

Baseline Perfusion Index as a Predictor of Post-Spinal Hypotension in Parturients Undergoing Caesarean Delivery: A Prospective Observational Study

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ABSTRACT

Background: Post-spinal hypotension is a common complication of spinal anaesthesia for caesarean delivery. Early identification of parturients at increased risk may facilitate timely haemodynamic management. This study evaluated baseline Perfusion Index (PI) as a predictor of post-spinal hypotension.

Methods: This prospective comparative study included 100 parturients undergoing caesarean delivery under spinal anaesthesia. Participants were allocated according to baseline PI into Group I (PI <3.5; n=50) and Group II (PI >3.5; n=50). Baseline PI was measured using a pulse oximeter before spinal anaesthesia. Hypotension was defined as a decrease in systolic blood pressure to ≤80% of baseline. The incidence and frequency of hypotensive episodes, rescue phenylephrine requirement, neonatal Apgar scores, and maternal bradycardia were assessed. The diagnostic performance of PI >3.5 was evaluated using sensitivity, specificity, predictive values, diagnostic accuracy, and area under the receiver operating characteristic curve (AUC). **Results:** Post-spinal hypotension occurred significantly more frequently in patients with baseline PI > 3.5 (Group II) compared to the patients with baseline PI < 3.5 (Group I) (74% vs. 30%; $P<0.0001$). Group II patients also experienced a greater number of hypotensive episodes ($P<0.0001$) and required significantly more rescue phenylephrine boluses ($P<0.0001$) compared to patients in group I. Baseline haemodynamic parameters (NIBP, HR) were comparable both groups, whereas baseline PI was significantly higher in Group II (8.71 ± 3.55 vs. 2.14 ± 0.82 ; $P<0.0001$). Based on our study results, Baseline PI >3.5 demonstrated 71.15% sensitivity, 72.92% specificity to predict post spinal hypotension with a 74.00% positive predictive value, 70.00% negative predictive value, and 72.00% diagnostic accuracy, with an AUC of 0.72 (95% CI, 0.62–0.81).

Apgar scores at 1, 5, and 10 min were comparable between groups, and no bradycardia occurred. **Conclusion:** Baseline PI >3.5 was associated with a significantly increased risk of post-spinal hypotension and greater vasopressor requirement in parturients undergoing caesarean delivery.

Baseline PI demonstrated moderate predictive tool to predict post spinal hypotension and may serve as a simple, non-invasive tool for pre-spinal haemodynamic risk stratification. **Keywords:** Perfusion Index; spinal anaesthesia; hypotension; caesarean delivery; parturients; phenylephrine; haemodynamic monitoring.

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Introduction:

Spinal anaesthesia is the preferred technique for most caesarean deliveries; however, maternal hypotension remains a common complication due to sympathetic blockade, vasodilatation, venous pooling, and the haemodynamic effects of pregnancy [1,2]. Maternal hypotension may cause significant maternal symptoms and, if severe or prolonged, compromise uteroplacental perfusion and fetal oxygenation, making its prevention and early treatment essential [2,3]. Reported incidence varies because of differences in the definitions and thresholds used to define hypotension [4]. Fluid administration, positioning, and prophylactic vasopressors such as

phenylephrine are commonly used to prevent or treat post-spinal hypotension [2,5]. However, identifying patients at increased risk before spinal anaesthesia could allow more individualized haemodynamic management. Perfusion Index (PI), a non-invasive parameter derived from the photoplethysmographic signal of a pulse oximeter, reflects peripheral vascular tone and has therefore been investigated as a predictor of spinal anaesthesia-induced hypotension [6]. Toyama et al. demonstrated a significant association between baseline PI and the fall in blood pressure following spinal anaesthesia for caesarean delivery, with a PI cut-off of 3.5 showing 81% sensitivity and 86%

