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# INJECTION SPEED OF SPINAL ANAESTHESIA IN CAESAREAN DELIVERY AND THE INCIDENCE OF HYPOTENSION—A PROSPECTIVE OBSERVATIONAL STUDY

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## ABSTRACT

**Background:** Spinal anaesthesia is the preferred technique for elective and emergency caesarean deliveries due to its rapid onset, reliability, and minimal fetal exposure. However, maternal hypotension remains a common and potentially serious complication. Factors such as the dose, baricity, and position during injection have been studied, but the role of injection speed in influencing haemodynamic responses is less explored. **Aims and Objectives:** This study compares the incidence of hypotension, bradycardia, nausea, vomiting, and the height of spinal block in women undergoing cesarean section who receive 2.0 ml of 0.5% hyperbaric bupivacaine via a 26G Whitacre needle at L3-L4. Patients are divided into two groups based on injection speed: SLOW (>40 seconds) and FAST (<40 seconds), to evaluate how injection rate affects these outcomes. **Materials and Methods:** This prospective observational study was conducted at NH-Rabindranath Tagore International Institute of Cardiac Sciences, Kolkata, a tertiary-level multi-speciality hospital, over a period of two years from December 2017 to December 2019. The study included 96 full-term pregnant women scheduled for elective caesarean delivery under spinal anaesthesia. After obtaining written informed consent, eligible patients were enrolled and assigned to either the SLOW or FAST injection group based on the observed speed of intrathecal drug administration. **Result:** The age distribution and maximum height of sensory block were comparable between Group A (SLOW injection) and Group B (FAST injection), with no statistically significant differences ($p = 0.97$ and $p = 0.437$, respectively). Adverse effects such as hypotension and bradycardia were monitored over 30 minutes. While no events occurred in the first 2 minutes, hypotension was more frequent in Group A from 3 to 10 minutes, with statistically significant differences at 9 minutes ($p = 0.003$) and 10 minutes ($p = 0.026$). Beyond 10 minutes, adverse effects subsided in both groups with no further significant differences. Overall, a higher incidence of hypotension was observed in the FAST injection group during the critical 9–10 minute window post-spinal anaesthesia. **Conclusion:** The speed of spinal anaesthetic injection significantly influences the incidence of maternal hypotension during caesarean delivery. Slower injection appears to be associated with a lower risk of hypotension without compromising anaesthetic efficacy or neonatal outcomes. This simple and modifiable factor may help improve maternal safety in spinal anaesthesia for caesarean sections.

## INTRODUCTION

Spinal anaesthesia remains the preferred technique for elective and emergency caesarean deliveries due to its rapid onset, simplicity, and minimal risk of drug transfer to the fetus.[1] It provides excellent sensory and motor block, allows the mother to remain conscious during delivery, and reduces neonatal respiratory complications associated with general anaesthesia.[2] Despite these advantages, maternal hypotension is a frequently encountered complication, with reported incidence ranging from 60% to 80% in parturients undergoing spinal anaesthesia for caesarean section.[3]


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Maternal hypotension following spinal anaesthesia primarily results from a sudden sympathetic blockade, leading to peripheral vasodilation and reduced venous return.[4] This decrease in systemic vascular resistance and cardiac output may compromise uteroplacental perfusion, potentially affecting both maternal and fetal outcomes. Clinically, hypotension may present with nausea, vomiting, dizziness, or even loss of consciousness, and if prolonged, can result in fetal acidosis and distress.[5] Hence, strategies to prevent or attenuate the severity of hypotension are of paramount importance.

Numerous interventions have been investigated to minimize the incidence and severity of spinal-induced hypotension. These include the use of intravenous fluids for preloading or co-loading, left uterine displacement to avoid aortocaval compression, vasopressors such as phenylephrine or ephedrine, and titration of the local anaesthetic dose.[6] However, another less-explored yet potentially modifiable factor is the speed of intrathecal drug injection, which may influence the spread of the anaesthetic agent within the cerebrospinal fluid (CSF), subsequently affecting the height and onset of sympathetic blockade.

The dynamics of drug spread in the subarachnoid space depend on several factors, including baricity of the solution, patient positioning, CSF volume, and injection speed.[7] It has been hypothesized that faster injection speeds may create greater turbulence and forceful cephalad spread of the local anaesthetic, leading to a higher block level and greater sympathetic blockade, which in turn increases the risk of hypotension.[8] Conversely, slower injection may result in more laminar flow and a gradual spread, potentially leading to a lower sensory block height and reduced haemodynamic fluctuations.

