Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical Anaesthesia

Journal homepage: www.ijca.in

Original Research Article

Effect of crystalloid coloading speed on hemodynamics in patient undergoing elective LSCS under spinal anaesthesia: A randomized control trial

Satyendra Yadav[1*], Divyanshu Naithani[1], Nidhi Nautiyal[2], Surinder Singh[1]

[1]Dept. of Anaesthesiology, Veer Chandra Singh Garhwali Govt. Institute of Medical Sciences & Research, Srinagar Garwhal, Uttarakhand, India

[2]Dept. of Community Medicine, Veer Chandra Singh Garhwali Govt. Institute of Medical Sciences& Research, Srinagar Garwhal, Uttarakhand, India

Abstract

Background & Objective: Crystalloid preloading has been found ineffective in preventing maternal hypotension following spinal anaesthesia for lower segment cesarean section (LSCS), while coloading has shown variable results. One crucial but underexplored factor is the speed of crystalloid coloading, particularly during the peak sympathetic block-induced vasodilatation (5–7 minutes post-spinal anaesthesia). This double-blind randomized controlled trial (RCT) aimed to investigate the effect of different crystalloid coloading infusion speeds and volumes on maternal hemodynamics during elective LSCS to enhance perioperative stability and recovery.

Material and Methods: A double-blind, randomized, single-centre, parallel-group comparative trial was conducted on 68 patients undergoing elective LSCS. Patients were randomly allocated into two groups to assess the impact of crystalloid coloading speed on maternal hemodynamics. Group A received Ringer Lactate (RL) coloading through an 18G intravenous cannula at an infusion rate of ninety millilitres per minute, while Group B received RL coloading through a 16G intravenous cannula at an infusion rate of one hundred eighty millilitres per minute. Both groups received RL at 20 mL/kg following spinal anaesthesia. Mephentermine was administered to maintain mean arterial pressure (MAP) within ≥20% of baseline.

Results: A significant drop in MAP (≥20% below baseline) was observed in 88.24% of patients in Group A and 82.35% in Group B ($P<0.05$). Despite a higher infusion rate in Group B, the required coload volume could not be fully delivered within the critical first 10 minutes post-spinal anaesthesia, likely due to limitations in venous flow capacity. The requirement for mephentermine was significantly lower in Group B ($P=0.004$), suggesting that a higher coloading speed partially compensated for the MAP drop, though complete hemodynamic stability was not achieved in either group.

Conclusion: Crystalloid coloading alone not effectively prevent maternal hypotension following spinal anaesthesia, likely due to an inability to achieve the optimal infusion speed and volume within 5–7 minutes of peak sympathetic blockade. Venous cannula size and vein selection may significantly impact fluid administration efficiency, necessitating further research.

Keywords: Crystalloid, Coloading, Preloading, Spinal anaesthesia, LSCS.

Received: 02-11-2025; **Accepted:** 08-02-2025; **Available Online**: 16-04-2025

1. Introduction

Regional anaesthesia is widely recommended in obstetric patients as it avoids the airway complications associated with general anaesthesia and helps in saving lives.[1,2] Spinal anaesthesia, commonly used in lower segment cesarean section (LSCS), is associated with hypotension and bradycardia, particularly when the block level reaches T4 to T6 dermatome. The incidence of hypotension during spinal anaesthesia for LSCS ranges from 55% to 82%, and it can be as high as 90% in obstetric patients, which is more severe than in the general population if no intervention is made.[3,4,5] If hypotension persists for more than two minutes, it can lead to a decrease in umbilical artery pH, adversely affecting both maternal and fetal outcomes.[1,6]

Maternal hemodynamics during spinal anaesthesia are typically managed using intravenous fluids, vasopressors, anticholinergics, the Trendelenburg position, and mechanical devices to improve venous return, all of which contribute to enhanced recovery.[7,8,9,10] The timing, speed, and volume of intravenous fluid infusion are crucial factors in preventing

*Corresponding author: Satyendra Yadav
Email: sathyendra.homein@yahoo.com

https://doi.org/10.18231/j.ijca.2025.034

maternal hypotension during the 5-7 minutes following spinal anaesthesia, when sympathetic blockade and vasodilatation occur. This period is critical for maintaining maternal hemodynamics and minimizing the requirement for vasopressors while ensuring adequate uteroplacental perfusion.[5]

Kinetic studies on Ringer Lactate (RL) coload infusion within 2 minutes after spinal or general anaesthesia induction have shown to prevent hypotension caused by central hypovolemia in non-obstetric surgeries.[11,12] The speed and volume of crystalloid infusion, when administered during the peak vasodilatation phase (5-7 minutes after spinal anaesthesia), are essential to counteract the effects of central hypovolemia and low central venous pressure (CVP), both of which result from sympathetic blockade.[13,14] Infusion during this period prevents fluid from redistributing to the interstitial space, thus maximizing the volume within the functional compartment.[15] This enhances cardiac output and stroke volume within 10 minutes of spinal anaesthesia, thereby maintaining intravascular volume and mean arterial pressure (MAP) without increasing urinary output.[12,16]

