



PERFUSION INDEX AS AN INDICATOR OF SPINAL ANAESTHESIA INDUCED HYPOTENSION AND EFFECT

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Abstract

Background: Identifying patients at higher risk of developing hypotension before the onset of anaesthesia could allow preventive strategies and improved patient safety. The perfusion index (PI), a simple non-invasive parameter derived from pulse oximetry, reflects the ratio of pulsatile to non-pulsatile blood flow and has shown promise as an indicator of peripheral perfusion and sympathetic tone. Its role in predicting spinal anaesthesia-induced hypotension has been of growing clinical interest. **Aim:** The present study aims to evaluate the role of baseline perfusion index as an indicator of spinal anaesthesia-induced hypotension and to assess its effect on the magnitude of blood pressure drop, vasopressor requirement, and early haemodynamic outcomes among patients undergoing spinal anaesthesia. **Methods:** This prospective observational study was conducted on 100 adult patients of either sex, aged 20 to 60 years, belonging to ASA physical status I and II, scheduled for elective lower abdominal and lower limb surgeries under spinal anaesthesia. Baseline perfusion index was measured using a pulse oximeter before anaesthesia. Standard spinal anaesthesia was administered using 3 ml of 0.5% hyperbaric bupivacaine at the L3–L4 interspace. Haemodynamic parameters such as systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR) were recorded at baseline, and at 2, 5, 10, 15, 20, and 30 minutes after spinal anaesthesia. Hypotension was defined as a decrease of 20% or more in SBP from baseline and was managed with intravenous fluids and incremental doses of mephentermine. Patients were divided into two groups: Group A (PI $\leq$ 3.5) and Group B (PI > 3.5). The incidence of hypotension, vasopressor requirement, and time to haemodynamic stabilization were compared between groups. **Results:** Out of 100 patients, 54 were males and 46 were females, with a mean age of 38.6 ± 10.4 years. The mean baseline perfusion index in Group A was 2.9 ± 0.4 and in Group B was 4.7 ± 0.6 . The incidence of hypotension was 22% in Group A and 68% in Group B ($p < 0.001$). The mean fall in systolic blood pressure was 18.5 ± 6.2 mmHg in Group A and 34.2 ± 8.1 mmHg in Group B. The mean total dose of mephentermine required was 3.5 ± 1.2

mg in Group A and 7.9 ± 2.5 mg in Group B. The average time to haemodynamic stabilization was 8.6 ± 2.3 minutes in Group A and 15.2 ± 3.8 minutes in Group B. The mean duration of sensory block regression to T12 was 112 ± 14 minutes in Group A and 118 ± 16 minutes in Group B. **Conclusion:** The study demonstrated that a higher baseline perfusion index is significantly associated with an increased risk of spinal anaesthesia-induced hypotension. Patients with a baseline PI greater than 3.5 experienced a higher incidence and severity of hypotension and required greater vasopressor support compared to those with lower PI values. Hence, baseline perfusion index measurement can serve as a reliable, simple, and non-invasive tool for predicting hypotension following spinal anaesthesia, allowing timely preventive measures and improved haemodynamic stability during surgery.

Keywords: perfusion index, spinal anaesthesia, hypotension, vasopressor requirement, haemodynamic stability, predictive indicator

Introduction

Spinal anaesthesia is widely employed for surgeries involving the lower abdomen, pelvis and lower limbs because of its rapid onset, simplicity and favourable recovery profile. Nevertheless, one of its most common and clinically significant complications is hypotension, which is primarily a consequence of sympathetic blockade, vasodilatation, decreased systemic vascular resistance and venous pooling in the lower extremities and splanchnic circulation. This drop in arterial pressure may compromise organ perfusion and result in adverse outcomes, especially in haemodynamically vulnerable patients [1,2].

Pre-emptively identifying patients at higher risk of spinal anaesthesia-induced hypotension could enable anaesthesiologists to implement targeted prophylactic strategies such as fluid co-loading, vasopressor infusion or modification of block technique, thereby improving perioperative haemodynamic stability and patient safety.

The perfusion index (PI) is a non-invasive parameter derived from the pulse oximetry waveform; it represents the ratio of pulsatile (arterial) blood flow to the non-pulsatile (venous and tissue) blood flow in a monitored peripheral site, such as a fingertip or toe. PI thus serves as an indirect marker of peripheral perfusion and vascular tone [3,4]. In context of neuraxial blockade, a higher baseline PI may indicate lower baseline peripheral vascular tone (i.e., relative vasodilatation) and hence a greater propensity for further vasodilatory effect of sympathetic blockade, predisposing to hypotension [5,6].

