International Journal of Health Sciences and Research
[Indexed, Peer-Reviewed Journal]
Volume 16; Issue: 9; September 2026
Website: www.ijhsr.org
Original Research Article *ISSN: 2249-9571*

Crystalloid Preloading versus Coloading for Prevention of Spinal Anaesthesia-Induced Hypotension in Inguinal Hernioplasty

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DOI: https://doi.org/10.52403/ijhsr.20260901

Received: 17/04/2026; Revised: 20/07/2026; Accepted: 29/08/2026

ABSTRACT

Background: Spinal anaesthesia is widely used for inguinal hernioplasty but is frequently complicated by hypotension. Fluid management strategies such as preloading and coloading with crystalloids are employed to mitigate this risk, though their relative efficacy remains debated.
Objective: To compare haemodynamic outcomes and adverse effects of crystalloid preloading versus coloading in patients undergoing inguinal hernioplasty under spinal anaesthesia.
Methods: In this prospective, randomised, double-blind trial, 120 ASA I–II patients were allocated to receive lactated Ringer's solution either 20 minutes before (preload group) or immediately after (coload group) spinal anaesthesia. Blood pressure, heart rate, oxygen saturation, incidence of hypotension, and adverse effects were recorded for 20 minutes post-block.
Results: Demographic variables were comparable between groups. Pulse rate (p=0.65–0.99 across time points) and oxygen saturation (p=0.09–1.00) remained stable. Preloading maintained significantly higher systolic blood pressure at 3 minutes (p=0.02) and 10 minutes (p=0.04), and higher diastolic pressure at 10 minutes (p=0.01) and 15 minutes (p<0.01). Mean arterial pressure was also significantly higher in the preload group immediately after spinal anaesthesia (p=0.06, not significant), at 3 minutes (p=0.01), 10 minutes (p<0.01), and 15 minutes (p<0.01). At 20 minutes, MAP was slightly higher in the coload group (p=0.13). Hypotension occurred in 13.3% of preload patients versus 28.3% of coload patients (p=0.07). Vomiting was the only adverse effect, observed in 18.3% of preload and 13.3% of coload patients (p=0.61). No bradycardia, pulmonary oedema, or desaturation were reported.
Conclusion: Both preload and coload strategies are safe and effective in preventing severe hypotension during spinal anaesthesia. Preloading resulted in higher blood pressure values at selected time points (p<0.05), but this did not translate into a statistically significant reduction in the overall incidence of hypotension.

Keywords: Spinal anaesthesia; Inguinal hernioplasty; Crystalloid preload; Crystalloid coload; Hypotension prevention; Haemodynamic stability; Adverse effects

INTRODUCTION

Inguinal hernia repair is one of the most frequently performed general surgical procedures worldwide, and spinal anaesthesia is often the preferred anaesthetic technique for these operations due to its rapid onset, dense neural blockade, effective muscle relaxation, and reduced postoperative analgesic requirements compared to general anaesthesia. [1] Despite these advantages, spinal anaesthesia is associated with significant haemodynamic changes, the most common being hypotension, which occurs in 25–75% of patients. [2] This hypotension results primarily from sympathetic blockade, leading to vasodilation, decreased systemic vascular resistance, and reduced venous return. [3] If inadequately managed, spinal-induced hypotension can cause dizziness, nausea, vomiting, syncope, and, in severe cases, cardiac arrhythmias or aspiration, thereby compromising patient safety and surgical outcomes. [4]

Intravenous fluid administration remains the cornerstone of prophylaxis against spinal-induced hypotension. Traditionally, preloading with crystalloids has been employed, with fluids administered before the subarachnoid block to augment intravascular volume and counteract anticipated vasodilatory effects. [5] However, crystalloids are rapidly redistributed into the interstitial space and excreted by the kidneys, limiting their sustained intravascular effect. [6] Consequently, the protective benefit of preloading is often short-lived, raising concerns about its efficacy in consistently preventing hypotension.

An alternative strategy, co-loading, involves administering crystalloids immediately after the intrathecal injection, thereby synchronising fluid expansion with the onset of sympathetic inhibition. [7] This approach theoretically provides better haemodynamic stability by ensuring intravascular volume is maximised during the critical vasodilatory phase. Several studies have suggested that co-loading may be superior to preloading in reducing the incidence of hypotension, particularly in obstetric and non-obstetric populations. [8,9] For instance, Artawan et al. (2020) demonstrated that co-loading with crystalloids significantly reduced hypotension compared to preloading in patients undergoing caesarean section. [10] Similarly, Ni et al. (2017) reported in a meta-analysis that co-loading was more effective than preloading in preventing hypotension during spinal anaesthesia for caesarean delivery. [11]

Nevertheless, both techniques have limitations. Preloading may fail due to rapid fluid redistribution, while co-loading carries theoretical risks, including haemodilution, decreased oxygen-carrying capacity, and pulmonary oedema in susceptible patients. [12] Moreover, the literature remains inconclusive, with some studies reporting comparable efficacy between the two methods. [13] This lack of consensus underscores the need for further research, particularly in non-obstetric populations such as patients undergoing inguinal hernioplasty, where spinal anaesthesia is commonly employed.