specificity [7]. Duggappa et al. similarly reported a higher incidence of hypotension in parturients with $PI > 3.5$, with an AUC of 0.848 [8]. Other studies have also supported the association between higher baseline PI and post-spinal hypotension, although the optimal cut-off has varied across populations and protocols [9,10]. Systematic and subsequent studies have highlighted heterogeneity in the predictive performance of PI, which may be influenced by patient characteristics, hypotension definitions, anaesthetic technique, fluid management, and timing of PI measurement [11-13]. Therefore, baseline PI may provide a simple, non-invasive means of preoperative haemodynamic risk stratification. The present study evaluated the predictive value of baseline PI for post-spinal hypotension in parturients undergoing caesarean delivery by comparing patients with $PI < 3.5$ and $PI > 3.5$, and also assessed rescue phenylephrine requirement and neonatal Apgar scores.

Materials and Methods Study Design and Setting

This prospective comparative study was conducted in the Department of Anaesthesia and Intensive Care, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, over a period of 18 months. The study protocol was approved by the Institutional Ethics Committee of the institute, and written informed consent was obtained from all participants before enrolment.

Study Population

Parturients scheduled for caesarean delivery under spinal anaesthesia were assessed for eligibility. The inclusion criteria were age 18–45 years, height 150–165 cm, American Society of Anesthesiologists (ASA) physical status II, and term singleton pregnancy. Patients were excluded if they had coagulopathy, thrombocytopenia, local skin infection at the lumbar puncture site, increased risk of postpartum haemorrhage, pregnancy-induced hypertension, morbid obesity, neurological deficits, or cardiovascular or cerebrovascular disease.

Sample Size

The sample size was calculated based on a previous study (Lal et al [14]) that reported an incidence of postspinal hypotension of 40% in patients with baseline $PI \leq 3.5$ and 73.3% in those with baseline $PI > 3.5$. Assuming a two-sided alpha error of 5% and 90% power, the minimum required sample size was calculated as 42 participants in each group. To account for possible exclusions and increase the precision of the study, a total of 100 parturients were enrolled, with a minimum of 50 participants planned for each group.

Preoperative Assessment

All participants underwent a detailed pre-anaesthetic evaluation, including history,

physical examination and relevant investigations. Age, height, weight, parity, gestational age and medication history were recorded. The study procedure was explained to each participant in her preferred language, and written informed consent was obtained. Patients were instructed to fast before surgery and received oral ranitidine 150 mg approximately 2 h before surgery as anti-aspiration prophylaxis.

Baseline Perfusion Index Measurement and Group Allocation

On arrival in the operating room, standard monitoring comprising continuous electrocardiography, non-invasive blood pressure (NIBP) and pulse oximetry was instituted. Patients were positioned supine with left lateral tilt/uterine displacement and allowed to rest undisturbed for 5 min before baseline measurements.

Baseline systolic blood pressure (SBP), heart rate (HR) and Perfusion Index (PI) were obtained as the mean of three consecutive readings recorded at 1-min intervals. The baseline SBP and 80% of the baseline SBP were calculated for each participant. PI was measured from the index finger of the left hand using a Dr Trust USA Professional Series–202TM pulse oximeter (Nureca Inc., New York, USA). Based on the baseline PI value, participants were classified into two groups: Group I, $PI < 3.5$, and Group II, $PI > 3.5$.

Anaesthetic Technique

An 18-gauge intravenous cannula was inserted into a forearm vein. A total of 500 mL Ringer's lactate was co-loaded during administration of spinal anaesthesia. After co-loading, PI, NIBP, mean arterial pressure (MAP), and HR were recorded again.

With the patient in the sitting position, the skin was infiltrated with 1 mL of 2% lignocaine. Spinal anaesthesia was performed using a 25-gauge disposable spinal needle at the estimated L3–L4 or L4–L5 intervertebral space. After confirmation of free flow of cerebrospinal fluid, 2 mL of 0.5% hyperbaric levobupivacaine with fentanyl 10 µg was administered intrathecally. The patient was subsequently placed supine with a 10-cm wedge under the right hip to maintain uterine displacement. Oxygen was administered at 5 L/min by face mask throughout surgery.

