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Original Research Article

Comparison of Effect of 6% Hydroxyethyl Starch versus Ringer Lactate on Blood Sugar Level during Lower Limb Surgery under Subarachnoid Block: A Prospective Randomised Interventional Study

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Abstract

Introduction: Ringer's Lactate (RL) is commonly used to prevent hypotension during subarachnoid block (SAB). Hydroxyethyl Starch (HES), a synthetic colloid, provides greater volume expansion but may affect blood glucose levels. As perioperative hyperglycemia can worsen surgical outcomes, this study compared the effects of 6% HES and RL on intraoperative blood glucose and hemodynamic parameters in non-diabetic patients undergoing lower limb surgery under SAB.

Materials and Methods: Ninety ASA I–II non-diabetic adults were randomly assigned to two groups: Group A received 6% HES 130/0.4 (n=45) and Group B received RL (n=45), administered as co-loading fluids at 20 mL/kg after SAB. Blood glucose levels and vital parameters (blood pressure, heart rate, and SpO_2) were recorded at baseline and at 15, 30, 45, 60, 120, and 150 minutes intraoperatively.

Results: Blood glucose increased significantly from baseline in both groups. The RL group showed an earlier peak (~90 mg/dL at 45 min) with values returning to baseline by 150 minutes, whereas the HES group demonstrated a gradual rise, peaking at 60 minutes and remaining mildly elevated at 150 minutes. Intergroup differences were significant at several time points ($p<0.05$). Hemodynamic parameters showed no significant differences between groups ($p>0.05$).

Conclusion: In non-diabetic patients undergoing SAB, 6% HES produces a more prolonged mild increase in blood glucose compared with RL, although both fluids maintain similar hemodynamic stability.

Keywords: Hydroxyethyl Starch; Ringer's Lactate; Subarachnoid Block; Blood Glucose; Hemodynamic Stability.

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Introduction

Hypotension following spinal anesthesia is a common clinical problem caused by sympathetic blockade, which leads to arterial and venous vasodilatation, decreased systemic vascular resistance, and reduced venous return. Intravenous fluid administration is therefore widely used to prevent these hemodynamic changes.

Both crystalloids and colloids are commonly administered as preloading or co-loading fluids to reduce hypotension after central neuraxial blockade [1].

Ringer lactate (RL), a balanced crystalloid solution, is widely used due to its physiological electrolyte composition, safety profile, and cost-effectiveness. Colloids are also recommended in several resuscitation guidelines for rapid intravascular volume expansion [2,3]. Hydroxyethyl starch (HES), a synthetic colloid, provides prolonged intravascular volume expansion because of its large ethylated glucose polymers, which are metabolized by serum amylases into smaller molecules and glucose residues. Surgical stress and catecholamine release may accelerate this degradation, potentially increasing blood glucose levels [4].

The surgical stress response itself can induce hyperglycemia through neuroendocrine activation involving catecholamines, cortisol, and glucagon, and excessive perioperative hyperglycemia may impair wound healing and increase infection risk [5]. Although both RL and HES are widely used for maintaining hemodynamic stability, their metabolic effects may differ [6–11].

Therefore, this study aimed to compare the effects of 6% hydroxyethyl starch and Ringer lactate on perioperative blood glucose levels and hemodynamic parameters in patients undergoing lower limb surgery under subarachnoid block [10,12].

Methods

This hospital-based prospective randomized double-blinded interventional study was conducted in the orthopedic operation theatres of the Department of Anesthesiology, Sawai Man Singh Medical College, Jaipur, after approval from the Institutional Ethics Committee. The study was carried out until completion of the required sample size.

Ninety patients aged 20–60 years, belonging to American Society of Anesthesiologists (ASA) physical status I–II, scheduled for elective lower limb surgery under subarachnoid block were enrolled. Non-diabetic patients with body mass index less than 30 kg/m² who provided written informed consent were included. Patients with diabetes mellitus, pregnancy, chronic renal or liver disease, cardiac disease, coagulation disorders, low hematocrit (packed cell volume <30%), regular steroid or ascorbic acid intake, substance abuse, or anticipated surgery duration exceeding three hours were excluded.

