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Original article

A RANDOMIZED DOUBLE-BLIND STUDY TO COMPARE THE EFFECT OF SPEED OF INJECTION (15 SECONDS VERSUS 60 SECONDS) OF 0.5% HEAVY BUPIVACAINE ON QUALITY OF BLOCK AND HAEMODYNAMIC PARAMETERS IN INFRAUMBILICAL SURGERY UNDER SPINAL ANAESTHESIA.

(IMPACT OF INJECTION SPEED ON QUALITY OF BLOCK AND HAEMODYNAMIC PARAMETERS UNDER SPINAL ANAESTHESIA)

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Abstract

Introduction: *Injection speed during spinal anaesthesia may influence cerebrospinal fluid dynamics, potentially affecting block characteristics and haemodynamic outcomes. However, literature on these parameters remains inconclusive. This study was planned to evaluate the impact of intrathecal injection speed (15 seconds vs. 60 seconds) of 3 ml of 0.5% heavy bupivacaine on block quality and haemodynamic parameters in infraumbilical surgeries.* ***Methods:*** *Sixty ASA I–II adult patients undergoing elective infraumbilical surgeries under spinal anaesthesia were randomized into two groups: Group A received bupivacaine over 15 seconds, Group B over 60 seconds. The primary objective was to compare time taken to achieve T10 sensory block. The secondary objectives included evaluating the changes in key haemodynamic parameters—namely heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP)—from baseline at defined intraoperative intervals. Additional secondary objectives included comparison of the block height at 5 minutes, the maximum sensory level achieved and the total dose of mephentermine required to treat spinal anaesthesia-induced hypotension. The study also aimed to compare the incidence of side effects or complications, such as hypotension, bradycardia, respiratory depression, or nausea, between the two groups.* ***Results:*** *Group A had a significantly faster time to T10 block (1.91 ± 0.26 min in Group A vs. 4.23 ± 0.61 min in Group B; $p < 0.001$) and faster onset of motor (6.13 ± 1.02 in Group A vs. 9.19 ± 1.86 in Group B) and sensory block (3.52 ± 0.56 in Group A vs. 5.96 ± 0.87 in Group B) with $p < 0.001$. Group B showed higher cephalad spread at 5 minutes post- injection (T4 in 63.33% in Group B vs. 13.33% in Group A) and lower mephentermine requirement (3.4 ± 4.9 mg in Group B vs. 9.6 ± 5.8 mg in Group A; $p < 0.001$). Early hypotension and bradycardia were more frequent in Group A.* ***Conclusion:*** *Rapid intrathecal injection leads to faster onset but greater haemodynamic instability. Slower injection offers more predictable spread and better haemodynamic stability. Standardizing injection speed may improve anaesthesia safety.*

Keywords: *Spinal anaesthesia; bupivacaine; injection speed; haemodynamics; sensory block; vasopressor*

Introduction

Spinal anaesthesia, also referred to as subarachnoid block, is a time-tested regional anaesthetic technique that involves the introduction of a local anaesthetic agent into the cerebrospinal fluid (CSF) of the subarachnoid space.[1] Since its inception in the late 19th century by August Bier, spinal anaesthesia has gained widespread popularity across surgical disciplines, particularly for procedures involving the lower abdomen, pelvis, perineum, and lower limbs.[2] Its continued use in modern anaesthetic practice is attributed to several key advantages such as rapid onset of action, profound sensory and motor blockade, reduced perioperative stress response, minimal systemic drug expo-

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sure, lower risk of pulmonary complications, and superior postoperative analgesia when compared to general anaesthesia.[3] Moreover, spinal anaesthesia is a relatively cost- effective technique, which makes it particularly valuable in high-volume healthcare settings like tertiary referral hospitals in India.[4]

Despite its overall safety and efficacy, spinal anaesthesia is not without complications. The most frequently encountered physiological perturbations include hypotension and bradycardia, resulting from sympathetic blockade.[5] The extent and severity of these haemodynamic changes are influenced by several factors such as patient characteristics (age, body mass index, volume status), drug properties (dose, baricity, volume, temperature) and technical factors (site of injection, patient positioning, and speed of injection).[6] While considerable research has been devoted to standardising variables like the optimal dose, drug concentration and positioning protocols, the rate at which the intrathecal drug is administered has not received equivalent scientific attention.