Several observational studies in obstetric and non-obstetric populations undergoing spinal anaesthesia have explored the predictive role of baseline PI for hypotension. For example, in parturients undergoing lower-segment caesarean section, a baseline PI cut-off of >3.5 was associated with substantially increased incidence of hypotension and greater vasopressor requirements [7]. A recent meta-analysis found that the pooled sensitivity and specificity of baseline PI to predict post-spinal hypotension was moderate (≈ 0.75 and 0.64 respectively), with area under the ROC curve around 0.75 , indicating that while PI has promise, it may not suffice as a stand-alone predictor [8].

Despite these encouraging findings, the evidence remains limited in non-obstetric surgical populations, and optimal cut-off thresholds, timing of measurement, interplay with volume status and other patient-specific factors (age, comorbidities, ASA status) are not yet fully defined. Therefore, the present study aims to evaluate baseline perfusion index as an indicator for spinal-anaesthesia induced hypotension and assess its effect on magnitude of blood pressure drop, vasopressor requirement and early haemodynamic outcomes.

Materials and Methods

Study design and duration

This study was a prospective observational study conducted in the Department of Anaesthesiology at Government Medical College, Doda, over a period of six months, from January 2025 to June

2025. The study was designed to evaluate the role of baseline perfusion index (PI) as an indicator of spinal anaesthesia-induced hypotension and its impact on intraoperative haemodynamic parameters and vasopressor requirements.

Study population

A total of 100 adult patients of either sex, aged between 20 and 60 years, belonging to the American Society of Anesthesiologists (ASA) physical status I and II, and scheduled for elective lower abdominal, pelvic, and lower limb surgeries under spinal anaesthesia were included in the study.

Preoperative assessment

All patients underwent a detailed pre-anaesthetic check-up that included medical history, clinical examination, and relevant investigations. Baseline vital parameters such as heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded in the preoperative holding area. The perfusion index (PI) was measured using a standard pulse oximeter (Masimo Radical-7) placed on the index finger. The reading was taken after ensuring stable waveform and constant room temperature for at least three minutes. The average of three consistent PI readings was considered the baseline value.

Anaesthetic technique

All patients were kept nil per oral for eight hours prior to surgery. Upon arrival in the operating room, routine monitors were attached, including non-invasive blood pressure, electrocardiogram, and pulse oximetry. Baseline HR, SBP, DBP, MAP, and PI were recorded. Intravenous access was secured with an 18G cannula, and all patients received preloading with 10 ml/kg of Ringer's lactate over 15 minutes before the spinal block. Spinal anaesthesia was performed under aseptic precautions at the L3–L4 interspace with the patient in a sitting position using a 25G Quincke spinal needle. After confirming free flow of cerebrospinal fluid, 3 ml of 0.5% hyperbaric bupivacaine was injected intrathecally. Patients were immediately placed in the supine position with a 10-degree left lateral tilt. Oxygen was administered at 3 L/min via a face mask throughout the procedure.

Grouping

Patients were divided into two groups based on their baseline PI values:

Group A – $PI \leq 3.5$

Group B – $PI > 3.5$

Monitoring and data collection

Haemodynamic parameters including HR, SBP, DBP, and MAP were recorded at baseline (before spinal anaesthesia) and at 2, 5, 10, 15, 20, and 30 minutes after administration of the spinal block. Hypotension was defined as a fall of $\geq 20\%$ from baseline systolic blood pressure or an absolute $SBP < 90$ mmHg. Bradycardia was defined as $HR < 50$ beats per minute.

If hypotension occurred, it was treated with a rapid infusion of 200 ml of crystalloid solution and intravenous mephentermine 6 mg bolus, repeated as necessary. Bradycardia, if present, was treated with intravenous atropine 0.6 mg. The total dose of mephentermine administered, number of hypotensive episodes, and time to haemodynamic stabilization were recorded.

Sensory block level was assessed by the loss of pinprick sensation every two minutes until it reached the desired level for surgery. The duration of sensory block regression to T12 and total surgical time were also recorded.

Outcome parameters

1. Incidence of hypotension.
2. Magnitude of fall in SBP, DBP, and MAP.
3. Total dose of mephentermine used.
4. Number of hypotensive episodes.
5. Time to haemodynamic stabilization.

