Journal of Chemical Health Risks
www.jchr.org
JCHR (2026) 16(1), 2151-2156 | ISSN:2251-6727

"A Comparative Study between Fractionated Dose Versus Bolus Dose Injection of Hyperbaric Levobupivacine in Patients Undergoing Infraumbilical Surgeries Under Subarachnoid Block"

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(Received: 05 December 2025 Revised: 15 January 2026 Accepted: 10 February 2026)

KEYWORDS

Spinal anaesthesia; Fractionated dose; Bolus dose; Hyperbaric levobupivacaine; Haemodynamic stability; Infraumbilical surgeries

ABSTRACT:

Introduction: Spinal anaesthesia is widely employed for infraumbilical surgeries due to its rapid onset, reliable sensory and motor blockade, and favorable postoperative recovery profile. However, sudden sympathetic blockade following intrathecal local anaesthetic administration may result in significant haemodynamic instability. Fractionated dosing of spinal anaesthesia has been proposed as a technique to provide a gradual spread of local anaesthetic, thereby improving cardiovascular stability. Levobupivacaine, a safer S-enantiomer of bupivacaine, offers effective spinal anaesthesia with reduced cardiotoxicity. This study was undertaken to compare the clinical effects of fractionated versus bolus dosing of hyperbaric levobupivacaine in infraumbilical surgeries.

Aim :Comparison of fractionated dose of hyperbaric levobupivacaine versus bolus dose of levobupivacaine in infraumbilical surgeries

Materials and Methods This prospective, comparative study was conducted on 100 adult patients (ASA I–II) undergoing elective infraumbilical surgeries under subarachnoid block. Patients were randomly allocated into two groups: Group F received hyperbaric levobupivacaine in a fractionated manner, while Group B received the same dose as a single bolus. Sensory and motor block characteristics, haemodynamic parameters, and duration of postoperative analgesia were assessed and statistically analyzed.

Results Fractionated dosing demonstrated significantly better haemodynamic stability with fewer episodes of hypotension and reduced vasopressor requirement compared to bolus dosing. Although the onset of sensory and motor blockade was slower in the fractionated group, the duration of sensory block, motor block, and postoperative analgesia was significantly prolonged. Bolus dosing produced faster onset but was associated with greater cardiovascular fluctuations.

Conclusion: Fractionated intrathecal administration of hyperbaric levobupivacaine provides superior haemodynamic stability and prolonged analgesia compared to bolus dosing, making it a safer and more effective technique for infraumbilical surgeries.

INTRODUCTION :

Spinal anaesthesia (SA) is widely regarded as the technique of choice for surgical procedures involving the lower extremities, lower abdomen, pelvis, and perineum. Its popularity stems from several advantages over general anaesthesia, including rapid onset, dense sensory and motor blockade, reduced intraoperative blood loss, preservation of airway reflexes, minimal cognitive impairment, and decreased risk of

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thromboembolic events [1]. Despite these benefits, SA is frequently associated with haemodynamic instability, primarily due to sympathetic blockade. The resulting vasodilatation and reduced venous return may precipitate significant hypotension and bradycardia, occasionally leading to serious morbidity if not promptly managed [1,2].

To mitigate these adverse haemodynamic effects, alternative dosing strategies such as fractionated spinal anaesthesia have been explored. In this technique, two-thirds of the calculated intrathecal dose is administered initially, followed by the remaining one-third after a short interval (approximately 90 seconds). This staged administration aims to achieve adequate sensory and motor blockade while allowing gradual sympathetic blockade, thereby improving cardiovascular stability compared with the conventional bolus technique [3–5].

Hyperbaric 0.5% bupivacaine remains the standard local anaesthetic for SA, providing reliable anaesthesia for procedures lasting up to 2–2.5 hours [6]. The addition of intrathecal adjuvants enhances block quality and prolongs postoperative analgesia. Buprenorphine, a highly lipid-soluble partial opioid agonist, has demonstrated prolonged analgesic effects with minimal haemodynamic changes and fewer opioid-related side effects [8,9]. However, limited studies have compared bolus and fractionated techniques using buprenorphine as an adjuvant. The present study therefore aims to evaluate and compare these two dosing regimens in terms of block characteristics, haemodynamic stability, and postoperative analgesic profile.