Haemodynamic Monitoring

PI, HR and BP were recorded at 2-min intervals from administration of spinal anaesthesia until delivery of the baby and subsequently every 5 min until skin closure. HR and PI were recorded simultaneously with each BP measurement.

The sensory and motor blockade was assessed after spinal anaesthesia. Sensory block level was assessed 5 min after intrathecal injection, and a sensory level of T6 was considered adequate for surgery. Motor blockade was

assessed using the modified Bromage scale (0 = no motor block; 1 = inability to raise the extended leg; 2 = inability to flex the knee; and 3 = inability to flex the ankle and foot). Patients requiring supplemental analgesia or anaesthesia because of inadequate spinal blockade were excluded from the study.

Definition and Management of Hypotension

The primary outcome was the incidence of post-spinal hypotension. Maternal hypotension was defined as a decrease in SBP to $\leq 80\%$ of the individual baseline SBP. Whenever this criterion was met, intravenous phenylephrine was administered as a bolus dose of 0.5 $\mu\text{g/kg}$. The number of hypotensive episodes and the total number of phenylephrine boluses required were recorded. Bradycardia was defined as HR < 60 beats/min, while tachycardia was defined as HR > 100 beats/min. Atropine 0.6 mg intravenously was administered in the presence of bradycardia associated with hypotension or when HR fell below 50 beats/min irrespective of SBP.

Maternal and Perioperative Variables

The times of spinal anaesthesia, skin incision, uterine incision and delivery were recorded. The induction-to-skin incision, induction-to-delivery, incision-to-delivery and uterine incision-to-delivery intervals were subsequently calculated. Following delivery, oxytocin 10 units was administered by slow intravenous injection according to institutional protocol. Intraoperative intravenous fluid administration, estimated blood loss, requirement for blood transfusion, if any, and duration of surgery were recorded. At the completion of surgery, patients were transferred to the post-anaesthesia care unit and subsequently to the ward after haemodynamic stability and resolution of the motor block.

Neonatal Outcome

Neonatal outcome was assessed using the Apgar score at 1, 5 and 10 min after birth. The Apgar assessment was performed by the attending paediatrician who was unaware of the maternal PI group allocation.

Study Outcomes

The primary outcome was the incidence of post-spinal hypotension, defined as SBP $\leq 80\%$ of baseline, in participants with baseline PI < 3.5 compared with those with baseline PI > 3.5 .

The secondary outcomes were:

1. Number of rescue phenylephrine bolus doses required for treatment of hypotension.
2. Neonatal Apgar scores at 1, 5 and 10 min.
3. Occurrence of maternal bradycardia and requirement for atropine.

These outcomes correspond to the prespecified objectives of the original study.

Statistical Analysis

Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), as appropriate, while categorical variables were presented as frequencies and percentages. Continuous variables between the two PI groups were compared using the independent-samples t-test or the Mann–Whitney U test, as appropriate. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. The association between baseline PI category and the occurrence of hypotension was assessed using the appropriate categorical analysis. The predictive performance of a baseline PI > 3.5 for postspinal hypotension was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy and the area under the receiver operating characteristic (ROC) curve (AUC). A two-sided P value < 0.05 was considered statistically significant. The statistical methods documented in the thesis included independentsamples t-tests for continuous variables and chi-square/Fisher's exact tests for categorical variables. The study reported an AUC of 0.72 (95% CI, 0.62–0.81) for PI > 3.5 in predicting hypotension.

