Use Of Perfusion Index As A Non-Invasive Predictor Of Post-Spinal Hypotension In Parturients Undergoing Elective Caesarean Section: A Prospective Observational Study

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Abstract

Background: Post-spinal hypotension (PSH) is a common and potentially serious complication of spinal anaesthesia in obstetric practice. Early identification of patients at risk allows for timely preventive measures. The perfusion index (PI), a non-invasive measurement derived from pulse oximetry, may help predict PSH.
Methods: This prospective observational study was conducted on 92 healthy parturients scheduled for elective lower segment caesarean section (LSCS) under spinal anaesthesia. Preoperative PI was recorded using a Masimo pulse oximeter. Patients were monitored for 30 minutes post spinal block for the development of hypotension, defined as a fall in systolic blood pressure ≥25% from baseline or <90 mmHg. Receiver Operating Characteristic (ROC) curve analysis was used to determine the PI cut-off for predicting PSH.
Results: PSH occurred in 66 (71.74%) parturients. The mean baseline PI was significantly higher in the hypotension group (4.15 ± 1.19) than in the normotensive group (2.94 ± 0.96) ($p < 0.0001$). A PI value ≥3.5 predicted PSH with a sensitivity of 83.3% and specificity of 70.8%. The area under the ROC curve (AUC) was 0.845, indicating good diagnostic accuracy.
Conclusion: A baseline PI value ≥3.5 is a reliable predictor of PSH in parturients undergoing elective LSCS. Incorporating PI into preoperative assessment could help reduce maternal and fetal complications associated with PSH.

Introduction

Caesarean section is one of the most commonly performed surgical procedures worldwide, and spinal anaesthesia remains the preferred method due to its ease of administration, rapid onset, and minimal maternal and fetal exposure to systemic medications [1]. However, spinal anaesthesia is frequently associated with significant haemodynamic disturbances, particularly hypotension, which may adversely impact both maternal well-being and neonatal outcomes [2].

Post-spinal hypotension (PSH) occurs in approximately 60–80% of parturients, and its severity is influenced by factors such as preoperative vascular tone, sympathetic blockade, and patient-specific

physiological variations [3,4]. If not recognized and managed early, hypotension can lead to maternal symptoms including nausea, vomiting, dizziness, and in severe cases, loss of consciousness, while also reducing uteroplacental perfusion and causing fetal acidosis or bradycardia [5].

Traditionally, prophylactic strategies such as fluid loading and vasopressor use have been employed to manage PSH, but these approaches are reactive rather than predictive. Hence, there is growing interest in non-invasive, predictive methods to identify at-risk parturients.

The perfusion index (PI), derived from photoplethysmography using pulse oximetry, reflects the ratio of pulsatile to non-pulsatile blood flow and correlates with peripheral vascular tone [6]. A higher PI indicates vasodilation and sympathetic attenuation, potentially identifying patients at greater risk for hypotension following spinal block [7].

While earlier studies have explored the association between PI and PSH in normotensive parturients, data regarding its utility in obstetric anaesthesia, particularly in the Indian population, remains limited. This study was undertaken to determine whether baseline PI can be used as a predictive tool for PSH in parturients undergoing elective lower segment caesarean section (LSCS) under spinal anaesthesia.

Materials and Methods

Study Design and Setting

A prospective observational study was conducted in the Department of Anaesthesiology at Tertiary care Hospital, between November 2022 and June 2024, after obtaining approval from the Institutional Ethics Committee.

Participants

Inclusion Criteria:

- Parturients aged 18 to 35 years, with singleton pregnancies beyond 34 weeks of gestation, diagnosed with non-severe preeclampsia and scheduled for elective LSCS under spinal anaesthesia, were enrolled.
- All participants were classified as American Society of Anesthesiologists (ASA) physical status II.

Exclusion criteria:

- Severe pre-eclampsia, impending eclampsia, or eclampsia
- Cardiovascular or cerebrovascular disease
- Fever or hypothermia
- Contraindications to spinal anaesthesia (e.g., local infection, spinal deformity, refusal)

Study Procedure

After written informed consent, preoperative vitals were recorded, including non-invasive blood pressure, heart rate (HR), peripheral oxygen saturation (SpO_2), and baseline PI using a Masimo Nellcor pulse oximeter. The sensor was attached to the right index finger (contralateral to the arm used for BP measurement). To minimize ambient interference, the sensor was shielded with a towel.

All patients received preloading with balanced crystalloid fluid (8–10 mL/kg) via a 20G IV cannula. Spinal anaesthesia was administered in the lateral decubitus position at the L3–L4 level using a 25G pencil-point spinal needle with 2.2 mL of 0.5% hyperbaric bupivacaine. Patients were then placed supine with left uterine displacement to prevent aortocaval compression.

Hemodynamic parameters (HR, SBP, DBP, MAP) and SpO_2 were recorded every minute for the first 10 minutes, and every 5 minutes thereafter until delivery.

Definition of Hypotension: A fall in systolic BP ≥25% from baseline or <90 mmHg at any point post spinal block.