The aim of the study is to comparing bolus versus fractionated dosing with a buprenorphine adjuvant, this prospective study aims to identify a regimen that optimizes the **analgesic profile**—specifically onset, peak level, and duration—while maintaining superior haemodynamic stability in patients undergoing lower limb surgery.

MATERIALS & METHODS

This prospective comparative study was conducted over 12 months in the Department of Anaesthesiology at Integral Institute of Medical Sciences & Research Centre, Lucknow. Adult patients (18–60 years), ASA I–II, scheduled for elective infraumbilical surgeries under subarachnoid block (SAB) were enrolled after informed consent. Patients with ASA ≥III, contraindications to spinal anaesthesia, hypersensitivity to amide local anaesthetics, neurological deficits, severe systemic disease, pregnancy, or autonomic-altering medications were excluded.

Sample size was calculated using $\alpha = 0.05$ and 80% power, with an additional 10% for dropouts. Patients were randomized into two groups: Group F (fractionated dose) and Group B (bolus dose). Under aseptic precautions, SAB was performed at L3–L4 using 0.5% hyperbaric levobupivacaine. Group F received the dose in two fractions (2/3 followed by 1/3 after 90 seconds); Group B received a single bolus. Sensory and motor block characteristics, haemodynamic parameters, adverse effects, and rescue medication requirements were recorded. Statistical analysis was performed using SPSS; $p < 0.05$ was considered significant.

RESULTS:

Demographic and Hemodynamic Comparison

The following table synthesizes the demographic characteristics and heart rate trends for Group F (Fractionated) and Group B (Bolus).

Parameter	Group F (n=50)	Group B (n=50)	Significance (P-value)
Age (Years)	Predominantly 41–70 (74%)	Predominantly 11–40 (64%)	-
Gender (M/F)	25 / 25 (50% each)	25 / 25 (50% each)	Matched
ASA Grade (I/II)	46% / 54%	52% / 48%	-
Baseline HR (bpm)	76.24 ± 6.91	76.74 ± 5.54	0.691 (NS)
HR @ 9 min	76.60 ± 5.89	82.72 ± 4.63	0.001
HR @ 30 min	75.70 ± 4.72	82.20 ± 4.71	0.001
HR @ 90 min	74.38 ± 4.43	80.20 ± 5.74	0.001

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The Group F trended older with a slightly higher ASA II representation. Despite these baseline differences, **Group F exhibited superior hemodynamic stability**. While baseline heart rates were comparable, Group B showed a statistically significant and progressive increase in heart rate starting at 3 minutes, peaking between 12 and 22 minutes. Conversely, the fractionated dosing in Group F prevented sustained tachycardia, maintaining a stable, consistent heart rate throughout the 90-minute observation period. This suggests fractionated administration effectively mitigates the cardiovascular stress typically seen with bolus spinal injections.

Table 2. Distribution of study participants based on SBP

Mean SBP	Group F	Group B	P value
Baseline	129.60±5.07	128.76±9.88	0.594
@ 3min	135.28±7.28	135.40±12.74	0.054
@ 6min	137.86±8.48	113.34±11.33	0.001
@ 9min	114.22±5.42	105.46±7.86	0.001
@ 12min	111.04±4.75	107.42±9.07	0.001
@ 22min	116.70±6.57	112.98±9.34	0.002
@ 30min	123.62±6.44	116.90±9.30	0.001
@ 60min	127.14±6.62	121.66±9.96	0.002
@ 90min	123.76±5.44	125.34±9.49	0.310

Baseline systolic blood pressure (SBP) was comparable between groups. From 6 to 60 minutes, Group F maintained significantly higher SBP than Group B ($p < 0.05$), indicating less intraoperative hypotension. By 90 minutes, values equalized. Overall, fractionated dosing provided superior haemodynamic stability compared with the bolus technique.