Sample size was calculated at 80% power and 5% alpha error, assuming a standard deviation of 8.64 mg/dl and a minimum detectable difference of 5.59 mg/dl in blood glucose levels. A minimum of 40 patients per group was required, which was increased to 45 per group to account for possible attrition, resulting in a total sample size of 90 patients.

Patients were randomized using sealed envelope technique into two equal groups. Group A received intravenous preloading with 20 ml/kg of 6% hydroxyethyl starch, while Group B received 20 ml/kg of Ringer lactate. Patients were blinded to group allocation.

All patients underwent preanesthetic evaluation including medical history, physical examination, airway assessment, and routine laboratory investigations. In the operating theatre, standard monitoring including electrocardiography, non-invasive blood pressure, and pulse oximetry was instituted. Baseline heart rate, blood pressure, oxygen saturation, and capillary blood glucose levels were recorded.

Subarachnoid block was performed under aseptic precautions using a 25-gauge spinal needle with 15 mg of 0.5% hyperbaric bupivacaine. After achieving adequate sensory and motor block, surgery was commenced. Intraoperative monitoring included heart rate, systolic and diastolic blood pressure, mean arterial pressure, oxygen saturation, and blood glucose levels recorded at 15, 30, 45, 60, 120, and 150 minutes. Normal saline was used as maintenance fluid throughout the procedure.

Statistical Analysis: All data were entered into Microsoft Excel and analyzed using Epi Info version 7.2.1.0. Categorical variables were expressed as frequencies and percentages and analyzed using the chi-square test. Continuous variables were presented as mean ± standard deviation and compared using the independent sample t-test. A p value <0.05 was considered statistically significant.

Results

A total of 90 patients were analyzed (45 in Group A: HES; 45 in Group B: RL). Baseline characteristics were comparable between groups. The mean age was 41.22 ± 11.11 years in Group A and 40.91 ± 12.35 years in Group B ($p = 0.900$). Sex distribution (64.4% vs 53.3% males, $p = 0.28$), body mass index (24.78 ± 3.25 vs 23.63 ± 3.51 kg/m², $p = 0.111$), ASA grade distribution (57.8% ASA I and 42.2% ASA II in both groups, $p = 0.831$), baseline blood glucose (81.8 ± 4.4 vs 82.6 ± 4.4 mg/dL, $p = 0.417$), and duration of surgery (93.2 ± 18.2 vs 89.8 ± 18.0 min, $p = 0.37$) were similar, indicating well-matched groups.

Blood Glucose Levels: Both groups showed a significant rise in blood glucose from baseline after spinal anesthesia and fluid loading ($p < 0.05$). In the RL group, glucose increased rapidly, peaking at 45 minutes (90.22 ± 5.63 mg/dL), then gradually declined toward baseline by 150 minutes (~83 mg/dL). In contrast, the HES group demonstrated a slower but sustained increase, peaking at 60 minutes (90.24 ± 5.99 mg/dL) and remaining mildly elevated at 150 minutes (87.5 ± 5.8 mg/dL). Intergroup differences were significant at several time points, including 30 min ($p = 0.037$), 45 min ($p = 0.027$), 60 min ($p = 0.005$), 120 min ($p = 0.002$), and 150 min ($p = 0.002$), indicating an earlier peak with RL and a more prolonged elevation with HES.

Figure 1: Trend of intraoperative capillary blood glucose levels (mg/dL) over time in the two groups (mean values). The RL group (orange line) shows a prompt rise and earlier peak at 45 min followed by a decline toward baseline, whereas the HES group (yellow line) exhibits a slower rise with a later peak at 60 min and a more gradual return toward baseline. Error bars (SD) omitted for clarity. Both

fluids caused only modest changes in glucose, remaining within normal range in all patients.

The results showed a significant interaction between fluid type and time on blood glucose levels. Initially, the RL group had slightly higher glucose values, but after 60 minutes the HES group demonstrated higher levels. Although statistically significant at some intervals, the differences were small (approximately 3–5 mg/dL). Importantly, blood glucose remained within the normal physiological range (<150 mg/dL) in all patients. Thus, HES produced a more prolonged mild elevation in blood sugar compared with RL, without clinically significant hyperglycemia.

