A study to evaluate perfusion index as a predictor of hypotension following spinal anesthesia for caesarean section

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Abstract

Background and Aims: The perfusion index (PI) has been used as a marker of peripheral perfusion. A lower PI indicates greater peripheral vascular tone and increased risk of hypotension following spinal anesthesia. The present study was conducted to evaluate and correlate perfusion index (PI) with incidence of hypotension following spinal anesthesia for caesarean section.

Material and Methods: The present prospective, double blind, observational study included sixty full term parturients in the age group 18-35 years belonging to American Society of Anesthesiologists (ASA) physical status I and II, having singleton pregnancy undergoing caesarean section under spinal anesthesia. On the basis of baseline PI, patients were allocated into one of the two groups: Group I (n = 30) Patients with baseline PI ≤ 3.5 and Group II (n = 30) Patients with PI > 3.5.

Results: The incidence of hypotension in group I was 40% as compared to 73.3% in group II (p = 0.009). Thus, the incidence of hypotension in group II with baseline PI > 3.5 was more as compared to group I. Patients in group II with baseline PI > 3.5 had significantly more episodes of hypotension as compared to those in group I with baseline PI ≤ 3.5.

Conclusion: PI can be used as a useful tool for predicting hypotension in parturients undergoing elective caesarean section under spinal anesthesia in everyday practice.

Keywords: Caesarean section, hypotension, perfusion index, spinal anesthesia

Introduction

Caesarean section is routinely performed under spinal anesthesia that induces sympathetic blockade which leads to decreased vascular resistance resulting in hypotension. This spinal anesthesia induced hypotension is aggravated in pregnant patients because of decreased cardiac output due to blood pooling in blocked areas of the body in addition to decreased vascular resistance due to sympathetic blockade. The peripheral vascular tone is decreased in parturients at term, especially in those who are multiparous. Although baseline volume status affects the degree of hypotension, baseline peripheral vascular tone may also have an influence on the development of hypotension. As a result of decreased peripheral vascular tone, blood volume gets trapped in the extremities even before spinal anesthesia and the sympathetic blockade with spinal anesthesia further increases the blood pooling. Therefore, parturients who have low baseline vascular tone may be at an increased risk of developing hypotension after spinal anesthesia. As compared to 33% of non-pregnant patients, approximately 70% parturients develop hypotension following spinal anesthesia. Severe adverse effects are related to hypotension in mother such as dizziness, nausea, and vomiting and may cause umbilical arterial acidosis in infants. Therefore, it is critically important to identify those who are at risk of hypotension while performing spinal anesthesia in caesarean section, as

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it would give clinicians an opportunity to take preventative measures such as pre-anesthetic volume expansion and prophylactic vasopressor administration. Non-invasive blood pressure (NIBP) measurement is the standard method of monitoring intraoperative hemodynamics. However, beat to beat variation in perfusion dynamics cannot be measured by this method and limits its efficacy.\(^{[3]}\)

The perfusion index (PI) has been used as a marker of peripheral perfusion. A lower PI indicates greater peripheral vascular tone. Thus PI is a valuable objective during anesthetic practice to find out non-invasive methods for predicting the hemodynamic responses to anesthetic drugs and techniques.\(^{[4]}\) Clinical studies demonstrated that an increase in PI is an early indicator that spinal anesthesia has initiated peripheral vasodilatation which typically occurs before the onset of anesthetic effect; however, the literature is limited.\(^{[5,6]}\) Thus, PI can be used as a marker of peripheral perfusion and can be used to assess peripheral perfusion dynamics due to changes in peripheral vascular tone and to detect the likelihood of development of hypotension following spinal anesthesia. Hence, the present study was conducted to evaluate and correlate PI with incidence of hypotension following spinal anesthesia for caesarean section.

