Original Article

Perfusion index to predict post spinal hypotension in lower segment caesarean section

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Abstract

Background and Aims: It is important to predict and prevent post-spinal hypotension in lower segment cesarean section (LSCS). Peripheral vascular tone can be monitored as a perfusion index (PI) from a pulse oximeter. We aimed to study baseline PI as a predictor of post-spinal hypotension in LSCS.

Material and Methods: Prospective observational study conducted in a tertiary care teaching public hospital on patients posted for elective LSCS under spinal anesthesia. Baseline PI and hypotension were compared. A receiver operating characteristic (ROC) curve was plotted and data were analyzed using SPSS version 20.

Results: Among 90 females, 43 (47.8%) had a PI ≤3.5 and 47 (52.2%) had a PI >3.5. In the PI >3.5 group, 46 (97.9%) females had hypotension and required a high volume of IV fluids, and 29 (61.7%) required vasopressors, and the association with PI was statistically significant with Pearson's Chi-square values of 32.26 and 32.36, respectively ($P = 0.001$). In the ROC, the area under the curve (AUC) was 0.917, proving baseline PI >2.9 as an excellent classifier ($P < 0.0001$,95% confidence interval [CI] 0.840–0.965) and can predict hypotension with a sensitivity of 83.08% and specificity of 96.00%.

Conclusion: Baseline PI >3.5 was associated with significant post-spinal hypotension and vasopressor administration in LSCS. We established baseline PI >2.9 can predict post-spinal hypotension with high sensitivity and specificity. PI is simple, quick, and non-invasive and can be used as a predictor for post-spinal hypotension in parturients undergoing LSCS so that prophylactic measures can be considered in at-risk patients for better maternal and fetal outcomes.

Keywords: Lower segment cesarean section (LSCS), perfusion Index (PI), post-spinal hypotension

Introduction

Spinal anesthesia for lower segment cesarean section (LSCS) is one of the most common procedures. The spinal anesthesia-associated sympathetic blockade is exaggerated in parturients due to physiological changes associated with pregnancy and resultant hypotension may have maternal and fetal implications.[1] Prediction of patients likely to develop hypotension will ensure effective prevention and prompt management, which is of paramount importance for the best quality care. Various parameters have been studied to predict hypotension after spinal anesthesia but a precise indicator was not established.[2,3]

Perfusion index (PI) is a non-invasive, continuous, photo-plethysmographic pulse wave monitored from a pulse oximeter and can be used to assess peripheral perfusion dynamics due to changes in the peripheral vascular tone.[4] It is defined as the ratio of pulsatile blood flow to non-pulsatile blood flow in peripheral vascular tissue and the value ranges between 0.02% and 20%.[5,6] In parturients, at term, due to

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decreased peripheral vascular tone, blood volume is pooled in the extremities, which increases further after sympathetic blockade of spinal anesthesia resulting in hypotension.[7] Peripheral vascular tone can be monitored as PI. A decrease in tone is associated with higher PI values due to an increase in the pulsatile component. After spinal anesthesia, there is vasodilatation and venous pooling leading to an increase in pulsatile blood flow, which ultimately increases PI.[8] Parturients with high baseline PI are expected to have lower peripheral vascular tone and hence are at higher risk of developing hypotension following spinal anesthesia; however, there is limited literature regarding the use of PI to predict spinal hypotension with contrasting results.[5,8,9] Therefore, we hypothesized that higher baseline PI may predict post-spinal hypotension. Hence in this study, we aimed to evaluate baseline PI as an indicator for the prediction of the development of hypotension after spinal anesthesia in elective LSCS. The primary objective was to evaluate the association of development post spinal hypotension with baseline PI, and the secondary objective was vasopressor use with baseline PI in LSCS.

Material and Methods

This was an observational prospective study initiated after taking permission from Institutional Ethics and Research Committee (ECARP/2018/20), and valid written informed consent was obtained from all patients. It was conducted for 1 year in the obstetrics operation theater of a tertiary care teaching public hospital. We included patients posted for elective LSCS in the age group of 20 to 35 years belonging to the American Society of Anesthesiologists (ASA) class II done under standard spinal anesthesia with a T6 level. Patients posted for emergency LSCS, any contraindications to spinal anesthesia, morbidly obese, and patients with associated pre-eclampsia, diabetes mellitus, cerebrovascular, cardiovascular, or peripheral vascular diseases were excluded from the study.

