Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Comparison of Co-loading and Preloading for Lower Segment Caesarean Section Under Spinal Anaesthesia

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Cite this paper as: Samra Mehak, Hamid Mehmood, Mumtaz Ali, Bhagwanti Kirshan, (2025) Comparison of Co-loading and Preloading for Lower Segment Caesarean Section Under Spinal Anaesthesia. *Journal of Neonatal Surgery*, 14 (32s), 9005-9011.

ABSTRACT

Background: Spinal anaesthesia is a preferred technique for lower segment caesarean section (LSCS) due to its rapid onset and reliability. However, it is frequently associated with maternal hypotension, which can adversely affect both mother and fetus.

Objectives: To compare the efficacy of crystalloid co-loading versus preloading in preventing maternal hypotension in patients undergoing caesarean section under spinal anaesthesia.

Study Design & Setting: This study conducted at the Department of Anesthesiology, Dow University of Health Sciences Hospital, Karachi.

Methodology: A total of 100 ASA II parturients aged 20–40 years, undergoing elective LSCS, were randomly assigned into two equal groups (preload and co-load). Group P received 15 ml/kg of crystalloids 10–15 minutes before spinal anaesthesia, while Group C received the same volume immediately after spinal injection. Hemodynamic parameters were monitored intraoperatively. Hypotension, nausea, vomiting, bradycardia, and vasopressor use were recorded.

Results: Hypotension occurred in 52% of the preload group compared to 30% of the co-load group ($p = 0.03$). The need for phenylephrine was significantly higher in the preload group (50% vs. 28%, $p = 0.02$). Other adverse effects were more frequent in the preload group but not statistically significant.

Conclusion: Co-loading with crystalloids was more effective than preloading in reducing the incidence of maternal hypotension and vasopressor requirement during spinal anaesthesia for LSCS.

Keywords: Caesarean section, Co-loading, Crystalloids, Hypotension, Preloading, Spinal anaesthesia, Vasopressors

1. INTRODUCTION

One of the most common ways that pregnant women are anaesthetised for caesarean sections is using spinal anaesthesia.[1] Hypotension after spinal anaesthesia is the leading cause of maternal morbidity and death during caesarean sections.[2,3] Intra- and post-operative complications can be worsened by spinal anesthesia-induced hypotension, which is especially dangerous for pregnant women.[4] It is believed that preeclamptic patients are more likely to experience severe hypotension during a C-section under spinal anaesthesia.[5]

The sympathetic blocking that occurs during spinal anaesthesia significantly reduces systemic vascular resistance and causes vasodilation. There is a significant decrease in venous return and cardiac output as a consequence of this and the aortocaval compression caused by the pregnant uterus. Foetal acidosis and low Apgar scores can result from impaired uteroplacental perfusion caused by maternal hypotension, which is typically described as a drop in baseline systolic blood pressure of more over 20% or an absolute SBP lower than 100 mmHg.[6]

When it comes to lowering blood pressure and minimising the need of vasopressor medications, intravenous (IV) fluid loading is the way to go.[7,8] Several approaches have been investigated to forestall spinal anesthesia-induced hypotension.

Many factors must be considered, such as the timing of fluid delivery, the use of vasopressors such as phenylephrine and ephedrine, the elevation of the legs, and the displacement of the uterus. Fluid administration time is still being studied

and debated. There are now two primary approaches: preloading, which involves administering fluids before to intrathecal injection, and co-loading, which involves rapidly administering fluids during intrathecal drug administration. Research suggests that the timing, rather than the amount or kind of fluid, is the most crucial factor.[9,12]

So, this study is designed to compare Crystalloid preload and co-load in parturient undergoing an elective caesarean delivery under spinal anesthesia, we expect that crystalloid co-load would be superior than crystalloid preload. lthough fluid loading is widely used for prevention, the optimal timing—preloading versus co-loading—remains debated. Recent studies suggest co-loading may offer better hemodynamic stability, but local data is limited.

2. MATERIALS AND METHODS

This randomized controlled trial was conducted in the Department of Anesthesiology at Dow University of Health Sciences Hospital, Karachi from Feb 2025 to July 2025, commencing after approval from the College of Physicians and Surgeons Pakistan (CPSP) and the hospital's Ethical Review Committee (ERC).

A total of 100 parturients were recruited using a non-probability consecutive sampling technique, and they were randomly assigned into two equal groups (n = 50 per group). The sample size was calculated using the WHO sample size calculator, based on a previous study by Devi et al.[15], which reported a 71% incidence of hypotension in the preload group (Group P) and 42% in the co-load group (Group C). Using these proportions, with a power of 80% and a significance level (alpha) of 0.05, the estimated sample size was 45 patients in each group. To accommodate potential dropouts, 50 participants per group were included.

