



Original Article

Perfusion Index as A Predictor of Hypotension Following Spinal Anaesthesia

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ABSTRACT

Background: Hypotension is one of the most common and clinically significant complications following spinal anesthesia, resulting from sympathetic blockade and peripheral vasodilatation. Early identification of patients at increased risk may facilitate timely preventive interventions and improve perioperative outcomes. Perfusion Index (PI), a non-invasive parameter derived from pulse oximetry, reflects peripheral vascular tone and has emerged as a potential predictor of hemodynamic instability following neuraxial blockade.

Objectives: To evaluate the role of baseline Perfusion Index as a predictor of hypotension following spinal anesthesia and to determine its optimal cut-off value for risk stratification. **Methods:** This prospective observational study was conducted in the Department of Anaesthesiology of a tertiary care teaching hospital. Eighty adult patients aged 18–65 years, belonging to ASA physical status I–II and scheduled for elective surgeries under spinal anesthesia, were enrolled. Baseline PI was recorded before administration of spinal anesthesia. Hypotension was defined as a reduction in systolic blood pressure greater than 20% from baseline or an absolute systolic blood pressure below 90 mmHg. Patients were categorized according to a PI cut-off value of 3.5, and hemodynamic outcomes were compared.

Results: Patients with baseline PI >3.5 had a significantly higher incidence of hypotension compared to those with PI ≤3.5 (70.0% vs. 25.0%, p<0.001). ROC analysis identified a PI cut-off of 3.5 with an area under the curve of 0.82, sensitivity of 73.7%, and specificity of 71.4%. Higher PI values were also associated with greater systolic blood pressure reduction, increased vasopressor requirement, higher mepentermine doses, and a greater incidence of nausea.

Conclusion: Baseline Perfusion Index is a simple, non-invasive, and reliable predictor of hypotension following spinal anesthesia. A PI value greater than 3.5 effectively identifies patients at increased risk, enabling improved perioperative hemodynamic management and potentially reducing anesthesia-related complications.

Keywords: Perfusion Index, Hypotension, Spinal Anaesthesia.

INTRODUCTION

Spinal anesthesia is a widely practiced regional anesthetic technique for lower abdominal, pelvic, perineal, obstetric, and lower limb surgeries because of its rapid onset, reliable sensory and motor blockade, excellent perioperative analgesia, and reduced physiological stress response. Despite these advantages, hypotension remains one of the most common and clinically important complications associated with spinal anesthesia.¹ The incidence of spinal anesthesia-induced hypotension varies considerably, ranging from 15% to 80%, depending on patient characteristics, type of surgery, anesthetic technique, and criteria used for defining hypotension.²

The primary mechanism responsible for hypotension following spinal anesthesia is sympathetic blockade, which results in vasodilatation of arterial and venous vessels, reduced systemic vascular resistance, pooling of blood in the lower extremities, decreased venous return, and subsequent reduction in cardiac output.² Although often transient, hypotension can have significant clinical implications. In elderly individuals and patients with pre-existing cardiovascular disease, it may lead to myocardial ischemia, cerebral hypoperfusion, renal dysfunction, and delayed postoperative recovery. In obstetric patients, maternal hypotension can reduce uteroplacental perfusion and may contribute to fetal acidosis, nausea, vomiting, dizziness, and adverse neonatal outcomes.³ Therefore, the early identification of patients at risk of developing hypotension after spinal anesthesia is of considerable clinical importance.

Various predictors of post-spinal hypotension have been investigated, including age, body mass index, baseline blood pressure, heart rate variability, inferior vena cava collapsibility index, pleth variability index, stroke volume variation, and autonomic function tests. However, many of these methods require specialized equipment, technical expertise, or complex calculations, limiting their routine use in everyday anesthetic practice.⁴ Consequently, there is an increasing interest in identifying a simple, reliable, non-invasive, and readily available predictor for spinal anesthesia-induced hypotension.

Perfusion Index (PI) has emerged as a promising parameter for this purpose. PI is derived from pulse oximetry and represents the ratio of pulsatile to non-pulsatile blood flow in peripheral tissues. It serves as an indicator of peripheral perfusion and vascular tone and can be measured continuously using standard pulse oximeters available in most operating rooms.⁵ Because PI measurement is non-invasive, inexpensive, and easily obtainable, it has gained attention as a potential predictor of hemodynamic instability during anesthesia.

