



Comparative Efficacy of Ringer's Lactate and 6% Hydroxyethyl Starch Preloading for Hemodynamic Stability During Lower-Limb Surgery Under Subarachnoid Block: A Prospective Randomized Study.

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Abstract

Background: Hypotension is one of the most frequent hemodynamic consequences of subarachnoid block. Sympathetic blockade produces peripheral vasodilatation and venous pooling, thereby reducing venous return and cardiac output. Intravenous fluid preloading is commonly employed to attenuate these changes, although the comparative effectiveness of crystalloids and colloids remains clinically relevant. **Objective:** To compare the hemodynamic effects of preloading with 500 mL Ringer's lactate and 500 mL 6% hydroxyethyl starch in patients undergoing lower-limb surgery under subarachnoid block and to assess intraoperative hypotension, intravenous fluid requirement, vasopressor requirement, and adverse effects. **Materials and Methods:** This prospective randomized study included 100 patients aged 18–55 years with American Society of Anesthesiologists (ASA) physical status I or II undergoing elective or emergency lower-limb surgery under spinal anaesthesia. Patients were allocated into two groups of 50 each. Group A received 500 mL Ringer's lactate, while Group B received 500 mL 6% hydroxyethyl starch 30 minutes before subarachnoid block. Subarachnoid block was performed using 3 mL of 0.5% hyperbaric bupivacaine. Heart rate and arterial pressure were monitored serially. Between-group comparisons were performed using the t-test and chi-square test, with $P < 0.05$ considered statistically significant. **Results:** Baseline characteristics and preoperative hemodynamic variables were comparable between groups. Following spinal anaesthesia, Group A demonstrated greater reductions in blood pressure than Group B. At 20 minutes, mean systolic blood pressure was 94.04 ± 6.90 mmHg in the RL group compared with 120.64 ± 8.39 mmHg in the HES group ($P = 0.001$). Mean arterial pressure at 15 minutes was 73.58 ± 5.76 versus 90.50 ± 5.31 mmHg, respectively ($P = 0.001$). Total intravenous fluid requirement was significantly greater with RL (1625 ± 256.80 mL) than with HES (1501.16 ± 235.90 mL; $P = 0.014$), while mean vasopressor usage was 1.46 ± 1.22 versus 0.62 ± 0.86 , respectively ($P < 0.001$). Vomiting occurred in 12 patients receiving RL and none receiving HES ($P < 0.001$). **Conclusion:** In this study population, preloading with 500 mL 6% HES provided greater hemodynamic stability than an equal volume of Ringer's lactate, with lower fluid and vasopressor requirements and fewer episodes of vomiting.

Keywords: Subarachnoid block; spinal anaesthesia; Ringer's lactate; hydroxyethyl starch; preloading; hypotension; hemodynamic stability.



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INTRODUCTION

Subarachnoid block is widely employed for lower abdominal and lower-limb procedures because it is relatively simple to perform and provides rapid onset, dense sensory blockade, motor blockade, and satisfactory operating conditions. Despite these advantages, hypotension remains an important physiological consequence of spinal anaesthesia. The sympathetic blockade produced by intrathecal local anaesthetic causes arterial and venous vasodilatation, peripheral pooling of blood, decreased venous return, and a consequent reduction in cardiac output and arterial pressure. The dissertation notes that hypotension after subarachnoid block may occur with an incidence of up to 80%. Clinically significant hypotension may be associated with nausea, vomiting, dizziness, syncope and cardiac rhythm disturbances. Therefore, maintenance of adequate intravascular volume and arterial pressure is an important component of perioperative management during spinal anaesthesia. Intravenous fluid loading before administration of spinal anaesthesia, commonly termed preloading, has traditionally been used to reduce the magnitude of spinal-induced hypotension.

Crystalloids such as Ringer's lactate are inexpensive, readily available and widely used. However, because crystalloids redistribute relatively rapidly from the intravascular compartment into the interstitial space, their intravascular volume-expanding effect may be relatively short-lived. Larger crystalloid volumes may consequently be required to maintain adequate circulating volume.