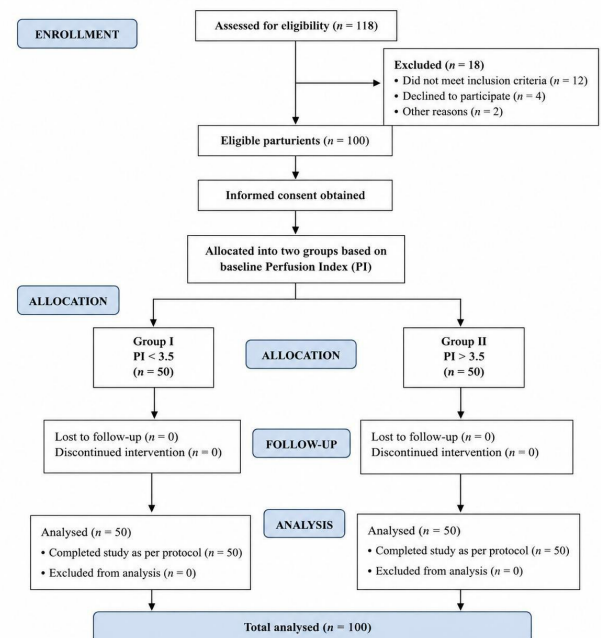


Figure 1. Flow diagram of participant recruitment and group allocation.

Results

Study population and baseline characteristics

A total of 118 parturients were assessed for eligibility, of whom 18 were excluded. The remaining 100 eligible parturients were enrolled and allocated into two groups according to their baseline Perfusion Index (PI): Group I (PI < 3.5 ; $n = 50$) and Group II (PI > 3.5 ; $n = 50$). All 100 participants completed the study and were included in the final analysis, with no loss to follow-up or postenrolment exclusions.

The baseline demographic characteristics of the two groups are presented in Table 1. The mean age was 25.56 ± 3.96 years in Group I and 25.94 ± 3.95 years in Group II ($P=0.632$). Mean body weight was 60.46 ± 7.31 kg and 60.70 ± 7.09 kg, respectively ($P=0.868$). Similarly, no statistically significant difference was observed in height or BMI between the groups ($P=0.432$ and $P=0.426$, respectively).

Baseline haemodynamic parameters

Baseline haemodynamic variables were comparable between the two groups. Mean baseline heart rate was 96.44 ± 14.16 beats/min in Group I and 95.74 ± 14.89 beats/min in Group II ($P=0.810$). Baseline systolic blood pressure was 121.42 ± 7.30 mmHg and 120.86 ± 9.14 mmHg, respectively ($P=0.736$), while baseline diastolic blood pressure was 76.44 ± 6.02 mmHg and 76.42 ± 6.15 mmHg ($P=0.987$). Baseline mean arterial pressure was also comparable between the groups (91.42 ± 5.71 vs. 91.24 ± 6.54 mmHg; $P=0.884$). As expected from the predefined grouping criterion, baseline PI was significantly different between the groups. Mean baseline PI was 2.14 ± 0.82 in Group I compared with 8.71 ± 3.55 in Group II ($P<0.0001$).

Perfusion Index following spinal anaesthesia

The PI remained significantly higher in Group II than in Group I at most assessed time points following spinal anaesthesia. At T2, mean PI was 2.41 ± 0.80 in Group I compared with 8.95 ± 3.55 in Group II ($P<0.0001$). At T4 and T6, the corresponding values were 2.42 ± 0.80 vs. 9.08 ± 3.57 and 2.43 ± 0.78 vs. 9.16 ± 3.44 , respectively (both $P<0.0001$). At T8, T10 and T12, mean PI values were 2.60 ± 0.65 vs. 8.83 ± 3.52 ($P<0.0001$), 2.50 ± 0.57 vs. 8.59 ± 3.27 ($P=0.002$), and 2.00 ± 0.00 vs. 8.90 ± 5.01 ($P=0.355$), respectively. After delivery, PI continued to be significantly higher in Group II at TD, TD5, TD10, TD15, TD20, TD25 and TD30, with P values ranging from <0.0001 to 0.003 .

