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# Evaluation of perfusion index to predict hypotension in lower segment caesarean section under spinal anaesthesia

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## ABSTRACT

**Background:** Spinal Anaesthesia is the most popular choice for elective caesarean section. Both general anaesthesia and regional anaesthesia are acceptable techniques for anaesthesia for elective and emergency caesarean sections.

**Objectives:** The study aimed to investigate the role of the perfusion index in predicting the incidence of hypotension following spinal anaesthesia in parturients undergoing elective lower segment caesarean sections.

**Methods:** A prospective observational study was carried out among sixty parturients posted for elective caesarean section. The study was conducted in the operation theatres of Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi. About 60 participants were interviewed for the study. Data were entered and analysed with the help of the Statistical Package for Social Science (SPSS) version.16.

**Results:** Sixty eligible ASAI (American society of anaesthesiologist's physical status classification) parturients scheduled for elective caesarean section were divided into two groups pre-operatively after determining their baseline Perfusion Index (PI) as those with PI ≤ 3.5 and those with PI > 3.5 using a Masimo® pulse oximeter probe. When comparing the heart rate at time intervals among the two groups, it became increasingly clear that those with baseline PI > 3.5 had generally higher heart rate especially immediately after the block and at 2$^{nd}$, 4$^{th}$, 6$^{th}$,8$^{th}$, 10$^{th}$, 12$^{th}$, 14$^{th}$ and 20$^{th}$ minutes.

**Conclusion:** The study concludes that a Perfusion Index > 3.5 is associated with a higher incidence of hypotension in lower segment caesarean section under spinal anaesthesia. The hemodynamic parameters such as increased heart rate and significantly lower systolic, diastolic and mean arterial pressures in parturients with baseline PI > 3.5 suggest that these patients have lower baseline SVR and depleted autonomic resilience to hypotension compared to those with baseline PI ≤ 3.5. High BMI seems to be significantly associated with high baseline PI.

**Keywords:** Caesarean section, Hypotension, Perfusion index, Spinal anaesthesia

## 1. Introduction

Spinal anaesthesia is the most popular choice for elective caesarean sections [1]. Both general anaesthesia and regional anaesthesia are acceptable techniques for anaesthesia for elective and emergency caesarean sections [1].

Spinal anaesthesia is the preferred technique, but it is also not without complications, the most prominent being hypotension. If not dealt with promptly, it may lead to unconsciousness, pulmonary aspiration, apnoea and cardiac arrest. Sustained hypotension impairs placental perfusion as well and may induce fetal hypoxia and fetal acidosis [2]. Sympathetic blockade and decreased cardiac output due to pooling of blood in the blocked part is the probable cause of hypotension after spinal anaesthesia [3-6]. Furthermore, parturients are more sensitive to local anaesthetics and less responsive to vasopressors, making them more susceptible to hypotension [7]. Body mass index, the mother's age and the sensory block height are some of the risk factors that can contribute to the incidence of hypotension after spinal anaesthesia for caesarean section [8].

While performing caesarean section under spinal anaesthesia, it is pivotal to identify patients who are at high risk of developing hypotension. This will allow anaesthesiologists to take pre-emptive steps for adequate preparation in the perioperative phase and guide possible changes in treatment regimens such as early initiation of vasopressor therapy in order to avoid adverse maternal or fetal outcomes [9-11].

Hypotension during spinal anaesthesia is hypothesized to be associated with intravascular volume before the block [12]. Therefore, monitoring techniques that can evaluate intravascular volume may predict hypotension and guide the fluid therapy and vasopressor therapy [1, 8].

Dynamic indices like stroke volume variation, pulse pressure variation and the Pleth variability index are well documented for assessing the response of fluid therapy in patients who are on mechanical ventilation [13,14]. Various non-invasive methods that have gained attention to predict hypotension after spinal anaesthesia include respiratory variation in pulse oximeter plethysmography waveform, pulse transit time, and heart rate variability [15-19].

Further, measures based upon preoperative vital signs before and after an orthostatic challenge were also attempted to identify parturients at risk for post spinal hypotension

[20]. A high baseline heart rate could also be predictive of obstetric post spinal hypotension as a result of higher sympathetic tone [21, 22].