A detailed pre-anesthesia check was done on all patients. Age, weight, medical, and obstetric history, examination, and relevant investigations were recorded. Preoperative baseline heart rate (HR), blood pressure (BP), electrocardiography (ECG), oxygen saturation (SPO_2), and PI were noted. Baseline PI values were measured uniformly in all parturients using the standard specific pulse oximeter probe (Mindray Bene View T8 patient monitor, Mindray Bio-Medical Electronics Co. Ltd., Shenzhen, China) on the left index finger to ensure consistency. It was recorded with utmost care without patient movement, in a comfortable supine position with 15 degrees left uterine displacement (LUD) to avoid aortocaval compression. Spinal anesthesia was administered in L3–L4 or L2–L3 interspace, in a sitting position, after adequate pre-hydration with Lactated Ringer's (RL) solution of 10 mL/kg (approximately 500 mL). The standard dose of 10 mg bupivacaine 0.5% (hyperbaric) with 20 μg of fentanyl was administered using Quincke's 25 gauge spinal needle. Surgery started when the sensory level of T6 was attained. Heart rate (HR), systolic, diastolic, mean arterial pressure (SBP, DBP, MAP), and PI were noted every 5 min for the first 20 min and at 10 min intervals thereafter. Hypotension was defined as a decrease in MAP <65 mm of Hg and MAP was defined as average pressure in a patient's arteries during one cardiac cycle, it was calculated by using the formula MAP= [SBP + 2(DBP)]/3.[8,10,11]

Hypotension was treated promptly with IV fluid (RL) and if required vasopressorssuch asphenylephrine and ephedrine. Total IV fluid and dosage of vasopressor used werenoted. Development of any other complications such as nausea and vomiting, or bradycardia was noted and management of the same was recorded.

Patients were divided into two groups according to a baseline PI value of 3.5, based on the studies by Duggappa *et al.* and Toyama *et al.*[5,8] Group 1 included patients with a baseline PI ≤3.5 and Group 2 with a baseline PI >3.5. The sample size was calculated using the following formula based on the study by Duggappa *et al.*[5] The total sample size= $[(Za + Zb)/C]^2 + 3 = 43$ (Za-the standard normal deviate for alpha = 1.960, Zb-the standard normal deviate for beta = 0.842, C-expected correlation coefficient = 0.443). Anticipating near equal distribution of baseline PI on either side of the cut-off point of 3.5, keeping the confidence interval at 95%, a minimum of 43 parturients would be required in each group, to achieve a power of 80% if the same result had to be reproduced. We enrolled 100 parturients for the study, anticipating near equal distribution of patients in both groups. Of these, 10 dropped out due to inadequate spinal levels in 4 and a spinal level higher than T6 in 6 patients.

Patient characteristic data are presented as mean ± standard deviation (SD). The Chi-square test was applied to assess statistical significance for discrete and categorical data. An independent sample *t*-test was applied for continuous data. Pearson's product-moment correlation coefficient (Pearson's correlation) was used to assess the correlation between baseline PI with various parameters. A receiver operating characteristic (ROC) curve was obtained for baseline PI compared with the hypotension. The area under the curve (AUC) was plotted, which is a measure of the parameter's accuracy, and the optimal cut-off point that has the smallest false-positive and false-negative rates were

obtained. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 20 (IBM SPSS Statistics for Windows, version 20.0, IBM Corp., Armonk, NY, USA). $P < 0.05$ was considered statistically significant.

Results

A total of 90 parturients fulfilling the inclusion criteria were analyzed in this study. The distribution of women according to baseline PI (cut-off used 3.5) was comparable and 43 (47.8%) women had PI ≤3.5 (Group 1) and 47 (52.2%) had PI >3.5 (Group 2).