The rationale for using PI as a predictor of hypotension is based on its relationship with peripheral vascular resistance. Higher baseline PI values generally indicate peripheral vasodilatation and lower vascular tone, whereas lower PI values reflect increased sympathetic activity and vasoconstriction. Patients with higher baseline PI may therefore be more vulnerable to the additional sympathetic blockade produced by spinal anesthesia, resulting in a greater likelihood of significant hypotension.⁶

Several clinical studies have supported this hypothesis. Duggappa et al. demonstrated that baseline PI could predict hypotension following spinal anesthesia in parturients undergoing cesarean section, with higher PI values associated with increased incidence of hypotension.⁷ Similarly, Lal et al. reported that patients with baseline PI values greater than 3.5 experienced significantly more episodes of hypotension and required greater vasopressor support following spinal anesthesia.⁸ Rajanalini et al. further confirmed the usefulness of PI as an early predictor of hypotension during cesarean delivery, highlighting its value as a simple bedside assessment tool.⁹ Likewise, Mallawaarachchi et al. observed that elevated baseline PI was associated with a higher risk of post-spinal hypotension and suggested its utility in identifying high-risk patients before neuraxial blockade.¹⁰

Recent evidence has extended the applicability of PI beyond obstetric anesthesia. Studies in non-obstetric surgical populations have demonstrated a significant association between elevated baseline PI values and the occurrence of spinal anesthesia-induced hypotension, suggesting that PI may serve as a universal predictor across different patient groups.¹¹ Additionally, PI has been shown to predict hypotension following induction of general anesthesia, further supporting its role as an indicator of vascular tone and cardiovascular reserve.^{12,13,14,15}

One of the major advantages of PI is its simplicity and cost-effectiveness. Unlike invasive monitoring techniques or ultrasound-based assessments, PI does not require additional equipment, operator expertise, or patient discomfort. Since pulse oximetry is routinely employed in perioperative monitoring, PI can be easily incorporated into standard preoperative evaluation. Continuous real-time assessment of peripheral perfusion also makes it particularly useful in resource-limited settings.⁵

Given the high incidence of spinal anesthesia-induced hypotension and the need for an easily accessible predictive tool, Perfusion Index appears to be a promising parameter for risk stratification. Early identification of susceptible patients may facilitate timely preventive interventions, optimize hemodynamic management, reduce perioperative complications, and ultimately improve patient outcomes.

MATERIALS AND METHOD-

The present study was a hospital-based prospective observational study conducted in the Department of Anaesthesiology at a private tertiary care teaching hospital in Maharashtra after obtaining approval from the Institutional Ethics Committee. A total of 80 adult patients aged 18–65 years, belonging to American Society of Anesthesiologists (ASA) physical status I and II and scheduled for elective lower abdominal, pelvic, perineal, gynecological, urological, and lower limb surgeries under spinal anesthesia were enrolled after obtaining written informed consent. Patients with cardiovascular diseases, autonomic dysfunction, peripheral vascular disease, obesity (BMI >35 kg/m²), contraindications to spinal anesthesia, pregnancy, or those receiving vasoactive medications were excluded from the study. Demographic data including age, gender, height, weight, body mass index, and baseline vital parameters were recorded. Upon arrival in the operating room, standard monitoring comprising electrocardiography, non-invasive blood pressure, pulse oximetry, and Perfusion Index

(PI) monitoring was established. After a 5-minute resting period in the supine position, baseline heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, oxygen saturation, and three consecutive PI readings were recorded, and the average value was considered as the baseline Perfusion Index.

All patients received preloading with Ringer's lactate 10 mL/kg prior to administration of spinal anesthesia. Subarachnoid block was performed under strict aseptic precautions at the L3–L4 or L4–L5 intervertebral space using a 25G Quincke spinal needle, and 3–3.5 mL of 0.5% hyperbaric bupivacaine was injected intrathecally. Following the block, patients were placed in the supine position and hemodynamic parameters were recorded every 2 minutes for the first 20 minutes and every 5 minutes thereafter until completion of surgery. Hypotension was defined as a reduction in systolic blood pressure greater than 20% from baseline or an absolute systolic blood pressure below 90 mmHg. Episodes of hypotension were managed with intravenous mephentermine and fluid administration as required. The primary outcome assessed was the association between baseline Perfusion Index and the occurrence of hypotension following spinal anesthesia. Secondary outcomes included determination of the optimal PI cut-off value for predicting hypotension and assessment of its correlation with vasopressor requirement and severity of hypotension. Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 25.0.