Although theoretical and in vitro models support this hypothesis, clinical evidence on the impact of spinal injection speed on haemodynamic parameters in obstetric anaesthesia is limited. Some studies have demonstrated a correlation between fast injection speeds and higher block levels or increased hypotension, while others found no significant differences.[9] The inconsistency in existing data underscores the need for more focused observational or randomized studies in obstetric populations to better understand this relationship.

Moreover, the physiological changes during pregnancy—such as increased intra-abdominal pressure, engorged epidural veins, and reduced CSF volume—may amplify the effects of rapid drug spread in the subarachnoid space compared to non-pregnant patients.[10] These changes make pregnant women particularly sensitive to even subtle variations in anaesthetic technique, including injection speed.

In this context, the present study aims to evaluate the effect of injection speed of spinal anaesthesia on the incidence of hypotension in patients undergoing caesarean delivery. By comparing haemodynamic outcomes between a "slow" and "fast" injection group, we hope to determine whether adjusting this modifiable technical factor can contribute to improved maternal stability and safety during spinal anaesthesia. Given the simplicity of implementation, if proven effective, controlling injection speed could become a valuable tool in standard obstetric anaesthesia practice.

## MATERIALS AND METHODS

**Study design:** Prospective Observational Study.

**Place of study:** NH-Rabindranath Tagore International Institute of Cardiac Sciences, Kolkata, a tertiary level multi-speciality hospital in Kolkata.

**Period of study:** The study period will be for two years from December 2017 to December 2019.

**Study population:** In patients admitted for elective caesarean section under spinal anaesthesia

**Study Variables:**

- Bradycardia
- Hypotension
- Ht of Block
- Age

**Sample size:** 96 Full-term pregnant women Patients undergoing elective caesarean delivery under spinal anaesthesia.

**Inclusion Criteria**

- Patients graded ASA (American Society of Anesthesiology) II (only due to pregnancy)
- No other co-morbidities.
- Age group of 18-35 years
- Height>=150 cm and <=180cm
- No past bad obstetric history.
- Spinal injection given at L3-L4 level with a 26G Whitacre needle.
- Volume of drug given is 2.0ml of 0.5% hyperbaric Bupivacaine without any additive.

**Exclusion Criteria**

- Patient's refusal
- Patients is unable to understand the study protocol and the procedure.
- Patients with history of allergy to the drug used
- Patient under any medication influencing autonomic/cardiovascular response to study
- Diabetes mellitus or any other co morbid conditions causing autonomic neuropathy.
- Patients with coagulopathy or on anti-platelets an anticoagulant drug.
- Patients with severe pre-eclampsia

**Statistical Analysis:** Based on a prior study by Simon L et al, a sample size of 42 patients per group was calculated to detect a statistically significant difference with a power of 80% and $\alpha = 0.05$. Patients were randomly allocated into two groups—SLOW and FAST—using a computer-generated block randomization method with concealed allocation, following written informed consent. Categorical variables will be presented as numbers and percentages and analyzed using Pearson's Chi-square


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test, while continuous variables will be expressed as mean ± standard deviation and compared using the unpaired t-test or Mann-Whitney U test based on data distribution. Statistical analysis will be performed using SPSS version 20, with a p-value < 0.05 considered statistically significant.

## RESULTS

**Table 1: Comparison of Age Distribution between Group A (SLOW) and Group B (FAST)**

| | | GROUP A | GROUP B | Total | P Value | Significance |
|---|---|---|---|---|---|---|
| AGE | 19-20 | 2(4.17) | 2(4.17) | 4(4.17) | 0.97 | Not Significant |
| | 21-30 | 35(72.92) | 36(75) | 71(73.96) | | |
| | 31-40 | 11(22.92) | 10(20.83) | 21(21.88) | | |
| | | 28.23 ± 3.31 (Mean ± sd) | 28.15±3.48 (Mean ± sd) | | | |
| Total | | 48(100) | 48(100) | 96(100) | | |

**Table 2: Comparison of Maximum Height of Sensory Block between Group A (SLOW) and Group B (FAST)**

| | | GROUP | | | | |
|---|---|---|---|---|---|---|
| | | GROUP A | GROUP B | Total | p Value | Significance |
| HT OF BLOCK | T6 | 12(25) | 9(18.75) | 21(21.88) | 0.437 | Not Significant |
| | T8 | 34(70.83) | 34(70.83) | 68(70.83) | | |
| | T10 | 2(4.17) | 5(10.42) | 7(7.29) | | |
| Total | | 48(100) | 48(100) | 96(100) | | |