Table 1 shows the distribution of patients according to age in relation to baseline PI and it was comparable in both PI groups. The association between age and the PI groups was statistically not significant ($P = 0.451$).

Mean (± SD) values for various patient parameters were age 25(± 0.45) years, weight 58(± 2.54) Kg, hemoglobin 11(±0.85) gm%. Baseline vital parameters were HR 88 (± 6)/min, SBP 128 (± 15) mmHg, DBP 78 (± 10) mmHg, SPO_2 98(± 1)%and baseline PI 3.58(± 0.80).

Table 2 shows the distribution of patients according to hypotension in relation to baseline PI.A higher incidence of hypotension 46 (97.9%) was seen in women with baseline PI >3.5 and the association was found to be statistically significant using Pearson's Chi-square value of 32.26 with a *P* value of 0.001.

Hypotension was treated first with fast IV fluid infusion and if required vasopressors. In the PI >3.5 group, IV fluid use was higher at 1.5(± 0.22) L as compared to the PI ≤3.5 group at 1.2(± 0.15) L although not statistically significant. Table 3 shows the distribution of patients according to vasopressor use in relation to baseline PI. Vasopressors used were IV phenylephrine 50 µg and ephedrine 6 mg boluses. Higher incidence of hypotension and resultant vasopressor use (29,61.7%) was seen in women with baseline PI >3.5, and the association between the baseline PI and vasopressor use was found to be statistically significant with a Pearson Chi-square value of 32.36 and a *P* value of 0.001. Two patients in the PI >3.5 group had nausea and were treated successfully with an IV fluid bolus and injection of ondansetron.

Table 1: Distribution of patients according to age and baseline PI

	Group 1 (PI ≤3.5)		Group 2 (PI >3.5)	
	No.	%	No.	%
Age				
20-25 years	20	46.5	16	34.0
26-30 years	16	37.2	23	48.9
31-35 years	7	16.3	8	17.0
Total	43	100.0	47	100.0

Pearson Chi-square value=1.593, df=2, P=0.451 (not significant).

Table 2:Distribution of patients according to hypotension in relation to baseline PI

	Group 1 (PI ≤3.5)		Group 2 (PI >3.5)	
	No.	%	No.	%
Hypotension				
No	24	55.8	1	2.1
Yes	19	44.2	46	97.9
Total	43	100.0	47	100.0

Pearson Chi-square value=32.261, df=1, P=0.001 (significant).

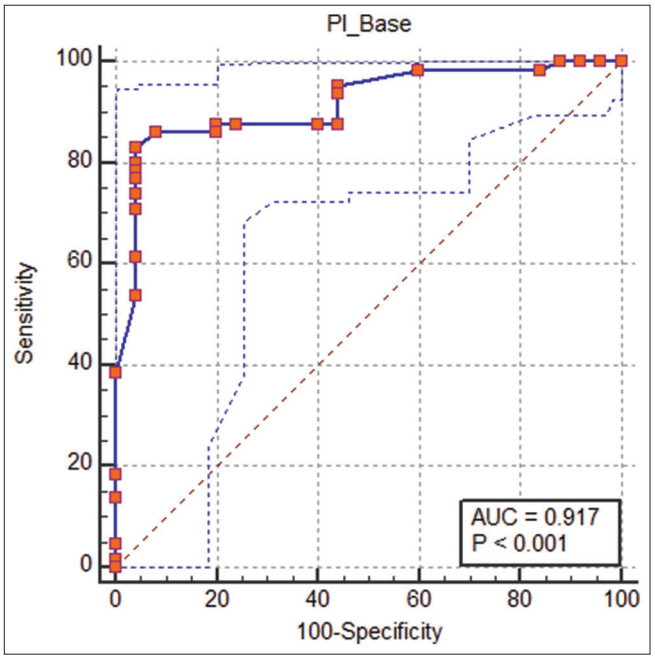

Figure 1: Area under the receiver operating curve (ROC) for baseline PI and hypotension