**Material and Methods**

The present prospective, double blind, observational study was conducted in the department of Anaesthesiology and Critical Care, PGIMS Rohtak. Approval for the study was obtained from Institutional Ethics Committee and the trial was registered (CTRI/2019/03/018058). Sixty full term parturients in the age group 18-35 years belonging to American Society of Anesthesiologists (ASA) physical status I and II, having singleton pregnancy undergoing caesarean section with Pfannenstiel incision under spinal anesthesia were included in the study. Informed written consent was taken. Parturients with contraindications to spinal anesthesia, known risk factor for postpartum hemorrhage, significant obstetric disease such as pregnancy induced hypertension or preeclampsia, cardiovascular or cerebrovascular disease, morbid obesity with a BMI >40 kg m\(^{-2}\) and gestational age <36 or >41 weeks were excluded from the study.

All patients were subjected to complete general physical and systemic examination. Investigations like hemoglobin, bleeding time, clotting time, and urine examination were carried out in all the patients. The purpose and protocol of the study was explained to the patients and informed written consent was obtained. Patients were kept fasting for 8 hours prior to the scheduled time of surgery. They were premedicated with oral ranitidine 150 mg night before and with metoclopramide 10 mg and ranitidine 150 mg two hours prior to surgery with sips of water.

Upon arrival in the operating room, all patients were laid supine with wedge under right flank to achieve leftward tilt of 15\(^{\circ}\). Routine monitoring including heart rate, electrocardiogram, NIBP and Sp\(_O_2\) was started. Peripheral venous access was secured with 18G cannula and baseline hemoglobin was taken. All patients were preloaded with 10 mL kg\(^{-1}\) of Ringer Lactate solution over 10 minutes before spinal anesthesia. Base line systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure (MAP), heart rate (HR) and Sp\(_O_2\) were recorded. Baseline perfusion index was measured by an anesthesiologist who was not involved in the further intraoperative monitoring of the patient, using a specific pulse oximeter probe (Masimo Radical 7\(^{[7]}\); Masimo Corp., Irvine, CA) which was attached to left index finger of all patients to ensure uniformity.

On the basis of baseline PI, patients were allocated into one of the two groups: Group I (n = 30) Patients with baseline PI \(\leq 3.5\) and Group II (n = 30) Patients with PI \(>3.5\). A standard anesthesia protocol was followed. All patients were given spinal anesthesia in sitting position at L3-L4 or L4-L5 interspace with 25 G Quincke’s spinal needle. After free flow of cerebrospinal fluid, 10 mg of 0.5% hyperbaric bupivacaine was administered without barbotage. Patients were immediately placed in supine position with 15\(^{\circ}\) left lateral tilt. Oxygen was delivered to all patients via face mask at the rate of 4 L min\(^{-1}\). Intravenous Ringer Lactate was infused at constant rate of 15 mL kg\(^{-1}\) hr\(^{-1}\) till the end of surgery.

Sensory block height level was checked by assessing the perception of coldness using spirit swab at 2 minutes interval till 10 minutes and thereafter at 5 minutes interval till 20 minutes. At the same point of time, motor blockade was assessed using modified Bromage scale. Surgery was allowed to commence as soon as T6 dermatome was anesthetized. After delivery of fetus and clamping of umbilical cord, oxytocin infusion was started (20 U of oxytocin in 500 ml of 0.9% normal saline at the rate of 250 ml hr\(^{-1}\)). Hypotension, defined as decrease in systolic blood pressure by more than 20% from baseline or less than 80 mm Hg was treated with boluses of 6 mg intravenous ephedrine and 100 ml Ringer Lactate. Bradycardia, defined as HR less than 60 beats per min (bpm) was treated with boluses of 0.6 mg IV atropine.

A second anesthesiologist who was blinded to the group allocation recorded demographic data (age, height, weight, body mass index), hemodynamic variables (SBP, DBP, MAP, HR, Sp\(_O_2\) and PI) and need for atropine and ephedrine.
Hemodynamic variables were noted at 2 min interval after spinal injection for the first 20 minutes and then at 5 minutes interval for further 50 minutes and then at the end of surgery. Following completion of the study the data was collected and subjected to statistical analysis.

