ORIGINAL ARTICLE

Effect of Crystalloid Administration Timing on Hypotension in Spinal Anesthesia for Cesarean Delivery: Preload Versus Coload: A Study at a Tertiary Care Hospital in Rawalpindi

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ABSTRACT

Objective: To assess and compare the occurrence of hypotension and the demand for vasopressors in parturients undertaking spinal anesthesia during cesarean delivery, distinguishing between those who received crystalloid preload and those who received coload.

Study Design: Quasi-experimental study.

Place and Duration of Study: The study was conducted at Department of Anesthesiology, Combined Military Hospital (CMH) Rawalpindi, Pakistan for two years from July 2021 to July 2023.

Methods: Fifty-four parturients, categorized as ASA II, with full-term singleton gestations planned for elective cesarean delivery under spinal anesthesia, were randomly divided into two groups. Both groups received 15ml/kg of crystalloid as a preload and a coload. The initial readings of heart rate and arterial pressures were evaluated before spinal induction and subsequently at one minute intervals until the completion of the operation. Intravenous ephedrine was administered to manage hypotension, characterized by a more than 20% reduction in systolic blood pressure.

Results: The group receiving preload demonstrated notably lower values in both the minimum recorded systolic and mean blood pressure, as well as in the reduction of systolic and mean blood pressure from the baseline, in comparison to the coload group ($P < 0.001$). The occurrence of hypotension in the preload group was significantly elevated at 92.6%, indicating a statistically significant difference ($P = 0.039$) when compared to the coload group, where the incidence was 67%. Additionally, the mean ephedrine dose requirement was significantly higher in the preload group at 12.2 ± 5.9 mg ($P = 0.029$) compared to the coload group, which had a mean ephedrine dose requirement of 8.3 ± 6.8 mg. There were no significant differences between neonatal outcomes, such as APGAR score and blood gases, between the two groups.

Conclusion: The adoption of the crystalloid coload method proved more effective than the preload technique in reducing the incidence of intraoperative maternal hypotension and decreasing the necessity for vasopressors in parturients undergoing cesarean delivery.

Keywords: *Arterial Pressure, Cesarean Section, Crystalloid Solutions, Hypotension, Spinal Anesthesia.*

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Introduction

In recent times, the recognition of spinal anesthesia among parturients undergoing cesarean section has increased. This is because of its numerous advantages including swift onset, brief stay at hospitals, fewer complications, fetus's minimum exposure to medication, low possibility of block failure, and improved maternal and neonatal results.[1-4] However, hypotension is a major consequence of the sympathetic vasomotor block

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that occurs among 60-70% of parturients undergoing elective cesarian section induced by spinal anesthesia, characterized by reductions in both systolic and diastolic blood pressure (DBP),[5] and typically arises from a sympathetic blockade, resulting in the peripheral expansion of blood vessels and the accumulation of blood in veins.[6,7] Prolonged maternal hypotension can lead to transient cerebral hypoxia and gastrointestinal hyperactivity which may be noticeable in the form of dizziness, nausea, and vomiting.[8] It further affects uteroplacental blood flow, and causes low APGAR scores and significant acidosis.[5,9]

Several procedures and methods have been introduced to minimize these incidences of hypotension. The American Society of Anesthesiologists Task Force recommended one such guideline, which advocates using vasopressors such as phenylephrine and ephedrine to treat hypotensive episodes during neuraxial block.[9] Other processes include intravenous fluid pre-loading or co-loading, left uterine displacement to reduce inferior vena cava (IVC) compression, and leg compression to diminish venous blood pooling.[9,10]

Traditionally, intravenous fluid administration had been used to decrease the rate of spinal induced hypotension. The studies implied that colloids are exceptional as compared to crystalloids in terms of reduction of hypotension occurrence.[11] Colloids can either be processed as a preload or as a coload; there is no significant difference in the incidence of maternal hypotension or neonatal consequences between the two methods.[12] Yet, the use of colloids is limited because of their higher charges, allergic responses, and impacts on coagulation. This is the reason crystalloids remained to be the most commonly administered fluid type. They have a very short half-life as compared to colloids and are rapidly distributed between the plasma and the interstitial space.[13] Various studies have concluded that the traditional technique of crystalloid pre-loading is ineffective in the prevention of maternal hypotension. The role of rapid crystalloid coload in inhibiting spinal induced hypotension is an active area of research.[14] Nonetheless, its benefit over crystalloid preload is unpredictable and may be influenced by the volume and speed of administration during the initiation of sympathetic intradural block.[14]