Crystalloid and colloid preloading have proven ineffective in preventing hypotension, as normal central venous pressure (CVP) leads to the release of atrial natriuretic peptide (type C) due to atrial stretching. This process fails to increase intravascular volume during the critical 5-7 minutes of maximum vasodilatation following spinal anaesthesia and is no longer recommended.[17,18,19] Various studies have shown the effectiveness of coloading, while others report variable or contradictory outcomes.[5,15,17] These variations may be due to inadequate infusion rates or speeds that prevent the optimal volume from being administered during the peak onset of sympathetic block, which has not been well studied.[15,20,21]

According to the Hagen-Poiseuille equation, the speed of intravenous fluid administration is directly proportional to the pressure gradient of the fluid and the fourth power of the catheter radius, and inversely related to the viscosity of the fluid and catheter length. Increasing the size of the catheter improves flow rate, with short, wide-diameter catheters providing the best flow.[22] Based on this principle, we hypothesize that the variable effectiveness of crystalloid coloading in preventing spinal anaesthesia-associated hypotension may result from the failure to achieve an adequate infusion rate, speed, and volume. By optimizing the infusion rate, speed, and volume with appropriate cannula size, the goal is to time the peak onset (5-7 minutes) of sympathetic blockade and prevent spinal hypotension effectively.[14]

This study aimed to evaluate the effectiveness of crystalloid RL coloading speed or rate of infusion using different cannula sizes, addressing the contradictory results observed in earlier studies and resolving the issue of post-spinal hypotension in patients undergoing LSCS. The primary objective of this study was to assess the incidence of maternal hypotension in patients undergoing elective LSCS following spinal anaesthesia, comparing crystalloid coloading with an 18G intravenous cannula (flow rate 90 mL/min) versus a 16G intravenous cannula (flow rate 180 mL/min). The secondary objectives were to study the crystalloid coloading flow speeds/rates with an 18G (in vitro flow rate 90 mL/min) versus 16G (in vitro flow rate 180 mL/min) intravenous cannula in patients undergoing elective LSCS under spinal anaesthesia, and to evaluate the requirement for vasopressors or anticholinergics to prevent maternal hypotension following spinal anaesthesia with crystalloid fluid coloading.

2. Materials and Methods

This prospective, randomized, controlled, double-blind, single-center, parallel-group comparative clinical trial was conducted following institutional ethical committee approval. The study was also registered with the Clinical Trial Registry of India (CTRI/2023/01/049010). This study followed the Good Clinical Practice (GCP) guidelines established by the Central Drugs Standard Control Organization (CDSCO) under the Ministry of Health, Government of India. It also adhered to the specified standards of ethics outlined in the Declaration of Helsinki and the Ethical Guidelines for Biomedical Research on Human Participants issued by the Indian Council of Medical Research (ICMR).

After pre-anesthetic evaluation and informed consent, pregnant patients aged 18 to 40 years undergoing elective lower segment cesarean section (LSCS) without significant comorbidity were randomly assigned into two groups (A and B) using a chit-box method. Group A consisted of 34 patients who were cannulated with an 18G intravenous cannula (L-45mm, OD-1.3mm, with in vitro flow rate 90 mL/min) and were coloaded with Ringer Lactate (RL) following spinal anaesthesia. Group B also included 34 patients who were cannulated with a 16G intravenous cannula (L-45mm, OD-1.7mm, with in vitro flow rate 180 mL/min) and coloaded with RL after spinal anaesthesia.

The exclusion criteria comprised patients with hemoglobin levels less than 10 g/dL, height less than 5 feet, weight less than 40 kg, twin pregnancies, hypothyroidism, hyperthyroidism, cardiac disease, gestational diabetes mellitus, antepartum haemorrhage, pregnancy-induced hypertension, or perioperative complications such as incision-to-delivery time greater than 10 minutes or intraoperative blood loss exceeding 600 ml.

The sample size for this study was calculated using OpenEpi software with a 95% confidence interval, $\alpha = 0.05$, and $\beta = 0.80$. The required sample size for each group was determined to be 34 patients, based on the methodology outlined by Jackson et al. in their study.[23] Statistical analysis was performed using SPSS software, with ANOVA applied to assess statistical differences between the groups.

Patients were randomized by nursing staff using the chit-box method, and the assigned group was provided to the resident doctor on duty for IV cannula placement. To ensure concealment, the colour of the cannula ports (18G green, 16G grey) was covered with white tape. Both the investigator and the patient were blinded to the group allocation throughout the perioperative period.