Duggappa et al. found incidence of hypotension in group I (PI < 3.5) to be 15% and in group II (PI > 3.5) to be 65%[5]. Based on this study and taking α error of 5% and 1-β power to be 95% we enrolled 60 cases, allocated in two groups of 30 each. The data were coded and entered into Microsoft Excel spreadsheet. Analysis was done using SPSS version 20 (IBM SPSS Statistics Inc., Chicago, Illinois, USA) Windows software program. Chi square test for categorical data and student t-test for continuous data were used. Quantitative variables are expressed as mean ± SD and compared between groups using unpaired t-test. Level of significance was set at $P \leq 0.05$.

**Results**

The two groups were comparable with respect to age, weight, height, and BMI. The mean age of patients in group I was 25.23 ± 2.69 years and in group II was 26 ± 2.94 years ($P = 0.148$). The mean weight of patients in group I was 65.23 ± 4.61 kg and in group II was 66.47 ± 5.4 kg ($P = 0.148$). Mean height of patients in group I was 155.37 ± 3.37 cm and in group II was 156.60 ± 3.82 cm ($P = 0.095$). The mean BMI of patients in group I was 27.07 ± 2.42 kgm$^{-2}$ and in group II was 27.64 ± 2.13 kgm$^{-2}$ ($P = 0.459$).

The baseline PI in group I was 1.79 ± 0.96 and in group II was 5.85 ± 1.46. The difference in PI at various interval was significant in both the groups ($P < 0.05$) [Table 1]. Mean baseline SBP in group I was 124 ± 9.27 mmHg and in group II was 117.93 ± 8.58 mmHg ($P = 0.002$). Thus the patients in group II (PI > 3.5) had significant lower mean baseline SBP as compared to group II. The mean baseline DBP in group I was 79.73 ± 7.59 mmHg while in group II was 74.50 ± 5.4 mmHg ($P = 0.002$). The mean baseline MAP in group I at baseline was 95.77 ± 8.07 mmHg and in group II was 89.90 ± 5.44 mmHg ($P < 0.001$).

The incidence of hypotension in group I was 40% as compared to 73.3% in group II ($P = 0.009$) [Table 2]. Thus, the incidence of hypotension in group II with baseline PI > 3.5 was more as compared to group I. In group I, 18 patients (60%) did not have any episode of hypotension, 4 patients (13.3%) had 1 episode and 8 (26.6%) patients had multiple episodes. In group II, 8 patients (26.7%) did not have any episode of hypotension, 5 patients (16.7%) had 1 episode and 17 (56.6%) patients had multiple episodes of hypotension. When compared statistically using Chi square test, there was significant difference in the two groups with respect to number of episodes of hypotension ($P$ value = 0.006) [Table 3]. Thus, the patients in group II with baseline PI >3.5 had significantly more episodes of hypotension as compared to those in group I with baseline PI ≤3.5.

The mean bolus of ephedrine required in group I was 2.00 ± 0.82 whereas in group II, it was 3.05 ± 1.33 ($P = 0.03$). The mean dose of ephedrine used in group I was 12.00 ± 4.90 mg whereas in group II, it was 18.27 ± 7.96 mg ($P = 0.030$). Thus, the dose of ephedrine required was more in group II as compared to group I. The mean fluid consumption in group I was 1331.67 ± 332.05 ml and in group II was 1630.00 ± 289.05 ml ($P < 0.001$). The fluid consumption in group II was significantly more as compared to group I.

**Discussion**

Hypotension following spinal anesthesia results due to blockade of pre-ganglionic sympathetic fibers and due to blood pooling in blocked areas of body. Changes in peripheral circulation are seen in normal pregnancy viz decreased peripheral vascular resistance, arterial, and venous vasodilation and increased intravascular volume. These changes further have an influence on degree of hypotension which occurs after spinal anesthesia.[7] Hypotension may have severe adverse effects on maternal and fetal morbidity and vasopressors are required in up to 80% of patients to treat it.[8]