RESULTS-

Table 1. Baseline Demographic Characteristics

Variable	Value	Percentage
Male	46	57.5%
Female	34	42.5%
Mean Age (years)	42.8 ± 11.6	–
Mean BMI (kg/m ²)	24.7 ± 3.4	–
ASA Physical Status I	52	65.0%
ASA Physical Status II	28	35.0%

Table 2. Incidence of Hypotension According to Baseline Perfusion Index

PI Group	Hypotension (%)	n	No Hypotension (%)	Total	P value
PI ≤ 3.5	10 (25.0)		30 (75.0)	40	<0.001
PI > 3.5	28 (70.0)		12 (30.0)	40	<0.001

Table 3. ROC Analysis for Prediction of Hypotension

Parameter	Value
Optimal PI Cut-off	3.5
AUC	0.82
Sensitivity	73.7%
Specificity	71.4%
PPV	70.0%
NPV	75.0%

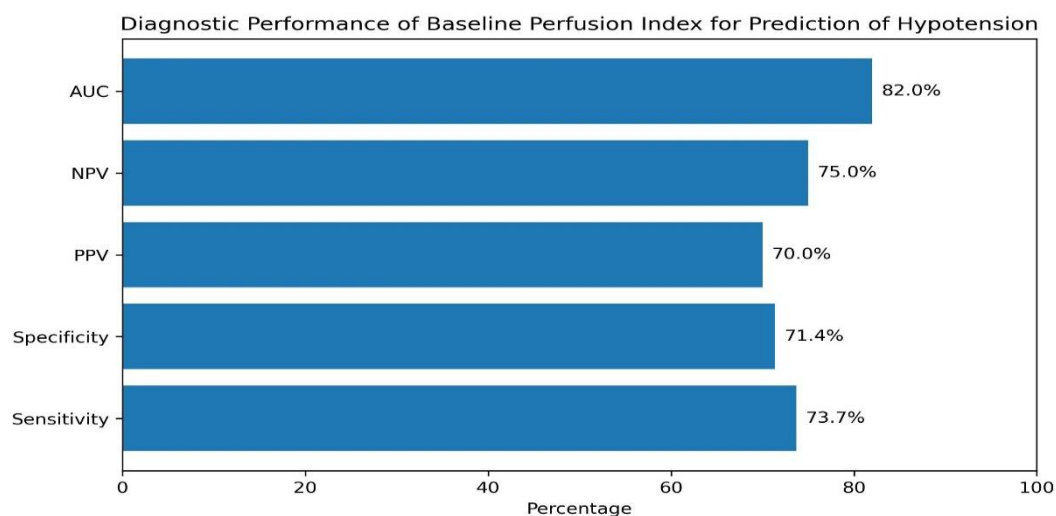


Figure 1. Diagnostic performance of baseline Perfusion Index for prediction of hypotension following spinal anesthesia. ROC analysis demonstrated an optimal PI cut-off value of 3.5 with an AUC of 0.82, sensitivity of

73.7%, specificity of 71.4%, positive predictive value of 70.0%, and negative predictive value of 75.0%, indicating good predictive accuracy

Table 4. Severity of Hypotension and Vasopressor Requirement

Outcome	PI ≤3.5 (n=40)	PI >3.5 (n=40)	P value
Mean SBP Fall (%)	14.2 ± 6.1	26.8 ± 8.4	<0.001
Mephentermine Required n (%)	12 (30.0)	29 (72.5)	<0.001
Mean Mephentermine Dose (mg)	7.8 ± 3.2	15.6 ± 5.4	<0.001
Nausea/Vomiting n (%)	5 (12.5)	16 (40.0)	0.006

A total of 80 patients undergoing elective surgeries under spinal anesthesia were included in the study. The baseline demographic characteristics are presented in Table 1. Of the study participants, 46 (57.5%) were males and 34 (42.5%) were females. The mean age of the study population was 42.8 ± 11.6 years, while the mean body mass index (BMI) was 24.7 ± 3.4 kg/m². Most patients belonged to ASA Physical Status I [52 (65.0%)], whereas 28 (35.0%) patients were categorized as ASA Physical Status II.

Table 2 demonstrates the association between baseline Perfusion Index (PI) and the incidence of hypotension following spinal anesthesia. Patients were divided into two groups based on a PI cut-off value of 3.5. Among patients with PI ≤3.5, hypotension occurred in only 10 (25.0%) patients, whereas 30 (75.0%) remained hemodynamically stable. In contrast, among patients with PI >3.5, hypotension developed in 28 (70.0%) patients, while only 12 (30.0%) did not experience hypotension. This difference was statistically highly significant (p<0.001), indicating a strong association between elevated baseline PI and subsequent development of hypotension.