Bupivacaine, a long-acting amide-type local anaesthetic, is the most commonly used agent for spinal anaesthesia in elective infraumbilical procedures.[7] The hyperbaric formulation (0.5% heavy bupivacaine), prepared by combining the base drug with dextrose, provides predictable spread in the spinal column, especially when gravity is utilised through positional adjustment.[8] However, evidence suggests that even subtle changes in the mode of delivery—such as the speed of injection—may significantly alert the distribution of the anaesthetic agent in the CSF, consequently affecting both the block height and its haemodynamic profile.[9]

From a physiological perspective, the injection speed may alter CSF dynamics, causing variations in the turbulence, layering, and mixing of the local anaesthetic within the intrathecal space.[10] Faster injections may induce greater turbulence, potentially leading to more unpredictable drug spread, whereas slower injections may facilitate controlled diffusion and laminar distribution, possibly resulting in more predictable and higher sensory levels.[11] Some authors have reported a more cephalad spread of the block and a longer time to reach peak sensory level with slower injection speeds.[12,13] This may also result in a higher sympathetic blockade, thus influencing the incidence and severity of hypotension and bradycardia, necessitating more frequent use of vasopressors such as mephentermine.[14]

However, despite these physiologically plausible mechanisms, studies examining the effect of injection speed have produced conflicting results. While a few investigations observed significant differences in block characteristics and cardiovascular effects based on injection rate, others have failed to demonstrate any such correlation. **[15]** This inconsistency may be attributed to heterogeneity in study design, sample sizes, and injection techniques, underscoring the need for further controlled studies. Moreover, in day-to-day clinical practice, the speed of injection is often left to individual practitioner preference rather than being guided by evidence-based protocols, potentially contributing to variability in block characteristics and patient outcomes.

With this background, we planned to conduct a well-structured, randomized, double-blind study to assess whether the speed of intrathecal injection (15 seconds versus 60 seconds) of 3 ml of 0.5% heavy bupivacaine significantly influences the quality of the spinal block—as measured by the onset time, dermatome height of sensory block, and degree of motor blockade—and to determine its impact on key haemodynamic parameters such as heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure. This study is particularly relevant in the Indian clinical context, where spinal anaesthesia is the preferred technique for infraumbilical surgeries across both public and private healthcare setups and standardisation of anaesthetic practice is of critical importance for optimizing perioperative care.

Materials and methods

Aim: To assess the effect of injection speed of 0.5% heavy bupivacaine on the quality of spinal block and haemodynamic parameters in patients scheduled for infraumbilical surgeries under spinal anaesthesia.

Methods: The present study was conducted as a randomized double-blind comparative clinical trial in a teaching hospital from January 2024 to December 2024. The study was conducted in accordance with the ethical principles of the Declaration

of Helsinki. Ethical clearance was obtained from the Institutional Ethics Committee of SMS Medical College, Jaipur. Written informed consent was obtained from all participants. Confidentiality of participant data was strictly maintained. Subjects were free to withdraw from the study at any time without compromising their standard of care. (Ref. No.: 182 MC/EC/2023). This study was registered in Clinical Trial Registry of India (CTRI/2024/07/071753)
The inclusion-exclusion criteria followed were:

Inclusion Criteria

- Adult patients aged between 20 and 60 years.
- Patients belonging to ASA Grade I or II.
- Patients scheduled for elective infraumbilical surgeries under spinal anaesthesia.
- Patients providing informed written consent for participation in the study.

Exclusion Criteria

- Presence of infection at the injection site.
- History of coagulopathy or thrombocytopenia.
- Known allergy to bupivacaine or local anaesthetics.
- Presence of severe dehydration or hypovolemia.
- Spinal deformities or previous spinal surgery.
- BMI more than 30.
- Contraindications to regional anaesthesia.