Variable	PI_Baseline
Classification variable	Hypotension_No
Sample size	90
Positive group[a]	65 (72.22%)[a] Hypotension=1 (positive)
Negative group[b]	25 (27.78%)[b] Hypotension=0 (negative)
Disease prevalence (%)	Unknown
Area under the ROC curve (AUC)	0.917
Standard error	0.0308
95% confidence interval	0.840-0.965 (lower bound-upper bound)
Z statistic	13.562
Significance level P (area=0.5)	<0.0001
Youden index J	0.7908
Associated criterion	>2.9
Sensitivity	83.08%
Specificity	96.00%

Table 3: Distributionof patients according to vasopressors use in relation to baseline PI

	Group 1 (PI ≤3.5)		Group 2 (PI >3.5)	
	No.	%	No.	%
Vasopressor use				
No	41	95.3	18	38.3
Yes	2	4.7	29	61.7
Total	43	100.0	47	100.0

Pearson Chi-square value=32.368, df=1, P=0.001 (significant).

The ROC analysis and AUC shown in Figure 1 were plotted to measure the baseline PI accuracy to predict post-spinal hypotension. In the above ROC curve, the AUC was found to be 0.917, with the associated criteria cut-off found to be >2.9. This establishes baseline PI as an excellent classifier for detecting parturients at risk for hypotension and if the baseline PI value is >2.9, the chances of having hypotension post spinal are very high. This was proved with high statistical significance with a *P* value <0.0001 and a 95% confidence interval (CI) of 0.840 to 0.965. At this baseline PI value >2.9, the sensitivity of PI to predict hypotension was 83.08% and the specificity was 96.00%.

Discussion

Spinal anesthesia is the preferred technique for LSCS. For optimal quality care and outcome, prevention and prompt management of post-spinal hypotension are of utmost importance. Hence, it is vital to identify patients at risk of exaggerated post-spinal hypotension using a specific prediction measure to prevent parturients from hypotensive episodes. Various parameters have been under evaluation for the same, Brenck *et al.* identified risk factors such as maternal age, BMI, prehypertensive, diabetes, anemia, and level of the sensory blockade as independent factors for the development of hypotension but a specific predictor was not mentioned.[2] Heart rate variability and baseline heart rate were studied as predictors of severe hypotension after spinal anesthesia for LSCS.[4,12] However, heart rate depends on multiple variables such as age, sex, baseline heart rate, anxiety, stress, and pain and may not be a definite predictor. Berlac *et al.* suggested that near-infrared spectroscopy (NIRS) could provide an early warning of hypotension, with a ≥5% decrease in saturation preceding hypotension.[13]

PI has been proven as a reliable indicator of vascular tone changes.[4,14] Mehandale *et al.* confirmed PI as a predictor of hypotension following propofol induction.[15] Hence, in this study, we tried to evaluate baseline PI as an indicator for the prediction of the development of hypotension after spinal anesthesia in elective LSCS. In an attempt to eliminate the effect of contributing risk factors, which may affect the vascular tone such as maternal age >35 years, co-morbidities such as gestational hypertension and diabetes mellitus were excluded from the study. Any patient movements, anxiety, or pain, which can have an impact on PI were avoided and the baseline value was recorded with utmost care. We evaluated 90 parturients undergoing elective LSCS who achieved a T6 spinal level of anesthesia. Patients were divided into two groups, with 43 patients having a baseline PI ≤3.5 and 47 patients with a PI >3.5.We observed PI was comparable with the age of women in both groups.

We observed that in the PI >3.5 group, 46 (97.9%) women had hypotension and the relation between baseline PI and development of hypotension was statistically significant. Pregnancy is associated with increased total blood volume and a decrease in systemic vascular resistance resulting in reduced vascular tone, which corresponds to an increase in pulsatile component and higher PI values.[7] Sympathetic blockade after SA causes a further decrease in peripheral vascular tone and increasedvenous pooling and hypotension. Thus, parturients with high baseline PI(>3.5) are at higher risk of developing exaggerated hypotension following SA. Therefore, baseline PI >3.5 can predict post-spinal hypotension and in these patients, necessary precautions such as IV fluid and prophylactic vasopressor can be considered. Similar findings were demonstrated by Toyama *et al.*and Duggappa *et al.*[5,8] Mallawaarachchi *et al.*and Kuwata *et al.*in their recent research also confirmed the same.[16,17] However, Yokose *et al.* observed contrasting results due to methodological differences.[9]