Hemodynamic Parameters: Intraoperative hemodynamic variables were well maintained in both groups. There were no significant differences between groups in systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), or heart rate (HR) at any time point ($p > 0.05$). Baseline SBP was approximately 123 mmHg in both groups, with similar trends throughout surgery. Both groups showed a mild transient decrease in SBP (about 5–7%) after spinal anesthesia, with comparable recovery by 60 minutes. Likewise, DBP and MAP values remained stable and comparable between groups throughout the intraoperative period.

Figure 2 (below) illustrates that blood pressure remained stable in both groups without hypotensive episodes requiring treatment. Diastolic blood pressure showed similar trends in both groups with no significant differences at any time point (e.g., 15 min: 70.9 ± 7.1 mmHg in HES vs 73.4 ± 10.3 mmHg in RL, $p = 0.179$). Heart rate increased mildly after spinal anesthesia in both groups but remained within normal limits. Baseline HR was ~76–77 bpm, rising slightly at 15 minutes and gradually returning to ~74–75 bpm by 150 minutes, with no significant intergroup differences. Oxygen saturation remained stable (>99%) throughout the procedure in all patients.

No severe hypotension (SBP <90 mmHg) occurred after fluid loading. Mild hypotension requiring a single dose of mephentermine occurred in 4 patients in the HES group and 5 in the RL group ($p = 1.0$). Bradycardia requiring atropine occurred in one patient in each group.

No spinal anesthesia–related complications, allergic reactions, or significant differences in urine output or blood loss were observed, and no patient required blood transfusion. Overall, both 6% HES and Ringer's Lactate maintained comparable hemodynamic stability during subarachnoid block for lower limb surgery. The only notable difference was in blood glucose trends, with HES producing a slightly delayed and more prolonged rise compared with RL.

Table 1: Intraoperative Systolic Blood Pressure (SBP) at key time points (Mean ± SD).

Time point	HES Group (SBP mmHg)	RL Group (SBP mmHg)	p-value
Baseline (0 min)	123.1 ± 6.9	122.7 ± 8.0	0.832
15 min	115.6 ± 8.4	117.8 ± 9.8	0.258
30 min	116.9 ± 8.2	115.7 ± 9.1	0.536
45 min	118.6 ± 11.1	115.9 ± 8.9	0.209
60 min	119.0 ± 10.6	116.0 ± 10.0	0.171
120 min	120.9 ± 12.5	118.5 ± 7.8	0.283
150 min	121.0 ± 13.1	118.4 ± 9.3	0.284

(There were also no inter-group differences in DBP, MAP, or HR at corresponding time points; data not shown for brevity. SpO_2 remained 99–100% in both groups throughout.)

Summary of Key Findings: Co-loading with 6% HES caused a slightly more prolonged rise in blood glucose compared with RL, although values remained within normal limits in this non-diabetic population. Both fluids were equally effective in maintaining hemodynamic stability during subarachnoid block, with no significant differences in blood pressure or heart rate. No fluid-related adverse events were observed. Overall, HES 130/0.4 was as effective as RL for preventing SAB-induced hypotension, with only a minor, clinically insignificant difference in glucose levels.

Discussion

In this randomized study of non-diabetic surgical patients, 6% HES and Ringer's Lactate (RL), administered as equal-volume co-loads during subarachnoid block (SAB), produced similar hemodynamic outcomes but different blood glucose patterns. Both fluids effectively prevented significant hypotension after spinal anesthesia, supporting previous findings that adequate volume loading with either crystalloids or colloids stabilizes hemodynamics. The main difference observed was in blood glucose response: HES produced a slower but more prolonged rise in glucose compared with RL. Although statistically significant differences were observed at several time points, the magnitude was small (approximately 3–4 mg/dL) and clinically insignificant, as no patient developed hyperglycemia or required intervention.