Spinal anaesthesia was administered with 2 mL of 0.5% heavy Bupivacaine in the conventional sitting position, followed by the patient being placed in the supine position with left uterine displacement. No mechanical means (e.g., Esmarch bandage, anti-thromboembolic stockings, calf compression pump) were used, except for the Trendelenburg position with leg elevation (15–30 degrees) to increase venous return from the lower limbs by adjusting the operative table. The level of spinal block was determined by cold temperature and pinprick tests, aiming for a block up to the T4–T6 dermatome. Coloading with RL (20 mL/kg) was started immediately after spinal anaesthesia, and the time to complete the RL coload was noted for both groups.

Hypotension was defined as a mean arterial pressure (MAP) fall greater than 20% of baseline MAP. If MAP. If MAP fell by 20% or more, 6 mg boluses of Mephentermine were used to maintain MAP. Bradycardia, defined as a heart rate less than or equal to 60 beats per minute (BPM), was treated with a 0.6 mg bolus of Atropine.

Perioperative monitoring included non-invasive blood pressure (NIBP), SpO2, ECG, and temperature. Data collected included heart rate, systolic and diastolic blood pressure, MAP, SpO2, and urine output.

Statistical analysis was performed using SPSS software, version 21. Descriptive statistics, including mean, standard deviation, and percentages, were calculated for continuous and categorical variables. The primary outcome, the incidence of maternal hypotension, was compared between the two groups using an independent t-test for continuous variables and the chi-square test for categorical variables. The analysis of variance (ANOVA) was used to assess the differences in hemodynamic parameters such as systolic and diastolic blood pressure, mean arterial pressure (MAP), and heart rate between the groups. A P-value of less than 0.05 was considered statistically significant.

3. Results

Sixty-eight pregnant patients of ASA 2 status undergoing elective lower segment cesarean section (LSCS) under spinal anaesthesia with 2 mL of injection Bupivacaine heavy were randomized into two groups (Group A and Group B), with 34 patients in each group.

Both groups were coloaded with Ringer Lactate (RL) at 20 mL/kg. The groups were comparable in terms of mean age, weight, basal mean arterial pressure (MAP), level of spinal block (up to T4-T6 dermatome), and incision-to-delivery interval. The study primarily assessed the incidence of hypotension, the time taken to infuse the coload volume, and the requirement of the vasopressor mephentermine to maintain MAP above 20% of baseline values during the perioperative period (**Table 1**). The incidence of nausea, vomiting, and the APGAR score of new-borns were noted.

The primary outcome of the study revealed that the mean incidence of maternal hypotension was 88.24% in Group A and 82.35% in Group B (**Table 1**). There was a significant fall in MAP in both groups ($P<0.05$) at all time points except at 10 minutes, indicating that despite coloading, the fall in MAP from baseline was significant in both groups (**Table 2**). However, the difference in MAP fall between Groups A and B, as well as within each group, was not significant ($P>0.05$, ANOVA, **Table 3**, **Figure 1**), except at 10 minutes, where the difference between the groups was significant ($P<0.05$, ANOVA, **Table 3**).

The secondary outcomes of the study showed that in Group A, the mean coload volume of 1171 mL required 27 minutes and 30 seconds to be infused, as opposed to the 13 minutes calculated in vitro (**Table 1**). In Group B, the mean coload volume of 1157.6 mL required 21 minutes and 40 seconds to be infused, compared to the 6 minutes and 26 seconds calculated in vitro (**Table 1**). In both groups, the required coloading speed or rate, and consequently the volume, could not be achieved as calculated in vitro (**Table 1**). Therefore, the in vitro calculated volume of crystalloid infusion (20 mL/kg) took significantly longer to infuse in both groups following spinal anaesthesia than initially expected (**Table 1**).

At 4 minutes after the onset of spinal anaesthesia, the maximum number of patients required mephentermine (**Figure 2**). The requirement for mephentermine was significantly lower in Group B, with a total dose of 426 mg compared to 516 mg in Group A ($P<0.004$, **Table 4**). This indicates that the requirement for mephentermine was significantly less in Group B, demonstrating that crystalloid coloading with a 16G cannula was more effective in preventing maternal hypotension following spinal anaesthesia, despite not achieving the in vitro calculated coload infusion rate (**Table 1**).

In terms of bradycardia, 5 patients in Group A and 7 patients in Group B required atropine to maintain a heart rate above 60 BPM, with 3 patients in both groups experiencing bradycardia at 4 minutes post-spinal anaesthesia (**Figure 3**). The incidence of nausea was 12.12% in Group A and 9.09% in Group B. Both groups maintained a normal urine output of greater than 0.5 mL/kg/hr, and all patients maintained normal SpO_2 levels. None of the patients exhibited difficulty in breathing, crepitation in the lungs, or signs of fluid overload during the perioperative period. All new-borns had normal APGAR scores at birth.