Table 3: Hemodynamic and Block Characteristics

The following table consolidates the physiological trends and block characteristics for Group F (Fractionated) and Group B (Bolus).

Parameter	Group F (Mean ± SD)	Group B (Mean ± SD)	P-value
Baseline DBP (mmHg)	84.46 \pm 4.92	77.72 \pm 7.77	0.001
DBP at 6 minutes	85.34 \pm 6.38	74.62 \pm 8.02	0.001
Mean SpO_2 (90 min)	97.38 \pm 0.83	98.04 \pm 0.66	0.001
Sensory Block Onset (min)	7.92 \pm 1.05	5.20 \pm 0.76	Significant
Motor Block Onset (min)	9.80 \pm 1.20	4.42 \pm 0.81	Significant
Sensory Block Duration (min)	210.68 \pm 7.68	173.56 \pm 7.62	Significant

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Motor Block Duration (min)	202.06 \pm 7.61	181.20 \pm 6.09	Significant
Total Analgesia Time (min)	215.24 \pm 7.52	194.88 \pm 4.39	Significant

The fractionated-dose technique (Group F) demonstrated superior hemodynamic stability, maintaining higher and more consistent Diastolic Blood Pressure (DBP) compared to the sharp declines seen in Group B. While Group B achieved a faster onset of both sensory (5.20 min) and motor (4.42 min) blockade—likely due to rapid intrathecal spread—this speed was associated with abrupt sympathetic blockade.Conversely, Group F provided a more prolonged clinical effect. The duration of sensory and motor blockade was significantly extended in Group F, resulting in a superior analgesic profile with a total duration of 215.24 minutes compared to 194.88 minutes in Group B. Respiratory parameters (RR and SpO_2) remained clinically stable in both groups, though Group B maintained marginally higher saturation levels. Overall, fractionated dosing trades rapid onset for increased safety and extended postoperative relief.

Table 4: ***Association between variables and groups***

	Group F	**Group B**	**t- value**	**P value**
Age	40.81±11.65	34.82±8.063	2.971	0.001
ASA grading	1.52±0.50	1.38±0.49	1.40	0.164
Onset of sensory blockade	7.96±1.03	5.20±0.25	15.15	0.001
Onset of Motor Blockade	9.85±1.18	4.42±0.81	26.59	0.001
Duration of sensory blockade	211.06±7.35	173.56±7.61	24.78	0.001
Duration of Motor blockade	202.04±7.40	181.04±6.01	15.44	0.001
Time for Analgesia	215.02±7.22	194.88±4.38	16.75	0.001

The table presents a comparative analysis of demographic parameters and characteristics of sensory and motor blockade between Group F (fractionated dose) and Group B (bolus dose) of hyperbaric levobupivacaine. The mean age was significantly higher in Group F (40.81 ± 11.65 years) compared to Group B (34.82 ± 8.06 years, p = 0.001), while ASA grading was comparable (1.52 ± 0.50 vs. 1.38 ± 0.49, p = 0.164), indicating similar baseline health status between the groups.Regarding the onset of block, Group F showed a slower onset of sensory blockade (7.96 ± 1.03 vs. 5.20 ± 0.25 minutes) and motor blockade (9.85 ± 1.18 vs. 4.42 ± 0.81 minutes), both statistically significant (p = 0.001). The delayed onset in Group F is likely due to gradual administration, resulting in slower intrathecal spread and controlled establishment of Anaesthesia. In contrast, the bolus dose in Group B produces rapid onset due to higher initial drug concentration.Despite the slower onset, Group F demonstrated significantly longer durations of sensory blockade (211.06 ± 7.35 vs. 173.56 ± 7.61 minutes), motor blockade (202.04 ± 7.40 vs. 181.04

± 6.01 minutes), and analgesia (215.02 ± 7.22 vs. 194.88 ± 4.38 minutes, p = 0.001). This prolonged effect can be attributed to sustained drug release in cerebrospinal fluid, providing extended intraoperative Anaesthesia and postoperative analgesia. Overall, fractionated dosing offers a slower but more prolonged and stable anaesthetic and analgesic profile compared to bolus dosing.