Hemodynamic Effects: Our finding that HES and RL provided comparable blood pressure stability is consistent with previous studies. Singh et al. and Chakraborty et al. also reported no significant difference in the incidence of hypotension when comparing RL and HES as preload fluids for spinal anesthesia in general surgical patients. In the present study, only mild hypotension occurred and at similar frequencies in both groups, likely due to the relatively large volume of fluid (20 mL/kg) administered. This suggests that when given in adequate volume, RL can be as effective as HES in maintaining blood pressure during SAB. In contrast, studies in obstetric populations have shown some advantages of colloids. Siddik et al. and Mercier et al. reported reduced hypotension and vasopressor requirements with HES compared with RL in cesarean patients . Such differences may be more pronounced in pregnant patients due to increased vasodilation and aortocaval compression. In our non-obstetric cohort, however, RL maintained hemodynamic stability comparable to HES. Heart rate trends were also similar in both groups, indicating adequate intravascular volume status.

Blood Glucose Changes: The unique aspect of this study was the serial measurement of blood glucose levels, which demonstrated different temporal patterns between RL and HES. RL produced a slightly earlier rise in glucose at 30–45 minutes, possibly due to lactate metabolism through the Cori cycle, where lactate is converted to glucose in the liver. RL contains lactate that can serve as a gluconeogenic substrate, potentially explaining this early increases.

In contrast, HES consists of large glucose polymers that require enzymatic degradation by serum amylases before releasing glucose residues. Consequently, glucose levels in the HES group increased more gradually, peaking later (around 60 minutes) and remaining mildly elevated for a longer period.

This pattern is consistent with the pharmacokinetics of tetrastarch, where partial degradation occurs over time . Despite these differences, all glucose values remained within the physiological range (approximately 80–95 mg/dL). These findings align with previous studies by Patki et al., Imran et al., and Jung et al., which reported no clinically significant changes in blood glucose with colloid use during surgery.

Clinical Implications: For healthy non-diabetic patients undergoing surgery under SAB, both HES and RL appear safe and effective as co-loading fluids. Our results suggest that HES does not produce clinically significant hyperglycemia, with maximum glucose levels remaining well within normal limits. However, caution may be warranted in patients with impaired glucose tolerance or diabetes, where even small elevations could be relevant. From a hemodynamic perspective, either fluid can be used effectively, with HES offering the advantage of achieving intravascular expansion with smaller volumes, while RL may be preferred in patients at risk of renal dysfunction or coagulopathy. Overall, both fluids provided stable intraoperative conditions without adverse effects in this study population.

Limitations: This study has several limitations. It evaluated only short-term intraoperative effects, and postoperative glucose or insulin levels were not assessed. The sample included only relatively healthy, non-diabetic patients from a single center with a moderate sample size, which may limit generalizability. Additionally, hormonal stress markers such as cortisol or insulin were not measured to explain the observed glucose changes.

Conclusion

In conclusion, co-loading with 6% hydroxyethyl starch (HES) and Ringer Lactate (RL) during spinal anesthesia provides comparable hemodynamic stability in non-diabetic patients. Both fluids effectively maintained blood pressure and heart rate without significant differences in hypotension or vasopressor requirement. HES produced a slightly delayed and more prolonged rise in blood glucose compared to RL, though all values remained within normal physiological limits. Thus, both fluids are safe and effective for SAB, with cautious use of HES recommended in patients at risk of hyperglycemia.

References

1. Dong WH, Yan WQ, Song X, Zhou WQ, Chen Z. Fluid resuscitation with balanced crystal loids versus normal saline in critically ill patie nts: a systematic review and meta-analysis. Scand J Trauma Resusc Emerg Med. 2022; 30(1):28. DOI: 10.1186/s13049-022-01015-3.
2. Nicholson JP, Wolmarans MR, Park GR. The role of albumin in critical illness. Br J Anaesth. 2000; 85(4):599–610. DOI: 10.1093/bja/85. 4.599.
3. Raghunathan K, Murray PT, Beattie WS, et al. Choice of fluid in acute illness: what should be given? An international consensus. Br J Anaesth. 2014; 113(5):772–783. DOI: 10.109 3/bja/aeu301.
4. Caironi P, Tognoni G, Masson S, et al. Albumin replacement in patients with severe sepsis or septic shock. N Engl J Med. 2014; 370(15):1412–1421. DOI: 10.1056/NEJMoa1 305727.