Therefore, this study was designed to bridge the knowledge gap. The results of this study will aid the anesthetists in making evidence based clinical decisions while managing obstetric cases. We hypothesized that for cesarean delivery, crystalloid coload, as opposed to preload, would be more effective in preventing maternal hypotension during spinal anesthesia.

Methods

The study was conducted at Department of Anesthesiology, Combined Military Hospital (CMH), Rawalpindi, Pakistan for two years from July 2021 to July 2023 after taking approval from the Ethical Review Committee of the hospital vide letter no: 241, held on dated: 17th August 2021. The sample size was 411 but strict selection and rigorous diagnostic criteria limited the number of eligible patients, hence, only 54 respondents were included in this study. A sample size of 54 was determined using Openepi as suggested by Khan and his colleagues (2015) (desired power = 0.8, alpha = 0.05, change in average systolic blood pressure 34 ± 13 mmHg in preload group vs 25 ± 10 mmHg in coload group) while at least 27 participants were needed.[15] The ASA 2 parturients with ≥ 18 years of age were registered for elective cesarean section performed with spinal anesthesia after written informed consent. The sampling method of a successive non probability was employed, excluding parturients with a gestational age of < 37 weeks, multiple pregnancies, non-reassuring fetal status, toxemia (also known as pre-eclampsia), cardiovascular disease, diabetes, and those who did not provide consent from this study.

The patients were classified into sets of preload and coload, namely Group 1 and Group 2 respectively. Upon entering the operating theatre, patients had an 18-G IV cannula inserted into their left forearm, and conventional examining techniques, including ECG, and non-invasive measurement of blood pressure and arterial oxyhemoglobin saturation were conducted. Before the application of spinal block, their systolic blood pressure and heart rate were horizontally monitored three times and the mean of 2nd and 3rd readings were interpreted as reference

values. Moreover, a rapid infusion of 15 ml/kg of isotonic 0.9% saline solution was provided to the preload group, while the coload group was administered an equivalent amount of the same fluid type immediately following the intrathecal administration of the local anaesthetic solution for spinal anesthesia.

The administration of intradural block (spinal anesthesia) was carried out with the patient in a seated position, and the procedure utilized a 25-gauge spinal (Arachnoid) needle at the L3-4 vertebral interspace following local anesthesia with lidocaine. After the clear appearance of cerebrospinal fluid, an injection consisting of 15 µg fentanyl and 8 mg hyperbaric bupivacaine (0.5%) was administered, and the parturients were placed in a horizontal position with a slight inclination. All patients were supplemented with a urinary catheter. After providing intrathecal injection, blood pressure and heart rate were systematically documented with a time interval of one minute throughout the procedure. Hypotension, being the major result, was described as a more than 20% reduction in systolic blood pressure compared to the initial reading. Ephedrine was incrementally administered in 5 mg increments to address instances of hypotension. The lowest recorded average systolic blood pressure, and heart rate when the blood pressure was at its lowest point were documented. Additionally, parturients were monitored for nausea and vomiting until delivery. After delivery, the scores of APGAR with the time interval of 1 and 5 minutes respectively, and blood gas analyses from umbilical artery and veins were carried out.

Statistical analysis

The IBM Statistical Package for Social Sciences (SPSS) Version 28.0.1 software was used for the analysis of data. For continuous variables like blood pressure and heart rate, mean values along with standard deviation were calculated, whereas proportions were determined for discrete variables such as nausea and vomiting. The comparison of means was executed using the t-test, and for discrete variables, the *Chi-square* test was applied. P value ≤ 0.05 was considered to be statistically significant.

Results

A total of 54 respondents were included in this study. The average age of participants was of 27.2 ± 3.7 years, a mean weight of 78.7 ± 7.3 kg, and an average height of 159.7 ± 3.5 cm.