**Table 3: Comparison of Adverse Effects over Time between Group A (SLOW) and Group B (FAST)**

| Adverse Effect | | Bradycardia | Hypotension | Hypotension, Bradycardia | None | p Value | Significance |
|---|---|---|---|---|---|---|---|
| 1 Minute | Group A | | | | 48(100) | NA | NA |
| | Group B | | | | 48(100) | | |
| 2 Minute | Group A | | | | 48(100) | NA | NA |
| | Group B | | | | 48(100) | | |
| 3 Minute | Group A | | 1(2.08) | | 47(97.92) | 0.315 | Not Significant |
| | Group B | | 0(0) | | 48(100) | | |
| 4 Minute | Group A | | | | 48(100) | NA | NA |
| | Group B | | | | 48(100) | | |
| 5 Minute | Group A | | 4(8.33) | | 44(91.67) | 0.362 | Not Significant |
| | Group B | | 1(2.08) | | 47(97.92) | | |
| 6 Minute | Group A | 1(2.08) | 5(10.42) | | 42(87.5) | 0.268 | Not Significant |
| | Group B | 0(0) | 2(4.17) | | 46(95.83) | | |
| 7 Minute | Group A | | 4(8.33) | | 44(91.67) | 0.677 | Not Significant |
| | Group B | | 2(4.17) | | 46(95.83) | | |
| 8 Minute | Group A | | 6(12.5) | | 42(87.5) | 0.486 | Not Significant |
| | Group B | | 3(6.25) | | 45(93.75) | | |
| 9 Minute | Group A | | 9(18.75) | | 39(81.25) | 0.003 | Significant |
| | Group B | | 0(0) | | 48(100) | | |
| 10 Minute | Group A | | 5(10.42) | 1(2.08) | 42(87.5) | 0.026 | Significant |
| | Group B | | 0(0) | 0(0) | 48(100) | | |
| 15 Minute | Group A | | 3(6.25) | | 45(93.75) | 0.242 | Not Significant |
| | Group B | | 0(0) | | 48(100) | | |
| 20 Minute | Group A | | 3(6.25) | | 45(93.75) | 0.242 | Not Significant |
| | Group B | | 0(0) | | 48(100) | | |
| 25 Minute | Group A | | | | 48(100) | NA | NA |
| | Group B | | | | 48(100) | | |
| 30 Minute | Group A | | | | 48(100) | NA | NA |
| | Group B | | | | 48(100) | | |

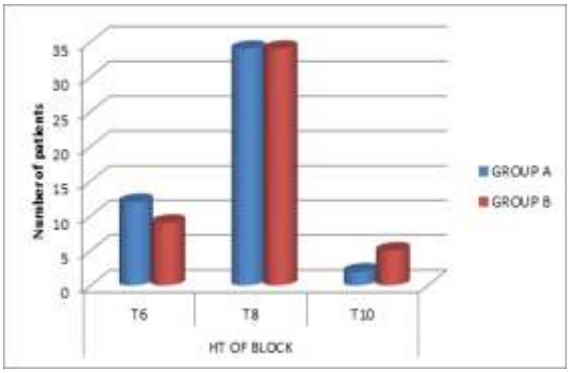


**Figure 1: Comparison of Maximum Height of Sensory Block between Group A (SLOW) and Group B (FAST)**

The age distribution among the two groups was comparable. In Group A, 2 patients (4.17%) were aged 19–20 years, 35 patients (72.92%) were aged 21–30 years, and 11 patients (22.92%) were aged 31–40 years. Similarly, Group B had 2 patients (4.17%) in the 19–20 age group, 36 patients (75%) in the 21–30 age group, and 10 patients (20.83%) in the 31–40 age group. The mean age in Group A was 28.23 ± 3.31 years, while in Group B it was 28.15 ± 3.48 years. The difference in age distribution between the groups was not statistically significant (p = 0.97).

The distribution of the maximum height of sensory block was similar between the two groups. In Group A, 12 patients (25%) achieved a T6 level, 34 patients


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(70.83%) reached T8, and 2 patients (4.17%) had a block height of T10. In Group B, 9 patients (18.75%) had a T6 block, 34 patients (70.83%) achieved T8, and 5 patients (10.42%) had a T10 level. The difference in block height distribution between the groups was not statistically significant (p = 0.437).