Incidence of post-spinal hypotension

The primary outcome was the incidence of post-spinal hypotension. Hypotension, defined as a decrease in systolic blood pressure to $\leq 80\%$ of baseline, occurred in 15 (30%) patients in Group I (PI <3.5) compared with 37 (74%) patients in Group II (PI >3.5). This difference was statistically significant ($P<0.0001$). Thus, patients with baseline PI >3.5 demonstrated a substantially higher incidence of post-spinal hypotension than those with PI <3.5 . The frequency of hypotensive episodes also differed significantly between the groups ($P<0.0001$). No hypotensive episode occurred in 35 (70%) patients in Group I compared with 13 (26%) in Group II. One episode occurred in 10 (20%) and 18 (36%), two episodes in 3 (6%) and 13 (26%), and three episodes in 1 (2%) and 6 (12%) patients in Groups I and II, respectively. Four episodes

occurred in 1 (2%) patient in Group I and none in Group II.

Rescue phenylephrine requirement

The requirement for rescue phenylephrine was significantly greater among patients with baseline PI >3.5 ($P<0.0001$). No rescue phenylephrine bolus was required in 35 (70%) patients in Group I compared with 13 (26%) patients in Group II. One bolus was required in 10 (20%) and 18 (36%), two boluses in 3 (6%) and 12 (24%), and three boluses in 1 (2%) and 7 (14%) patients in Groups I and II, respectively. Four boluses were required in 1 (2%) patient in Group I and none in Group II.

Predictive performance of baseline Perfusion Index

The diagnostic performance of a baseline PI >3.5 for predicting post-spinal hypotension is presented in Table 6. A PI >3.5 demonstrated a sensitivity of 71.15% (95% CI, 56.92–82.87%) and specificity of 72.92% (95% CI, 58.15–84.72%). The positive predictive value was 74.00% (95% CI, 59.66–85.37%), while the negative predictive value was 70.00% (95% CI, 55.39–82.14%). The overall diagnostic accuracy was 72.00%. The receiver operating characteristic (ROC) analysis demonstrated an area under the curve (AUC) of 0.72 (95% CI, 0.62–0.81), indicating moderate discriminatory ability of baseline PI for predicting post-spinal hypotension (Figure 2).

Neonatal and maternal outcomes

Neonatal Apgar scores were comparable between the two groups. The mean Apgar score at 1 min was 6.24 ± 0.72 in Group I and 6.34 ± 0.77 in Group II ($P=0.504$). At 5 min, the corresponding values were 8.38 ± 0.67 and 8.36 ± 0.72 ($P=0.886$), while at 10 min they were 9.68 ± 0.47 and 9.60 ± 0.49 , respectively ($P=0.410$). No episode of bradycardia was observed in either group, and consequently no patient required atropine.

Table 1. Baseline demographic and obstetric characteristics

Variable	Group I (PI <3.5 , n=50)	Group II (PI >3.5), n=50	P value

Baseline Perfusion Index as a Predictor of Post-Spinal Hypotension in Parturients Undergoing Caesarean Delivery:

Age (years)	25.5 6 ± 3.96	25. 94 ± 3.9 5	0. 6 3 2
Weight (kg)	60.4 6 ± 7.31	60. 70 ± 7.0 9	0. 8 6 8
Height (cm)	154. 40 ± 10.6 7*	15 5.6 4 ± 3.1 4	0. 4 3 2
BM I (kg/m²)	26.0 6 ± 8.65 *	25. 04 ± 2.6 5	0. 4 2 6

Values are mean ± SD. P values are from independent-samples t-tests.

Table 2. Comparison of baseline and perioperative hemodynamic parameters

Parameter	Group I (PI <3.5)	Group II (PI >3.5)	P value
Baseline HR (beats/min)	96.44 ± 14.16	95.74 ± 14.89	0.810
Baseline SBP (mmHg)	121.42 ± 7.30	120.86 ± 9.14	0.736
Baseline DBP (mmHg)	76.44 ± 6.02	76.42 ± 6.15	0.987
Baseline MAP (mmHg)	91.42 ± 5.71	91.24 ± 6.54	0.884
Baseline PI	2.14 ± 0.82	8.71 ± 3.55	<0.0001