6. Duration of sensory block regression to T12.

Statistical analysis

All collected data were entered into Microsoft Excel and analysed using SPSS version 26. Quantitative variables were expressed as mean $\pm$ standard deviation, and qualitative variables as percentages. Independent t-test was used for continuous variables, and chi-square test for categorical variables. Receiver operating characteristic (ROC) curve analysis was used to determine the optimal PI cut-off value for predicting hypotension. A p-value < 0.05 was considered statistically significant.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of Government Medical College, Doda. Written informed consent was obtained from all participants before inclusion in the study.

Results

The mean age of patients in Group A was 37.8 ± 10.2 years and in Group B was 39.5 ± 9.8 years, which was statistically not significant. The male-to-female ratio was comparable between both groups. The mean body mass index (BMI) and duration of surgery were similar, showing that both groups were demographically comparable. There was no statistically significant difference between the groups regarding age, sex, body mass index, or baseline haemodynamic parameters, indicating that both groups were comparable before administration of spinal anaesthesia [Table].

Table 1: Demographic and baseline characteristics of patients (n = 100)

Parameter	Group A (PI $\leq$ 3.5) (n=50)	Group B (PI $>$ 3.5) (n=50)	p-value
Age (years)	37.8 ± 10.2	39.5 ± 9.8	0.41
Gender (M/F)	27/23	27/23	1.00
Weight (kg)	65.4 ± 8.9	66.1 ± 9.2	0.68
Height (cm)	166.2 ± 7.5	167.5 ± 8.1	0.46
BMI (kg/m ²)	23.7 ± 2.8	23.9 ± 2.9	0.72
ASA Grade (I/II)	30/20	28/22	0.68
Duration of surgery (min)	82.3 ± 15.4	80.6 ± 14.8	0.52
Baseline SBP (mmHg)	124.6 ± 10.3	123.1 ± 11.1	0.53
Baseline DBP (mmHg)	78.2 ± 6.8	77.5 ± 7.1	0.68
Baseline MAP (mmHg)	93.7 ± 7.5	92.9 ± 8.1	0.71
Baseline HR (beats/min)	78.4 ± 8.5	79.6 ± 9.1	0.52

The incidence and characteristics of hypotension following spinal anaesthesia are shown in Table 2. The overall incidence of hypotension was significantly higher in Group B (PI $>$ 3.5) as compared to Group A (PI $\leq$ 3.5). Patients in Group B exhibited a significantly greater reduction in systolic and mean arterial pressures following spinal anaesthesia and developed hypotension earlier compared to Group A [Table 2].

Table 2: Incidence and characteristics of hypotension

Parameter	Group A (PI $\leq$ 3.5)	Group B (PI $>$ 3.5)	p-value
Patients developing hypotension (%)	11 (22%)	34 (68%)	<0.001
Mean fall in SBP (mmHg)	18.5 ± 6.2	34.2 ± 8.1	<0.001
Mean fall in MAP (mmHg)	12.4 ± 5.1	26.5 ± 6.8	<0.001
Onset time of hypotension (min)	7.8 ± 2.4	5.6 ± 1.8	0.002

Patients with higher baseline perfusion index values required more frequent doses of vasopressor and larger fluid boluses to maintain haemodynamic stability. These findings indicate that a higher baseline perfusion index correlates strongly with a higher incidence of hypotension and greater vasopressor requirement [Table 3].

Table 3: Vasopressor and fluid requirements

Parameter	Group A (PI ≤ 3.5)	Group B (PI > 3.5)	p-value
Total mephentermine dose (mg)	3.5 ± 1.2	7.9 ± 2.5	<0.001
Number of mephentermine doses	0.8 ± 0.6	2.2 ± 0.9	<0.001
Total fluid administered (ml)	1250 ± 220	1420 ± 260	0.002
Patients requiring multiple vasopressor doses (%)	12%	46%	<0.001

Table 4 shows the haemodynamic trends following spinal anaesthesia over a 30-minute period. A greater and more sustained reduction in blood pressure was observed in Group B compared to Group A, though heart rate changes were comparable. The fall in SBP and MAP in Group B was statistically significant at 5, 10, and 20 minutes after spinal anaesthesia, indicating more profound hypotension in patients with higher baseline PI.