5. Schortgen F, Lacherade JC, Bruneel F, et al. Effects of hydroxyethyl starch and gelatin on renal function in severe sepsis: a multicentre randomized study. Lancet. 2001; 357(9260):91 1–916. DOI: 10.1016/S0140-6736(00)04211-2.
6. Van der Linden P, James M, Mythen M, Weiskopf RB. Safety of modern starches used during surgery. Anesth Analg. 2013; 116(1):35–48. DOI: 10.1213/ANE.0b013e318 27175da.
7. Mutter TC, Ruth CA, Dart AB. Hydroxyethyl starch (HES) versus other fluid therapies: effects on kidney function. Cochrane Database Syst Rev. 2013;(7):CD007594. DOI: 10.1002/ 14651858.CD007594.pub3.
8. Perner A, Haase N, Guttormsen AB, et al. Hyd roxyethyl starch 130/0.42 versus Ringer's acet ate in severe sepsis. N Engl J Med. 2012; 367(2):124–134. DOI: 10.1056/NEJMoa120 4242.
9. Brunkhorst FM, Engel C, Bloos F, et al. Intensive insulin therapy and pentastarch resuscitation in severe sepsis. N Engl J Med. 2008; 358(2):125–139. DOI: 10.1056/NEJ Moa070716.
10. Gattas DJ, Dan A, Myburgh J, et al. (CHEST Management Committee). Fluid resuscitation with 6% hydroxyethyl starch (130/0.4) in acutely ill patients: systematic review of effects on mortality and treatment with renal replacement therapy. Intensive Care Med. 2013; 39(4):558–568. DOI: 10.1007/s00134-013-2840-0.
11. Yunos NM, Bellomo R, Hegarty C, Story D, Ho L, Bailey M. Association between a chloride-liberal vs chloride-restrictive intravenous fluid strategy and kidney injury in critically ill adults. JAMA. 2012; 308(15):1 566–1572. DOI: 10.1001/jama.2012.13356.
12. Ertmer C, Rehberg S, Van Aken H, Westphal M. Relevance of non-albumin colloids in intensive care medicine. Best Pract Res Clin Anaesthesiol. 2009; 23(2):193–212. DOI: 10.1016/j.bpa.2008.11.001.
13. Siddik SM, Aouad MT, Kai GE, Sfeir MM, Baraka AS. Hydroxyethyl starch 10% is superior to Ringer's solution for preloading before spinal anesthesia for Cesarean section. Can J Anesth. 2000; 47(7):616–621. DOI: 10.1007/BF03018992.
14. Zorko N, Kamenik M, Starc V. The effect of Trendelenburg position, lactated Ringer's solution and 6% hydroxyethyl starch solution on cardiac output after spinal anesthesia. Anesth Analg. 2009; 108(2):655–659. DOI: 10.1213/ane.0b013e31818ec9e5.
15. Patki A, Shelgaonkar V. Effect of 6% hydroxyethyl starch-450 and low molecular weight dextran on blood sugar levels during surgery under subarachnoid block: a prospective randomized study. Indian J Anaesth. 2010; 54(5):448–452. DOI: 10.4103/ 0019-5049.71045.
16. Fathi M, Imani F, Joudi M, Goudarzi V. Comparison between the effects of Ringer's lactate and hydroxyethyl starch on hemodynamic parameters after spinal anesthesia: a randomized clinical trial. Anesthesiol Pain Med. 2012; 2(3):127–133. DOI: 10.5812/aapm.7850.
17. Azevedo VLF de, Santos PSS, Oliveira Júnior GSD, et al. The effect of 6% hydroxyethyl starch vs Ringer's lactate on acute kidney injury after renal ischemia in rats. Acta Cir Bras. 2013; 28(1):5–9. DOI: 10.1590/S0102-86502013000100002.
18. Mercier FJ, Diemunsch P, Ducloy-Bouthors AS, et al. 6% Hydroxyethyl starch (130/0.4) vs Ringer's lactate preloading before spinal anesthesia for Caesarean delivery: the randomized, double-blind, multicentre CAESAR trial. Br J Anaesth. 2014; 113(3):459–467. DOI: 10.1093/bja/aeu103.
19. Imran D, Padmanabha S, Rehman F, Sahoo D. A comparative study of preloading efficacy of Ringer's lactate vs 6% Heta starch solutions in preventing hypotension following spinal anesthesia. IOSR J Dent Med Sci. 2014; 13(3):43–48. DOI: 10.9790/0853-13324348.
20. Matsota P, Karakosta A, Pandazi A, et al. The effect of 0.5 L 6% hydroxyethyl starch (130/0.42) versus 1 L Ringer's lactate preload on the hemodynamic status of parturients undergoing spinal anesthesia for elective cesarean delivery using arterial pulse contour analysis. J Anesth. 2015; 29(3):352–359. DOI: 10.1007/s00540-014-1926-3.
21. Narayanan SV, Mubarack AM, Iniya R, Rajalekshmi M. Comparison of the effects of preloading with 6% hydroxyethyl starch 130/ 0.4 versus Ringer lactate in preventing spinal anesthesia–induced hypotension in Caesarean section. Indian J Clin Anaesth. 2016; 3(3):39 3–399. DOI: 10.5958/2394-4994.2016.00068. 8.
22. Singh B. Comparative study of preloading with Ringer lactate vs 6% hexa starch solutions to prevent hypotension following spinal anesthesia in elective surgery. Int J Med Dent Sci. 2016; 5(2):1178–1184. DOI: 10.19056/ij mdsjssmes/2016/v5i2/100603.
23. Jung KT, Shim SB, Choi WY, An TH. Effect of hydroxyethyl starch on blood glucose levels. Korean J Anesthesiol. 2016; 69(4):350–354. DOI: 10.4097/kjae.2016.69.4.350.
24. Yaghobi S, Alirezaei AH, Bakhtiyari M, Khezri MB, Massoudi N. The effects of 6% hydroxyethyl starch compared with normal saline on controlling undesirable hemody namic changes following spinal anesthesia in patients undergoing orthopedic surgery: a