Given the high incidence of spinal-induced hypotension and its potential complications, identifying the most effective fluid management strategy is crucial. The present study aims to compare crystalloid preloading and co-loading in patients undergoing inguinal hernioplasty under spinal anaesthesia. By evaluating haemodynamic outcomes and adverse effects, including bradycardia, nausea, and vomiting. This research aims to provide evidence to guide anaesthesiologists in optimising perioperative fluid management and improving patient safety.

Importantly, this study was conducted at Tripura Medical College & Dr. BRAM Teaching Hospital in North East India, a region where spinal anaesthesia is routinely employed for lower abdominal surgeries.

The findings are expected to contribute not only to the local practice environment but also to the broader anaesthesia literature, offering insights relevant to both resource-limited and advanced healthcare settings. By contextualising the results within the North East Indian population, the study adds valuable data to the ongoing debate on whether crystalloid preloading or co-loading provides superior haemodynamic stability during spinal anaesthesia.

MATERIALS AND METHODS

Study Setting and Design: The study was conducted in the Operation Theatre of Tripura Medical College & Dr BRAM Teaching Hospital, Hapania, Tripura, North East India. It was designed as a prospective, randomised, double-blind clinical trial. Randomisation was achieved using a computer-generated sequence to minimise bias.

Study Duration: The trial was conducted over a period of 6 months.

Participants: A total of 120 adult patients scheduled for elective inguinal hernioplasty under spinal anaesthesia were enrolled. Inclusion criteria were age between 18–60 years and ASA physical status I or II. Patients were excluded if they had a history of drug allergy, cardiovascular disease (including arrhythmias or prior CVA), were on beta-blockers/calcium channel blockers/digoxin therapy, or had hepatic, renal, haematological, or neuromuscular disorders. Pregnant or lactating women, patients with substance abuse, or those anticipated to have difficult spinal anaesthesia were also excluded.

Sample Size Calculation: Sample size was calculated using the formula:

$n = 2(Z_\alpha + Z_{1-\beta})^2 \cdot p \cdot q/d^2$

n= $2(Z\alpha+Z[1-\beta])^2$ x p x q/d^2

n= $2(1.96+0.842)^2$ x 51 x 49/ 26^2

=39240.317/676

= 58.04

Based on this, the required sample size was 58 per group. After adjusting for dropout, 60 patients were recruited per arm, for a total of 120 participants.

Intervention: Participants were randomly allocated into two groups:

- **Group A (Preload):** Received 15 ml/kg lactated Ringer's solution 20 minutes before spinal anaesthesia.
- **Group B (Coload):** Received 15 ml/kg lactated Ringer's solution immediately after administration of spinal anaesthesia.

A large-bore intravenous cannula was inserted in all patients. Standard ASA monitors (pulse oximetry, ECG, and non-invasive blood pressure) were applied. Baseline mean arterial pressure (MAP) was recorded prior to fluid administration.

Anaesthetic Technique: Spinal anaesthesia was performed in the sitting position at the L3/L4 or L4/L5 interspace under aseptic precautions using a 25-gauge Quincke needle. Each patient received 3 mL of 0.5% hyperbaric bupivacaine.

Outcome Measures: MAP was recorded at baseline, immediately after spinal anaesthesia, and at 3, 5, 10, 15, and 20 minutes post-block. Hypotension was defined as a ≥20% reduction in MAP from baseline and treated with intravenous mephentermine. Bradycardia, nausea, and vomiting were noted and treated appropriately. The number of rescue doses of mephentermine and atropine was documented.

Data Analysis: Statistical analysis was performed using descriptive and inferential statistical methods. Continuous variables were summarised as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Baseline demographic and clinical characteristics between the two groups were compared using the independent samples t-test for continuous variables and the chi-square test for categorical variables. Hemodynamic parameters, including pulse rate, systolic blood pressure (SBP), diastolic

blood pressure (DBP), MAP, and peripheral oxygen saturation (SpO_2), measured at multiple time points, were initially compared between groups at each time point using independent-samples t-tests. To evaluate the overall effects of treatment group, time and the interaction between group and time on repeated hemodynamic measurements, a two-way mixed-design analysis of variance (mixed repeated-measures ANOVA) was performed with results reported as F-statistics and corresponding p-values. Statistical significance was determined using two-tailed tests with a significance level of $p < 0.05$.

Ethical Considerations: Written informed consent was obtained from all participants. The study was approved by the institutional ethics committee of Tripura Medical College & Dr. BRAM Teaching Hospital.