Table 4: Haemodynamic trends after spinal anaesthesia

Time (min)	SBP (mmHg) Group A	SBP (mmHg) Group B	MAP (mmHg) Group A	MAP (mmHg) Group B	HR (bpm) Group A	HR (bpm) Group B
Baseline	124.6 ± 10.3	123.1 ± 11.1	93.7 ± 7.5	92.9 ± 8.1	78.4 ± 8.5	79.6 ± 9.1
2 min	120.2 ± 9.8	116.5 ± 10.4	90.6 ± 7.1	88.4 ± 7.8	78.1 ± 8.3	78.8 ± 8.6
5 min	115.1 ± 9.5	107.8 ± 9.9	87.5 ± 6.4	81.2 ± 7.3	77.2 ± 8.1	76.9 ± 8.7
10 min	111.8 ± 8.6	96.3 ± 8.5	85.1 ± 6.1	75.3 ± 6.8	77.0 ± 7.8	76.5 ± 8.2
20 min	113.5 ± 8.9	98.2 ± 8.1	86.3 ± 6.5	77.1 ± 6.9	77.4 ± 7.7	76.1 ± 7.9
30 min	118.4 ± 9.1	104.7 ± 8.6	89.7 ± 6.8	81.9 ± 7.2	77.6 ± 8.0	77.2 ± 8.4

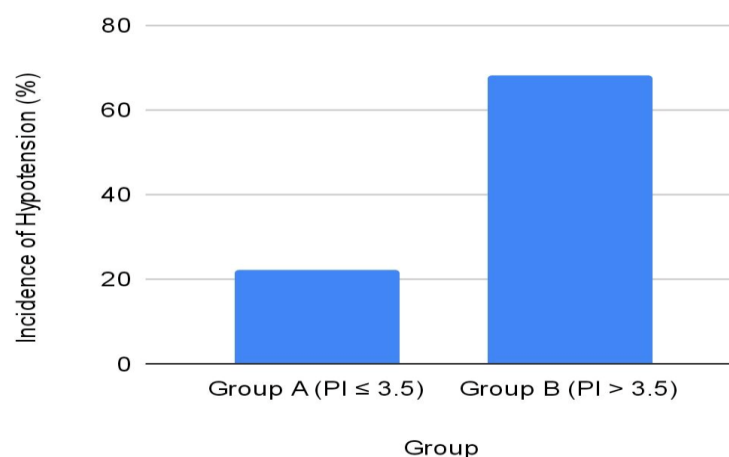
Although there was no significant difference in the duration of surgery or regression of sensory block between groups, Group B patients took longer to achieve haemodynamic stabilization and required greater intraoperative management efforts [Table 5].

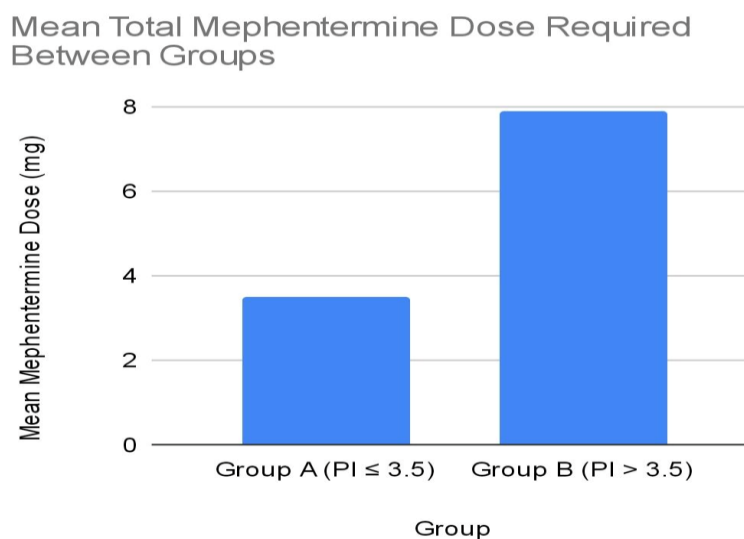
Table 5: Post-anaesthetic recovery and outcome parameters

Parameter	Group A (PI ≤ 3.5)	Group B (PI > 3.5)	p-value
Duration of surgery (min)	82.3 ± 15.4	80.6 ± 14.8	0.52
Time to haemodynamic stabilization (min)	8.6 ± 2.3	15.2 ± 3.8	<0.001
Regression to T12 (min)	112 ± 14	118 ± 16	0.09
Incidence of bradycardia (%)	6%	10%	0.41
Oxygen supplementation required (%)	4%	12%	0.12

Bar graph: Incidence of Hypotension Between Group A and Group B.

Incidence of Hypotension Between Group A and Group B



Bar graph 2: Mean Total Mephenetermine Dose Required Between Groups.

