e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(11); 14-17

Original Research Article

Comparison of Intrathecal Isobaric and Hyperbaric Bupivacaine in Patients Undergoing Lower Abdominal Surgery: A Prospective, Randomized, Double-Blind Study

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Received: 01-08-2026 / Revised: 15-09-2026 / Accepted: 21-10-2026

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Conflict of interest: Nil

Abstract

Background: Baricity influences how intrathecal bupivacaine spreads and how long the block lasts. We compared isobaric and hyperbaric bupivacaine for spinal anaesthesia in lower abdominal surgery.

Methods: In this prospective, randomized, double-blind study, 60 ASA I-II adults (18-60 years) scheduled for elective lower abdominal surgery received 3.5 mL (17.5 mg) of 0.5% isobaric (Group I, n=30) or hyperbaric (Group H, n=30) bupivacaine at L3-L4 or L4-L5. The primary outcome was duration of effective analgesia (time to first rescue analgesic). Secondary outcomes were sensory and motor block characteristics, haemodynamics, vasopressor use, adverse events, recovery times and satisfaction. Continuous data were compared with Student's t-test and categorical data with the chi-square test; $p < 0.05$ was significant.

Results: Groups were comparable at baseline. Time to first analgesia was longer with isobaric bupivacaine (277.7 ± 33.1 vs 204.0 ± 26.9 min, $p < 0.0001$). Hyperbaric bupivacaine gave faster sensory onset (4.94 ± 1.25 vs 6.90 ± 1.35 min) and motor onset (4.27 ± 0.88 vs 6.18 ± 1.13 min), and higher peak sensory levels (mostly T5-T7 vs T7-T9). Sensory regression to S2 (261.6 ± 31.9 vs 192.6 ± 27.2 min) and motor block duration (246.9 ± 32.8 vs 196.5 ± 26.4 min) were longer with isobaric bupivacaine, as was time to ambulation (299.8 vs 241.9 min). Mean HR, SBP, DBP, MAP and SpO2 did not differ between groups at any time point. Hypotension (30.0% vs 13.3%) and bradycardia (16.7% vs 0%) were numerically more frequent with hyperbaric bupivacaine without reaching significance, but mephentermine use was higher (6.9 ± 7.1 vs 2.8 ± 4.2 mg, $p = 0.021$). Satisfaction was high in both groups.

Conclusion: Both formulations provided effective spinal anaesthesia. Isobaric bupivacaine gave a slower-onset, lower, longer-lasting block with prolonged analgesia; hyperbaric bupivacaine gave faster onset and higher spread with more vasopressor requirement. The choice should match surgical needs and patient profile.

Keywords: Spinal Anaesthesia; Bupivacaine; Isobaric; Hyperbaric; Baricity; Lower Abdominal Surgery.

DOI: 10.25258/ijcpr.18.11.3

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Introduction

Spinal anaesthesia is widely used for lower abdominal surgery because it is simple, reliable and avoids airway instrumentation. Bupivacaine remains the most commonly used intrathecal local anaesthetic. The distribution of an intrathecal drug depends on the density of the solution relative to cerebrospinal fluid (CSF), on patient posture, and on CSF dynamics [1,2]. Hyperbaric solutions, made with dextrose, settle under gravity and tend to produce faster onset and higher spread. Isobaric solutions are largely independent of posture and are thought to give a more predictable, longer-lasting block. The evidence comparing the two is mixed. A systematic review and meta-analysis found differences in block characteristics and recovery but little difference in hypotension overall [3]. Individual trials differ in onset, peak level, haemodynamic effects and recovery [4-8]. Few studies from India have addressed this in a general lower abdominal surgical population using duration of effective analgesia as the primary endpoint. We therefore compared isobaric and hyperbaric bupivacaine at an identical dose and volume, with duration of effective postoperative analgesia as the primary outcome, and sensory and motor block, haemodynamic stability, adverse effects and recovery as secondary outcomes.

Methods

Design and setting: This prospective, randomized, double-blind comparative study was conducted in the Department of Anaesthesiology, Shri Vinoba Bhave Civil Hospital, NAMO Medical Education & Research Institute, Silvassa, between June 2024 and November 2025. The Institutional Ethics Committee approved the protocol before enrolment, and written informed consent was obtained from all participants. The study followed ICMR guidelines for biomedical research.