Receiver Operating Characteristic (ROC) curve analysis (Table 3) identified a PI value of 3.5 as the optimal cut-off for predicting hypotension. The area under the curve (AUC) was 0.82, suggesting good predictive accuracy. The sensitivity and specificity of the test were 73.7% and 71.4%, respectively, while the positive predictive value and negative predictive value were 70.0% and 75.0%, respectively.

As shown in Table 4, patients with PI >3.5 experienced significantly greater hemodynamic instability compared to those with PI ≤3.5. The mean systolic blood pressure fall was significantly higher in the high PI group (26.8 ± 8.4% vs. 14.2 ± 6.1%, p<0.001). Similarly, vasopressor requirement was markedly increased, with 72.5% of patients in the high PI group requiring mephentermine compared to 30.0% in the low PI group (p<0.001). The mean dose of mephentermine administered was also significantly higher in patients with PI >3.5 (15.6 ± 5.4 mg vs. 7.8 ± 3.2 mg, p<0.001). Furthermore, the incidence of nausea and vomiting was significantly greater in the high PI group (40.0% vs. 12.5%, p=0.006). These findings indicate that a higher baseline Perfusion Index is associated not only with an increased incidence of hypotension but also with greater severity of hypotension and increased vasopressor requirements following spinal anesthesia

DISCUSSION

Spinal anesthesia-induced hypotension remains one of the most frequent and clinically significant complications encountered during regional anesthesia. Early identification of patients at risk allows anesthesiologists to implement preventive strategies and optimize perioperative hemodynamic management. The present study evaluated the role of baseline Perfusion Index (PI) as a predictor of hypotension following spinal anesthesia in 80 adult patients undergoing elective surgeries.

In the present study, hypotension occurred significantly more frequently among patients with a baseline PI >3.5 compared to those with PI ≤3.5 (70.0% vs. 25.0%, p<0.001). These findings suggest that patients with higher baseline peripheral perfusion and lower vascular tone are more susceptible to sympathetic blockade-induced vasodilatation and subsequent hypotension following spinal anesthesia. Similar observations were reported by Duggappa et al., who evaluated parturients undergoing cesarean section and found that patients with higher baseline PI values had a significantly greater incidence of post-spinal hypotension. The authors reported that PI could serve as a useful bedside predictor of hemodynamic instability following neuraxial blockade.⁷

Receiver Operating Characteristic (ROC) analysis in the present study demonstrated an optimal PI cut-off value of 3.5 with an area under the curve (AUC) of 0.82, sensitivity of 73.7%, and specificity of 71.4%. These findings indicate good predictive accuracy of baseline PI in identifying patients at risk of hypotension. Comparable findings were reported by Lal et al., who observed that a baseline PI greater than 3.5 was associated with a significantly increased incidence of hypotension and vasopressor requirement following spinal anesthesia for cesarean delivery. The authors concluded that PI is a simple, non-invasive, and reliable predictor of post-spinal hypotension.⁸

The present study further showed that patients with PI >3.5 experienced a significantly greater fall in systolic blood pressure ($26.8 \pm 8.4\%$ vs. $14.2 \pm 6.1\%$, $p < 0.001$) and required vasopressor support more frequently than patients with lower PI values. Mephentermine administration was required in 72.5% of patients in the high PI group compared to others

CONCLUSION-

The present study demonstrated that baseline Perfusion Index (PI) is a useful, non-invasive, and reliable predictor of hypotension following spinal anesthesia. Patients with a baseline PI greater than 3.5 had a significantly higher incidence of hypotension, greater reductions in systolic blood pressure, increased vasopressor requirements, and a higher frequency of associated adverse events such as nausea and vomiting compared to patients with lower PI values. Receiver Operating Characteristic (ROC) analysis revealed good predictive performance, indicating that baseline PI can effectively identify patients at increased risk of developing post-spinal hypotension. As PI is readily available through routine pulse oximetry monitoring, it offers a simple, cost-effective, and practical tool for perioperative risk stratification without the need for additional equipment or invasive procedures. Early identification of high-risk patients using baseline PI may facilitate timely preventive interventions, optimize hemodynamic management, reduce perioperative complications, and improve overall patient outcomes. Therefore, Perfusion Index can be considered a valuable adjunct in the preoperative assessment of patients undergoing spinal anesthesia.

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