RESULTS

A total of 130 patients were assessed for eligibility during the enrolment period. Of these, 10 patients were excluded, including 8 who did not meet the predefined inclusion criteria and 2 who declined to participate. The remaining 120 patients were randomized equally into Group A (n=60) and Group B (n=60). All randomized patients received their respective allocated interventions. During the follow-up period, no patients were lost to follow-up in either group. Consequently, all 120 randomized participants were included in the final analysis, with 60 patients analysed in Group A and 60 patients analysed in Group B (figure 1).

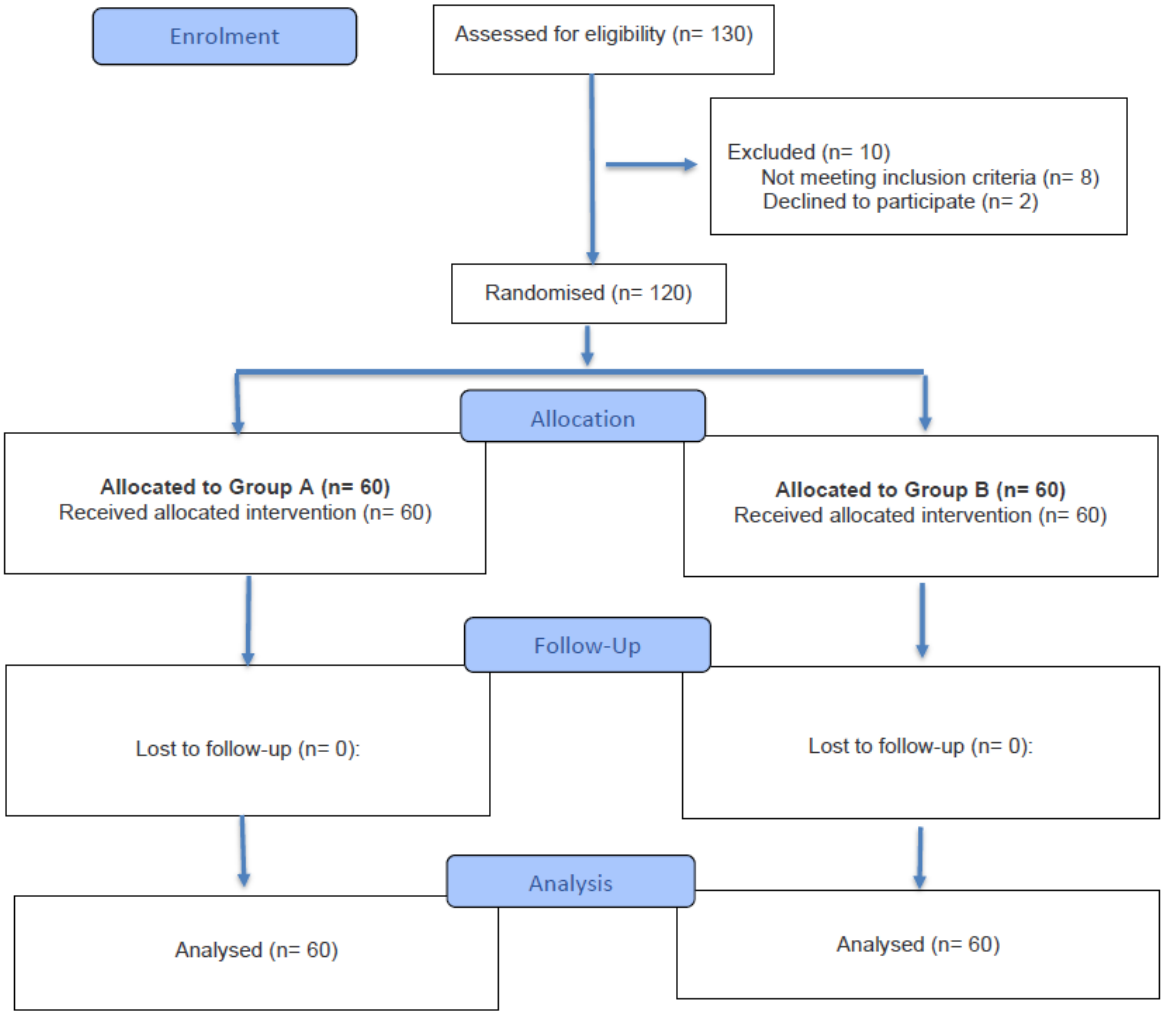

Figure 1: CONSORT flow diagram.