Table 1: Patient parameters and outcomes in group A (18G) vs. Group B (16G)

Patient Parameter (n=34)	Group A (18G)	Group B(16G)
Weight	58.56	57.88 kg
Blood Pressure (Systolic Mean)	125.5mmhg	121.97mmhg
Blood Pressure (Diastolic Mean)	79.62 mmhg	79.94mmhg
Initial MAP	94.06mmhg	89.56mmhg
20% of MAP	75.25mmhg	71.65mmhg
Coload infused (RL ml)	1171 ml	1157.6 ml
Coload Infusion Duration (In Vitro Calculated)	13min (90ml/min	6min 26s (180ml/min)
Mean Coload infusion duration in patients (In Vivo)	27 min 30s	21 min 40s
Incidence of Hypotension (20%Fall in MAP of Basal values)	88.24%	82.35%
Dose of Mehentermine (Mean)	516 mg	426mg
Incidence of Nausea	9.09%	12.12%
Bupivaicaine 0.5% Heavy Dose	2ml	2ml
Level Of Block	T4-6	T4-6
Mean Blood Loss	400ml-450	400- 450ml
Patient required mephentermine to prevent MAP fall <20%of basal	88.24% (n=30)	82.35% (n=28)
Nausea/vomiting	12.12%	9.09%

Table 2: Fall in MAP from Basal in Group A (18G Cannulation) vs. Group B (16G Cannulation) at different time intervals post-spinal anaesthesia

Time (min)	Group A (18G)	SD	p-value	Group B (16G)	SD	p-value
Basal	94.06	11.114	-	89.56	10.646	0.021
2	83.71	13.541	0.001	82.21	12.627	0.012
4	79.43	13.283	0.000	78.94	14.583	0.001
6	80.65	13.017	0.000	79.85	12.043	0.001
8	85.82	13.568	0.008	81.59	9.372	0.002
10	90.30	12.732	0.202	83.71	9.672	0.021
12	83.29	13.033	0.000	83.29	10.672	0.021
14	84.26	10.922	0.000	81.82	8.408	0.001
16	80.35	9.204	0.000	82.53	10.343	0.007
18	75.82	11.207	0.000	78.26	9.382	0.000
20	75.62	10.957	0.000	75.70	10.778	0.000
22	74.21	12.357	0.000	75.35	9.785	0.000
24	74.4	12.725	0.000	77.21	10.048	0.000
26	77.59	12.352	0.000	76.47	11.634	0.001
28	79.33	10.561	0.000	78.82	11.749	0.001
30	79.03	9.582	0.000	79.53	8.476	0.002

Table 3: Difference in MAP fall between and within group A and B

		Sum of Squares	Df	Mean Square	F	Sig.
2 Min	Between Groups	38.250	1	38.250	.223	.638
	Within Groups	11312.618	66	171.403		
	Total	11350.868	67			
4 Min	Between Groups	4.765	1	4.765	.024	.876
	Within Groups	12840.353	66	194.551		
	Total	12845.118	67			
6 Min	Between Groups	10.721	1	10.721	.058	.811
	Within Groups	12262.029	66	185.788		
	Total	12272.750	67			
8 Min	Between Groups	304.941	1	304.941	2.243	.139
	Within Groups	8973.176	66	135.957		
	Total	9278.118	67			
10 Min	Between Groups	728.837	1	728.837	5.726	.020
	Within Groups	8274.029	65	127.293		
	Total	9002.866	66			
12 Min	Between Groups	5.309	1	5.309	.040	.841
	Within Groups	8675.324	66	131.444		
	Total	8680.632	67			
14 Min	Between Groups	101.309	1	101.309	1.066	.306
	Within Groups	6269.559	66	94.993		
	Total	6370.868	67			
16 Min	Between Groups	80.529	1	80.529	.840	.363
	Within Groups	6326.235	66	95.852		
	Total	6406.765	67			
18 Min	Between Groups	101.309	1	101.309	.948	.334
	Within Groups	7049.559	66	106.811		
	Total	7150.868	67			
20 Min	Between Groups	.368	1	.368	.003	.956
	Within Groups	7760.147	66	117.578		
	Total	7760.515	67			
22 Min	Between Groups	21.795	1	21.795	.176	.676
	Within Groups	8047.280	65	123.804		
	Total	8069.075	66			
24 Min	Between Groups	129.207	1	129.207	.990	.323
	Within Groups	8351.278	64	130.489		
	Total	8480.485	65			
26 Min	Between Groups	20.796	1	20.796	.145	.705
	Within Groups	9196.189	64	143.690		
	Total	9216.985	65			
28 Min	Between Groups	4.142	1	4.142	.033	.857
	Within Groups	7789.608	62	125.639		
	Total	7793.750	63			
30 Min	Between Groups	1.868	1	1.868	.023	.882
	Within Groups	2566.678	31	82.796		
	Total	2568.545	32			

Table 4: Comparison of weight, coload infusion time, fluid volume, urine output, and mephentermine requirement between Group A (18G) and Group B (16G)