The sample size was calculated based on the primary outcome of vasopressor requirement which was approximately 85% in the fast injection group. Assuming a two-sided alpha error of 0.05 and a study power of 80%, a minimum of 28 patients per group was required to detect a statistically significant difference between the groups. To compensate for possible dropouts and protocol deviations, the sample size was rounded up to 30 patients in each group.

A total of 60 adult patients scheduled for elective infraumbilical surgeries under spinal anaesthesia were enrolled and randomly divided into two groups: Group A (received 3 ml of 0.5% heavy bupivacaine intrathecally over 15 seconds; n = 30) and Group B (received the same dose over 60 seconds; n = 30). Patients were randomized into two groups using the computer-generated random number table method. The study maintained a double- blind protocol. One anaesthesiologist (unblinded) administered the spinal anaesthesia as per group allocation. Another anaesthesiologist (blinded), unaware of the injection speed, recorded all outcome measures and monitored intraoperative parameters. All patients underwent pre-anaesthetic evaluation including demographic assessment, ASA grading, and routine investigations. The primary objective was the time to achieve T10 sensory block, while secondary objectives included the time of onset of sensory and motor block, sensory level at 5 minutes, maximum block height, time of onset of hypotension, total dose of mephentermine required, and incidence of side effects such as bradycardia, hypotension, nausea, vomiting, and respiratory depression. Haemodynamic parameters including heart rate, systolic and diastolic blood pressure, mean arterial pressure, and SpO_2 were recorded at baseline and at regular intervals intraoperatively. All spinal blocks were administered in the lateral position at the L3–L4 interspace using a 25G Quincke spinal needle under aseptic conditions, and injection time was recorded using a stopwatch. Data were collected systematically and analyzed to compare the effect of injection speed on block characteristics and haemodynamic stability between the two groups.

Outcomes variables:

1. Mean time of onset of sensory block.
2. Mean time of onset of motor block.
3. Mean time to achieve T10 dermatome block.
4. Mean block height at 5 minutes.
5. Mean of maximum sensory level achieved.
6. Mean of haemodynamic parameters (HR,SBP,DBP,MAP).
7. Mean dose of mephentermine required to correct hypotension.
8. Proportion of cases with side effects (if any).

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical clearance was obtained from the Institutional Ethics Committee of SMS Medical College, Jaipur. Written informed consent was obtained from all participants. Confidentiality of participant data was strictly maintained. Subjects

were free to withdraw from the study at any time without compromising their standard of care. (Ref. No.: 182 MC/EC/2023)

Statistical Analysis: Data were entered in Microsoft Excel and analyzed using SPSS version 26.0. Quantitative variables were expressed as mean ± standard deviation and analyzed using the unpaired t-test. Qualitative variables were presented as frequency and percentage and analyzed using the Chi-square test. A p-value ≤ 0.05 was considered statistically significant.

Procedure

After taking written informed consent and confirming overnight fasting, patient satisfying inclusion criteria were taken in operation theatre. In the operation theatre, standard monitors (NIBP, ECG, SpO_2) were attached and baseline haemodynamic parameters were recorded. Intravenous access was established with an 18G cannula and Ringer Lactate infusion was started at 10 ml/kg. Patients were placed in the lateral decubitus position. Spinal anaesthesia was administered at the L3–L4 interspace using a 25G Quincke spinal needle under strict aseptic precautions. After confirming free flow of cerebrospinal fluid (CSF), 3 ml of 0.5% hyperbaric bupivacaine was injected:

- Over 15 seconds in Group A
- Over 60 seconds in Group B

The time duration of injection was measured using a digital stopwatch. Following injection, patients were immediately turned supine and monitored continuously. Data were collected as per proforma. Surgery was allowed to commence after confirming adequate sensory and motor block. The sensory block was assessed by loss of cold sensation using ice cubes, and the motor block was evaluated using the Modified Bromage Scale. Hypotension was managed with intravenous mephentermine 6 mg boluses, repeated as required