Table 1 presents the demographic and clinical characteristics of the two study groups. The mean age of patients was comparable between Group A (43.62 ± 11.37 years) and Group B (45.23 ± 10.06 years), with no statistically significant difference. Similarly, the mean BMI values were nearly identical across groups (28.43 ± 4.02 vs. 28.64 ± 5.17 kg/m²), indicating homogeneity in baseline nutritional status. The sex distribution showed a predominance of males in Group A (65.0%) compared to Group B (51.7%), while females constituted 35.0% and 48.3%, respectively. The diagnostic pattern was balanced, with left inguinal hernia cases accounting for 56.7% in Group A and 55.0% in Group B, and right inguinal hernia cases accounting for 43.3% and 45.0%, respectively.

Table 1. Demographic and clinical characteristics of the two study groups

Parameter	Group A (n=60)	Group B(n=60)
Age (years), mean ± SD	43.62 ± 11.37	45.23 ± 10.06
BMI (kg/m²), mean ± SD	28.43 ± 4.02	28.64 ± 5.17
Sex, n (%)		
Male	39 (65.0)	31 (51.7)
Female	21 (35.0)	29 (48.3)
Diagnosis, n (%)		
Left inguinal hernia	34 (56.7)	33 (55.0)
Right inguinal hernia	26 (43.3)	27 (45.0)

Table 2 compares the pulse rate between the preload (Group A) and coload (Group B) groups at different time intervals following spinal anaesthesia. At baseline, the mean pulse rates were similar (88.22 ± 11.19 vs. 87.23 ± 12.93 beats/min; p = 0.65), and no significant differences were observed immediately after the block or at subsequent intervals. Across all measured time points—3, 5, 10, 15, and 20 minutes—the pulse rates remained stable within each group, with values ranging between 86–89 beats/min. The p-values for each interval (0.20 to 0.99) indicate that there were no statistically significant differences in heart rate trends between the two groups.

Table 2. Comparison of pulse rate (beats/min) between the two groups at different time intervals

Time point	Group A (n=60)	Group B (n=60)	p value
Baseline	88.22 ± 11.19	87.23 ± 12.93	0.65
Immediately after SAB	87.23 ± 11.11	87.85 ± 13.05	0.78
3 min	87.83 ± 10.92	87.82 ± 11.04	0.99
5 min	87.32 ± 10.41	88.95 ± 10.79	0.40
10 min	86.15 ± 9.16	88.42 ± 10.44	0.20
15 min	86.10 ± 9.39	86.45 ± 8.78	0.83
20 min	86.65 ± 10.63	86.30 ± 9.99	0.85

Table 3 compares SBP trends between the preload (Group A) and coload (Group B) groups at different time intervals. At baseline, SBP values were nearly identical (135.40 ± 11.59 vs. 136.08 ± 11.28 mmHg; p = 0.74), and no significant differences were noted immediately after spinal anaesthesia. However, at 3 minutes, Group A demonstrated a significantly higher SBP compared to Group B (135.82 ± 11.71 vs. 128.85 ± 11.84 mmHg; p = 0.02), and a similar trend was observed at 10 minutes (137.12 ± 13.31 vs. 130.40 ± 12.02 mmHg; p = 0.04). At other time points (5, 15, and 20 minutes), SBP values remained comparable between the two groups, with no statistically significant differences.

Table 3. Comparison of systolic blood pressure (mmHg) between the two groups at different time intervals

Time point	Group A (n=60)	Group B (n=60)	p value
Baseline	135.40 ± 11.59	136.08 ± 11.28	0.74
Immediately after SAB	122.98 ± 9.62	124.25 ± 10.23	0.48
3 min	135.82 ± 11.71	128.85 ± 11.84	0.02*
5 min	133.73 ± 10.62	132.82 ± 11.97	0.65
10 min	137.12 ± 13.31	130.40 ± 12.02	0.04*
15 min	135.22 ± 10.66	131.45 ± 12.76	0.08
20 min	134.48 ± 11.53	134.00 ± 11.22	0.81

Table 4 compares DBP between the preload (Group A) and coload (Group B) groups across different time intervals. At baseline, DBP values were similar (80.07 ± 9.94 vs. 81.48 ± 8.91 mmHg; p = 0.41), and no significant differences were noted immediately after spinal anaesthesia. At 3 and 5 minutes, Group A maintained slightly higher DBP compared to Group B, though the differences approached but did not reach statistical significance (p = 0.054 and p = 0.08, respectively). A significant difference emerged at 10 minutes, with Group A showing higher DBP (77.93 ± 9.81 vs. 73.50 ± 9.95 mmHg; p = 0.01). This trend was more pronounced at 15 minutes, where Group A maintained substantially higher DBP (80.90 ± 8.55 vs. 72.50 ± 8.30 mmHg; p < 0.01). By 20 minutes, DBP values converged again, with no significant difference (p = 0.051).