Participants: Adults aged 18-60 years, ASA physical status I or II, scheduled for elective lower abdominal surgery and giving written consent were eligible.

Exclusion criteria were refusal, infection at the injection site, coagulation abnormalities, hepatic, renal, cardiovascular or respiratory disease, epilepsy, chronic opioid or steroid use, allergy to study drugs, contraindications to spinal anaesthesia, and expected surgery longer than 120 minutes.

Sample size: Sample size was estimated from the study of Helmi et al. [4] using the formula $n = 2\sigma^2(Z\alpha/2 + Z\beta)^2/d^2$, with 80% power and a 5% significance level. This gave about 27 patients per group, rounded to 30 per group (60 in total).

Randomization and blinding: Patients were allocated by a computer-generated random number table. The study drug was prepared by an anaesthesiologist who took no part in intraoperative care or outcome assessment, keeping participants and assessors blinded.

Anaesthetic technique: All patients fasted for 8 h (solids) and 2 h (clear fluids) and received alprazolam 0.5 mg orally the night before surgery. Standard monitoring (ECG, non-invasive blood pressure, SpO2) was applied, Ringer's lactate 10 mL/kg was preloaded 20-30 minutes before the block, and ondansetron 4 mg was given intravenously. Spinal anaesthesia was performed at L3-L4 or L4-L5 with a 25G Quincke needle. Group I received 3.5 mL of 0.5% isobaric bupivacaine and Group H received 3.5 mL of 0.5% hyperbaric bupivacaine (in 8% dextrose), 17.5 mg in each case, with no adjuvants. Patients were positioned supine after injection.

Measurements: Sensory block was assessed by pinprick every 2 minutes until the maximum level and every 10 minutes thereafter until regression. Motor block was graded with the Modified Bromage scale (0-3). We recorded time to sensory onset (T10), time to motor onset, time to maximum sensory level, maximum sensory level, time to two-segment regression, duration of sensory block (regression to S2), duration of motor block (return to Bromage 0) and time to full motor recovery.

Heart rate, SBP, DBP, MAP and SpO2 were recorded every 2 minutes for the first 10 minutes and every 5 minutes thereafter. Hypotension (SBP < 90 mmHg or a fall of more than 30% from baseline) was treated with intravenous fluid and mephentermine; bradycardia (HR < 60 bpm) with atropine 0.6 mg. Postoperatively, pain was scored on a 10-point VAS at 0, 30 min, 1, 2, 4, 6, 12 and 24 h, and intravenous paracetamol 10-15 mg/kg was given as the rescue analgesic.

Outcomes: The primary outcome was the duration of effective analgesia (time from injection to first rescue analgesic).

Secondary outcomes were block characteristics, haemodynamics, adverse effects (hypotension, bradycardia, nausea, vomiting, shivering, high spinal, post-dural puncture headache, urinary retention), vasopressor and sedative requirement, recovery times, and surgeon and patient satisfaction (5-point scales).

Statistical analysis

Data were analysed in SPSS version 20. Continuous variables are mean ± SD and were compared with Student's t-test; categorical variables were compared with the chi-square test. $p < 0.05$ was considered significant.

Results

Sixty patients were analysed (30 per group). The groups were comparable in age, weight, height, BMI, sex, ASA status, type of surgery, baseline vital signs and procedural details (Tables 1-2).

Table 1: Baseline characteristics

Variable	Isobaric (n=30)	Hyperbaric (n=30)	p
Age (years)	43.13 ± 8.99	43.73 ± 9.37	0.801
Weight (kg)	67.70 ± 10.99	69.40 ± 9.20	0.519
Height (cm)	166.84 ± 7.14	168.76 ± 8.54	0.350
BMI (kg/m²)	24.39 ± 4.03	24.65 ± 4.68	0.816
Male / female (%)	70.0 / 30.0	53.3 / 46.7	0.288
ASA I / II (%)	53.3 / 46.7	66.7 / 33.3	0.429
Baseline HR (bpm)	79.43 ± 7.93	80.87 ± 8.01	0.489
Baseline MAP (mmHg)	92.93 ± 6.62	93.90 ± 5.88	0.552

Table 2: Surgical procedures (n)

Procedure	Isobaric	Hyperbaric
Appendectomy	5	8
Obstetric and gynaecological	6	5
Inguinal hernia	11	9
Umbilical hernia	2	1
Urological	6	7

Sensory and motor block: Sensory and motor onset were faster with hyperbaric bupivacaine, and its peak sensory level was higher. Regression of the sensory block, motor block duration and full motor recovery were all longer with isobaric bupivacaine. Time to complete motor block (Bromage 3) did not differ (10.01 ± 1.82 vs 10.83 ± 2.28 min, p = 0.131).