Table 3. Comparison of Perfusion Index at different time points

Time point	Group I (PI <3.5) Mean ± SD	Group II (PI >3.5) Mean ± SD	P value
Baseline	2.14 ± 0.82	8.71 ± 3.55	<0.0001
Ts	2.25 ± 0.74	8.85 ± 3.53	<0.0001
T0	2.28 ± 0.78	8.81 ± 3.59	<0.0001

T2	2.41 ± 0.80	8.95 ± 3.55	<0.0001
T4	2.42 ± 0.80	9.08 ± 3.57	<0.0001
T6	2.43 ± 0.78	9.16 ± 3.44	<0.0001
T8	2.60 ± 0.65	8.83 ± 3.52	<0.0001
T10	2.50 ± 0.57	8.59 ± 3.27	0.002
T12	2.00 ± 0.00	8.90 ± 5.01	0.355
TD	2.43 ± 0.77	9.01 ± 3.56	<0.0001
TD5	2.42 ± 0.71	9.05 ± 3.66	<0.0001
TD10	2.47 ± 0.73	9.02 ± 3.48	<0.0001
TD15	2.45 ± 0.70	9.17 ± 3.55	<0.0001
TD20	2.50 ± 0.77	9.07 ± 3.56	<0.0001
TD25	2.34 ± 0.65	9.21 ± 3.78	<0.0001
TD30	2.29 ± 0.55	8.69 ± 4.13	0.003

Table 4. Incidence and frequency of post-spinal hypotension

Outcome	Group I (PI <3.5), n=50	Group II (PI >3.5), n=50	P value
Hypotension – No	35 (70%)	13 (26%)	<0.0001
Hypotension – Yes	15 (30%)	37 (74%)	<0.0001

Number of episodes			
Nil	35 (70%)	13 (26%)	<0.0001
1 episode	10 (20%)	18 (36%)	
2 episodes	3 (6%)	13 (26%)	
3 episodes	1 (2%)	6 (12%)	
4 episodes	1 (2%)	0	

Table 5. Rescue phenylephrine requirements

Number of rescue boluses	Group I (PI <3.5), n=50	Group II (PI >3.5), n=50	P value
Nil	35 (70%)	13 (26%)	<0.0001
1	10 (20%)	18 (36%)	
2	3 (6%)	12 (24%)	
3	1 (2%)	7 (14%)	
4	1 (2%)	0	

Table 6. Diagnostic performance of PI >3.5 for predicting hypotension

Diagnostic parameter	Value (95% CI)
Sensitivity	71.15% (56.92–82.87%)
Specificity	72.92% (58.15–84.72%)
Positive predictive value	74.00% (59.66–85.37%)
Negative predictive value	70.00% (55.39–82.14%)
Diagnostic accuracy	72.00%
AUC	0.72 (0.62–0.81)

Table 7. Neonatal and maternal adverse outcomes

Outcome	Group I (PI <3.5)	Group II (PI >3.5)	P value
Apgar at 1 min	6.24 ± 0.72	6.34 ± 0.77	0.504
Apgar at 5 min	8.38 ± 0.67	8.36 ± 0.72	0.886
Apgar at 10 min	9.68 ± 0.47	9.60 ± 0.49	0.410
Bradycardia	0 (0%)	0 (0%)	—
Atropine requirement	0 (0%)	0 (0%)	—

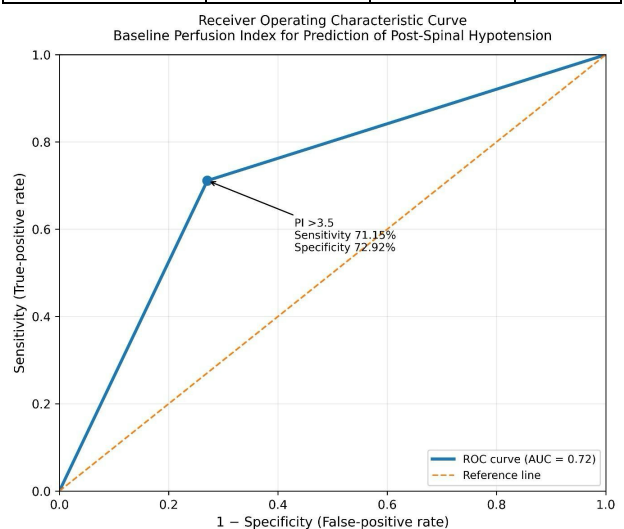


Figure 2. Receiver operating characteristic (ROC) curve of baseline Perfusion Index for prediction of post-spinal hypotension in parturients undergoing caesarean delivery. The area under the ROC curve was 0.72 (95% CI: 0.62–0.81). A baseline PI >3.5