Haemodynamic parameters (HR, SBP, DBP, MAP) were recorded at:

- Baseline
- Every 2 minutes for the first 10 minutes
- Every 5 minutes thereafter until the end of surgery

For the purpose of study, the following adverse effects were defined:

- Hypotension: was defined as SBP<90 mmHg or decrease in SBP by 20% or more from baseline values and was treated by IV fluids and incremental doses of mephentermine 6 mg IV as required.
- Bradycardia: was defined as fall in heart rate below 60 beats per minute and was treated with incremental doses of atropine 0.3 mg to 0.6 mg IV.
- Respiratory depression: was defined as respiratory rate less than 8 breaths per minute and or oxygen saturation less than 90 % on room air.

Results:

In the present study, anthropometric variables such as weight, height and body mass index (BMI) were assessed to evaluate their potential influence on spinal block characteristics. The mean weight of patients in Group A was 66.5 ± 12.87 kg, compared to 72.2 ± 11.04 kg in Group B, while the mean height was 162.4 ± 9.10 cm and 164.3 ± 6.52 cm, respectively. The calculated BMI was 25.4 ± 5.58 kg/m² for Group A and 26.9 ± 4.65 kg/m² for Group B. These differences were not statistically significant, indicating well-matched groups in terms of baseline anthropometric characteristics. (Table 1)

Table 1: Comparison of Mean Weight, Height, and BMI

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p value	Significance
Weight (kg)	66.5 ± 12.87	72.2 ± 11.04	0.068	NS
Height (cm)	162.4 ± 9.10	164.3 ± 6.52	0.365	NS
BMI (kg/m²)	25.4 ± 5.58	26.9 ± 4.65	0.263	NS

SD: Standard Deviation NS: Non-Significant S: Significant

The **primary outcome**, mean time to achieve T10 sensory block was significantly shorter in Group A (1.91 ± 0.26 min) as compared to Group B (4.23 ± 0.61 min; $p < 0.001$). This difference was statistically significant ($p < 0.001$), indicating that a faster injection speed results in a more rapid onset of spinal blockade. (Table 2)

Group A exhibited significantly earlier onset of both sensory (3.52 ± 0.56 min) and motor block (6.13 ± 1.02 min) compared to Group B (5.96 ± 0.87 min and 9.19 ± 1.86 min, respectively; both $p < 0.001$). These statistically significant findings reinforce the clinical relevance of injection speed as a determinant of block dynamics. (Table 3)

Table 2: Comparison of time taken to achieve T10 sensory level.

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p value	Significance
Time to T10 (min)	1.91 ± 0.26	4.23 ± 0.61	< 0.001	S

SD: Standard Deviation NS: Non-Significant S: Significant

Table 3: Comparison of Onset of Sensory and Motor Block

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p value	Significance
Onset of Sensory Block (min)	3.52 ± 0.56	5.96 ± 0.87	< 0.001	S
Onset of Motor Block (min)	6.13 ± 1.02	9.19 ± 1.86	< 0.001	S

SD: Standard Deviation NS: Non-Significant S: Significant

Table 4: Comparison of Sensory Block Height at 5 Minutes

Sensory Level (Dermatome)	Group A		Group B		p value	Significance
	Number	%	Number	%		
T4	04	13.33	19	63.33	< 0.001	S
T6	24	80	11	36.67	< 0.001	S
T8	02	6.67	00	00	0.492	NS
Total	30		30			

NS: Non-Significant S: Significant

At 5 minutes post-injection, a higher proportion of patients in Group A achieved a sensory block up to T6 (80%), while in Group B, the majority attained T4 (63%) which was statistically significant ($p < 0.001$). A small subset in Group A reached T8, whereas none in Group B did so. This distribution indicates a tendency towards more extensive cephalad spread with slower injection, which suggested greater block heights with prolonged injection time. (Table 4)

A distinct difference was observed in the maximum sensory block height achieved between the two groups. In Group A (15-second injection), 100% of patients reached a maximum level of T6, while in Group B (60-second injection), a significantly higher level of T4 was observed in 73% of patients, with the remaining 27% reaching T6.