Table 4. Comparison of diastolic blood pressure (mmHg) between the two groups at different time intervals

Time point	Group A (n=60)	Group B (n=60)	p value
Baseline	80.07 ± 9.94	81.48 ± 8.91	0.41
Immediately after SAB	71.87 ± 10.17	74.88 ± 8.55	0.08
3 min	76.83 ± 10.47	73.40 ± 8.80	0.054
5 min	78.15 ± 9.65	75.10 ± 9.79	0.08
10 min	77.93 ± 9.81	73.50 ± 9.95	0.01*
15 min	80.90 ± 8.55	72.50 ± 8.30	<0.01*
20 min	74.15 ± 10.01	77.55 ± 8.80	0.051

Table 5. Comparison of mean arterial pressure (mmHg) between the two groups at different time intervals

Time point	Group A (n=60)	Group B (n=60)	p value
Baseline	98.51 ± 7.25	99.68 ± 7.25	0.37
Immediately after SAB	88.91 ± 7.37	91.34 ± 6.79	0.06
3 min	96.49 ± 8.18	91.88 ± 6.52	0.01*
5 min	96.68 ± 7.27	94.34 ± 7.30	0.08
10 min	97.66 ± 8.09	92.47 ± 7.61	<0.01*
15 min	99.01 ± 6.93	92.15 ± 7.61	<0.01*
20 min	94.26 ± 8.30	96.37 ± 6.80	0.13

Table 5 compares MAP between Group A and Group B at different time intervals following spinal anaesthesia. At baseline, both groups had similar MAP values with no significant difference (p=0.37). Immediately after SAB, Group B showed slightly higher MAP than Group A, but the difference was not statistically significant (p=0.06). However, at 3 minutes, Group A maintained a higher MAP compared to Group B, and this difference was significant (p=0.01). The trend continued at 10 and 15 minutes, with Group A consistently showing higher MAP than Group B and highly significant differences (p<0.01). At 5 minutes, the difference was not significant (p=0.08), and by 20 minutes, Group B's MAP was slightly higher, though again not statistically

significant (p=0.13). Overall, the table indicates that Group A generally maintained a higher MAP than Group B during the critical early post-SAB period, with significant differences at 3, 10, and 15 minutes.

Table 6 compares peripheral oxygen saturation (SpO_2) between the preload (Group A) and coload (Group B) groups at different time intervals. At baseline, SpO_2 values were nearly identical (98.72 ± 1.30 vs. 98.85 ± 1.16%; p = 0.55), and this similarity persisted immediately after spinal anaesthesia (both 98.93%). Across all subsequent time points—3, 5, 10, 15, and 20 minutes—oxygen saturation remained consistently high (98–99%) in both groups, with no statistically significant differences (p values ranging from 0.09 to 1.00).

Table 6. Comparison of peripheral oxygen saturation (SpO2) between the two groups at different time intervals

Time point	Group A (n=60)	Group B (n=60)	p value
Baseline	98.72 ± 1.30	98.85 ± 1.16	0.55
Immediately after SAB	98.93 ± 1.07	98.93 ± 1.13	1.00
3 min	98.83 ± 1.21	98.98 ± 1.08	0.47
5 min	99.08 ± 0.98	98.87 ± 1.19	0.27
10 min	99.08 ± 1.01	99.07 ± 1.01	0.92
15 min	98.70 ± 1.31	99.07 ± 1.06	0.09
20 min	98.77 ± 1.01	98.88 ± 1.12	0.55

Table 7 compares the incidence of hypotension between the two study groups. In Group A, 8 patients (13.3%) experienced hypotension, whereas 17 patients (28.3%) developed hypotension in Group B. Conversely, most patients in Group A (86.7%) did not experience hypotension, compared with 71.7% in Group B. Although the coload group (Group B) showed a higher proportion of hypotension episodes, the difference between the two groups did not reach statistical significance (p = 0.07).

Table 7. Incidence of hypotension between the two groups

Outcome	Group A n (%)	Group B n (%)	p value
Hypotension present	8 (13.3)	17 (28.3)	0.07
Hypotension absent	52 (86.7)	43 (71.7)	

Table 8 compares the incidence of adverse effects between the preload (Group A) and coload (Group B) groups. The majority of patients in both groups experienced no adverse effects, with 81.7% in Group A and 86.7% in Group B remaining symptom-free. Vomiting was the only adverse effect observed, occurring in 18.3% of patients in Group A and 13.3% in Group B. Although the coload group showed a slightly lower incidence of vomiting, the difference was not statistically significant (p = 0.61).