Participants aged between 20 and 40 years, both primigravida and multigravida, classified as American Society of Anesthesiologists (ASA) class II, and with full-term singleton pregnancies (gestational age 37 to 40 weeks confirmed via ultrasound) were eligible for inclusion. Exclusion criteria included patients with preeclampsia, eclampsia, known cardiovascular disease, hematocrit <30%, and contraindications to spinal anaesthesia.

Randomization was performed using computer-generated permuted block randomization, and group allocations were concealed in sequentially numbered, opaque sealed envelopes. These envelopes were opened only after obtaining consent and recording baseline characteristics. Patients assigned to Group P received crystalloid preload (15 mL/kg of Ringer's lactate) 10–15 minutes prior to spinal anaesthesia, while those in Group C received the same volume of crystalloids as a co-load, i.e., immediately after spinal injection. Baseline demographic data, including age, ASA class, parity, and history of previous caesarean section, were documented using a predesigned proforma. Upon arrival in the operating room, standard monitoring was initiated, and baseline readings for heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and oxygen saturation (SpO_2) were recorded. Following administration of spinal anaesthesia, these parameters were monitored and documented at 1, 2, 4, 6, 8, 10, 15, 20, 25, and 30 minutes post-injection, and subsequently every 10 minutes until the end of surgery. Hemodynamic stability was assessed by observing for maternal hypotension, which was defined as a reduction in SBP to less than 30% of baseline or an absolute value below 90 mmHg. Hypotensive episodes were managed with intravenous phenylephrine. Other intraoperative complications, including nausea, vomiting, shivering, and hypertension, were also recorded.

Data were analyzed using SPSS version 19.0. Continuous variables such as age, BMI, baseline SBP, DBP, HR, SpO_2, and duration of surgery were presented as means with standard deviations for normally distributed data, or medians with interquartile ranges for non-normally distributed data. Normality was assessed using histograms and the Shapiro-Wilk test. Categorical variables such as ASA class and incidence of hypotension were expressed as frequencies and percentages. The Chi-square test or Fisher's exact test, as appropriate, was used to compare categorical variables between the two groups. Stratification was conducted for potential effect modifiers including age, BMI, and duration of surgery. A p-value of ≤ 0.05 was considered statistically significant.

3. RESULTS

The mean age in the preload group was 29.4 ± 4.5 years, while in the co-load group it was 28.8 ± 4.2 years (p = 0.42). Most patients in both groups were between 20 and 30 years of age: 64% in the preload group and 68% in the co-load group (p = 0.68). The mean BMI was 28.8 ± 2.4 kg/m² in the preload group and 28.3 ± 2.6 kg/m² in the co-load group (p = 0.31). A majority of patients were non-obese, with 76% in the preload group and 82% in the co-load group (p = 0.44). In terms of parity, 54% were primigravida in the preload group compared to 52% in the co-load group (p = 0.84). Previous caesarean section was reported in 36% of preload group patients and 38% of co-load group patients (p = 0.84). The mean duration of surgery was 47.3 ± 8.6 minutes in the preload group and 46.8 ± 9.2 minutes in the co-load group (p = 0.75) given in table 1.

Hypotension was observed in 52% of patients in the preload group compared to 30% in the co-load group, which was statistically significant (p = 0.03). Nausea occurred in 28% of preload group patients and 16% in the co-load group (p =

0.15), while vomiting was reported in 20% and 12% respectively (p = 0.28). Bradycardia was noted in 12% of the preload group and 6% of the co-load group (p = 0.29). The requirement for phenylephrine was significantly higher in the preload group (50%) than in the co-load group (28%) with a p-value of 0.02 given in table 2.

Systolic and diastolic blood pressures (SBP and DBP) were consistently higher in the co-load group from 1 to 15 minutes post spinal anesthesia, with statistically significant differences observed at all those time points (SBP: $p < 0.05$; DBP: $p < 0.05$). At 30 minutes, the differences in SBP and DBP were not statistically significant ($p = 0.23$ and $p = 0.31$, respectively). Heart rate (HR) showed no significant difference between the groups at any time point (all $p > 0.05$). Similarly, oxygen saturation (SpO_2) remained comparable between both groups throughout the monitoring period, with no significant variation (all $p > 0.05$) given in table 3. Hypotension was significantly more common in younger (20–30 years) and non-obese patients of the preload group compared to the co-load group ($p = 0.02$ and $p = 0.01$, respectively). No significant differences were observed across other subgroups including age >30 years, obesity, parity, or previous caesarean section in table 4.