Mean arterial pressure (MAP) showed a statistically significant decline in both groups following spinal anaesthesia; however, the drop was more pronounced and occurred earlier in Group A (15-second injection) compared to Group B (60-second injection). This difference was particularly significant during the first 3 minutes post-injection ($p < 0.05$). Thereafter, MAP values in both groups gradually stabilized and converged over time. (Figure 1)

The mean total dose of mephentermine required for management of hypotension was significantly higher in Group A (9.60 ± 5.81 mg) compared to

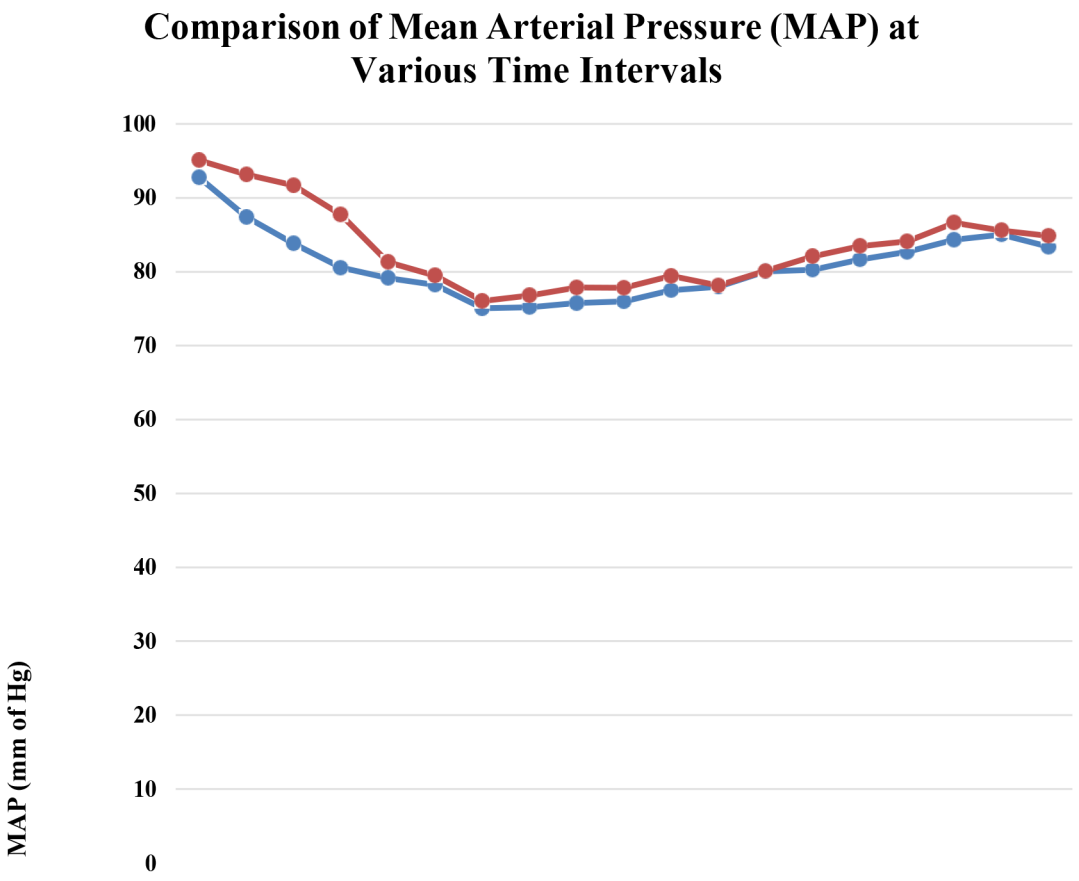

Figure 1: Comparison of Mean Arterial Pressure (MAP) at Various Time Intervals

Group B (3.40 ± 4.90 mg) which was statistically significant ($p < 0.001$). This finding underscores the increased need for vasopressor support associated with rapid intrathecal injection. (Table 5). The incidence of hypotension was notably higher in Group A (15-second injection), where 53% of patients experienced hypotension, compared to only 16% in Group B (60-second injection) which was statistically significant ($p < 0.05$). In the present study, no cases of respiratory depression were observed in either Group A (15-second injection) or Group B (60-second injection). (Table 6)