demonstrated a sensitivity of 71.15% and specificity of 72.92%.

Discussion

Spinal anaesthesia is widely used for caesarean delivery because it provides effective surgical anaesthesia while avoiding many of the airway and respiratory risks associated with general anaesthesia. However, maternal hypotension remains one of its most common adverse effects. Sympathetic blockade following spinal anaesthesia causes arterial and venous vasodilatation, reduction in systemic vascular resistance, and venous pooling, which may be further aggravated by the physiological changes of pregnancy and aortocaval compression [1-3]. Maternal hypotension is clinically important because severe or prolonged hypotension may compromise uteroplacental perfusion and adversely affect fetal oxygenation [2,3]. Therefore, early identification of parturients at increased risk may facilitate timely haemodynamic intervention.

Perfusion Index (PI), obtained from the photoplethysmographic signal of a routinely available pulse oximeter, reflects peripheral perfusion and vascular tone and provides a simple, noninvasive measure of peripheral vascular status [6]. A higher baseline PI may indicate greater peripheral vasodilatation and lower vascular tone. Following sympathetic blockade, these patients may therefore have a greater tendency for venous pooling and reduction in blood pressure. This physiological basis supports the use of baseline PI as a potential predictor of postspinal hypotension.

In the present study, baseline PI was significantly associated with the development of post-spinal hypotension. Hypotension occurred in 30% of parturients with PI <3.5 compared with 74% of those with PI >3.5 ($P<0.0001$). The frequency of hypotensive episodes was also significantly higher in the PI >3.5 group. These findings are consistent with previous studies demonstrating a greater incidence of spinal anaesthesia-induced hypotension among parturients with higher baseline PI values [7-10]. Toyama et al. reported hypotension in 25% of patients with PI <3.5 and 82% of those with PI >3.5, with sensitivity and specificity of 81% and 86%, respectively [7]. Similarly, Duggappa DR et al. reported hypotension in 10.5% and 71.42% of patients with PI <3.5 and >3.5, respectively [8]. Other prospective studies have also demonstrated a significant association between higher baseline PI and post-spinal hypotension [9,10].

Although the direction of association was consistent across these studies, the incidence of hypotension varied considerably. Such differences may be explained by variations in the definition of hypotension, intrathecal anaesthetic agent and dose, fluid management, measurement site, timing of PI assessment, and patient characteristics [4,11]. The systematic review by

Yu C et al. also highlighted considerable heterogeneity among studies evaluating predictors of spinal anaesthesia-induced hypotension, suggesting that PI performance may vary according to the clinical setting and methodology used [11]. Thus, while the present findings strengthen the evidence supporting baseline PI as a useful predictor, the threshold of 3.5 should not necessarily be considered universally applicable.