Perfusion Index (PI) has been promoted in various clinical settings to assess hemodynamic parameters. PI can be used to assess intravascular perfusion dynamics. It has been used to detect progressive reductions in central blood volume and it could be used to diagnose early clinically significant hypervolemia before onset of cardiovascular decompensation. There are very few studies that have described this in context of the Indian population [23]. There is a paucity of studies in the Indian population which evaluate the association of perfusion index and the incidence of hypotension in lower segment caesarean section under spinal anaesthesia. This study seeks to determine whether a baseline PI >3.5 predicts the development of hypotension after spinal anaesthesia for elective lower segment caesarean section in the Indian population. The study aimed to investigate the role of perfusion index to predict the incidence of hypotension following spinal anaesthesia in parturients undergoing elective lower segment caesarean section.

## 2. Methods

### 2.1 Study Area

The study was conducted in the operation theatres of Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi**.** The study period was from July 2019 to January 2021.

### 2.2 Study Design

A prospective, observational study was carried out among sixty parturients posted for elective caesarean sections.

### 2.3 Sample size and sampling

Parturients posted for elective caesarean sections. With reference to previous study conducted by Dugappa *et al*, incidence of hypotension in Group PI ≤ 3.5 was 10.5% compared to 71.4% in Group PI > 3.5 [18]. Thus, a sample size of 11 patients was required in each arm to show a significant difference between groups with a power 90% at 5% level of significance, $\alpha$=0.05 and $\beta$=0.1. The calculated final sample size taken was 60. Parturients posted for elective caesarean section were included. Patients with placenta previa, preeclampsia, cardiovascular or cerebrovascular disease, gestational diabetes, body mass index ≥40, gestational age & less than 36 or & greater

than 41 weeks' contraindications to spinal anaesthesia, those requiring additional oxytocic and/or additional surgical interventions, and those suffering from psychiatric illnesses and undertreatment were excluded.

### 2.4 Data Collection

The patient was received in the pre-operative room. The patient's particulars were checked. Standard monitoring with electrocardiography, automated NIBP (Non-Invasive Blood Pressure), and pulse oximetry (SpO2) were performed for baseline values and intraoperative monitoring. Baseline hemodynamic values including PI were recorded in the supine position. The PI was measured in the supine position using a specific pulse oximeter probe (Masimo® MightySat™ Fingertip Pulse Oximeter; Masimo Corp., Irvine, CA, USA) attached to the left index finger of all patients to ensure uniformity in measured PI values. Those with a baseline PI of ≤ 3.5 were classified into Group I and those with a PI of >3.5 were classified into Group II. The cut-off point was based on results of previous studies. Thereafter, peripheral venous access was secured with an 18-gauge IV cannula in the left upper limb, and Ringer's Lactate was started at the rate of 10ml/kg/hour. Injection Ranitidine 50mg and injection Metoclopramide 10mg were added to the intravenous fluid. While administering neuraxial blockade, the Masimo® pulse oximeter was disconnected to prevent observer bias and SpO2 was recorded using a different pulse oximeter. Spinal anaesthesia was performed by an anaesthesiologist using Quincke's 25-gauge spinal needle in left lateral decubitus position with 10 mg of injection bupivacaine 0.5% (hyperbaric) plus fentanyl 10μgms at rate of 0.2 ml/min, at the L3–L4 or L4–L5 interspace after confirming free flow of clear cerebrospinal fluid. The patient was returned to the supine position with a left lateral tilt of 15 to facilitate left uterine displacement. The Masimo® pulse oximeter was reconnected to monitor the patient till the end of surgery. Oxygen was given through a Venturi mask at 0.4 FiO2 at rate of 6 L/min. The level of sensory block was checked every 2 minutes after the spinal injection with a cold alcohol swab till the appropriate level (T4-T6) for surgery was attained. Surgery was initiated after a T6 sensory block was achieved. If a T6 sensory block level was not achieved, these patients were excluded from the study and managed according to institutional protocol. Maximum cephalad spread was checked every 2 minutes from time of Subarachnoid Block

(SAB) till the maximum level was achieved. Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure (MAP), heart rate (HR), SpO2 and PI were recorded at 2 minutes intervals after the SAB up to 20 minutes and then at 5 minutes interval till the end of surgery. Injection oxytocin (2 units intravenous bolus + 10 units in 500 ml of Ringer's Lactate slow infusion over 1 hour) was given as uterotonic following baby extraction. Patients requiring additional oxytocic's and/or additional surgical interventions were excluded from the study. The incidence of other side effects such as nausea, vomiting if observed, was recorded. Following extraction of the baby, APGAR score was recorded at 2 and 5 minutes followed by fetal PH and base excess (BE) utilizing umbilical cord blood gas analysis where samples were obtained from a segment of double clamped cord after delivery of the baby in pre-heparinized 1 ml syringe.