Discussion

This study was conducted to evaluate the effect of injection speed of 0.5% heavy bupivacaine on the quality of spinal block and haemodynamic parameters in patients undergoing infraumbilical surgeries under spinal anaesthesia. The aim was to determine whether the rate at which the intrathecal drug was administered—either rapidly over 15 seconds or slowly over 60 seconds—had a significant impact on quality of spinal block and hemodynamic parameters.

The age profile is consistent with that reported by **Jacob et al. (2022)**[12] and **Huang and Chang (2021)**[11], both of whom investigated spinal anaesthesia in non-obstetric, mixed adult surgical populations. In the present study, anthropometric variables such as weight, height and body mass index (BMI) were assessed to evaluate their potential influence on spinal block characteristics. There was no statistically significant difference, indicating well-matched groups in terms of baseline anthropometric characteristics. **Jacob et al. (2022)**[12] and **Huang and Chang (2021)**[11], where BMI values generally fell within the normal to overweight range and had no significant impact on block height or haemodynamic parameters when fixed volumes of hyperbaric bupivacaine were used.

In the present study, the mean time to achieve T10 sensory level was significantly shorter in Group A (1.91 ± 0.26 min) compared to Group B (4.23 ± 0.61 min, $p < 0.001$), clearly indicating

Table 5: Comparison of Mean Mephentermine Dose Required (mg)

Parameter	**Group A (Mean ± SD)**	**Group B (Mean ± SD)**	p value	Significance
Mephentermine Dose (mg)	09.60 ± 05.81	03.40 ± 04.90	< 0.001	S

SD: Standard Deviation NS: Non-Significant S: Significant

Table 6: Comparison of Complications Between the Study Groups

	Preop	1 min after spinal	2 min	3 min	4 min	5 min	7 min	9 min	11 min	13 min	15 min	20 min	30 min	40 min	50 min	60 min	70 min	80 min	90 min
Group A	92.7	87.4	83.8	80.5	79.1	78.2	75	75.2	75.7	76	77.5	78	80	80.2	81.6	82.7	84.3	85	83.4
Group B	95.1	93.2	91.7	87.7	81.3	79.5	76	76.8	77.8	77.8	79.4	78.1	80.1	82.1	83.5	84.1	86.6	85.6	84.8

faster onset of sensory block with rapid injection. This result closely matches findings by **Jacob et al. (2022)**[12], who reported a significantly faster sensory onset with a 15-second injection compared to 60 seconds (1.85 vs. 3.98 min). Similarly, **Ae Ra Kim et al. (2000)**[9] and **Tugcugil and Besir (2022)**[13] observed faster block onset with rapid injection speeds. Conversely, **Prakash et al. (2010)** [16] and **Singh et al. (2007)**[15] reported no significant difference in sensory onset times despite varying injection speeds. **Naveena et al. (2025)**[18] also found minimal differences in onset between injection speeds of 25 and 50 seconds. The observed differences in block onset times in our study might be attributed to faster dispersion of the anaesthetic solution within the CSF due to higher injection momentum, facilitating rapid and widespread neural blockade, as similarly noted by **Ae Ra Kim et al. (2000)**[9], **Jacob et al. (2022)**[12], and **Tugcugil and Besir (2022)**[13]. The studies showing no difference (**Prakash et al., 2010**[16]; **Singh et al., 2007**[15]; **Naveena et al., 2025**[18]) might reflect methodological variations or smaller injection speed differences compared to our study.