Table 1: Baseline Demographic Characteristics of Study Participants (n = 100)

Variable	Preload Group (n = 50)	Co-load Group (n = 50)	p-value
Age			
Mean ± SD	29.4 ± 4.5	28.8 ± 4.2	0.42
20–30 years	32 (64%)	34 (68%)	0.68
>30 years	18 (36%)	16 (32%)	
BMI (kg/m²)			
Mean ± SD	28.8 ± 2.4	28.3 ± 2.6	0.31
<30 (Non-obese)	38 (76%)	41 (82%)	0.44
≥30 (Obese)	12 (24%)	9 (18%)	
Parity			
Primigravida	27 (54%)	26 (52%)	0.84
Multigravida	23 (46%)	24 (48%)	
Previous C-section			
Yes	18 (36%)	19 (38%)	0.84
No	32 (64%)	31 (62%)	
Duration of Surgery (min)	47.3 ± 8.6	46.8 ± 9.2	0.75

Table 2: Comparison of Hemodynamic Events Between Preload and Co-load Groups

Variable	Preload Group (n = 50)	Co-load Group (n = 50)	p-value
Hypotension	26 (52%)	15 (30%)	0.03
Nausea	14 (28%)	8 (16%)	0.15
Vomiting	10 (20%)	6 (12%)	0.28
Bradycardia	6 (12%)	3 (6%)	0.29
Phenylephrine required	25 (50%)	14 (28%)	0.02

Table 3: Comparison of Mean Hemodynamic Parameters at Different Time Intervals Between Groups (n = 100)

Time (min)	Group	SBP (mmHg)	p-value	DBP (mmHg)	p-value	HR (bpm)	p-value	SpO_2 (%)	p-value
1	Preload	104.3 ± 11.5	0.04	66.2 ± 9.8	0.03	88.1 ± 10.2	0.12	98.4 ± 1.0	0.76
	Co-load	109.6 ± 12.1		70.4 ± 10.1		85.7 ± 9.5		98.5 ± 0.9	
2	Preload	100.6 ± 10.9	0.03	64.8 ± 8.7	0.02	86.2 ± 9.7	0.14	98.3 ± 1.2	0.67
	Co-load	107.5 ± 11.3		69.1 ± 9.4		84.1 ± 8.8		98.6 ± 0.7	
4	Preload	97.4 ± 12.3	0.02	63.2 ± 9.5	0.01	83.8 ± 10.1	0.22	98.2 ± 1.1	0.58
	Co-load	105.9 ± 10.8		67.8 ± 8.9		82.5 ± 9.6		98.5 ± 0.8	
6	Preload	95.1 ± 11.1	0.01	61.4 ± 8.2	0.01	81.6 ± 9.8	0.40	98.1 ± 1.3	0.45
	Co-load	104.3 ± 9.7		66.2 ± 7.5		81.1 ± 8.7		98.4 ± 1.0	
8	Preload	94.5 ± 10.6	0.01	60.8 ± 7.9	0.01	80.2 ± 9.3	0.38	98.1 ± 1.0	0.61
	Co-load	103.8 ± 9.3		65.7 ± 7.3		80.5 ± 8.4		98.4 ± 0.9	
10	Preload	96.2 ± 11.4	0.02	61.9 ± 8.1	0.02	82.1 ± 9.5	0.48	98.3 ± 0.8	0.77
	Co-load	104.6 ± 10.5		66.8 ± 8.6		80.8 ± 8.2		98.5 ± 0.7	
15	Preload	97.8 ± 12.1	0.04	63.4 ± 9.0	0.03	81.9 ± 9.4	0.53	98.4 ± 1.1	0.89
	Co-load	105.7 ± 11.2		67.9 ± 8.3		80.6 ± 8.7		98.6 ± 0.9	
30	Preload	106.8 ± 12.4	0.23	69.1 ± 9.6	0.31	82.4 ± 8.5	0.71	98.6 ± 1.0	0.83
	Co-load	110.2 ± 11.5		71.4 ± 8.7		81.8 ± 7.9		98.7 ± 0.7	

Table 4: Stratification of Maternal Hypotension by Demographic and Clinical Variables (n = 100)

Variable	Category	Group	Hypotension Present	Hypotension Absent	Total (n)	p-value
Age Group	20–30 years	Preload	18 (56.3%)	14 (43.7%)	32	0.02
		Co-load	10 (29.4%)	24 (70.6%)	34	