### 2.5 Data Analysis

Statistical analysis was performed using the SPSS program for Windows, version 17.0 (SPSS, Chicago, Illinois). Continuous variables are presented as mean±SD, and categorical variables are presented as absolute numbers and percentages. Data were checked for normality before statistical analysis. Normally distributed continuous variables were compared using the unpaired t test, whereas the Mann-Whitney U test was used for those variables that were not normally distributed. Categorical variables were analyzed using either the chi square test or Fisher's exact test.A receiver operating characteristics (ROC) analysis was calculated to determine optimal cut-off values for PI. The area under the curve and its standard deviation (AUC_SD), the sensitivity, and the specificity were calculated to analyze the diagnostic value of perfusion index correlating with hypotension. For all statistical tests, a p value less than 0.05 was taken to indicate a significant difference.

### 2.6 Ethical Clearance

Written informed consent was taken from all patients, followed by a detailed pre-anaesthetic evaluation and airway examination. The study received ethical approval from Guru Gobind Singh Indraprastha University (IEC/VMMC /SJH /2018-137). Permission was also obtained from Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi. All the participants were fully informed regarding the study objectives, and written informed

consent was obtained from each participant. Confidentiality of the data was fully maintained. All data were stored in the computer database which was accessible only to the researcher with password protection and was shared only with the research team members.

## 3. Results

Sixty eligible ASA I parturients scheduled for elective caesarean section were divided into two groups pre-operatively after determining their baseline Perfusion Index as those with PI ≤ 3.5 and those with PI > 3.5 using a Masimo® pulse oximeter probe. No parturient was excluded from the study.

### 3.1 Demographic Profile

The demographic profile of parturient in the both the groups was comparable with respect to age (p value = 0.851), gravida (p value = 0.474) and gestational age (p value = 0.885). However, there was a statistically significant association between BMI and the baseline perfusion index (p value = 0.001). The mean BMI of parturients with baseline PI > 3.5 was slightly higher, 23.48 ± 1.44, compared to 22.41± 0.60 in parturients with baseline PI ≤ 3.5. Among the 60 parturients in the study, 38 were primigravids (63.33%) and 22 were gravida II (36.67%) (Table 1). The median baseline perfusion index of PI ≤ 3.5 was 2.7 (IQR 0.50, Range 1.80 – 3.30) while that of PI > 3.5 was 4.2 (IQR 0.80, Range 3.70 – 6.80) (Table 2).

Table 1: Demographic comparison of age, BMI, gravida and gestational age

| Variable | PI ≤ 3.5 Mean ± SD | PI>3.5 Mean ± SD | P-value |
|---|---|---|---|
| **Age (in years)** | 24.90 ± 1.83 | 25.00 ± 2.30 | 0.851 |
| **BMI (in kg/m$^2$)** | 22.41 ± 0.60 | 23.48 ± 1.44 | <0.001 |
| **Gravida** | 1.333 ± 0.47 | 1.429 ± 0.51 | 0.474 |
| **Gestational Age (in weeks)** | 38.41 ± 0.75 | 38.38 ± 0.74 | 0.885 |

Table 2: Comparison of Baseline Perfusion Index

| Analysis | PI ≤ 3.5 | PI > 3.5 |
|---|---|---|
| Mean ± SD | 2.66 ± 0.36 | 4.47 ± 0.80 |
| Median (IQR) | 2.70 (0.50) | 4.20 (0.80) |
| Minimum | 1.80 | 3.70 |
| Maximum | 3.30 | 6.80 |

### 3.2 Duration of surgery and spinal block characteristics

Table 3 shows that after initiation of block, the median level of cephalad spread achieved was T6 in both the groups. No parturient in the PI > 3.5 group achieved a maximum spread of T4 while 4 parturients achieved maximum cephalad spread of T4 in the PI ≤ 3.5 group. Duration of surgery was comparable between both the groups (p value = 0.937) (Table 3).