The present study observed significantly faster onset times for sensory (3.52 ± 0.56 min vs. 5.96 ± 0.87 min, $p < 0.001$) and motor blocks (6.13 ± 1.02 min vs. 9.19 ± 1.86 min, $p < 0.001$) in Group A (15 s injection) compared to Group B (60 s injection). This finding aligns closely with **Jacob et al. (2022)**[12], **Ae Ra Kim et al. (2000)**[9], and **Tugcugil and Besir (2022)**[13], who also demonstrated faster block onset with rapid injection speeds. However, studies such as **Prakash et al. (2010)** [16], **Singh et al. (2007)**[15], **Chiang et al. (2017)** [17], and **Naveena et al. (2025)**[18] reported no significant differences in sensory and motor onset times, indicating variability in outcomes possibly related to injection rate differences, patient positioning, or total volumes administered. Our results clearly reinforce that rapid injection enhances quicker dispersion of local anaesthetic within the subarachnoid space, thereby producing a rapid blockade onset, a physiological mechanism similarly described by **Jacob et al. (2022)**[12] and **Ae Ra Kim et al. (2000)**[9].

At five minutes, sensory blockade levels differed significantly between groups: the majority in Group A reached T6 (80%), while Group B predominantly reached T4 (63%), suggesting higher sensory block levels associated with slower injections. This trend contrasts findings by **Jacob et al. (2022)**[12], who reported comparable block heights at five minutes irrespective of injection speed. Similarly, **Ae Ra Kim et al. (2000)**[9] and **Singh et al. (2007)**[15] found no substantial difference in initial sensory block height with varied injection speeds. Conversely, studies by **Simon et al. (2000)**[10] and **Tugcugil and Besir (2022)**[13] suggest differences in injection speeds impact initial block height differently depending on patient positioning and CSF dynamics. Variations observed in our study might be explained by differences in gravitational dispersion or laminar flow dynamics of hyperbaric

solutions when administered more slowly, as postulated by **Yu-Yin Huang and Kuang-Yi Chang (2021)**[11] and **Jacob et al. (2022)**[12].

The present study observed a distinct difference in the maximum sensory block height achieved between the two groups. This finding was in contrast with **Jacob et al. (2022)**[12] who reported that faster injection (15 seconds) led to higher maximum block levels, more patients reaching T4 (65%) compared to the slow injection group (60 seconds), where patients predominantly peaked at T6 (45%). Their conclusion attributed this to turbulent flow associated with faster injection, which facilitates upward drug movement within the subarachnoid space. Additionally, **Ae Ra Kim et al. (2000)**[9] reported no difference in maximal block height between rapid and slow injection groups in their caesarean section study, though time to reach block height was shorter in the fast group. This implies that total spread may not always differ significantly, especially in the presence of pregnancy-related CSF dynamics. The current study's findings contributed to the growing body of evidence suggesting that slower injection speeds allow hyperbaric solutions more time to settle and ascend, especially in non-obstetric adult patients.

Mean arterial pressure (MAP) in this study showed significantly greater reductions in Group A at early intervals (1–3 minutes post-spinal; $p<0.05$), consistent with studies by **Jacob et al. (2022)**[12], **Simon et al. (2000)**[10], and **Rani et al. (2023)**[14], who reported early significant hypotensive responses with rapid injection speeds. On the contrary, studies by **Ae Ra Kim et al. (2000)** [9], **Chiang et al. (2017)**[17], and **Singh et al. (2007)**[15] indicated no significant MAP differences, potentially due to methodological differences in vasopressor use or volume preloading strategies. Early pronounced MAP drops observed in our study are attributable to rapid sympathetic blockade and resultant vasodilation, consistent with previously documented physiological mechanisms discussed by **Jacob et al. (2022)**[12] and **Simon et al. (2000)**[10]. In the present study, both groups experienced an initial increase in heart rate following spinal anaesthesia, which gradually stabilized over time. However, no statistically significant differences in mean heart rate were observed between the two groups. This suggests that while injection speed significantly influenced blood pressure parameters, its effect on heart rate was minimal and clinically non-significant in this patient population. These findings are comparable to those of **Jacob et al. (2022)**[12], who also reported no significant difference in HR trends between fast and slow injection groups. Similarly, **Smita Prakash et al. (2010)**[16] observed no significant HR changes between fast and slow injection groups in elderly patients undergoing transurethral surgeries. Their results, like ours, reinforce that HR tends to remain within physiological limits, even when systolic and diastolic pressures fluctuate following sympathetic blockade.

