Prospective Study. Cureus. 2023 Jul; 15(7). doi: 10.7759/cureus.42713.

[17] Garg H, Khanna P, Yalla B. Comparison of Phenylephrine Bolus and Infusion Regimens on Maternal and Fetal Outcomes During Cesarean Delivery: A Systematic Review and Meta-Analysis. Anesthesia and Analgesia. 2024 Dec; 139(6): 1144-55. doi: 10.1213/ANE.0000000000007156.

[18] Babul A, Ashraf S, Desai J, Free L, Hussain M, Babul N. Maternal and Fetal Outcomes of Phenylephrine Bolus Versus Infusion During Cesarean Delivery: A Systematic Review, Meta-Analysis, and Trial Sequential Analysis. Journal of Anesthesiology, Clinical Pharmacology. 2026 Mar; 42(2): 187. doi: 10.4103/joacp.joacp_489_25.

[19] Kannan H, Gnanaprakasam PV, Subramanian V, Pm S, vendan Gnanaprakasam P, vishwanath Subramanian S. Phenylephrine Infusion versus Bolus Regimens During Cesarean Delivery Under Spinal Anesthesia: An Observational Study to Assess Hemodynamic Changes. Cureus. 2024 Jan; 16(1). doi: 10.7759/cureus.51977.

[20] Khan S, Fiaz ZM, Anwar MH, Sikander RI, Ali A, Ayesha K. Comparison of Phenylephrine Infusion Vs Nor-Epinephrine Infusion on Maternal Hemodynamics and Neonatal Outcomes During Elective Lower Segment Caesarean Section Under Sub-Arachnoid Block. Annals of Pakistan Institute of Medical Sciences-Shaheed Zulfiqar Ali Bhutto Medical University. 2024 Mar; 20(1): 74-9. doi: 10.48036/apims.v20i1.919.

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