Table 3: Duration of surgery and spinal block characteristics

| Analysis | PI ≤ 3.5 | PI > 3.5 | P-value |
|---|---|---|---|
| Duration of surgery in minutes (Mean ± SD) | 36.79 ± 5.19 | 36.91 ± 4.87 | 0.937 |
| Bupivacaine dose (Mean ± SD) | 10mg ± 0 | 10mg ± 0 | 0.953 |
| Dermatome level (Median ± IQR) | 6 ± 0 | 6 ± 0 | 0.430 |

### 3.3 Comparison of Heart Rate, Systolic Blood Pressure and Diastolic Blood Pressure

Table 4 shows that when comparing the heart rate at time intervals among the two groups it became increasingly clear that those with baseline PI > 3.5 had generally higher heart rate especially immediately after the block and at $2^{nd}$, $4^{th}$, $6^{th}$,$8^{th}$, $10^{th}$, $12^{th}$, $14^{th}$, and $20^{th}$ minutes as shown in the table. No parturient had any event of bradycardia.

Comparing the systolic blood pressures in the two groups showed that while systolic pressures are comparable immediately after the block for both groups (PI ≤ 3.5, 104.79 ± 6.67 mmHg and PI > 3.5, 101.62 ± 6.95 mmHg, p = 0.088), pressures were significantly lower for those parturients with baseline PI > 3.5 at time intervals $6^{th}$, $10^{th}$, $12^{th}$, $14^{th}$, and $16^{th}$ minutes.

Similarly, comparing the diastolic blood pressures in the two groups showed that diastolic pressure immediately after the block for those parturients with baseline PI > 3.5 (68.19 ± 5.15 mmHg) was significantly lower than PI ≤ 3.5 (73.95 ± 3.62 mmHg) with p value <0.001. Diastolic pressures were also significantly lower at $10^{th}$, $12^{th}$, $14^{th}$, $16^{th}$, $18^{th}$, $20^{th}$ and $25^{th}$ minutes for PI > 3.5 compared to the other group (Table 4).

Table 4: Comparison of Heart Rate, Systolic Blood Pressure and Diastolic Blood Pressure