Adverse effects such as hypotension and bradycardia were monitored at intervals up to 30 minutes following spinal anaesthesia. In the initial 2 minutes, no adverse effects were noted in either group. At 3 minutes, 1 patient (2.08%) in Group A developed hypotension, while none were affected in Group B (p = 0.315). At 5 minutes, hypotension occurred in 4 patients (8.33%) in Group A and 1 patient (2.08%) in Group B (p = 0.362). At 6 minutes, Group A had 1 case of bradycardia and 5 cases of hypotension, whereas Group B had 2 cases of hypotension with no bradycardia (p = 0.268). Between 7 and 8 minutes, a few more cases of hypotension were noted, but without statistical significance. However, at 9 minutes, a significant difference was observed: 9 patients (18.75%) in Group A developed hypotension, compared to none in Group B (p = 0.003). At 10 minutes, Group A reported 5 cases of hypotension and 1 case with both hypotension and bradycardia, while Group B had none, showing a statistically significant difference (p = 0.026). From 15 minutes onwards, no significant differences were found between the groups. Overall, adverse effects were more frequent in the FAST injection group during the 9–10 minute window post-injection.

## DISCUSSION

In the present study, the age distribution between the two groups (SLOW and FAST injection) was comparable, eliminating age as a confounding factor in evaluating haemodynamic responses. The majority of patients in both groups were between 21–30 years, with mean ages of 28.23 ± 3.31 years and 28.15 ± 3.48 years in Group A and B, respectively, indicating a homogenous obstetric population in line with most caesarean delivery cohorts.[11] The maximum height of sensory block achieved in both groups was predominantly at the T8 level. However, a slightly higher proportion of patients in the FAST group achieved T10 and T6 levels compared to the SLOW group. Although not statistically significant, this observation supports the hypothesis that a faster injection rate may lead to greater variability in block height due to turbulent flow and less predictable spread of the intrathecal drug.[12] These findings are consistent with those of Doganci et al., who reported higher sensory levels in patients receiving faster intrathecal injections, although the difference was modest.[13] In contrast, Elakany and Ahmed found a more prominent rise in block height and a higher incidence of hypotension with rapid injection speeds during spinal anaesthesia for caesarean sections, suggesting a direct correlation between injection dynamics and sympathetic blockade.[14] Adverse effects were carefully monitored throughout the 30-minute observation period. While no adverse events occurred in the initial 2 minutes, differences began to emerge from the 3rd minute onward. Hypotension and bradycardia were more frequent in the FAST injection group, with statistically significant differences noted at 9 minutes (p = 0.003) and 10 minutes (p = 0.026). These findings underscore the physiological importance of controlling injection speed to mitigate rapid onset of high spinal block and sympathetic decompensation.[15] Several authors have explored strategies to reduce the incidence of spinal anaesthesia-induced hypotension in obstetric patients. Cyna et al. suggested that the manipulation of physical factors such as baricity, patient positioning, and injection dynamics can alter anaesthetic spread and subsequent haemodynamic outcomes.[16] Harten et al. similarly concluded that even slight modifications in injection technique could influence block distribution and thereby affect cardiovascular stability.[17] Singh et al. emphasized the role of co-loading and preloading but acknowledged that technical aspects such as injection speed remain under-studied despite their potential impact.[18] Our study adds to this growing body of literature by providing evidence that a slower injection rate may reduce the peak sympathetic blockade, leading to more stable haemodynamics and fewer vasopressor interventions. This is particularly relevant in the obstetric setting, where maternal hypotension poses risks not only to the mother but also to fetal well-being through impaired uteroplacental perfusion.[19] A study by Bhatia et al. confirmed that fluctuations in maternal blood pressure correlate with fetal acidosis, reinforcing the need for preventive strategies that are simple, effective, and safe.[20]

## CONCLUSION

This study demonstrates that the speed of intrathecal injection during spinal anaesthesia for caesarean delivery has a significant impact on the incidence of maternal hypotension. While both slow and fast injection techniques provided adequate anaesthesia, the fast injection group experienced a higher frequency of hypotensive episodes, particularly during the 9–10 minute window post-injection, with some cases requiring intervention. These findings suggest that a slower injection technique may help reduce the risk of hypotension and enhance maternal haemodynamic stability without compromising anaesthetic efficacy. Therefore, controlling spinal injection speed represents a simple, safe, and effective strategy to improve outcomes in obstetric anaesthesia.

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