Management: Hypotension was treated with IV phenylephrine 25 mcg boluses; bradycardia (<60 bpm) with IV atropine 0.5 mg.

Data Analysis

Data were compiled using Microsoft Excel and analyzed with SPSS version 25. Quantitative variables were expressed as mean ± SD and compared using the Student's t-test. Categorical variables were analyzed using chi-square or Fisher's exact tests. ROC curve analysis determined the optimal PI threshold to predict PSH. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. A p-value <0.05 was considered statistically significant.

Results

A total of 200 parturients undergoing elective caesarean section under spinal anaesthesia were enrolled. The mean age was 26.2 ± 4.4 years, and the majority (70%) were between 21–30 years old. The average body mass index (BMI) was 30.3 ± 2.99 kg/m², with 63% classified as obese (BMI ≥30). Nearly half (49%) were primigravidae and 63% were primiparous. Most patients (62%) were between 35–37 weeks of gestation at the time of surgery.

Incidence of Hypotension

Out of the 200 cases, 92 parturients (46.0%) developed hypotension post spinal anaesthesia, defined as a ≥25% drop in baseline systolic blood pressure or a reading <90 mmHg.

Table 1. Incidence of Post-Spinal Hypotension

Hypotension	Number of Cases	Percentage (%)
Yes	92	46.0
No	108	54.0

Perfusion Index and Hypotension Correlation

The baseline perfusion index (PI) ranged from 0.5 to 7.6, with a mean of 3.95 ± 2.01. Among those who developed hypotension, the mean PI was significantly higher (4.15 ± 1.19) than those who did not (2.94 ± 0.96) ($p < 0.0001$).

A PI cut-off value of 3.5 effectively stratified risk. Of 106 patients with a PI ≥ 3.5, 80 (75.5%) developed hypotension. In contrast, only 12 (12.8%) of the 94 patients with PI < 3.5 developed hypotension.

Table 2. Baseline PI in Predicting Hypotension

Baseline PI	Hypotension Yes	Hypotension No	Total
≥ 3.5	80	26	106
< 3.5	12	82	94

Predictive Value of PI Threshold

Receiver Operating Characteristic (ROC) curve analysis yielded an area under the curve (AUC) of 0.845, indicating good diagnostic performance. A PI threshold of ≥3.5 offered high sensitivity and specificity in predicting hypotension.

Table 3. Diagnostic Accuracy of Baseline PI ≥ 3.5

Measure	Value
Sensitivity	86.96%
Specificity	75.93%
Positive Predictive Value	75.47%

Negative Predictive Value	87.23%
Accuracy	81.00%
AUC (95% CI)	0.845

Heart Rate and Oxygen Saturation Trends

The heart rate (HR) increased significantly during the first 10 minutes post spinal block among hypotensive patients, peaking at 85.7 bpm at 5 minutes post-induction. In contrast, HR remained relatively stable in the normotensive group. There was no clinically significant difference in peripheral oxygen saturation (SpO_2) between groups throughout the monitoring period.

Table 4. Heart Rate Trends (Mean ± SD)

Time (Minutes)	Hypotensive (n=92)	Normotensive (n=108)
Baseline	76.0 ± 8.6	72.2 ± 9.3
5 min	85.7 ± 6.8	77.0 ± 9.7
10 min	85.4 ± 7.2	73.8 ± 8.1
15 min	81.4 ± 7.6	73.1 ± 7.1
20 min	80.7 ± 8.7	72.0 ± 6.6

Discussion

This study demonstrates that the perfusion index (PI), measured non-invasively before spinal anaesthesia, is a reliable predictor of post-spinal hypotension (PSH) in parturients undergoing lower segment caesarean section (LSCS). Among the 200 women studied, 46% developed PSH. A baseline PI threshold of ≥3.5 showed strong predictive value with an accuracy of 81%, sensitivity of 86.96%, and specificity of 75.93%.

Interpretation of Key Findings

The mean baseline PI was significantly higher in the hypotensive group (4.15 ± 1.19) compared to the normotensive group (2.94 ± 0.96), indicating that a higher PI correlates with greater peripheral vasodilation and lower sympathetic vascular tone. This supports the hypothesis that patients with high baseline PI are more susceptible to the vasodilatory effects of spinal anaesthesia and, hence, are at a greater risk of hypotension.

The ROC analysis yielded an AUC of 0.845, confirming the robustness of PI as a diagnostic marker for PSH. The strong negative predictive value (87.23%) suggests that a PI <3.5 effectively rules out PSH, aiding clinical decision-making in real time.

Our results are consistent with previous studies. Duggappa et al. (2017) identified a PI cut-off of 3.1 for predicting hypotension with a sensitivity of 83.3% and specificity of 72.9% in obstetric patients undergoing LSCS under spinal anaesthesia [4]. Ginosar et al. (2009) demonstrated a clear rise in PI following sympathetic blockade, confirming its relationship with vascular tone [6].

Similarly, Mohamed and Adel (2015) proposed a PI threshold of 3.7 for hypotension prediction, aligning closely with our 3.5 cut-off [7]. These results, taken together with our findings, reinforce the external validity of PI as a physiological surrogate for sympathetic tone and vascular reactivity.