| Time | Heart Rate | | | Systolic Blood Pressure | | | Diastolic Blood Pressure | | |
|---|---|---|---|---|---|---|---|---|---|
| | PI≤3.5 Mean ± SD (in bpm) | PI>3.5 Mean ± SD (in bpm) | p value | PI≤3.5 Mean ± SD (in mmHg) | PI>3.5 Mean ± SD (in mmHg) | p value | PI≤3.5 Mean ± SD (in mmHg) | PI>3.5 Mean ± SD (in mmHg) | p value |
| Baseline | 85.59 ± 4.5 | 88.19 ±5.56 | 0.054 | 113.33 ± 7.64 | 111.38 ± 8.58 | 0.372 | 78.41 ± 3.81 | 79.6 ± 3.95 | 0.261 |
| After Block | 75.51 ± 5.16 | 78.48 ±5.19 | 0.038 | 104.79 ± 6.67 | 101.62 ± 6.95 | 0.088 | 73.95 ± 3.62 | 68.19 ±5.15 | <0.001 |
| 2nd min | 64.79 ± 6.43 | 68.95 ±5.11 | 0.013 | 107.31 ± 7.41 | 104.67 ± 8.11 | 0.208 | 70.83 ± 5.21 | 71.52 ±5.27 | 0.628 |
| 4th min | 64.67 ± 5.63 | 68.67 ± 6.1 | 0.022 | 108.41 ± 7.62 | 107.29 ± 7.79 | 0.591 | 70.91 ± 4.14 | 72.31 ±4.37 | 0.226 |
| 6th min | 65.63 ± 6.29 | 71.33 ±11.86 | 0.011 | 110.54 ± 6.64 | 101.95 ±12.15 | 0.001 | 71.26 ± 3.94 | 68.71 ±11.1 | 0.121 |
| 8th min | 68.05 ±12.78 | 78.1 ± 20.33 | 0.023 | 105.51 ±10.64 | 101.33 ± 12.6 | 0.179 | 68.49 ± 10.73 | 62.1 ±17.62 | 0.086 |
| 10th min | 70.15 ±15.19 | 90.14 ±22.58 | <0.001 | 103.05 ± 9.34 | 93.38 ± 14.8 | 0.003 | 66.91 ± 11.07 | 48.31±18 .17 | <0.001 |
| 12th min | 66.21 ± 9.48 | 79.33 ±20.94 | 0.001 | 104.82 ± 9.89 | 94.43 ± 11.72 | 0.001 | 68.37 ± 8.41 | 55.95 ± 15.9 | <0.001 |
| 14th min | 65.28 ± 6.17 | 77.62 ±19.87 | 0.001 | 107.62 ± 7.59 | 99 ± 8.5 | <0.001 | 70.56 ± 5.52 | 59.45±15 .09 | <0.001 |
| 16th min | 67.97 ±10.58 | 74.1 ± 12.24 | 0.073 | 107.41 ± 8.09 | 102.33 ±11.17 | 0.048 | 68.795 ± 9.47 | 62.38±13 .19 | 0.034 |
| 18th min | 64.9 ± 5.18 | 67.67 ± 5.9 | 0.065 | 107.64 ± 7.59 | 106.48 ± 9.54 | 0.613 | 67.796 ± 9.17 | 62.97±12 .29 | 0.032 |
| 20th min | 64.49 ± 5.74 | 70.62 ±12.27 | 0.011 | 105.82 ± 7.23 | 103.24 ±11.48 | 0.607 | 70.18 ± 6.06 | 64.88±10 .11 | 0.014 |
| 25th min | 76.33 ± 6.1 | 79.62 ± 9.82 | 0.115 | 108.13 ± 7.69 | 109.81 ± 8.23 | 0.289 | 70.18 ± 5.58 | 65.1 ± 9.34 | 0.011 |
| 30th min | 75.92 ± 5.09 | 79.14 ± 7.42 | 0.052 | 107.62 ± 8.55 | 109.1 ± 9.27 | 0.434 | 69.53 ± 7.5 | 69.81 ± 8.63 | 0.895 |
| 35th min | 76.74 ± 5.92 | 77.71 ± 5.83 | 0.545 | 107.64 ± 7.97 | 110.19 ± 7.69 | 0.537 | 70.53 ± 5.08 | 71.67 ± 4.68 | 0.398 |
| 40th min | 76.03 ± 4.99 | 77.95 ± 5.26 | 0.167 | 107.97 ± 9.06 | 106.62 ± 6.92 | 0.236 | 69.41 ± 7.02 | 72.88 ± 5.02 | 0.05 |
| 45th min | 75.77 ± 7.17 | 78.24 ± 6.24 | 0.189 | 107.49 ± 8.68 | 106.62 ± 6.31 | 0.553 | 70.37 ± 4.08 | 72.38 ± 4.17 | 0.076 |
| 50th min | 76.77 ± 8.61 | 79.1 ± 5.3 | 0.265 | 108.74 ± 7.7 | 108.86 ± 7.7 | 0.688 | 69.87 ± 8.52 | 71.52 ± 3.98 | 0.405 |
| 55th min | 75.62 ± 5.08 | 77.71 ± 5.85 | 0.153 | 107.95 ± 7.79 | 106.76 ± 7 | 0.957 | 70.41 ± 4.9 | 72.31 ± 4.95 | 0.159 |
| 60th min | 75.72 ± 5.22 | 78.52 ± 5.12 | 0.051 | 107.72 ± 5.22 | 105.52 ± 5.12 | 0.862 | 71.03 ± 4.75 | 72.02 ± 4.39 | 0.429 |

## 4. Discussion

Hypotension is the most common complication of spinal anaesthesia [1]. The most probable cause of hypotension after spinal anaesthesia is described as sympathetic blockade leading to decreased

vascular tone, pooling of blood in blocked areas and decreased cardiac output [3, 4, 6]. Normal pregnancy is associated with decreased peripheral vascular tone after 30 weeks of gestation and subarachnoid block further aggravates the sympathetic blockade, thus, parturients are more susceptible to hypotension after spinal anaesthesia [5, 24], [25]. Definitive objective monitoring systems which could predict the likelihood of developing hypotension do not exist. Studies have been attempted to assess the ability of perfusion index in predicting hypotension following spinal anesthesia in caesarean sections. Toyama et al, concluded that baseline PI > 3.5 was associated with profound hypotension and could predict its incidence after spinal anaesthesia during cesarean delivery [7]. In this study, we divided into two groups based on baseline PI <3.5 and PI >3.5, 60 ASA Grade I and II parturients posted for elective cesarean section under spinal anesthesia to compare and identify the possible role of Perfusion Index as a non-invasive, inexpensive and practical tool to predict hypotension in such parturients.