Discussion

In the present study of 100 adult patients undergoing elective infra-umbilical surgery under spinal anaesthesia at Government Medical College Doda from January 2025 to June 2025, we found that a higher baseline perfusion index (PI > 3.5) was associated with a significantly higher incidence of hypotension (68% vs 22%, $p < 0.001$), a greater magnitude of systolic blood pressure (SBP) fall (34.2 ± 8.1 mmHg vs 18.5 ± 6.2 mmHg), higher vasopressor (mephenetermine) requirement (7.9 ± 2.5 mg vs 3.5 ± 1.2 mg), and longer time to haemodynamic stabilization (15.2 ± 3.8 min vs 8.6 ± 2.3 min) compared to the low PI group. These results match the aim of the study and the hypothesis that baseline peripheral perfusion or vascular tone, as reflected by PI, may indicate vulnerability to sympathectomy-induced hypotension.

The pathophysiology of spinal anaesthesia-induced hypotension (SAIH) is well established. Spinal block produces sympathetic neural blockade, causing vasodilatation, venous pooling, decreased systemic vascular resistance (SVR), and reduced venous return, which lead to decreased cardiac output and arterial pressure. The degree of sympathetic tone prior to block may influence the magnitude of blood pressure drop: patients with lower vascular tone (i.e., more vasodilated baseline state) have less compensatory capacity and thus experience a greater fall in blood pressure. The PI, defined as the ratio of pulsatile to non-pulsatile blood flow in peripheral tissue measured via pulse oximeter plethysmography, serves as a surrogate for peripheral vascular tone and perfusion and has been studied for this predictive purpose [9,10].

Several earlier studies in parturients undergoing lower segment caesarean section under spinal anaesthesia reported that a baseline PI > 3.5 predicted a higher incidence of hypotension [11,12]. Our findings in a non-obstetric adult surgical population extend these observations. Duggappa et al. Found that parturients with baseline PI > 3.5 had a hypotension incidence of about 71.4% compared to approximately 10.5% in those ≤ 3.5 [12]. Furthermore, Hung et al. (2023) conducted a meta-analysis that found pooled sensitivity of 0.81 and specificity of 0.75 (AUC 0.84) for PI predicting post-spinal hypotension in parturients [11]. Our results (incidence 68% vs 22%) closely align with those earlier obstetric findings, validating the use of the PI threshold of 3.5 in our setting. A recent non-obstetric study also found that a baseline PI cut-off > 2.9 was an excellent classifier (AUC 0.917) for SAIH [13]. While our cut-off remains 3.5, the consistency of high incidence of hypotension in the high PI group supports the clinical utility of this monitoring.

In our study, patients in the high PI group required significantly higher doses of vasopressor and took longer to stabilize haemodynamically. This implies that baseline PI not only predicts the incidence of hypotension but also its severity and management burden. Clinically, this is significant

because preoperative knowledge that a patient with high PI is at risk allows implementation of preventive strategies such as fluid co-loading, prophylactic vasopressor infusion, and enhanced monitoring. The incremental fall in SBP and MAP in the high PI group (34.2 ± 8.1 mmHg and 26.5 ± 6.8 mmHg) is comparable to earlier studies [9,10,13], indicating a consistent physiological mechanism. The longer stabilization time (15.2 ± 3.8 min vs 8.6 ± 2.3 min) further underscores the haemodynamic challenge.

It is noteworthy that despite significant differences in the incidence and severity of hypotension, both groups had comparable demographics, BMI, ASA physical status, and baseline haemodynamic parameters. This finding suggests that baseline PI offers predictive value beyond conventional risk factors [14,15]. For routine anaesthesia practice, monitoring PI pre-block may serve as a simple and non-invasive method to identify at-risk patients.

However, certain limitations must be acknowledged. Our study included relatively healthy ASA I–II adults; therefore, findings may not be generalizable to higher-risk or obstetric patients [16]. The PI threshold we used (3.5) aligns with previous studies, but the optimal cut-off may vary with population, device, or temperature. Additionally, invasive haemodynamic parameters such as cardiac output or SVR were not recorded, which could have provided deeper insights into the mechanistic relationship between PI and hypotension. Finally, although our study demonstrates predictive value, interventional trials are required to confirm that PI-guided management can improve patient outcomes.

Conclusion

In conclusion, our study reinforces that in adult elective infra-umbilical surgery under spinal anaesthesia, a higher baseline perfusion index is significantly associated with a higher incidence, greater magnitude, and longer duration of spinal anaesthesia-induced hypotension. Preoperative assessment of PI can thus be a valuable, non-invasive tool for predicting haemodynamic instability and guiding preventive interventions. Further multicentre studies are needed to refine threshold values and evaluate the role of PI-guided protocols in improving perioperative safety.

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