Table 8. Comparison of adverse effects between the two groups

Adverse effect	Group A n (%)	Group B n (%)	p value
No adverse effect	49 (81.7)	52 (86.7)	0.61
Vomiting	11 (18.3)	8 (13.3)	

Table 9 summarises the two-way mixed-design ANOVA assessing the effects of group, time, and group × time interaction on haemodynamic parameters. For pulse rate, neither group effect (F = 0.18, p = 0.67), time effect (F = 0.68, p = 0.66), nor interaction (F = 0.44, p = 0.85) were significant, indicating stable heart rate trends across both groups. In contrast, SBP showed significant differences: group effect (F = 6.75, p = 0.01), time effect (F = 15.36, p < 0.01), and group × time interaction

($F = 2.83$, $p = 0.01$), suggesting that SBP varied both between groups and across time, with preload maintaining higher values at certain intervals. DBP demonstrated a borderline group effect ($F = 3.84$, $p = 0.052$), but significant time ($F = 7.77$, $p < 0.01$) and interaction effects ($F = 7.26$, $p < 0.01$), indicating dynamic changes over time with differences in group response patterns. MAP showed a significant group effect ($F=7.75$, $p=0.01$), a strong time effect ($F=17.64$, $p<0.01$), and a significant interaction ($F=9.17$, $p<0.01$), reflecting consistent differences between groups and varying trends over time.

For SpO_2, no significant effects were observed for group, time, or interaction (all $p > 0.40$), confirming stable oxygenation across both strategies.

Table 9. Two-way mixed-design ANOVA: effect of group, time, and group × time interaction on hemodynamic parameters

Parameter	F statistic	P value
Pulse	0.18	0.67
Time effect	0.68	0.66
Group × Time interaction	0.44	0.85
SBP	6.75	0.01*
Time effect	15.36	<0.01*
Group × Time interaction	2.83	0.01*
DBP	3.84	0.052
Time effect	7.77	<0.01*
Group × Time interaction	7.26	<0.01*
MAP	7.75	0.01*
Time effect	17.64	<0.01*
Group × Time interaction	9.17	<0.01*
SpO2	0.53	0.46
Time effect	1.03	0.40
Group × Time interaction	0.90	0.49

*Significant p values

DISCUSSION

This prospective, randomised study compared crystalloid preloading and coloading in patients undergoing inguinal hernioplasty under spinal anaesthesia. The demographic and baseline clinical characteristics were comparable between groups, ensuring that observed differences in haemodynamic outcomes were attributable to fluid management strategies rather than patient variability. Both groups had similar ages, BMI, sex distributions, and hernia laterality, which strengthens the internal validity of the findings.

Pulse rate remained stable across all time points in both groups, with no statistically significant differences. This indicates that neither preload nor coload affected heart rate trends and, importantly, that no episodes of bradycardia requiring atropine were observed. These findings are consistent with Hofhuizen et al. (2019), who reported that spinal anaesthesia-induced hypotension is primarily due to reduced stroke volume rather than changes in heart rate. [3] More recent evidence supports this observation: Gao et al. (2025) demonstrated in a randomised trial that cardiac output and stroke volume varied significantly during spinal anaesthesia, while heart rate remained largely unchanged, confirming that hypotension is driven by vascular and volume shifts rather than chronotropic suppression. [14] Together, these studies reinforce that fluid management strategies influence blood pressure stability but have minimal impact on heart rate, explaining the absence of bradycardia in our cohort.

Similarly, peripheral oxygen saturation remained consistently high (98–99%) in both groups, with no significant differences. This demonstrates that spinal anaesthesia combined with either fluid strategy preserved respiratory function and oxygen delivery. A

recent randomised trial by Du et al. (2026) showed that individualised, fluid-responsiveness-guided strategies effectively prevented hypotension during spinal anaesthesia without compromising oxygen saturation, confirming that SpO_2 stability is maintained even as haemodynamic parameters vary. [15] Likewise, Dahal et al. (2025) reported that ultrasound-guided fluid management prevented hypotension while maintaining stable oxygenation in patients undergoing spinal anaesthesia. [16] These findings reinforce that both preload and coload strategies are safe in terms of oxygen delivery, with no risk of desaturation.

Systolic, diastolic, and mean arterial pressures differed significantly. Group A (preload) consistently maintained higher SBP at 3 and 10 minutes post-block, and higher DBP at 10 and 15 minutes compared to Group B (coload). Regarding MAP, Group A maintained significantly higher values at 3 minutes, 10 minutes, and 15 minutes. Differences immediately after SAB and at 20 minutes were not statistically significant. The two-way mixed-design ANOVA confirmed significant group × time interactions for SBP (p=0.01), DBP (p<0.01), and MAP (p<0.01), reinforcing that preload better sustained blood pressure over time. These findings suggest that crystalloid preloading provides more consistent haemodynamic stability during the critical vasodilatory phase following sympathetic blockade.

Recent evidence supports these observations. Yousaf et al. (2026) reported that crystalloid preload significantly reduced the incidence of hypotension and vasopressor requirement compared to coload in adults undergoing elective lower abdominal and urologic surgery. [17] In contrast, Baboker et al. (2026) demonstrated in a prospective cohort study that coloading was more effective than preloading in reducing hypotension and vasopressor use during caesarean delivery. [18] The discrepancy highlights physiological differences between obstetric and non-obstetric populations, particularly the increased vascular capacitance and altered haemodynamics in pregnancy.