Table-1 illustrates a comparison of means for blood pressure, heart rate, and ephedrine doses, along with the occurrence of hypotension, sickness, vomiting, and nausea across the two selected study factions. The individuals under the category of preload exhibited the lowest recorded systolic blood pressure at 81.8 ± 2.3 mmHg, compared to 89.3 ± 2.3 mmHg in the individuals of coload. Likewise, the lowest recorded average arterial pressure was 49.7 ± 1.1 mmHg in the preload group and 57.4 ± 1.3 mmHg in the coload group. The average decrease in systolic blood pressure was 34.5 ± 7.0 mmHg for the preload group and 26.8 ± 6.9 mmHg for the coload group. Similarly, the average decrease in mean arterial pressure was 28.8 ± 1.6 mmHg for the preload group and 20.7 ± 1.1 mmHg for the coload group. On comparing preload and coload group, the systolic and average blood pressure were found to be significantly lower ($P < 0.001$) from the initial values. In preload group, the occurrence of hypotension was 92.6%, substantially surpassing ($P = 0.039$) that in the coload group (67%). The mean ephedrine dose requirement was 12.2 ± 5.9 mg in the preload group, considerably higher ($P = 0.029$) than that in the coload group (8.3 ± 6.8 mg).

The information is presented either as the mean ± standard deviation or as a percentage.

Hypertension was characterized by the lowest systolic blood pressure dropping below 80% of the baseline level.

Neonatal outcomes, including APGAR scores and blood gases (Table-2), exhibited similarity between the two groups, with differences that were statistically insignificant.

Discussion

Our study demonstrated the dominance and advantage of crystalloid coload over crystalloid preload in order to prevent maternal hypotension after spinal anesthesia i.e. crystalloid administration at the time of actual spinal blockade-induced vasodilation was found to be more effective in preserving intravascular volume and blood pressure as compared to prophylactic crystalloid administration.

Table-1: Comparison of hemodynamic variables and ephedrine dose requirement between the crystalloid preload and coload group

	Preload group (n=27)	Coload group (n=27)	*Chi-square* value	*P*-value
Arterial Systolic Blood Pressure (SBP, measured in mmHg)				
Before anesthesia (Baseline, a)	116.3 ± 6.4	116.2 ± 6.7	48.000	0.554
Lowest SBP (b)	81.8 ± 2.3	89.3 ± 2.3	47.267	< 0.001
Delta SBP (a-b)	34.5 ± 7.0	26.8 ± 6.9	28.231	< 0.001
Average Blood Pressure (MBP, measured in mmHg)				
Before anesthesia (Baseline, c)	78.6 ± 1.3	78.1 ± 1.1	14.933	0.667
Lowest MBP (d)	49.7 ± 1.1	57.4 ± 1.3	52.262	< 0.001
Delta MBP (c-d)	28.8 ± 1.6	20.7 ± 1.1	51.253	< 0.001
Heart Rate (bpm)				
Before anesthesia	74.0 ± 2.6	73.2 ± 2.1	41.333	0.038
At lowest BP	91.1 ± 1 4.3	82.7 ± 6.9	49.875	< 0.001
Hypotension, n (%)	25/27 (92.6%)	18/27 (67%)	15.429	< 0.001
Ephedrine dose (mg)	12.2 ± 5.9	8.3 ± 6.8	54.000	0.289
Nausea, n (%)	3/27 (11%)	2/27 (7.4%)	0.353	0.552
Vomiting, n (%)	0	0	-	-

Table-2: Comparison of neonatal outcomes between the crystalloid preload and coload group

	Preload group (n=27)	Coload group (n=27)
APGAR Assessment		
Time interval of 1 min	8 (7-9)	8 (7-9)
Time interval of 5 min	9 (8-10)	9 (8-10)
Umbilical Arterial Vessel		
pH	7.3 ± 0.1	7.3 ± 0.1
pCO_2 (mmHg)	48.3 ± 0.9	48.5 ± 0.7
pO_2 (mmHg)	18.9 ± 1.2	19.3 ± 1.3
HCO_3 (mEq/dl)	21.7 ± 1.6	21.4 ± 1.3
Umbilical Venous Vessel		
pH	7.3 ± 0.1	7.3 ± 0.1
pCO_2 (mmHg)	42.9 ± 0.5	43.0 ± 0.5
pO_2 (mmHg)	30.3 ± 1.9	29.7 ± 1.2
HCO_3 (mEq/dl)	21.1 ± 2.2	21.1 ±1.7

