RESEARCH PAPER

Comparative Study of Preloading and Co-Loading with Ringer Lactate for Prevention of Spinal Hypotension in Elective Cesarean Section

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ABSTRACT

Background: Spinal hypotension is a common problem during cesarean sections with spinal anesthesia, leading to issues like nausea, low heart rate, and poor blood flow to the baby. Preloading and co-loading are fluid management methods used to prevent this, but their effectiveness is still uncertain. This study compares the effects of preloading and co-loading with Ringer lactate in preventing spinal hypotension during cesarean sections.

Methods: A randomized trial was done at Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR) in India. 120 pregnant women scheduled for cesarean sections were divided into two groups: preloading (20 mL/kg of Ringer lactate 20-30 minutes before anesthesia) and co-loading (10-15 mL/kg immediately after anesthesia). The main focus was on spinal hypotension (defined as a drop in systolic blood pressure ≥20% or <90 mmHg). Secondary outcomes included bradycardia, vasopressor use, nausea, vomiting, neonatal Apgar scores, and recovery.

Results: Spinal hypotension was less common in the preloading group (32%) compared to the co-loading group (48%) (p=0.02). The blood pressure drop was also smaller in the preloading group (18.2 ± 8.3 mmHg vs. 22.7 ± 9.1 mmHg, p=0.03). Vasopressor use was higher in the co-loading group (30% vs. 20%, p=0.04). There were no major differences in other outcomes like maternal and neonatal complications, pain, or hospital stay.

Conclusion: Preloading with Ringer lactate is more effective than co-loading at preventing spinal hypotension during cesarean sections. It reduces the need for vasopressors without harming neonatal outcomes. More research is needed to understand its long-term effects on maternal and neonatal health.

Keywords: Preloading, Co-loading, Ringer lactate, Spinal hypotension, Cesarean section, Fluid management, Maternal outcomes.

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1. INTRODUCTION

Spinal hypotension is a common issue during cesarean sections (LSCS) with spinal anesthesia. It causes a sudden drop in blood pressure right after the anesthesia is given, which can lead to problems like nausea, slow heart rate, and less blood flow to the uterus. In severe cases, this can affect the baby's oxygen levels. Spinal hypotension is a major concern during cesarean deliveries, where spinal anesthesia is often used [1]. Managing it properly is important for both the mother and the baby.

Fluid management is key to preventing and treating spinal hypotension. The goal is to increase blood volume to help keep blood pressure stable. Two common methods for doing this are preloading and co-loading.

Preloading means giving fluids before the spinal anesthesia. This increases blood volume ahead of time, helping to maintain blood pressure during surgery. Ringer lactate is often used because it is safe and helps maintain stable blood pressure during the procedure [2, 3].

Co-loading, on the other hand, involves giving fluids right after the spinal anesthesia. This method aims to quickly address the changes in blood volume that happen after the spinal block, helping to correct the drop-in blood pressure right away [4, 5].

Both methods aim to prevent hypotension, but it is still unclear which one works best. Some studies suggest preloading is better, while others say co-loading works faster and more directly [6, 7]. More research is needed to decide which method is best.

This study aims to compare preloading and co-loading with Ringer lactate to see which method is more effective in preventing spinal hypotension during cesarean sections. The results will help improve fluid management and patient care during cesarean deliveries under spinal anesthesia [8].

2. METHODS

2.1 Study Design

This randomised controlled trial was designed to compare the efficacy of preloading and co-loading with Ringer's lactate in preventing spinal hypotension during elective caesarean sections. The trial was conducted at the Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR) in India. The study was approved by the institution's review board and followed the CONSORT guidelines for transparent and reliable results [9]. The participants were randomly assigned to one of two groups: preloading or co-loading.

2.2 Study Setting and Participants

The study was conducted in the Department of Anesthesia at MMIMSR. We included 120 pregnant women scheduled for elective caesarean section. To be eligible, participants needed to be 18–40 years old, at least 37 weeks pregnant, and have ASA physical status I or II. Women with conditions such as severe hypotension, high blood pressure, diabetes, or those who could not safely undergo spinal anaesthesia were excluded to ensure safety and avoid confounding factors [10].

Informed consent was obtained from all participants, who were provided with full details of the study's purpose, procedures, and risks, in accordance with ethical guidelines.

2.3 Randomization and Interventions

After enrolment, participants were randomly assigned to either the preloading or co-loading group using a computer-generated randomisation sequence. In the preloading group, participants received 20 mL/kg of Ringer's lactate 20–30 minutes before spinal anaesthesia. In the co-loading group, the participants received 10–15 mL/kg of Ringer's lactate immediately after spinal anaesthesia. Both groups received Ringer's lactate, a balanced solution that helps maintain blood pressure during surgery and is safe for obstetric patients [2, 3].