Many hemodynamic parameters have been studied as predictors of hypotension but none of the monitoring system can definitely predict the likelihood of hypotension.[3,9] PI is a non-invasive and continuous method for assessing the peripheral tissue perfusion by calculating the ratio of pulsatile (arterial component) and non-pulsatile components (venous, capillary, and other tissues) of light reaching the pulse oximeter detector.[10] The median (IQR) of baseline PI was 1.8 (1-2.7) in group I and 5.6 (5.07-6.4) in group II. The skewed distribution to the right around $P$ value of 3.5 was observed when baseline PI values of both groups were combined and assessed for normal distribution. The results of present study are consistent with a study conducted in which authors found that median PI in group I was 2.45 (1.8-2.8) and in group 2 was 5.4 (4.25-7.1).[11]

The incidence of hypotension in group I with baseline PI ≤3.5 was 40% (12/30) as compared to 73.3% (22/30) in group II. The incidence of hypotension in group II with
baseline PI was significantly more as compared to group 1 (p = 0.009) [Table 2]. The present study results are consistent with the various studies. Toyama et al. found that hypotension occurred in 82% of patients (17/19) with high baseline PI whereas hypotension was observed in 25% patients (4/16) with low baseline PI. They also found a significant correlation between baseline PI and degree of decrease in SBP from baseline after SA. Dugappa et al. also found that the incidence of hypotension was 10.5% (6/57) in patients with baseline PI ≤3.5 and 71.42% (45/63) in patients with baseline PI >3.5 which was clinically and statistically highly significant (p < 0.001). Varghese RV found that the incidence of hypotension in group 1 (PI >3.5) was 86.67% whereas in group 2 (PI ≤3.5) was 6.67% which was highly significant (p < 0.05). George et al. found that the incidence and severity of hypotension was higher in parturients with baseline PI >3.6.

There was a positive correlation of baseline PI with number of episodes of hypotension (r = 0.109, \(P = 0.01\)) in group II while there was no correlation between baseline PI and number of episodes of hypotension in group I (r = ‑0.236, \(P = 0.210\)). The results of present study are similar to different studies. In the study conducted by Dugappa et al., among the patients with baseline PI < 3.5, 4 patients had 1 episode, 1 patient had 2 episodes and 1 patient had 3 episodes. While in patients with PI > 3.5, 24 patients had 1 episode, 16 patients had 2 episodes, 4 patients had 3 episodes and 1 patient had 4 episodes. They also found that the number of episodes of hypotension were more in group with high baseline PI (p < 0.001). A significant correlation between PI > 3.5 and number of episodes of hypotension was found (r=0.416, P < 0.001). Varghese RV found that in patients with PI > 3.5, 11 patients had 1 episode, 12 patients had 2 episodes and 3 patients had 3 episodes of hypotension. In patients with PI < 3.5, 93% patients did not have hypotension. 1 pregnant woman had 1 episode and 1 had 2 episodes of hypotension. A significant difference was found in the number of episodes of hypotension between both groups (p = 0.000).

### Table 1: PI in both groups at different time points

| Time Points | Group I PI Mean ± SD | Baseline Comparison \(P^*\) | Group II PI Mean ± SD | Baseline Comparison \(P^*\) | Group 1 vs 2 \(P^*\) |
|-------------|----------------------|-----------------------------|-----------------------|-----------------------------|------------------------|
| Baseline    | 1.79±0.96            | 5.85±1.46                   | 0.009                 |
| 2 min       | 2.13±0.99            | 5.63±1.65                   | 0.009                 |
| 4 min       | 2.28±0.95            | 6.04±1.88                   | 0.009                 |
| 6 min       | 2.60±1.23            | 6.41±2.59                   | 0.009                 |
| 8 min       | 2.79±1.46            | 5.94±1.89                   | 0.009                 |
| 10 min      | 3.17±1.67            | 6.17±2.17                   | 0.009                 |
| 12 min      | 3.41±1.76            | 6.02±1.91                   | 0.009                 |
| 14 min      | 3.80±2               | 5.89±1.75                   | 0.009                 |
| 16 min      | 3.83±2.05            | 5.80±1.78                   | 0.009                 |
| 18 min      | 4.02±2.19            | 5.61±2.19                   | 0.009                 |
| 20 min      | 4.24±2.29            | 5.70±2.75                   | 0.003                 |
| 25 min      | 4.34±2.13            | 5.56±2.64                   | 0.015                 |
| 30 min      | 4.08±1.82            | 5.14±2.04                   | 0.026                 |
| 35 min      | 3.39±1.79            | 5.14±3.51                   | 0.019                 |
| 40 min      | 3.02±1.78            | 4.34±2.01                   | 0.011                 |
| 45 min      | 3.43±2.17            | 3.90±2.03                   | 0.008                 |
| 50 min      | 2.83±1.42            | 3.62±1.58                   | 0.246                 |
| EOS         | 1.96±1.06            | 2.39±1.47                   | 0.074                 |