Although the incidence of hypotension was numerically lower in the coload group (13.3%) compared to the preload group (28.3%), the difference was not statistically significant. This suggests that both strategies are broadly comparable in preventing hypotension. Recent randomised trials confirm this interpretation. Ben Marzouk et al. (2026) reported that cardiac ultrasound-guided preloading reduced hypotension compared with standard coloading, while Tolba et al. (2026) found that both colloid preload and crystalloid coload reduced the incidence of hypotension, but neither eliminated it. [19,20] The lack of statistical significance in our study may be attributed to the sample size and the relatively healthy ASA I–II population, in which severe hypotension is less common.

Adverse effects were minimal, with vomiting being the only symptom observed. Vomiting occurred more frequently in the preload group (18.3%) compared to the coload group (13.3%), but this difference was not significant. Importantly, no serious complications such as bradycardia, desaturation, or pulmonary oedema occurred, underscoring the safety of both fluid strategies. Recent findings by Muralidhar et al. (2025) confirm that while preload and coload are generally safe, mild nausea and vomiting remain the most common adverse effects, with no serious complications reported. [21]

Clinical Implications

The findings suggest that both preload and coload are safe and effective. This has practical implications in resource-limited settings, where minimising vasopressor use and ensuring stable intraoperative blood pressure are critical for patient safety. Given the variability in results across different populations, further multicentric trials are warranted to establish definitive guidelines.

Strengths and Limitations

A key strength of this study is its randomised, double-blind design, which minimises bias. The sample size was adequate, and the study

was conducted in a real-world clinical setting, enhancing external validity. However, limitations include the restriction to ASA I–II patients, which may not generalise to higher-risk populations. Additionally, only crystalloids were studied; colloids or balanced fluid strategies may yield different results. Future research should explore these aspects and include larger, diverse populations.

CONCLUSION

This randomised trial demonstrates that both crystalloid preloading and coloading are safe and effective strategies for managing haemodynamic changes during spinal anaesthesia in inguinal hernioplasty. Preloading provided more consistent blood pressure stability, while coloading showed a numerically lower incidence of hypotension, though not statistically significant. Importantly, no serious adverse events occurred, underscoring the safety of both approaches. Larger multicentric studies across diverse populations are warranted to establish definitive guidelines for fluid management in spinal anaesthesia.

Declaration

Ethical Approval: Approved
Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Kataria AP, Singh H, Mohan B, Thakur M, Jarewal V, Khan S. Intrathecal Nalbuphine versus Ketamine with Hyperbaric Bupivacaine in Lower Abdominal Surgeries. Anesth Essays Res. 2018; 12(2):366–370. doi: 10.4103/aer.AER_3_18
2. Lee JE, George RB, Habib AS. Spinal-induced hypotension: Incidence, mechanisms, prophylaxis, and management: Summarizing 20 years of research. Best Pract Res Clin Anaesthesiol. 2017; 31(1):57-68. doi: 10.1016/j.bpa.2017.01.001.
3. Hofhuizen C, Lemson J, Snoeck M, Scheffer GJ. Spinal anesthesia-induced hypotension is caused by a decrease in stroke volume in elderly patients. Local Reg Anesth. 2019; 12:19-26. doi: 10.2147/LRA.S193925.
4. Ferré F, Martin C, Bosch L, Kurrek M, Lairez O, Minville V. Control of Spinal Anesthesia-Induced Hypotension in Adults. Local Reg Anesth. 2020; 13:39-46. doi: 10.2147/LRA.S240753.
5. Cyna AM, Andrew M, Emmett RS, Middleton P, Simmons SW. Techniques for preventing hypotension during spinal anaesthesia for caesarean section. Cochrane Database Syst Rev. 2006; (4):CD002251. doi: 10.1002/14651858.CD002251.pub2.
6. Chooi C, Cox JJ, Lumb RS, Middleton P, Chemali M, Emmett RS, et al. Techniques for preventing hypotension during spinal anaesthesia for caesarean section. Cochrane Database Syst Rev. 2017; 8(8):CD002251. doi: 10.1002/14651858.CD002251.pub3.
7. Tawfik MM, Hayes SM, Jacoub FY, Badran BA, Gohar FM, Shabana AM, et al. Comparison between colloid preload and crystalloid co-load in cesarean section under spinal anesthesia: a randomized controlled trial. Int J Obstet Anesth. 2014; 23(4):317-23. doi: 10.1016/j.ijoa.2014.06.006.
8. Khan MU, Memon AS, Ishaq M, Aqil M. Preload Versus Coload and Vasopressor Requirement for the Prevention of Spinal Anesthesia Induced Hypotension in Non-Obstetric Patients. J Coll Physicians Surg Pak. 2015;25(12):851-5.
9. 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):1126-1142. doi: 10.1097/EJA.0000000000001371.
10. Artawan IM, Sarim BY, Sagita S, Dedi MAE. Comparison the effect of preloading and coloading with crystalloid fluid on the incidence of hypotension after spinal anaesthesia in caesarean section. Bali J Anaesthesiol. 2020;4(1):3-7. doi: 10.4103/BJOA.BJOA_17_19
11. Ni HF, Liu HY, Zhang J, Peng K, Ji FH. Crystalloid Coload Reduced the Incidence of Hypotension in Spinal Anesthesia for