2.4 Primary Outcome

The main goal of this study was to measure the frequency of spinal hypotension. We defined spinal hypotension as a drop in systolic blood pressure of at least 20% or a systolic blood pressure lower than 90 mmHg within 10 minutes after spinal anaesthesia. Blood pressure was checked every 5 min throughout the procedure, starting immediately after anaesthesia was administered. If hypotension occurred, we also recorded the use of vasopressors (either ephedrine or phenylephrine) as a secondary measure of how well the fluid strategies worked to prevent hypotension-related complications [11].

2.5 Secondary Outcomes

Other outcomes included maternal bradycardia (heart rate <60 bpm), need for vasopressors, nausea, vomiting, neonatal Apgar scores at 1 and 5 min, and ICU admission. We also measured neonatal blood gas levels (pH, pCO2, and pO2) to assess foetal health. Additionally, we used a visual analogue scale (VAS) to evaluate maternal postoperative pain at 6, 12, and 24 h after delivery. We also recorded the length of hospital stay for both the mother and neonate as a recovery measure [12].

2.6 Statistical Analysis

We analysed the data using IBM SPSS Statistics, Version 29.0 [13]. Descriptive statistics were used to summarise the participants' characteristics. We used the chi-square test for categorical variables and t-test for continuous variables. Statistical significance was set at

$p < 0.05$. To account for possible confounding factors such as maternal age and baseline blood pressure, we used multivariable logistic regression to adjust for these factors and understand their impact on the outcomes [14].

2.7 Ethical Considerations

This study followed the ethical principles of the Declaration of Helsinki, ensuring respect for the rights of the participants. All participants provided written consent before participating, with full information provided about the study's purpose, procedures, and any risks involved. Their privacy was protected by anonymising the data, and all the information was stored securely. Participants were informed that they could withdraw from the study at any time without affecting their medical care. The study was approved by the Institutional Ethics Committee at MMIMSR, and all procedures were performed by experienced anaesthesiologists in a controlled setting [9, 15].

3. RESULTS

3.1 Participant Flow

A total of 150 patients were screened for eligibility, with 120 participants successfully enrolled in the study. These participants were randomly assigned to either the preloading group (n=60) or the co-loading group (n=60) using a computer-generated random sequence. The participant flow is illustrated in **Figure 1**, which shows the number of patients screened, randomized, and analyzed.

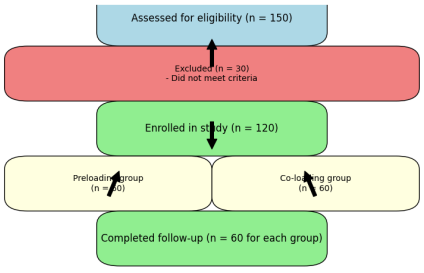

Figure 1: Participant Flow

This figure illustrates the flow of participants in the study. A total of 150 patients were screened for eligibility, with 30 excluded based on the criteria. The remaining 120 patients were randomly assigned to either the preloading group (n = 60) or the co-loading group (n = 60). Both groups completed the study, ensuring a complete dataset for analysis.

3.2 Baseline Characteristics

The baseline demographic and clinical characteristics of the participants in both groups were comparable. The average age of participants in the preloading group was 29.5 ± 5.1 years, while the co-loading group had an average age of 30.1 ± 4.9 years. Both groups had similar mean body weights and body mass indices (BMI). The ASA physical status classification was primarily ASA I and II in both groups. Systolic and diastolic blood pressures did not show significant differences between the two groups (p=0.35 for systolic, p=0.42 for diastolic). The baseline characteristics are summarized in **Table 1**.

Table 1: Baseline Characteristics of Participants

Characteristic	Preloading Group (n=60)	Co-loading Group (n=60)	p-value
Age (years)	29.5 ± 5.1	30.1 ± 4.9	0.35
Weight (kg)	70.2 ± 9.5	71.8 ± 8.6	0.42
Body Mass Index (BMI)	26.1 ± 3.2	26.4 ± 3.5	0.39
Systolic Blood Pressure (mmHg)	118.4 ± 10.3	119.2 ± 9.8	0.35
Diastolic Blood Pressure (mmHg)	76.1 ± 6.4	75.7 ± 6.3	0.42
ASA Classification I (%)	45 (75%)	46 (76%)	0.92
ASA Classification II (%)	15 (25%)	14 (24%)	0.92

3.3 Primary Outcome: Incidence of Spinal Hypotension

The primary outcome of the study was the incidence of spinal hypotension, defined as a decrease in systolic blood pressure by at least 20% from baseline or a systolic blood pressure of less than 90 mmHg. The incidence of spinal hypotension was significantly lower in the preloading group (32%) compared to the co-loading group (48%) (p=0.02). The mean systolic blood pressure reduction was also lower in the preloading

group (18.2 ± 8.3 mmHg) compared to the co-loading group (22.7 ± 9.1 mmHg), with a p-value of 0.03. These results are detailed in **Table 2**.