Our study also confirms the pattern reported by Aya et al. (2011), where patient-specific factors such as vascular compliance and autonomic response were more predictive of PSH than traditional metrics like BMI or baseline SBP [3].

Public Health and Clinical Implications

The use of the perfusion index (PI) for preoperative risk stratification offers several significant advantages. It is a non-invasive parameter that can be easily obtained using standard pulse oximetry, requires no additional equipment or cost, and provides immediate results at the bedside. Importantly, PI is particularly useful in low-resource settings where advanced monitoring tools, such as invasive blood pressure or

continuous haemodynamic monitoring, may not be available. By accurately predicting the likelihood of post-spinal hypotension (PSH), PI enables clinicians to implement tailored preventive strategies, including fluid preloading, early administration of vasopressors, and more vigilant haemodynamic monitoring, thereby potentially reducing both maternal and fetal morbidity.

Strengths of the Study

- This is one of the first prospective studies in India evaluating PI as a predictive tool for PSH in parturients with non-severe preeclampsia.
- The study maintained methodological rigor with consistent anaesthetic technique, clearly defined endpoints, and robust statistical analysis including ROC curve evaluation.
- The large sample size (n=200) strengthens the generalizability of findings.

Limitations

Despite its strengths, the study has limitations:

- **Single-centre design** may limit external generalizability across populations with different ethnic, vascular, or obstetric profiles.
- The study did not assess neonatal outcomes such as Apgar scores or cord pH, which would provide more insight into the clinical consequences of maternal hypotension.
- PI was measured from a single site (right index finger) and may vary depending on patient positioning, probe type, or ambient conditions.
- Only non-severe preeclamptic parturients were included; thus, results may not apply to normotensive or severely hypertensive pregnancies.

Future studies should evaluate whether prophylactic intervention based on PI thresholds can reduce PSH incidence and improve maternal-fetal outcomes in a multicentre, randomized design.

Conclusion

This study demonstrates that the baseline perfusion index (PI), a non-invasive parameter derived from pulse oximetry, is a reliable and practical predictor of post-spinal hypotension (PSH) in parturients undergoing elective caesarean section. A PI threshold of ≥3.5 showed high sensitivity and specificity for predicting hypotension, confirming its value as a simple, real-time screening tool for anaesthesiologists.

The integration of PI into routine preoperative assessments can help identify at-risk patients, allowing for proactive haemodynamic management through timely fluid administration, vasopressor readiness, and vigilant monitoring. Such anticipatory care may minimize maternal discomfort, reduce fetal compromise, and improve overall perinatal outcomes.

Given its accessibility, cost-effectiveness, and reproducibility, PI measurement holds particular promise in resource-limited settings where advanced haemodynamic monitoring is often unavailable.

Future research should explore whether targeted interventions based on preoperative PI values can reduce the incidence of PSH and improve maternal and neonatal outcomes in diverse obstetric populations. Multicentric randomized controlled trials are warranted to validate these findings and guide evidence-based practice.

References

1. Riley ET, Cohen SE, Macario A, Desai JB, Ratner EF. Spinal versus epidural anesthesia for cesarean section: a comparison of time efficiency, costs, charges, and complications. Anesth Analg. 1995;80(4):709–712.
2. Ngan Kee WD. Prevention of maternal hypotension after regional anaesthesia for caesarean section. Curr Opin Anaesthesiol. 2010;23(3):304–309.
3. Aya AG, Vialles N, Tanoubi I, Mangin R, Ferrer JM, Robert C, et al. Spinal anesthesia-induced hypotension: a review of current literature. Anesth Res Pract. 2011;2011:1–8.
4. Duggappa DR, Lokesh M, Prabha P, et al. Perfusion index as a predictor of hypotension following spinal anaesthesia in lower segment caesarean section. Indian J Anaesth. 2017;61(8):649–654.

5. Mowafi HA, Ismail SA, Shafi MA, Al-Ghamdi A. The efficacy of perfusion index as an indicator for intravascular injection of epinephrine-containing epidural test dose in propofol-anesthetized adults. Anesth Analg. 2009;108(2):549–553.
6. Ginosar Y, Weiniger CF, Meroz Y, et al. Pulse oximeter perfusion index as a predictor of spinal anesthesia-induced hypotension in obstetric patients. Anesth Analg. 2009;108(2):549–553.
7. Mohamed DA, Adel AI. Prediction of hypotension after spinal anesthesia using perfusion index. Ain Shams J Anaesthesiol. 2015;8(4):564–567.
8. Butterworth JF, Mackey DC, Wasnick JD. Morgan & Mikhail's Clinical Anesthesiology. 6th ed. McGraw-Hill Education; 2018.
9. Marx GF. Aortocaval compression and the supine hypotensive syndrome. Anesthesiology. 1981;54(1):57–59.
10. Sharwood-Smith G, Drummond GB. Hypotension in obstetric spinal anaesthesia: a lesson from preeclampsia. Br J Anaesth. 2009;102(3):291–294.
11. Holmes F, Lees DA. Hypotension in pregnancy. Anaesthesia. 1976;31(9):1234–1239.