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Table 5:. ***Association between Vasopressor requirement with respect to Groups***

Vasopressor Requirement	**Group F**	**Group B**	**Total**
Yes	6 (12%)	18 (36%)	24 (25%)
No	44 (88%)	32 (64%)	76 (76%)
Total	50 (100%)	50 (100%)	100 (100%)

X2=7.44 p value= 0.0067

This table demonstrates that vasopressor requirement was significantly higher in Group B, where 36% of patients required vasopressor support compared to only 12% in Group F. This difference was statistically significant (p = 0.006), indicating greater hemodynamic instability in the bolus dose group. In contrast, the fractionated dose technique was associated with more stable blood pressure and reduced need for pharmacological intervention during intraoperative management.

DISCUSSION

The present study compared fractionated versus bolus intrathecal administration of hyperbaric levobupivacaine for infraumbilical surgeries, focusing on block characteristics, analgesia, and haemodynamic stability. Demographic variations were noted, with relatively older patients in Group F and younger individuals in Group B. Although age-related physiological differences can influence cerebrospinal fluid dynamics and sympathetic responsiveness, both groups were comparable in gender distribution, minimizing confounding variability. Similar demographic balancing was reported by Patel et al. and Derashri et al. [10,11].

Haemodynamically, fractionated dosing demonstrated superior stability. Heart rate fluctuations were smoother in Group F, whereas Group B showed greater variability, reflecting abrupt sympathetic blockade after bolus injection. Comparable findings were reported by Badheka et al. [1], who observed improved cardiovascular stability with fractionated dosing. Systolic and diastolic blood pressures were better maintained in Group F from early intraoperative periods, consistent with reports by Khare and Nema and Derashri et al. [11]. These findings support the concept that gradual drug administration prevents sudden vasodilation and hypotension.Vasopressor requirement further reinforced this observation. Group B required significantly more vasopressor support (36%) compared to Group F (12%), aligning with findings from Mishra et al. [12], Patel et al., and Badheka et al. [1], who consistently demonstrated reduced hypotension and vasopressor use with fractionated techniques.

Regarding block characteristics, bolus dosing produced faster onset of sensory and motor blockade, likely due to higher initial intrathecal concentration gradients. However, fractionated dosing significantly prolonged sensory, motor, and analgesic duration, corroborating Derashri et al. [11], who reported extended time to rescue analgesia in fractionated groups. Prolonged analgesia may result from sustained cerebrospinal drug concentration and gradual neural receptor binding.Physiologically, fractionated dosing moderates sympathetic blockade, allowing compensatory cardiovascular adaptation while maintaining prolonged neural exposure. Hyperbaric levobupivacaine, known for greater cardiac safety compared with racemic bupivacaine, further enhances this stability. Clinically, fractionated spinal anaesthesia appears advantageous in elderly or ASA II patients prone to hypotension, while bolus dosing may remain appropriate for short procedures requiring rapid onset. Overall, the findings support fractionated dosing as a safer and more haemodynamically stable technique.

CONCLUSION

This comparative study demonstrates that both fractionated and bolus intrathecal hyperbaric levobupivacaine techniques provide effective surgical anaesthesia for infraumbilical procedures. However, significant differences were observed in onset time, duration of block, and haemodynamic responses. The bolus technique produced a faster onset but was associated with greater fluctuations in heart rate and blood pressure, indicating a higher tendency toward haemodynamic instability. In contrast, the fractionated-dose technique resulted in a smoother onset with more stable cardiovascular parameters and prolonged duration of anaesthesia and analgesia. These findings suggest that fractionated dosing may offer a safer and more controlled approach, particularly in elderly or haemodynamically vulnerable patients.

We are grateful to all the patients who participated in the research for their cooperation and trust. Special

thanks to the medical and technical staff for their assistance in data collection and patient care. MCN: IU/R&D/2026-MCN0004322

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