Colloid solutions have greater intravascular persistence and therefore may theoretically provide more sustained plasma-volume expansion. Hydroxyethyl starch is a synthetic colloid that has been investigated as a preload for prevention of spinal-anaesthesia-associated hypotension. Earlier studies cited in the dissertation have produced differing results regarding the superiority of colloids over crystalloids. For example, Sharma et al. reported hypotension in 52% of patients receiving Ringer's lactate compared with 16% receiving 6% hetastarch, together with greater vasopressor requirements in the crystalloid group. Other investigations, however, have found smaller or no clinically meaningful differences between fluid strategies. Considering this continuing uncertainty, the present study was undertaken to compare an equal volume of Ringer's lactate and 6% hydroxyethyl starch administered as preload in patients undergoing lower-limb surgery under subarachnoid block. The primary focus was on perioperative hemodynamic stability, while fluid requirement, vasopressor use and adverse events were also evaluated.

MATERIALS AND METHODS

This prospective, randomized, hospital-based study was conducted at Vilasrao Deshmukh Government Medical College and Hospital, a tertiary-care centre, between July 2022 and July 2024 after institutional ethics committee approval. One hundred patients aged 18–55 years undergoing elective or emergency lower-limb surgery under spinal anaesthesia were included. Patients with ASA physical status I or II, normal cardiorespiratory status, adequate fasting status and normal renal function who provided written informed consent were eligible. Patients refusing participation, those with known allergy to RL or 6% HES, ASA status above II, bleeding disorders or anticoagulant therapy, and significant cardiovascular, respiratory, hepatic or renal disease were excluded.

Patients were randomly allocated into two equal groups:

- Group A (n=50): 500 mL Ringer's lactate administered as preload 30 minutes before spinal anaesthesia.
 - Group B (n=50): 500 mL 6% hydroxyethyl starch administered as preload 30 minutes before spinal anaesthesia.
- Following preloading, subarachnoid block was performed in the sitting position under aseptic precautions at the L3–L4 or L4–L5 intervertebral space using a 25-G Quincke spinal needle. Three millilitres of 0.5% hyperbaric bupivacaine was administered intrathecally. Patients were subsequently placed supine, and an adequate sensory block to approximately T8 was confirmed by pinprick testing.

Heart rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure were monitored every 5 minutes during the first 30 minutes and every 30 minutes thereafter until completion of surgery, with observation extending to approximately three hours. Hypotension was treated by increasing intravenous fluid administration and administering bolus vasopressor until blood pressure returned to within 80% of the baseline value. Patients were also monitored for nausea, vomiting, respiratory depression, bleeding, allergic reactions, pruritus and bradycardia. Data were compiled in Microsoft Excel. Continuous variables were summarized using mean and standard deviation and categorical variables using frequencies and percentages. Intergroup continuous-variable comparisons were performed using the t-test, while categorical variables were compared using the chi-square test. A P value <0.05 was considered statistically significant.

RESULTS

All 100 patients completed the study, with 50 participants in each treatment group. The two groups were comparable regarding demographic characteristics, type and duration of surgery, thereby reducing the likelihood that baseline differences accounted for the observed hemodynamic findings.

Table 1. Selected perioperative hemodynamic parameters

Parameter	Time	RL Group	HES Group	P value
Heart rate (beats/min)	Preoperative	97.34±15.33	93.00±14.59	0.150
Heart rate	10 min	101.20±13.88	93.54±14.19	0.008
Heart rate	20 min	97.68±12.36	88.54±10.54	0.001
SBP (mmHg)	Preoperative	121.04±10.14	119.84±12.55	0.201
SBP	10 min	96.84±7.43	131.16±3.41	0.001
SBP	20 min	94.04±6.90	120.64±8.39	0.001
MAP (mmHg)	Preoperative	90.30±9.07	88.30±9.56	0.294
MAP	15 min	73.58±5.76	90.50±5.31	0.001
MAP	30 min	75.22±8.74	77.18±7.31	0.049

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The baseline heart rate, SBP and MAP were not significantly different. After spinal anaesthesia, significant between-group differences emerged during the early intraoperative period. The RL group demonstrated a more pronounced fall in SBP and MAP, whereas blood pressure was better maintained in the HES group.