In the present study, a baseline PI >3.5 demonstrated 71.15% sensitivity, 72.92% specificity, 74.00% positive predictive value, 70.00% negative predictive value, and 72.00% diagnostic accuracy, with an AUC of 0.72 (95% CI, 0.62–0.81). This represents moderate discriminatory ability and indicates that PI can provide clinically useful risk stratification, although it should not be used as an isolated predictor. The moderate predictive performance observed in our study is in agreement with the broader evidence suggesting that no single preoperative variable reliably predicts spinal anaesthesia-induced hypotension in all parturients [11]. More recent work has likewise reported variable diagnostic accuracy of preoperative PI, emphasizing the need for validation across different populations and protocols [12,13]. Several studies have identified different optimal cut-off values for PI in predicting hypotension, reflecting variations in study populations, anaesthetic techniques, and outcome definitions. George et al. [15] found a PI cutoff of 3.6 using ROC analysis, with 80% sensitivity and 40% specificity. Inamanamelluri et al. [16] reported a cut-off of 2.85 with 80% sensitivity and 75% specificity in parturients undergoing caesarean delivery. Malavika et al. [17] found a higher cut-off of 4.25 in parturients with nonsevere pre-eclampsia, with 74.5% sensitivity and 89.7% specificity. Gupta et al. [18] identified a cut-off of 3.1 in patients undergoing below-umbilical surgeries. These variations further suggest that the optimal PI threshold may depend on the characteristics of the study population, anaesthetic technique, and definition of hypotension. An important finding of the present study was the significantly greater requirement for rescue phenylephrine in patients with PI >3.5. Patients in this group not only experienced hypotension more frequently but also required a greater number of rescue boluses ($P<0.0001$). This observation provides additional clinical support for the association between elevated baseline PI and haemodynamic susceptibility following spinal anaesthesia. Phenylephrine is widely used for prevention and treatment of spinal anaesthesia-associated hypotension during caesarean delivery because of its effectiveness in maintaining maternal blood pressure and its favourable fetal acid-base profile [2,5]. Baseline PI could therefore potentially be incorporated into pre-spinal assessment to

identify patients who may benefit from closer haemodynamic monitoring and early vasopressor intervention. Despite the higher incidence of hypotension in the high-PI group, neonatal Apgar scores at 1, 5 and 10 minutes were comparable between the groups. No maternal bradycardia or atropine requirement was observed in either group. These findings suggest that, with prompt recognition and treatment of hypotension, the greater incidence of hypotension associated with higher PI did not result in a measurable difference in the neonatal outcomes assessed in this study. However, Apgar score alone may not fully reflect the effects of transient maternal hypotension on neonatal well-being, and larger studies incorporating additional neonatal outcomes would be useful. Overall, the present study demonstrates that baseline PI >3.5 is significantly associated with a higher incidence and greater frequency of post-spinal hypotension and increased rescue phenylephrine requirement in parturients undergoing caesarean delivery. Given that PI can be obtained easily and non-invasively using a standard pulse oximeter, it may have practical value in identifying women at increased risk before spinal anaesthesia. Future larger, multicentre prospective studies are warranted to validate the optimal PI threshold and determine whether PI-guided preventive strategies can improve maternal haemodynamic stability and obstetric outcomes [11-13].

Limitations of the Study

This study was conducted at a single tertiary-care centre with a relatively modest sample size of 100 parturients, which may limit the generalizability of the findings. The study population was restricted to healthy term parturients with ASA physical status II, and therefore the findings may not be directly applicable to women with significant obstetric or medical comorbidities. The PI cutoff of 3.5 was predefined based on previous evidence and may require validation in different populations. PI can also be influenced by peripheral vascular tone and other physiological factors. Finally, the moderate predictive performance observed (AUC 0.72) suggests that PI is best considered as an adjunctive risk-stratification tool rather than a standalone predictor. Larger, multicentre prospective studies are needed to validate these findings and establish the broader clinical utility of baseline PI.

Conclusion

Baseline Perfusion Index was significantly associated with the development of post-spinal hypotension in parturients undergoing caesarean delivery. Patients with a baseline PI >3.5 had a substantially higher incidence of hypotension and required more rescue phenylephrine than those with a PI <3.5 . Baseline PI >3.5 demonstrated moderate predictive performance, with a

sensitivity of 71.15%, specificity of 72.92%, and an AUC of 0.72. Neonatal Apgar scores were comparable between the groups, with no episodes of maternal bradycardia observed. These findings suggest that baseline Perfusion Index, a simple non-invasive parameter readily obtainable from pulse oximetry, may be useful for pre-spinal haemodynamic risk stratification and early identification of parturients at increased risk of post-spinal hypotension.

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