Various factors influence the variation in systemic vascular resistance in parturients [5, 26]. Advanced maternal age and increased maternal weight are well-documented risks for maternal hypertension. The physiological decrease in SVR in pregnancy is attributed to early hormonal changes that induce peripheral vasodilation [24, 27]. This may occur as early as 8th week of gestation [24, 25]. In this study, demographic characteristics such as age, gravida and gestational age did not vary between the two groups. However, patients with PI >3.5 had a higher BMI (23.48 ± 1.44 kg/m2) as compared to those with PI ≤ 3.5 (22.41± 0.60 kg/m2). Other studies have not compared BMI with PI. Vinaygam *et al*, described that SVR (systemic vascular resistance) is computed from mean arterial pressure and cardiac output. Cardiac output increases with weight which should theoretically imply a decrease in SVR with increase in weight. However, mean arterial pressure also increases with weight [27]. Hence, these effects may cancel out each other and therefore maternal weight does not have a statistical correlation with SVR. In the same study advanced maternal age was strongly related to increased SVR. Parturients who were habitual smokers were found in the study by Vinaygam *et al*, to have lower SVR and therefore a protective role in the incidence of maternal hypertension [27].

Our study did not find any difference in the block characteristics and duration of surgery between the two groups. It is well documented that higher dosages of local anaesthetic than appropriate in pregnancy results in higher cephalad spread, which blocks sympathetic cardio-acceleratory fibres leading to severe hypotension.

In this study it was attempted to explore the predictive ability of PI in the Indian population. The baseline PI > 3.5 and probability of hypotension have a statistically significant correlation (Odds ratio 8.145, p = <0.001) which is comparable to the study by Toyama et al and other similar studies. The decrease in vascular tone corresponds to higher perfusion index values as a result of increased pulsatile component as detected by the pulse oximeter due to vasodilatation. Mowafi *et al*, used PI to detect vasoconstriction following inadvertent intravascular injection of the epinephrine containing epidural test dose and successfully demonstrated the reliability of perfusion index to detect vessel tone [28]. Sympathectomy resulting from subarachnoid block produces a further decrease in peripheral vascular tone [26]. Ginosar *et al* demonstrated that increase in PI following epidural anaesthesia was a clear and reliable indicator of sympathectomy [29]. Parturients with high baseline perfusion index are at higher risk of developing severe hypotension following spinal anaesthesia since they already have a lower peripheral vascular tone. Conflicting reports from a recent study demonstrated that PI had no predictive value for hypotension in parturients undergoing LSCS following SAB [30]. This is still contentious and the disagreement is attributed to various methodological differences which include the definition of hypotension, co-loading with colloids and method of calculation of baseline PI.

The cutoff value of baseline perfusion index for prediction of hypotension following spinal anaesthesia was chosen as 3.5. This was based on the study conducted by Toyama et al where regression analysis and ROC curve analysis concluded that a baseline perfusion index cutoff point of 3.5 could be used to identify parturients at risk of hypotension due to its high sensitivity and positive predictive value [7]. Toyama et al. found a sensitivity and specificity of 81% and 86%, respectively, for baseline PI with a cutoff of 3.5 to predict hypotension, whereas in our study, the specificity was comparable, at 81.8%, while the sensitivity was lower at 70.4%. The sensitivity is similar to the study

by Dugappa et al, on the Indian population at 69.84% [23]. This statistic suggests that the Indian population characteristics are different from the population in Toyama's study and further studies to determine these characteristics are recommended.

No parturient developed any episode of bradycardia. The incidence of hypotension is significantly lower after 25 minutes in both groups. This indicates that hypotension is likely the result of autonomic nervous system imbalance following spinal anesthesia. It may be suggested that those parturients who have baseline PI ≤ 3.5 seem to have autonomic regulations that keep the hemodynamics fairly resistant to sudden changes in vascular tone after spinal anaesthesia. This is especially true when comparing the mean diastolic and mean MAP blood pressures of parturients where immediately after the block those parturients with higher PI have drastically lower values for these pressures. Consequently, they also have higher heart rates presumably to compensate for the decrease in pressure and maintain cardiac output.