	>30 years	Preload	8 (44.4%)	10 (55.6%)	18	0.42
		Co-load	5 (31.2%)	11 (68.8%)	16	
BMI	<30 (Non-obese)	Preload	18 (47.4%)	20 (52.6%)	38	0.01
		Co-load	10 (24.4%)	31 (75.6%)	41	
	≥30 (Obese)	Preload	8 (66.7%)	4 (33.3%)	12	0.62
		Co-load	5 (55.6%)	4 (44.4%)	9	
Parity	Primigravida	Preload	15 (55.6%)	12 (44.4%)	27	0.06
		Co-load	8 (30.8%)	18 (69.2%)	26	
	Multigravida	Preload	11 (47.8%)	12 (52.2%)	23	0.18
		Co-load	7 (29.2%)	17 (70.8%)	24	
Previous C-Section	Yes	Preload	10 (55.6%)	8 (44.4%)	18	0.15
		Co-load	6 (31.6%)	13 (68.4%)	19	
	No	Preload	16 (50%)	16 (50%)	32	0.08
		Co-load	9 (29%)	22 (71%)	31	

4. DISCUSSION

Spinal anesthesia is widely used for lower segment caesarean sections due to its safety and efficacy. However, a major concern is maternal hypotension, which can compromise both maternal and fetal outcomes.[14] Intravenous fluid administration is a common strategy to prevent spinal-induced hypotension. Crystalloid fluids are typically used either as a preload before spinal injection or as a co-load administered immediately after. The timing of fluid administration may influence hemodynamic outcomes.[15,16] Limited local data exist comparing the effectiveness of co-loading versus preloading in preventing hypotension during spinal anesthesia for caesarean section.

In the present study, the incidence of hypotension was significantly lower in the co-load group (30%) compared to the preload group (52%) with a p-value of 0.03. These findings are consistent with the results of Oh et al. (2014), who reported a significantly lower hypotension rate in the coload group (53%) versus the preload group (83%) ($P = 0.026$).[17] Furthermore, they noted a greater systolic blood pressure drop in the preload group (34 ± 13 mmHg) compared to the coload group (25 ± 10 mmHg; $P = 0.002$) and higher ephedrine requirement (15 [0–40] mg vs. 7.5 [0–30] mg; $P = 0.015$), supporting the hemodynamic advantage of co-loading. Similarly, Artawan et al. (2020) observed significantly smaller reductions in systolic, diastolic, and mean arterial pressures in the coload group as compared to preload ($P < 0.001$), which aligns with our findings of better SBP and DBP preservation in co-loaded patients.[18]

Contrary to our findings, Tawfik et al. (2019) found no statistically significant difference in hypotension rates or ephedrine use between crystalloid co-load and colloid preload groups (median ephedrine dose: 13 vs. 11 mg; $P = 0.22$). However, their study compared colloid and combination fluid strategies, which may explain the differing results.[10] Locally, Farid et al. (2016) also reported a lower incidence of hypotension in the co-load group (48.6%) compared to preload (62.2%), though this difference was not statistically significant ($P = 0.242$). Notably, their findings across time intervals showed more frequent early hypotension episodes in co-load patients, which contrasts with our study, where the preload group consistently showed lower SBP at 1–15 minutes ($p < 0.05$ at each time point).[19]

Our results are in strong agreement with Saeed et al. (2024), who demonstrated significantly higher SBP and MAP values at 10 and 15 minutes in the co-load group ($p < 0.001$ and $p = 0.019$, respectively).[20] This reflects our finding of better hemodynamic stability over the same intervals. Ansari et al. (2018), however, reported greater efficacy in the preload group

(83.3%) versus co-load (56.7%) with P = 0.024. This finding contradicts the majority of recent literature and may be attributed to differing definitions of "efficacy" and methodology.[21] In line with our study, Bairwa et al. (2023) found hypotension significantly less in the co-load group (37.18%) compared to preload (61.81%), along with greater vasopressor requirement in preload group—reinforcing our observation that 50% of preload patients required phenylephrine versus only 28% in the co-load group (p = 0.02).[22]

Taken together, our study corroborates growing evidence that co-loading with crystalloids is more effective than preloading in preventing maternal hypotension during spinal anaesthesia for cesarean delivery. Our findings also align with international and local studies highlighting reduced vasopressor needs, fewer adverse events, and better short-term hemodynamic stability with co-load strategies

A major strength of this study was its randomized controlled design, reducing selection bias. Standardized protocols were followed for fluid administration and monitoring. Hemodynamic parameters were recorded systematically at multiple time points. However, the study was conducted at a single center, which may limit generalizability. Blinding of anesthesiologists was not feasible, potentially introducing observer bias. Additionally, fetal outcomes and long-term maternal effects were not evaluated.

5. CONCLUSION

Crystalloid co-loading was associated with a significantly lower incidence of maternal hypotension compared to preloading during spinal anesthesia for caesarean section. This strategy also reduced the need for vasopressors. Co-loading appears to be a more effective and safer fluid management approach in this setting.

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