Cesarean Delivery, When Compared to Crystalloid Preload: A Meta-Analysis. Biomed Res Int. 2017:2017:3462529. doi: 10.1155/2017/3462529.
12. Šklebar I, Bujas T, Habek D. SPINAL ANAESTHESIA-INDUCED HYPOTENSION IN OBSTETRICS: PREVENTION AND THERAPY. Acta Clin Croat. 2019;58(Suppl 1):90-95. doi: 10.20471/acc.2019.58. s1.13.
13. Theodoraki K, Hadzilia S, Valsamidis D, Kalopita K, Stamatakis E. Colloid Preload versus Crystalloid Co-Load in the Setting of Norepinephrine Infusion during Cesarean Section: Time and Type of Administered Fluids Do Not Matter. J Clin Med. 2023;12(4):1333. doi: 10.3390/jcm12041333
14. Gao X, Huang Y, Hu S, Lin C, You Y, Huang S, et al. Effect of combined colloid preloading and crystalloid coloading versus combined colloid and crystalloid coloading on maternal cardiac output during spinal anesthesia for cesarean section under combined prophylactic noradrenaline infusion. Front Med (Lausanne). 2025; 12:1421947. doi: 10.3389/fmed.2025.1421947
15. Du CC, Chen W, Wang H, Guo L, Wang B, Wang YL, et al. Fluid responsiveness-guided individualized strategy for preventing hypotension after spinal anesthesia in cesarean delivery: a randomized trial of prehydration versus norepinephrine preinfusion. BMC Anesthesiol. 2026; 26(1):174. doi: 10.1186/s12871-026-03672-8.
16. Dahal S, Pradhan B, Bhattarai AS, Paudyal SP, Shrestha A, Shrestha GS. Inferior vena cava ultrasound to guide fluid management for prevention of hypotension after spinal anesthesia in a tertiary level teaching hospital. Ann Med Surg (Lond). 2025; 88(1):327-333. doi: 10.1097/MS9.0000000000004449.
17. Yousaf J, Abdullah M, Hanif S, Ullah I, Dar SH, Ullah TR, et al. Comparative analysis of coload and preload in the prevention of spinal anesthesia-induced hypotension. J Health Wellness Clin Res. 2026;4(2): e1228. doi:10.61919/mpzs1m06
18. Baboker P, Demissie H, Assefa E, Tesfaye N, Abebe M, Solomon E, et al. Comparison of crystalloid preloading and co-loading for the prevention of spinal induced-hypotension in elective cesarean delivery: a prospective cohort study. Ann Med Surg (Lond). 2026; 88(6):3085-3090. doi: 10.1097/MS9.0000000000005010.
19. Ben Marzouk S, Fouzai B, Dhraief N, Ben Amor F, Hkiri T, Hamdi H, et al. Cardiac ultrasound-guided crystalloid preloading before spinal anesthesia vs. standard coloading for scheduled cesarean delivery: a randomized controlled trial. Int J Obstet Anesth. 2026; 66:104840. doi: 10.1016/j.ijoa.2025.104840.
20. Tolba MA, Abaalkhayl M, Alkhuraif RA, Alobaid AF, Aldubayan RS, Alotaibi NS. Transthoracic echocardiographic evaluation of maternal cardiac output: colloid preload versus crystalloid coload during cesarean delivery under spinal anesthesia: randomized clinical trial. BMC Anesthesiol. 2026; 26(1):247. doi: 10.1186/s12871-026-03702-5.
21. Muralidhar H, Sheelavantar J, Wali S. Study of requirement of vasopressors and side effects of preloading versus co-loading using crystalloids and colloids during elective LSCS under spinal anaesthesia. Int J Med Pharm Res. 2025;6(4):1712-8.

How to cite this article: Saha A, Bhattacharya A, Saha S, Chaudhuri K. Crystalloid Preloading versus Coloading for prevention of spinal anaesthesia induced hypotension in inguinal hernioplasty. *Int J Health Sci Res.* 2026; 16(9):1-11. DOI: *10.52403/ijhsr.20260901*

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