NTESTVAR (Number of test variables)		N	Mean	Std Deviation	Std ErrorMean	F	Sig(P)
Weight Kg	16G	34	57.82	7.594	1.302	1.701	.197
	18G	34	58.68	9.054	1.553		
IV Fluid Given	16G	**34**	1156.47	151.875	26.046	1.701	.197
	18G	**34**	1173.53	181.089	31.057		
Time(In Secs)	16G	34	1229.71	241.89	41.484	2.805	.099
	18G	34	1650.00	201.58	34.571		
Mephentermine	16G	34	12.53	8.659	1.485	8.839	.004
	18G	34	15.18	11.272	1.933		
Urine Output	16G	34	85.59	21.347	3.661	2.098	.152
	18G	34	77.50	25.651	4.399		

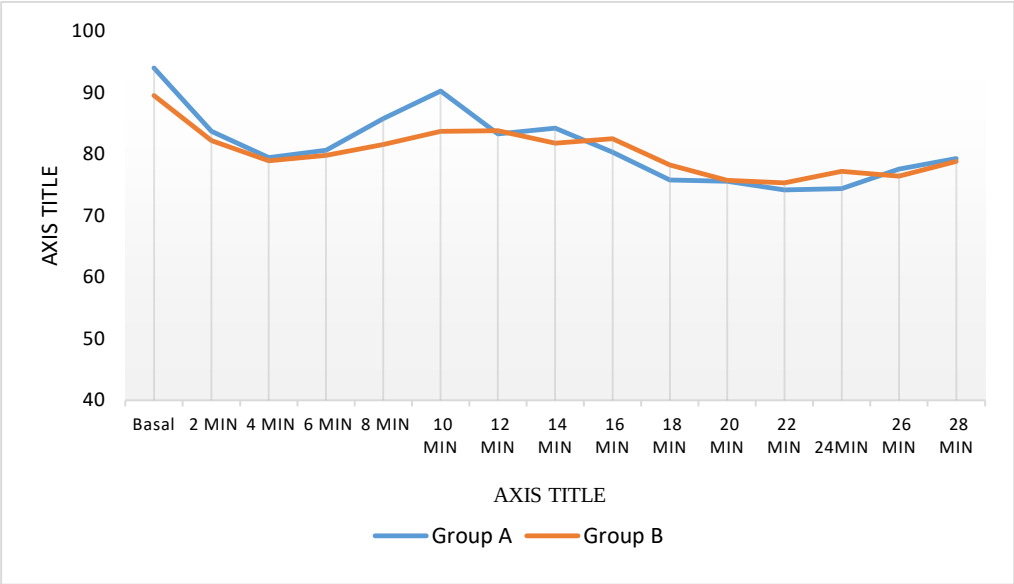

Figure 1: Change in mean MAP of Group A and B

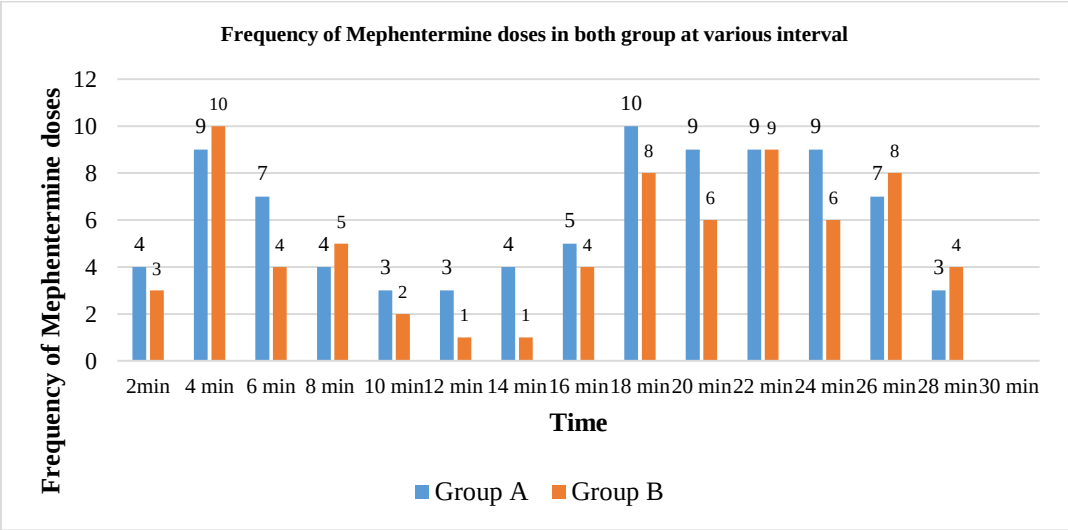

Figure 2: Frequency of Mephentermine doses in both group

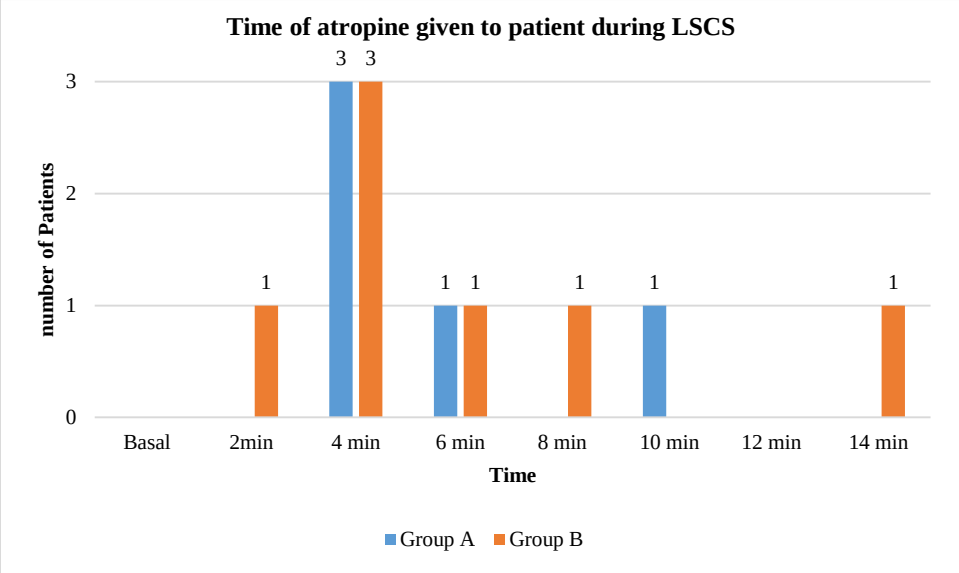

Figure 3: Time of atropine given to patient during LSCS

4. Discussion

Spinal anaesthesia for LSCS results in a high incidence of hypotension unless intervened, primarily due to the high level of sympathetic block vasodilatation.[24] Preloading is no longer recommended, with studies showing no significant benefits.[5] A meta-analysis conducted in 2010 by Banerji et al. demonstrated that the incidence of hypotension was 59.3% in the coloading group versus 62.4% in the preload group (OR 0.93; 95% CI 0.54–1.6), favouring coloading but without statistical significance. This suggests that the timing of fluid loading does not significantly affect the incidence of maternal hypotension, and the analysis concluded that there is no benefit of crystalloid coloading versus preloading.[10] Other studies on coloading have shown variable or contradictory results.[6,7,8,10,25,26] These inconsistencies may be due to inadequate coload infusion rates.[7,12] However, none of these studies considered the rate or speed of coloading, which is critical during the first 10 minutes after spinal anaesthesia.[5]

In this study, we tested the hypothesis that inadequate flow rates and the resultant suboptimal volume during coloading lead to the inconsistent results seen in various studies. MAP and heart rate were used as measures of cardiac output and placental perfusion, with a 20% fall in MAP from baseline being intervened with vasopressor mephentermine and a heart rate <60 bpm being treated with atropine.