In the present study, the mean mephentermine dose required to manage hypotension was significantly higher in Group A (15-second injection) compared to Group B (60-second injection) (9.60 ± 5.81 mg vs. 3.40 ± 4.90 mg, $p<0.001$). This finding aligns closely with **Jacob et al. (2022)**[12], who reported greater vasopressor use following rapid injection due to pronounced initial hypotension. Similarly, **Simon et al. (2000)**[10] documented increased ephedrine use following fast injections, attributing this to rapid blockade of sympathetic fibers causing intense vasodilation. Contrasting findings were noted in studies by **Ae Ra Kim et al. (2000)**[9], **Chiang et al. (2017)**[17], **Singh et al. (2007)**[15], and **Prakash et al. (2010)**[16], who observed no significant difference in vasopressor requirements across varying injection speeds. Differences from these studies might stem from methodological variations such as anaesthetic volume, adjunct drugs used, or prophylactic measures (fluid preloading strategies). Additionally, **Rani et al. (2023)**[14] found higher hypotension incidence and vasopressor use with slower injection, contrary to our study, potentially due to differing patient demographics (obstetric population) and total anaesthetic volumes. The higher vasopressor requirements with rapid injections in our study are justified by the rapid, extensive sympathectomy and resultant marked peripheral vasodilation, as similarly explained by **Jacob et al. (2022)**[12] and **Simon et al. (2000)**[10].

In the current study, the higher incidence of hypotension was in the fast injection group which provided further evidence that the injection speed is a modifiable factor influencing the likelihood of early spinal anaesthesia-related complications. **Jacob et al. (2022)**[12] reported a significantly higher incidence of hypotension in their fast

injection group, which required both more vasopressor support and fluid boluses. They concluded that rapid spread of hyperbaric bupivacaine within the cerebrospinal fluid leads to a more abrupt sympathetic blockade, particularly affecting the lower thoracic sympathetic outflow responsible for maintaining vascular tone. On the other hand, **Smita Prakash et al. (2010)**[16] and **Singh et al. (2007)** [15] reported no significant difference in hypotension between fast and slow injection groups in elderly and obstetric populations, respectively.

Limitations:

This study was conducted at a single tertiary care hospital, which may limit the generalizability of the findings to other settings or populations with different demographic or clinical characteristics. Although statistically adequate, the sample size of 60 patients may not fully capture the range of variability seen in broader clinical practice or detect less common adverse events. Our study did not include obese patients and those with age more than 60 years, so age and obesity related changes in outcomes could not be addressed. Patients with significant comorbidities, higher ASA grades, or contraindications to spinal anaesthesia were excluded, which limits applicability to higher-risk or more complex surgical cases. While the study was double- blinded for observers and data collectors, the anaesthesiologist administering the spinal block could not be blinded to injection speed, potentially introducing procedural bias.

Only a single dose and concentration (3 ml of 0.5% heavy bupivacaine) was used for all patients, so results may not apply to different local anaesthetic regimens or varying dose requirements.

Conclusion

In conclusion, rapid intrathecal injection of 0.5% heavy bupivacaine over 15 seconds results in a significantly faster onset of sensory and motor block compared to injection over 60 seconds. However, the faster the injection is also associated with a higher incidence of hypotension and greater vasopressor requirement. Both techniques provide effective anaesthesia, but slower injection offers better haemodynamic stability and fewer complications. Therefore, administering bupivacaine over 60 seconds may be preferable for reducing the risk of hypotension during spinal anaesthesia for infraumbilical surgeries

Declarations

Ethics Approval and Consent: Approved by Institutional Ethics Committee, SMS Medical College, Jaipur. Informed consent obtained from all participants. (Ref. No.: 182 MC/EC/2023)
Funding: None.
Conflicts of Interest: None declared.

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