randomized clinical trial. J Cell Mol Anesth. 2017; 2(4):[online] (no pagination). DOI: 10.22037/jcma.v2i4.18532.

25. Daklalah LK, Alshiyyab OM, Kassawneh JM. Comparison between hydroxyethyl starch and Ringer's lactate preloading solutions in elective inguinal hernia repair under subarachnoid block anesthesia. J R Med Serv. 2017; 24(1):64–67. DOI: 10.12816/0034772.
26. Singh TM, Linus L. Comparative study of Ringer's lactate solution and 6% hydroxyethyl starch solution as pre-loading fluid for prevention of hypotension following spinal anesthesia. Int J Res Med Sci. 2017; 5(2):415–421. DOI: 10.18203/2320-6012.ijrms20170023.
27. Chakraborty J, Mandal U. Comparative study of hemodynamic changes between 6% hydroxyethyl starch 130/0.4 and Ringer lactate co-loading in elderly patients undergoing lower limb orthopedic surgery under spinal anesthesia. Int J Med Biomed Stud. 2019; 3(6):[online]. DOI: 10.32553/ijmbs.v3i6.289.
28. Sultan A, Abd Al-Karem H, Said AM, El-Garhy AM. Effect of colloid vs crystalloid preload on hemodynamic stability in elderly patients undergoing lower limb orthopedic surgery under spinal anesthesia. Al-Azhar Med J. 2021; 50(2):1271–1280. DOI: 10.21608/amj.2021.158299.
29. Kottayil S, Mary AJ, Shenoy M. Comparative study of Ringer's lactate and 6% hydroxyethyl starch as preloading fluid for prevention of hypotension following subarachnoid block. Glob J Res Anal. 2022; 11(2):60–62. DOI: 10.36106/gjra/6209116.
30. Pratyusha AC, Prasad ChRK, Rajasekhar M, Ranganathan G. Evaluation of perioperative renal function in elderly patients with administration of hydroxyethyl starch (130/0.4) in below-umbilicus orthopedic surgery – a randomized controlled trial. Indian J Anaesth. 2023; 67(5):463–466. DOI: 10.4103/ija.ija_626_22.
31. Cho SY, An TH, Shim SB, Lee M, Jung KT. The effect of 6% hydroxyethyl starch 130/0.4 preloading on the blood glucose levels in diabetic patients undergoing orthopedic surgery with spinal anesthesia: a randomized pilot study. Anesth Pain Med (Seoul). 2023; 18(2):139–147. DOI: 10.17085/apm.22246.