Table 3: Block characteristics (mean ± SD)

Variable	Isobaric	Hyperbaric	p
Sensory onset, T10 (min)	6.90 ± 1.35	4.94 ± 1.25	<0.0001
Time to maximum level (min)	11.53 ± 2.30	9.14 ± 1.84	<0.0001
Two-segment regression (min)	72.77 ± 10.79	58.03 ± 10.24	<0.0001
Sensory block duration, to S2 (min)	261.63 ± 31.93	192.57 ± 27.24	<0.0001
Motor onset (min)	6.18 ± 1.13	4.27 ± 0.88	<0.0001
Time to Bromage 3 (min)	10.01 ± 1.82	10.83 ± 2.28	0.131
Motor block duration (min)	246.90 ± 32.76	196.50 ± 26.39	<0.0001
Full motor recovery (min)	264.87 ± 34.65	212.83 ± 24.50	<0.0001

Maximum sensory level was T7-T9 in the isobaric group (T7 13.3%, T8 63.3%, T9 23.3%) and T5-T7 in the hyperbaric group (T5 20.0%, T6 60.0%, T7 20.0%) (p < 0.0001).

Analgesia (Primary Outcome): Time to first rescue analgesic was significantly longer with isobaric bupivacaine (277.73 ± 33.14 vs 203.97 ± 26.87 min, p < 0.0001). VAS scores were zero in both groups up to 1 h and similar at 2 h. At 4 h and 6 h they were higher with hyperbaric bupivacaine (2.30 vs 3.03 and 2.23 vs 3.70, both p < 0.0001). At 12 h and 24 h scores were higher in the isobaric group (3.23 vs 2.93, p = 0.027; 3.00 vs 2.03, p < 0.0001).

Haemodynamics and vasopressor use: Mean HR, SBP, DBP, MAP and SpO2 did not differ significantly between groups at any of the 15 time points from 3 minutes to 6 hours (all p > 0.05). Even so, hypotension occurred in 9 patients (30.0%) with hyperbaric bupivacaine and 4 (13.3%) with isobaric (p = 0.21), and bradycardia in 5 (16.7%) versus none (p = 0.062); neither difference was significant. Mephentermine requirement was higher with hyperbaric bupivacaine (6.90 ± 7.10 vs 2.80 ± 4.20 mg, p = 0.021), as was intravenous midazolam 1 mg for sedation (30.0% vs 6.7%, p = 0.04). Fluid volume in the first 30 minutes was identical (about 614 mL). No patient needed conversion to general anaesthesia.

Adverse events and recovery

Table 4: Adverse events, n (%)

Event	Isobaric	Hyperbaric	p
Hypotension	4 (13.3)	9 (30.0)	0.21
Bradycardia	0	5 (16.7)	0.062
High spinal	0	1 (3.3)	1.0
Failed block	1 (3.3)	1 (3.3)	1.0
Nausea/vomiting	5 (16.7)	1 (3.3)	0.197
Shivering	4 (13.3)	6 (20.0)	0.729
Post-dural puncture headache	1 (3.3)	3 (10.0)	0.605
Urinary retention	0	3 (10.0)	0.236

Time to ambulation was longer with isobaric bupivacaine (299.8 ± 38.9 vs 241.9 ± 28.8 min, p < 0.0001).

Time to first void (295.2 vs 297.0 min, p = 0.91) and PACU stay (111.4 vs 119.3 min, p = 0.149) were similar. Surgeon satisfaction (4.20 ± 0.66 vs 4.30 ± 0.60) and patient satisfaction (4.47 ± 0.57 vs 4.37 ± 0.61) were high and did not differ.