Ringer lactate at 20 mL/kg was selected as the crystalloid for coloading, as trans sequential analysis with sensitivity analysis showed no definitive superiority of any fluid.[23] Crystalloids are preferred over colloids, as although colloids have been found effective for coloading, their use is debated and discouraged by several regulatory agencies.[7,10] This preference is due to the higher costs of colloids and their side effects, such as allergic reactions like pruritus, coagulation defects, and the potential for adverse effects on neonates.[4,5]

In our study, both groups were comparable in terms of patient body weight, ASA status, and basal heart rate (HR) and mean arterial pressure (MAP), ensuring that these factors did not contribute to differences in the results. The study demonstrated that crystalloid coloading of 20 mL/kg of Ringer Lactate in both Group A and Group B failed to prevent hypotension following spinal anaesthesia, as reflected by the high incidence of hypotension in both groups (88% in Group A and 82% in Group B). These findings are consistent with previous studies, which also observed that coloading did not consistently prevent hypotension.[25,26] There was a significant ($P < 0.05$) fall in MAP in both groups at various time points post-spinal anaesthesia, reinforcing the understanding that spinal anaesthesia-induced hypotension is a common and expected phenomenon.

The analysis of the fall in MAP between and within the groups revealed that, while there was a significant decrease in MAP at certain time points, the difference between the groups was not significant ($P > 0.05$) except at 10 minutes post-spinal anaesthesia. This finding suggests that, although there was a drop in MAP, the rate and speed of coloading did not significantly alter the hemodynamic outcomes between the groups. The results indicate that while coloading is a commonly used technique, the timing, rate, and volume of fluid administration may need to be optimized further to effectively manage spinal anaesthesia-induced hypotension.

The 20% fall in MAP from the basal level, despite coloading, is likely due to the inability to achieve the expected infusion flow rates of crystalloid in both groups, as calculated in vitro. In Group A, the mean coload volume required 27 minutes and 30 seconds to be infused, rather than

the expected 13 minutes. Similarly, in Group B, the mean coload volume required 21 minutes and 40 seconds, instead of the calculated 6 minutes and 26 seconds for infusion.