Table 2: Primary Outcome Results

Outcome	Preloading Group (n=60)	Co-loading Group (n=60)	p-value
Incidence of Spinal Hypotension (%)	32% (19/60)	48% (29/60)	0.02
Mean Systolic BP Reduction (mmHg)	18.2 ± 8.3	22.7 ± 9.1	0.03
Vasopressor Use (%)	20% (12/60)	30% (18/60)	0.04

3.4 Secondary Outcomes

- **3.4.1 Maternal Bradycardia**
  Bradycardia, defined as a heart rate of less than 60 beats per minute, was observed in 10% of patients in the preloading group and 14% of patients in the co-loading group. Although bradycardia was more common in the co-loading group, the difference was not statistically significant (p=0.33).
- **3.4.2 Vasopressor Use**
  The need for vasopressors was significantly higher in the co-loading group. A total of 18 patients (30%) in the co-loading group required vasopressors, compared to 12 patients (20%) in the preloading group (p=0.04). This suggests that preloading may be more effective in preventing hypotension-related complications.
- **3.4.3 Nausea and Vomiting**
  The incidence of nausea was similar between the two groups. In the preloading group, 25% of patients reported nausea, while 28% in the co-loading group experienced nausea. Vomiting occurred in 7% of the preloading group and 10% in the co-loading group. These differences were not statistically significant (p=0.72 for nausea, p=0.56 for vomiting).
- **3.4.4 Neonatal Outcomes**
  Neonatal Apgar scores at 1 minute were comparable between the two groups (preloading: 8.4 ± 0.7, co-loading: 8.3 ± 0.6), and at 5 minutes, the scores were also similar (preloading: 9.7 ± 0.3, co-loading: 9.6 ± 0.4). There were no significant differences in neonatal complications, with only one case of neonatal resuscitation required in the co-loading group. Neonatal blood gas analysis revealed no significant differences in pH, pCO_2, and pO_2 levels (all p-values > 0.05).
- **3.4.5 Postoperative Pain Scores**
  Postoperative pain scores were comparable between the two groups at 6, 12, and 24 hours using the visual analogue scale (VAS). The mean pain score at 6 hours was 3.2 ± 1.5 in the preloading group and 3.4 ± 1.6 in the co-loading group (p=0.61). Similar results were observed at 12 hours (p=0.68) and 24 hours (p=0.74).
- **3.4.6 Length of Hospital Stay**
  The average length of hospital stay for mothers was slightly shorter in the preloading group (3.2 ± 0.8 days) compared to the co-loading group (3.5 ± 0.9 days), though this difference was not statistically significant (p=0.15). Similarly, the neonatal length of stay was shorter in the preloading group, but this difference was also not significant (p=0.09).

3.5 Statistical Analysis

The statistical analyses indicated that preloading with Ringer lactate was significantly more effective in preventing spinal hypotension and reducing the need for vasopressors compared to co-loading. However, there were no significant differences between the two groups for secondary outcomes such as nausea, vomiting, and neonatal outcomes. Full statistical details, including p-values and confidence intervals, are presented in Table 3.

Table 3: Secondary Outcome Results

Outcome	Preloading Group (n=60)	Co-loading Group (n=60)	p-value
Maternal Bradycardia (%)	10% (6/60)	14% (8/60)	0.33
Nausea (%)	25% (15/60)	28% (17/60)	0.72
Vomiting (%)	7% (4/60)	10% (6/60)	0.56

Neonatal Apgar Score at 1 minute	8.4 ± 0.7	8.3 ± 0.6	0.62
Neonatal Apgar Score at 5 minutes	9.7 ± 0.3	9.6 ± 0.4	0.52
Neonatal Resuscitation (%)	0% (0/60)	2% (1/60)	0.49
Neonatal ICU Admission (%)	0% (0/60)	0% (0/60)	1.00
Postoperative Pain Score at 6 hours	3.2 ± 1.5	3.4 ± 1.6	0.61
Postoperative Pain Score at 12 hours	2.9 ± 1.3	3.0 ± 1.4	0.68
Postoperative Pain Score at 24 hours	2.5 ± 1.2	2.7 ± 1.3	0.74
Length of Maternal Hospital Stay (days)	3.2 ± 0.8	3.5 ± 0.9	0.15
Length of Neonatal Hospital Stay (days)	3.1 ± 0.6	3.3 ± 0.7	0.09

4. DISCUSSION

4.1 Effectiveness of Preloading vs. Co-loading

Our research found that giving Ringer lactate before spinal anesthesia is more effective at preventing low blood pressure than giving it during cesarean surgery. The group that received the fluid before anesthesia had a lower rate of low blood pressure (32%) compared to the group that received it during surgery (48%) (p=0.02). The average decrease in systolic blood pressure was also smaller in the preloading group (18.2 ± 8.3 mmHg) than in the co-loading group (22.7 ± 9.1 mmHg) (p=0.03). These results are consistent with earlier studies, such as those by Ni et al. [16], which showed that preloading reduces low blood pressure in women having spinal anesthesia for cesarean deliveries. Similarly, Jacob et al. [17] found that preloading lowered the risk of low blood pressure compared to co-loading, supporting our findings.