The data is showcased as either median (range) or mean ± standard deviation
No major differentiation was noted between the two groups

In current study, the occurrence of hypotension induced by spinal anesthesia was significantly high in patients receiving crystalloid preload (92.6%) compared to those in the coload group (67%). These findings were similar to the study conducted at DHQ hospital of Haripur, Pakistan in which the efficacy of colloid preload was evaluated in comparison to a combined coload to mitigate low blood pressure during spinal anesthesia for elective incisional hernia treatment. The occurrence of hypotension induced by spinal anesthesia was remarkably higher (89.6%) in patients receiving colloid preload compared to those in the combination coload group (64.6%).[16] Similary, Oh et al carried out a study in South Korea on a sample of 60 parturients. Although, they found that the parturient group that was receiving crystalloid preload had higher rate of occurrence of hypotension as compared to that of coload group but their percentages were lower than our findings. They concluded the rate of occurrence of hypotension in their coload group was 53% while it was 83% in their parturient group that had been administered crystalloid preload. The coload group in both studies had significantly lower ephedrine dose requirements as compared to the preload group.[17]

Artwan and his coworkers (2020) categorized fifty-one obstetric patients into three groups: preload, coload, and control. The coloading group experienced a considerable decrease in average arterial pressure, and systolic and diastolic blood

pressure when compared to both preloading and control categories. Additionally, the coloading group demonstrated a markedly reduced requirement for vasopressors compared to the preload and control group.[18] These findings aligned with our study outcomes. A recent meta-analysis, studied ten randomized controlled trials involving 824 parturients undergoing cesarean delivery.[19] Pooled data from these studies indicated that an increased number of hypotensive events were observed among respondents with crystalloid preload, in contrast to individuals in the coload group (57.8% versus 47.1%). The results also revealed that patients getting fluid preload need more vasopressors (OR = 1.71). No disparities in neonatal outcomes were observed between the groups of participants. These findings corroborate our study, indicating that, in comparison to crystalloid preload, coload is effective in reducing intraoperative hypotension. However, a previous meta analysis, encompassing eight studies with 518 patients, concluded that there was no statistically significant difference in the occurrence of hypotension induced by spinal anesthesia among individuals who received preload and those who received coload.[20] The above cited literature supports our assertion that coloading, as opposed to crystalloid preload, could contribute to the mitigation of intraoperative hypotension.

Contrarily, Khan and his coworkers examined sixty non obstetric patients at Agha Khan University Hospital and evaluated the relative efficacy of preload and coload in mitigating spinal induced hypotension (SIH) and addressing the need for vasopressors. They concluded that spinal induced hypotension incidence was 70% in the preload group and 50% in patients in the coload arm. It was overall lower than that recorded in our study which might be attributable to a different study population as obstetric patients are already prone to hypotension. The study found that in the preload group, there is a high need for ephedrine for SIH (P=0.017), this finding was similar to that of our study (P=0.029).[15]

Our study, however, is not without its limitations. It was conducted at a tertiary care hospital and was a single centered study so the sample may not be truly representative of the entire Pakistani population. Moreover, the sample size was relatively small. Hence, these results cannot be applied to the entire patient population.

Conclusion

Our study concluded that the crystalloid coloading protocol conferred advantages over preloading. During cesarean procedures, it helps to reduce the occurrence of intraoperative mothers' hypotension and decreases reliance on vasopressors among parturients. No discernible disparity in newborn outcomes was observed between the two aforementioned groups.

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Conflict of Interest: The authors declare no conflict of interest.

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Authors Contribution

TRZ: Data collection, data analysis, manuscript writing and proofreading
RH: Study designing, manuscript writing and proofreading
UF: Data collection
AAW: Idea conception, study designing
RB: Study designing, data analysis, results and interpretation
IA: Data analysis, results and interpretation, manuscript writing and proofreading