This inadequate infusion speed and volume, particularly during the critical first 10 minutes post-spinal anaesthesia, likely contributed to the high incidence of hypotension. A systematic review by Mercier in 2011, which included six studies, concluded that the speed of crystalloid coloading infusion should be high enough to reach the target volume within 5-7 minutes of spinal anaesthesia induction for it to be effective.[5] The difference between the in vitro calculated and the actual infused coload volume in patients could be attributed to several factors, including variations in vein selection, the experience of the healthcare professional inserting the IV cannula, the movement of the patient's arm and hand position, and the effect of gravity on the infusion rate due to the relative height of the infusion stand to the operating table during the perioperative period. These variables could not be strictly standardized in our study, leading to the failure to achieve the optimal flow rate and coload infusion volume in both groups. As a result, this led to a high incidence of hypotension in Group A (88.24%) and Group B (82.35%), along with a significant fall in MAP from basal levels in both groups.

The dose of mephentermine in Group B was 17.44% less compared to Group A, and this difference was found to be statistically significant (P = 0.004). This reduction in the need for mephentermine in Group B is likely due to the higher rate of coloading, which effectively maintained maternal hemodynamics and reduced the incidence of hypotension, requiring less vasopressor support compared to Group A. A study by Dyer et al., using 20 mL/kg of crystalloid, demonstrated that coloading with faster infusion rates resulted in a reduced need for vasopressors like ephedrine.[4] They achieved 1386 mL infusion in 9.8 minutes using a 16G cannula with a pressure bag, suggesting that the use of a pressure bag can significantly maximize the infusion speed and volume, improving the effectiveness of coloading.

Changes in heart rate between the groups were insignificant. Atropine (0.6 mg) was administered to 5 patients in Group A and 7 patients in Group B to maintain a heart rate above 60 bpm. Urine output was maintained at greater than 0.5 mL/kg/hr in both groups, indicating adequate renal perfusion and function, with no significant differences (P > 0.05).

In contrast to crystalloid and colloid preloading, which have been associated with significant increases in central venous pressure (CVP), our study did not observe any such increase or adverse effects.[8,14] None of the patients in our study experienced arrhythmias, breathlessness, or signs of fluid overload such as lung crepitations. All patients maintained normal SpO_2 levels, which is a significant concern in obstetric patients.[18] Additionally, the APGAR scores of all new-borns were within normal ranges, indicating no adverse effects on neonatal outcomes from the study interventions.

5. Limitation

Although this study was aimed to address the contradictory results seen in earlier studies regarding crystalloid coloading, several limitations affected the outcome. One key limitation was the venous cannulation performed by resident doctors, which may have led to variability in the selection of veins, potentially affecting the infusion rate. Additionally, the non-availability of vein finders to assist in locating suitable veins further contributed to variability in cannulation efficiency. Another limitation was the lack of pressure bags, which are known to optimize the infusion rate and volume. The absence of these devices likely limited the effectiveness of the coloading process, potentially impacting the study's ability to fully assess the benefits of optimized fluid infusion rates. Despite these limitations, the study provides valuable insights and directions for future research, highlighting the need for standardizing techniques and equipment to improve outcomes.

6. Conclusion

Crystalloid coloading alone does not effectively prevent maternal hypotension following spinal anaesthesia, as optimal infusion speed and volume are not achieved during the critical 5-7 minute window of peak sympathetic blockade. Variations in venous cannula size and vein selection impact fluid administration efficiency. Further research should focus on optimizing infusion techniques, such as advanced vein selection, pressure-assisted infusion, and the use of colloid solutions, to improve hemodynamic stability and maternal outcomes.

7. Source of Funding

None.

8. Conflict of Interest

None.

References

1. Loubert C. Fluid and vasopressor management for Cesarean delivery under spinal anaesthesia: continuing professional development. *Can J Anaesth.* 2012;59(6):604–19.
2. Quarshie A, Anno A, Djagbletey R, Sarpong P, Sottie D, Phillips BJ, et al. Comparison of Crystalloid Preloading and Coloading for Prevention of Spinal-induced Hypotension in Cesarean Delivery: A Randomized Controlled Trial at a Tertiary Facility in Ghana. *Open Access Maced J Med Sci.* 2023;11(B):627–33.
3. Shnider SM, de Lorimier AA, Steffenson JL. Vasopressors in obstetrics. 3. Fetal effects of metaraminol infusion during obstetric spinal hypotension. *Am J Obstet Gynecol.* 1970;108(7):1017–22.
4. Dyer RA, Farina Z, Joubert IA, Du Toit P, Meyer M, Torr G, et al.. Crystalloid preload versus rapid crystalloid administration after induction of spinal anaesthesia (coload) for elective caesarean section. *Anaesth Intensive Care*. 2004;32(3):351-7.