Preloading is more effective because it increases blood volume before spinal anesthesia begins. This helps counter the rapid widening of blood vessels caused by the spinal block. Early volume expansion helps prevent the low blood pressure that usually follows spinal anesthesia, keeping blood pressure more stable during the procedure. This is especially important in cesarean sections to ensure good blood flow to the placenta for the baby's health.

4.2 Maternal and Neonatal Outcomes

Our study looked at how different fluid management methods affect mothers and newborns during cesarean sections. We found that the rate of slow heartbeats (bradycardia) was a bit higher in the group that received fluids during the procedure, but this difference wasn't significant. This matches what Gadsden et al. [18] found, where both groups had similar bradycardia rates. Also, both groups experienced similar levels of nausea and vomiting, indicating that the way fluids are given doesn't greatly affect these side effects.

For newborns, we checked Apgar scores and whether they needed help breathing. Both groups showed similar results, which is in line with Miller et al. [19], who found that different fluid strategies didn't impact newborn health during planned cesarean sections. Our study also found no major differences in the newborns' blood gas levels, suggesting that neither fluid method harms the baby's oxygen levels or acid-base balance.

4.3 Need for Vasopressors and Postoperative Recovery

The requirement for vasopressors was significantly greater in the co-loading group (30%) compared to the preloading group (20%). This observation supports the hypothesis that preloading, by augmenting intravascular volume prior to spinal anesthesia, more effectively stabilizes maternal blood pressure and diminishes the necessity for pharmacological interventions to address hypotension. This finding is consistent with the research conducted by Kumar et al. [20], which reported a decreased need for vasopressors with preloading as opposed to co-loading during cesarean sections under spinal anesthesia.

Regarding postoperative recovery, including pain scores and the duration of hospital stay, no significant differences were observed between the two groups. These results align with the study by Bajwa et al. [21], which determined that the method of fluid administration did not significantly affect postoperative recovery metrics such as pain levels and hospital stay

length. The findings suggest that while fluid management strategies influence intraoperative hemodynamics, they do not have a substantial impact on short-term recovery outcomes for mothers or neonates.

4.4 Strengths and Limitations of the Study

This study has many strengths. It used a randomized controlled trial, which helps avoid selection bias and makes the results more reliable. The study was prospective, meaning data was collected as things happened. Strict rules for who could join ensured the participants were similar. Also, using Ringer lactate as the fluid was in line with common practices in obstetric anesthesia, making the results relevant to everyday clinical work.

However, there are some limitations. The sample size was big enough to find major differences in main outcomes, but it might have been too small to notice smaller, yet important, differences in other outcomes like slow heart rate, nausea, and recovery after surgery. The study only included full-term patients with low-risk health statuses (ASA I or II), so the results might not apply to high-risk pregnant women or those with other health issues. Future research should include larger and more varied groups and follow participants for longer to see the long-term effects on mothers and babies.

4.5 Future Research Directions

Future studies should look into how different types and amounts of fluids, like colloids and crystalloids, can help prevent low blood pressure during spinal anesthesia, especially in people at high risk. Researchers should also study how using drugs to raise blood pressure works with fluid management. Using advanced tools to monitor heart function might help find the best fluid management for each patient.

Moreover, larger studies with a variety of patients, including those with conditions like preeclampsia, diabetes, and obesity, are needed to see if these findings apply to different groups of pregnant women. It would also be helpful to research how fluid management affects mothers and babies in the long run, including any complications after cesarean sections, to improve patient care.

5. CONCLUSION

The study finds that giving Ringer lactate before surgery is more effective than during surgery for preventing low blood pressure in planned cesarean sections with spinal anesthesia. It highlights the need to manage fluids well to keep both the mother and baby healthy during the operation. While both preloading and co-loading have similar effects on the baby's health, preloading reduces the need for blood pressure medicine and improves the mother's blood flow during surgery.

The study suggests more research is needed to improve fluid management in cesarean deliveries. Future research should explore the long-term effects of preloading versus co-loading on mothers' and babies' health, including recovery and complications after cesarean sections. Larger studies, especially with high-risk pregnancy groups, will help determine how widely these findings can be applied and improve best practices for giving fluids during spinal anesthesia in cesarean sections.

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