*Student t-test

### Table 2: Incidence of hypotension in both groups

| Incidence of hypotension | Group I | Group II | \(P^*\) |
|--------------------------|---------|----------|---------|
| Present                  | 12 (40%)| 22 (73.3%)| 0.009 (S)|
| Absent                   | 18 (60%)| 8 (26.7%) |         |
| Total                    | 30      | 30       |         |

*Chi square test

### Table 3: No of episodes of hypotension

| Number of episodes of hypotension | Group I | Group II | \(P^*\) |
|-----------------------------------|---------|----------|---------|
| 0                                 | 18      | 8        | 0.006 (S)|
| 1                                 | 4       | 5        | 0.16    |
| 2                                 | 6       | 2        | 0.72    |
| 3                                 | 1       | 9        | 0.36    |
| 4                                 | 0       | 5        | 0.16    |
| 5                                 | 1       | 3        | 0.33    |

*Chi square test
The ROC curve yielded 73.3% sensitivity and 76.67% specificity (AUC = 0.74 P = 0.03). The ROC curve revealed that PI discriminated well between patients who developed hypotension versus those who did not develop hypotension [Table 4 and Figure 1]. The present study results are consistent with various studies. Toyama et al. found the baseline cut-off point for PI that predicted hypotension as 3.5 with a sensitivity of 81%, specificity of 86%, a positive predictive value of 89% and negative predictive value of 75% based on ROC analysis (AUC = 0.866 P = 0.0003).[11] Duggappa et al. found the optimal cut-off of PI for predicting hypotension as 3.5 with sensitivity of 69.84% and specificity of 89.29% base on ROC analysis (AUC = 0.848 P = <0.001).[5] Varghese RV found that the ROC curve yielded 3.83 as an appropriate cut-off value to predict hypotension with sensitivity and specificity of 86.7% and 93.33% respectively with positive predictive value of 92.86% and negative predictive value of 87.5%.[16] George et al. also found that PI discriminated well between patients who developed hypotension versus those who did not. They found a cut-off value of 3.6 to predict hypotension with sensitivity 80% and specificity 40%.[12]

**Limitations**

There are several limitations in present study. Photoplethysmographic analysis is sensitive to patient movement and PI is also affected by several factors like stress and anxiety that can lead to sympathetic activation which leads to peripheral vasoconstriction leading to decrease in PI. In the present study, the baseline PI was recorded with utmost care to avoid patient movement and readings were recorded after stabilizing the patient. Patient temperature at monitoring site can also affect the PI values. PI can also be affected by systemic vascular resistance but since its measurement is invasive and unnecessary in uncomplicated CS, it was not recorded.

**Conclusion**

In conclusion, the present study demonstrated that parturients with baseline PI > 3.5 measured at the finger are at higher risk of developing hypotension during spinal anesthesia for caesarean section compared to those with baseline PI ≤ 3.5. Hence the baseline PI cut-off point of 3.5 can be used to identify parturients at risk for such hypotension. Thus, PI can be used as a useful tool for predicting hypotension in parturients undergoing elective caesarean section under spinal anesthesia in everyday practice.

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**Conflicts of interest**

There are no conflicts of interest.

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