5. Mercier FJ. Fluid loading for cesarean delivery under spinal anaesthesia: have we studied all the options? *Anesth Analg*. 2011;113(4):677–80.
6. Corke BC, Datta S, Ostheimer GW, Weiss JB, Alper MH. Spinal anaesthesia for Caesarean section. The influence of hypotension on neonatal outcome. *Anaesthesia.* 1982;37(6):658–62.
7. Rijs K, Mercier FJ, Lucas DN, Rossaint R, Klimek M, Heesen M. Fluid loading therapy to prevent spinal hypotension in women undergoing elective caesarean section: Network meta-analysis, trial sequential analysis and meta-regression. *Eur J Anaesthesiol*. 2020;37(12):1126–42.
8. Morgan PJ, Halpern SH, Tarshis J. The effects of an increase of central blood volume before spinal anaesthesia for cesarean delivery: a qualitative systematic review. *Anesth Analg*. 2001;92(4):997–1005.
9. Bhagwanjee S, Rocke DA, Rout CC, Koovarjee RV, Brijball R. Prevention of hypotension following spinal anaesthesia for elective caesarean section by wrapping of legs. *Br J Anaesth.* 1990;65(6):819–22.
10. Rout C, Rocke D, Gouws E. Leg elevation and wrapping in prevention of hypotension following spinal anaesthesiafor elective Caesarean section. *Anaesthesia.* 1993;48:304-8.
11. Hahn RG, Resby M. Volume kinetics of Ringer's solution and dextran 3% during induction of spinal anaesthesia for caesarean section. *Can J Anaesth*. 1998;45(12):443–51.
12. Ewaldsson CA, Hahn RG. Volume kinetics of Ringer's solution during induction of spinal and general anaesthesia. *Br J Anaesth.* 2001;87(3):406–14.
13. Hahn RG, Svensén C. Plasma dilution and the rate of infusion of Ringer's solution. *Br J Anaesth.* 1997;79(1):64–7.
14. Suga S, Nakao K, Itoh H, Komastu Y, Ogawa Y, Hama N et al. Endothelial production of C-type natriuretic peptide and its marked augmentation by transforming growth factor-beta. Possible existence of "vascular natriuretic peptide system." *J Clin Invest*. 1992;90(3):1145–9.
15. Rout C, Rocke DA. Spinal hypotension associated with caesarean section: will preload ever work? *Anesthesiology.* 1999;91(6):1565–7.
16. Teoh WH, Sia AT. Colloid preload versus coload for spinal anaesthesia for cesarean delivery: the effects on maternal cardiac output. *Anesth Analg*. 2009;108(5):1592–8.
17. Pouta AM, Karinen J, Vuolteenaho OJ, Laatikainen TJ. Effect of intravenous fluid preload on vasoactive peptide secretion during Caesarean section under spinal anaesthesia. *Anaesthesia*. 1996;51(2):128–32.
18. Karinen J, Rasanen J, Alahuhta S, Jouppila R, Jouppila P. Effect of crystalloid and colloid preloading on uteroplacental and maternal haemodynamics state during spinal anaesthesia for caesarean section. *Br J Anesth.* 1995;75(5):531–5.
19. Kee WDN. Prevention of maternal hypotension after regional anaesthesia for caesarean section. *Curr Opin Anaesthesiol.* 2010;23:304–9
20. Banerjee A, Stocche RM, Angle P, Halpern SH. Preload or coload for spinal anaesthesia for elective Cesarean delivery: a meta-analysis. *Can J Anaesth*. 2010;57(1):24-31.
21. Bouchnak M, BenCheikg N, Skhiri A, Yaacoubi M, Menif MA, Smaoui M, et al. Relevance of rapid crystalloid administration after spinal anaesthesia(coload) in prevention of hypotension during elective caesarean section:A-685. *Eur J Anaesthesiol*. 2006;23:178.
22. Scott DA, Fox JA, Cnaan A, Philip BK, Lind LJ, Palleiko MA, Stelling JM, Philip JH. Resistance to fluid flow in veins. *J Clin Monit*. 1996;12(4):331-7.
23. Jackson R, Reid JA, Thorburn J. Volume Preloading is not essential to prevent spinal -induced hypotension at caesarean section. *Br J Anaesth*. 1995;75(2):262–5.
24. Mojica JL, Melendez HJ, Bautista LE. The timing of intravenous crystalloid administration and incidence of cardiovascular side effect during spinal anaesthesia: The result from randomized controlled trial. *Anesth Analg*. 2002;94(2):432–7.
25. Bajwa SJ, Kulshrestha A, Jindal R. Coloading or preloading for prevention of hypotension after spinal anaesthesia! a therapeutic dilemma. *Anesth Essays Res*. 2013:7(2):155–9.
26. Hunie M, Wubishet T, Fenta E, Teshome D, Kibret S, Desse T, et al. The effect of Preloading and coloading in prevention of hypotension among mothers who underwent Cesarean Delivery under spinal Anaesthesia: A Prospective Cohort study. *Sys Rev Pharm*. 2022;13(3):213–8.

Cite this article: Yadav S, Naithani D, Nautiyal N, Singh S. Effect of crystalloid coloading speed on hemodynamics in patients undergoing elective LSCS under spinal anaesthesia: A randomized control trial. *Indian J Clin Anaesth*. 2025;12(2):198–206.