Table 2. Intravenous fluid and vasopressor requirements

Variable	RL Group	HES Group	P value
Total IV fluid requirement (mL)	1625±256.80	1501.16±235.90	0.014
Vasopressor usage	1.46±1.22	0.62±0.86	<0.001

Both outcomes were significantly greater in the RL group. Greater vasopressor usage in the RL group was interpreted as reflecting a higher frequency of recurrent hypotensive episodes.

Table 3. Incidence of vomiting

Vomiting	RL Group (n=50)	HES Group (n=50)
Yes	12 (24%)	0
No	38 (76%)	50 (100%)

Pearson $\chi^2 = 13.636$; $P < 0.001$

Vomiting occurred in 12 patients in the RL group and none in the HES group. The dissertation reports that vomiting was predominantly associated with hypotension. No allergic reactions, excessive bleeding or other major adverse effects were observed.

DISCUSSION

The present study demonstrated better preservation of intraoperative hemodynamic parameters after preloading with 500 mL of 6% HES than after an equal volume of Ringer's lactate in patients undergoing lower-limb surgery under spinal anaesthesia. Although the groups had similar baseline hemodynamic characteristics, significant differences in SBP, MAP and heart rate emerged after establishment of the subarachnoid block.

The physiological basis for these observations is consistent with the different intravascular behavior of crystalloids and colloids. Ringer's lactate rapidly distributes into the extracellular compartment, reducing the duration and magnitude of its intravascular volume-expanding effect. HES, being a colloid, has greater intravascular persistence. Consequently, an equivalent volume may provide a more sustained increase in effective circulating volume during the period of sympathectomy produced by spinal anaesthesia. This mechanism is consistent with the rationale described in the dissertation.

The present findings are broadly consistent with the study by Sharma et al., in which hypotension occurred in 52% of patients receiving Ringer's lactate compared with 16% receiving 6% hetastarch. Vasopressor requirement was also greater in the RL group. Similarly, studies summarized in the dissertation reported greater hemodynamic stability with colloid-based preloading in several clinical populations.

A particularly relevant finding in the present study was the significantly greater requirement for additional intravenous fluid in the RL group. The mean total fluid requirement was approximately 1625 mL with RL compared with 1501 mL with HES. Vasopressor usage was also more than twice as high numerically in the RL group. These findings provide additional support for the observed difference in blood-pressure stability.

The difference in adverse effects was also notable. Twelve patients in the RL group developed vomiting, compared with none in the HES group. Since nausea and vomiting during spinal anaesthesia may accompany hypotension, improved maintenance of arterial pressure could plausibly explain this finding.

Nevertheless, the findings should be interpreted within the context of the study population and protocol. The study was conducted at a single tertiary-care institution, involved 100 relatively healthy ASA I–II adults, and compared fixed 500-mL volumes. Therefore, extrapolation to elderly patients, critically ill patients, obstetric populations or individuals with substantial renal, cardiovascular or hepatic disease should be cautious. Furthermore, contemporary decisions regarding HES require consideration not only of short-term hemodynamic efficacy but also of its overall safety profile and patient-specific contraindications.

CONCLUSION

Among the patients studied, preloading with 500 mL of 6% hydroxyethyl starch provided greater intraoperative hemodynamic stability than 500 mL of Ringer's lactate before subarachnoid block for lower-limb surgery. The HES group demonstrated better maintenance of arterial pressure, lower additional intravenous fluid requirements, lower vasopressor

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use and fewer episodes of vomiting. These results support the superior short-term volume-expanding effect of HES under the specific conditions of this study. However, the choice of intravenous fluid in current clinical practice should also account for the patient's comorbidities and the established safety considerations associated with synthetic starch solutions.

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