Pulse oximeter readings in our study were above 95% throughout the study for all parturients despite episodes of hypotension. It is possible that episodes of hypoxia following hypotension can be prevented by a trained anaesthetist as soon as a hypotensive event is recognized and proper protocols for oxygen delivery are followed. In the study conducted by Dugappa *et al*, both vasopressor and intravenous fluid boluses were used to treat hypotension post spinal anaesthesia. They recorded an additional median intravenous fluid requirement of 1100 ml (1000 – 1150 ml) in parturients with baseline PI > 3.5 with hypotensive events as compared to those with baseline PI ≤ 3.5 with a strong correlation (rs 0.249, p = 0.019). In the current study, only injection mephentermine was used without using fluid boluses to treat hypotension. The results are comparable to vasopressor utilization in similar studies by Toyama et al, and Dugappa et al [7, 23]. Hence, additional boluses of intravenous fluid are unnecessary. Parturients with baseline PI > 3.5 who subsequently developed hypotension had increased complains of nausea (42.9%) than vomiting (33.3%). This is comparable to other studies, especially by Harten *et al* that showed higher incidence of nausea attributed to addition of adjuvants in the local anaesthetic [31]. Based on adjusted dosage of local anesthetic for weight and height for spinal anesthesia in patients undergoing cesarean section this study showed that the incidence nausea

(54.5%) was significantly more than vomiting (4.5%) despite adjustments in dosage strongly suggesting that this may be due to opioid adjuvants that modulate the spread and density of block rather than the dosage used since there is no significant difference between the two groups in terms of nausea [32].

Felice et al, compared maternal baseline perfusion index with neonatal outcome and reported that maternal baseline perfusion index < 1.9 was significantly associated with neonatal morbidity and is significantly related to subclinical placental inflammatory disease. [33] In this study there was one parturient who had a baseline PI of 1.8 but no signs of adverse neonatal outcome were evident post-delivery. Apgar scores at 2 and 5 minutes were similar in both groups, and the results are comparable to other studies that perform neonatal assessments following spinal anesthesia [33]. Toyama et al, found no difference in neonatal umbilical cord blood analysis and Apgar scores when comparing those with lower and higher baseline PI. Studies by Dugappa et al and Xu et al, also reported no difference in umbilical cord blood analysis amongst groups. Umbilical cord blood was examined for pH analysis to diagnose fetal acidosis which is a known complication of severe maternal hypotension. All neonates had a cord blood pH of more than 7.2 irrespective of the baseline PI of their mothers. There was no statistically significant difference in neonatal umbilical cord blood base excess analysis. No neonates presented with a base deficit of more than 12. In this study, neonatal outcomes were good and similar for both groups. There is a dearth of information in terms of neonatal assessments and maternal baseline PI, however, it can be agreed that if maternal hypotension is recognized early and treated aggressively, complications to neonates can be prevented [34].

There are a few limitations in this study. First, patient movement and any stimulus increasing sympathetic activity like anxiety could easily change the PI values. Baseline PI values were recorded with utmost care to avoid patient movement. To alleviate anxiety, all parturients were counselled before taking them up for surgery. However, some motion error and some amount of anxiety does remain and also varies from patient to patient. Second, the baseline value of PI could have been affected due to aortocaval compression in supine position while recording baseline values. Tilt was only applied after giving block. Third,

systemic vascular resistance (SVR) was not measured. It is an invasive technique and unjustified and unnecessary in an uncomplicated caesarean section. Arterial blood gas analysis was also not done which could have ruled out hypoxia resulting from hypoperfusion. But, since we did not observe desaturation in any patient and all patients had oxygen saturation of hemoglobin above 95%, hypoxia is very unlikely. Fourth, since PI is dependent on the vascular tone of digital vessels, its role in predicting hypotension in conditions where the tone of these vessels is affected is questionable. Therefore, further studies comparing PI with invasive and established tools of hemodynamic monitoring may provide more light regarding its utility.

## 5. Conclusion

The study concludes that a PI> 3.5 is associated with a higher incidence of hypotension in lower segment cesarean section under spinal anaesthesia. Hemodynamic parameters such as increased heart rate and significantly lower systolic, diastolic and mean arterial pressures in parturients with baseline PI > 3.5 suggest that these patients have lower baseline SVR and reduced autonomic resilience to hypotension compared to those with baseline PI $\leq$ 3.5. Additionally, high BMI appears to be a significantly associated with high baseline PI. Nausea is a more common side effect hypotension compared to vomiting. Baseline There is no statistically significant effect of baseline PI on neonatal outcomes, including umbilical cord pH or Apgar scores at 2 and 5 minutes.

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