Discussion

In this randomized comparison at an identical dose, isobaric bupivacaine gave a significantly longer duration of effective analgesia than hyperbaric

bupivacaine, by about 74 minutes. The trade-offs were slower onset, a lower peak sensory level, longer motor block and later ambulation. Hyperbaric bupivacaine acted faster and spread higher, with a numerically higher rate of hypotension and bradycardia and a significantly higher vasopressor requirement. The faster onset and higher level with hyperbaric bupivacaine fit the gravity-dependent spread of dextrose-containing solutions in a supine patient, and agree with several earlier trials [6-8] and with the pooled data of Uppal et al. [3]. Helmi et al. reported faster onset with isobaric bupivacaine [4]; differences in dose, positioning and CSF dynamics may explain this.

The longer sensory and motor block with isobaric bupivacaine is consistent with most previous work [3,4,5,7]. Slower redistribution of an isobaric solution within the CSF may explain the longer duration. The analgesic findings follow the block profile. Patients given hyperbaric bupivacaine needed rescue analgesia earlier and had higher VAS scores at 4-6 h, while isobaric bupivacaine delayed the first request. The reversed VAS pattern at 12-24 h, with higher scores after isobaric bupivacaine, probably reflects the later wearing off of the block; these late scores were low in both groups and their clinical significance is modest.

On haemodynamics, mean HR, SBP, DBP and MAP were similar at every time point, yet hypotension, bradycardia, vasopressor dose and sedative use all pointed the same way against hyperbaric bupivacaine. Mean values smooth out brief episodes, so event-based outcomes can differ even when time-point means do not. Only the vasopressor and sedative differences reached significance, and the study was not powered for adverse events, so the hypotension and bradycardia findings should be read as a signal and not a proven difference. Earlier studies report similarly inconsistent haemodynamic differences [3,6,7,9].

The slower recovery of motor function with isobaric bupivacaine delayed ambulation by about an hour, but time to void and PACU stay were unchanged, so overall recovery was not clearly prolonged. Both techniques gave high surgeon and patient satisfaction and no conversions to general anaesthesia. Clinically, isobaric bupivacaine may suit procedures where longer post-operative pain relief matters and early mobilisation is not a priority. Hyperbaric bupivacaine may suit short procedures needing rapid onset, or where early ambulation is wanted, with readiness for vasopressor support.

Limitations

This was a single-centre study of 60 ASA I-II patients and was powered for the primary outcome, not for adverse events. The mixed surgical population and the fixed supine positioning limit generalisability, and only a single dose was tested. Sensory assessment by pinprick and VAS scores are subjective. Findings may not extend to older, obstetric or high-risk patients.

Conclusion

Isobaric and hyperbaric bupivacaine both provide reliable spinal anaesthesia for lower abdominal surgery. Isobaric bupivacaine gives longer sensory and motor block and longer postoperative analgesia, with slower onset, lower spread and delayed ambulation. Hyperbaric bupivacaine gives faster onset and higher spread, with a higher vasopressor requirement. The formulation should be chosen according to the expected duration of surgery, the need for early mobilisation and the patient's haemodynamic reserve.

References

1. Hocking G, Wildsmith JAW. Intrathecal drug spread. Br J Anaesth. 2004;93(4):568-78.
2. Hallworth SP, Fernando R, Columb MO, Stocks GM. Effect of posture and baricity. Anesth Analg. 2005;100(4):1159-65.
3. Uppal V, Retter S, Shanthanna H, Prabhakar C, McKeen DM. Hyperbaric versus isobaric bupivacaine for spinal anesthesia: systematic review and meta-analysis. Anesth Analg. 2017;125(5):1627-37.
4. Helmi M, Uyun Y, Suwondo BS, Widodo U. Comparison of isobaric and hyperbaric bupi vacaine. J Anesthesiol. 2014;2014:141324.
5. Piacherski V, Muzyka L. Comparative spinal anesthesia study. Sci Rep. 2023;13(1):2736.
6. Upadya M, Neeta S, Manissery JJ, Kuriakose N, Singh RR. Intrathecal hyperbaric vs isobaric bupivacaine-fentanyl mixture in common urological procedures. Indian J Anaesth. 2016;60(1):44-9.
7. Arun R, Kumar G. Comparison of hyperbaric and isobaric bupivacaine. Acta Sci Neurol. 2021;4(8).
8. Pal M, Rawat G, Agrawal S. Isobaric levobupivacaine vs hyperbaric bupivacaine. Int J Acad Med Pharm. 2024;6(2):350-5.
9. Vangapalli N, Annepu KK, Priyadarshini PC, Alugolu M. Isobaric vs hyperbaric study. Int J Health Sci. 2022.