We analyzed the use of IV fluids and vasopressors for the management of hypotension. In the PI >3.5 group, IV fluid use was higher. Vasopressors used were IV boluses of phenylephrine 50 μg as the first choice or ephedrine 6 mg if associated with bradycardia. In the PI >3.5 group inspite of using a high volume of IV fluid, vasopressor requirement was also significantly high (61.7%). Hydration cannot be measured accurately and systemic vascular resistance (SVR) measurement was invasive and unnecessary for uncomplicated LSCS.[11] Two patients in the PI >3.5 group had nausea and were treated successfully with an IV fluid bolus and injection of ondansetron. No other complication was observed in any patient. In a study conducted by Duggappa *et al.* the use of vasopressors was found to be highly significant in patients with high baseline PI.[5]

Thus, there is a high predilection of post-spinal hypotension in parturients with high baseline PI, and prophylactic measures to prevent it can be considered. No specific intervention has been reliably proven to prevent post-spinal hypotension during LSCS.[11,18] Various suggested methods are large

volume expansion to increase cardiac output with crystalloid or colloid preloading, co-loading, and lower limb compression using mechanical measures, which increase the central blood volume.[19-21] Prophylactic phenylephrine infusion increases peripheral vascular tone and may be an appropriate choice to prevent hypotension in parturients with high baseline PI, which is due to low vascular tone.[22,23] Protocolized care to reduce hypotension after spinal anesthesia is under evaluation.[24] However, in the current study, we did not evaluate preventive measures and further studies are necessary.

We plotted the ROC curve, it demonstrated AUC 0.917 (95% CI 0.840–0.965) proving baseline PI as an excellent classifier for the prediction of hypotension with associated criteria >2.9.Thus, if baseline PI is >2.9; the chances of having hypotension post-spinal anesthesia are high. From the current study, a new cutoff for baseline PI >2.9, which can predict post spinal hypotension with a sensitivity of 83.08% and specificity of 96.06% was established. Thus, there is a high predilection of post-spinal hypotension in parturients with baseline PI >2.9, and prophylactic measures to prevent it can be considered. Toyama *et al.* found the cut-off value of baseline PI as 3.5 with a sensitivity and specificity of 81% and 86%, respectively.[8] Duggappa *et al.* found a specificity of 89.29% but a lower sensitivity of 69.84% for baseline PI 3.5.[5] Elshal *et al.* mention PI as a continuous, simple, and easy-to-interpret parameter and can be a new vital sign in operation theatre (OT) as well as intensive care unit (ICU).[25] Thus, PI has very useful applications in day-to-day anesthesia care.

Our study had some limitations as we did not measure invasive hemodynamic parameters such as cardiac output and SVR for comparison. This is a single-centered study with small sample size; a multi-centered blinded study with a large sample size will give a better prospective for the evaluation of PI as a predictor of hypotension after spinal anesthesia. Further studies are warranted to establish preferred preventative measures in patients who are predicted to develop hypotension during spinal anesthesia.

Thus, from the experience of the present study, we may conclude that baseline PI >3.5 was associated with significant post-spinal hypotension and vasopressor administration in LSCS. Hence PI derived from a pulse oximeter can be used as a predictor for spinal anesthesia-induced hypotension in parturients undergoing LSCS. We established baseline PI >2.9 as an excellent classifier (AUC = 0.917, 95% CI 0.840–0.965) for the prediction of post-spinal hypotension with high sensitivity (83.08%) and specificity (96.06%). PI is a simple, quick, non-invasive, continuous, and easy-to-monitor parameter and we may recommend its use as a predictor for post-spinal hypotension so that parturientsat risk will be recognized and prophylactic measures to prevent hypotension can be considered for better maternal and fetal outcomes and quality anesthesia care.

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Conflicts of interest
There are no conflicts of interest.

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