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Perfusion Index and its association with hypotension following spinal anaesthesia for lower segment caesarean section in a tertiary care center of rural Nepal

Robin Khapung[1], Subi Basnyat[2], Rohit Man Singh[3], Shirish Silwal[4], Anita Thapa[5], Alan Pandey[6], Apil Adhikari[6], Praveen Kumar Giri[7], Ramesh Bhattarai[8], Posan Samser Limbu[9], Pragya Shrestha[10], Kiran Kumar Chettri[11], Nikita Basnyat[12]

[1]Anesthesiologist, Department of Anesthesiology, Critical Care, and Pain Medicine, Karnali Academy of Health Sciences (KAHS), Jumla, Nepal
[2]Obstetrician and Gynecologist, Department of Obstetrics and Gynecology, KAHS, Jumla, Nepal
[3]Anesthesiologist, Department of Anesthesiology and Critical Care, United Mission Hospital, Tansen, Nepal
[4]Consultant Anesthesiologist, Department of Anesthesiology and Critical Care, Bharatpur Hospital, Chitwan, Nepal
[5]Consultant Anesthesiologist, Department of Anesthesiology and Critical Care, Janakpur Provincial Hospital, Janakpur, Nepal
[6]Resident, Department of Anesthesiology, Critical Care, and Pain Medicine, KAHS, Jumla, Nepal
[7]Associate Professor, Senior Consultant Intensivist, Department of Critical Care, Kirtipur Hospital, Kathmandu, Nepal
[8]Associate Professor, Senior Consultant, Department of Anesthesiology, Lumbini Eye Institute, Nepal
[9]Assistant Professor, Department of Internal Medicine, Division of Nephrology and Pulmonary/CC/Sleep Medicine, SSM St. Louis University Hospital, St. Louis, Missouri, USA
[10]Associate Professor, School of Nursing and Midwifery, KAHS, Jumla, Nepal
[11]FRCA ST5 Anaesthetics, North West School of Anaesthesia, England, UK
[12]Registered Nurse, Department of Emergency, Sunshine Hospital, Western Health, Australia

ABSTRACT

Introduction: Spinal anaesthesia is the preferred technique for lower segment caesarean section (LSCS) but is frequently complicated by hypotension. Conventional monitoring may not detect hypotension early, prompting interest in non-invasive predictors such as the perfusion index (PI). This study aims to evaluate the utility of baseline PI as an early predictor of spinal anaesthesia-induced hypotension in parturients undergoing LSCS at a tertiary care centre in rural Nepal.

Methods: This prospective observational study was conducted at Karnali Academy of Health Sciences from September 2024 to August 2025 after ethical approval. Parturients aged 18–40 years (ASA I–II) undergoing elective LSCS under spinal anaesthesia were enrolled. Haemodynamic parameters were recorded. Data were analyzed using SPSS v20 with $p < 0.05$ considered significant.

Results: A total of 86 parturients were enrolled with a median age of 27 years and gestational age of 41 weeks. Post-spinal hypotension occurred in 27 (31.4%) patients, with 31 (36%) requiring mephentermine support; bradycardia (3.5%) and vomiting (2.3%) were minor adverse events. Baseline perfusion index showed a significant association with post-spinal hypotension ($p < 0.001$) and a negative moderate correlation with mean arterial pressure ($r = –0.373$, $p < 0.001$) and systolic blood pressure ($r = –0.368$, $p = 0.001$), while no association was observed with parity or caesarean history.

Conclusion: Baseline PI >3.5 predicts spinal-induced hypotension in elective CS, with higher incidence, lower early MAP, and negative PI-MAP correlation. It may be used for early risk identification and haemodynamic management.

Keywords: Hypotension, Jumla, Perfusion Index, Spinal Anaesthesia, Tertiary care center

INTRODUCTION

Spinal anaesthesia is the preferred technique for lower segment caesarean section (LSCS) because of ease of administration, faster onset, and fetomaternal safety.[1] However, spinal anaesthesia-induced hypotension remains common, with reported incidences ranging from about 60–80% in parturients (and lower in non-pregnant patients), and differences partly relate to patient factors and how hypotension is defined.[1,2] Hypotension is associated with maternal symptoms such as dizziness, nausea, and vomiting, and may be associated with adverse fetal effects, including fetal acidosis and bradycardia.[3,4]

Traditional monitoring during LSCS commonly uses non-invasive blood pressure (NIBP), but it may fail to detect hypotensive episodes promptly and does not provide beat-to-beat perfusion dynamics.[1,3,5] Therefore, non-invasive predictors (e.g., Perfusion index (PI), Plethysmographic Variability Index (PVI), Heart Rate Variability (HRV), ultrasound/(near-infrared spectroscopy) (NIRS) approaches) have been studied to help anticipate hypotension and enable timely preventive measures, such as prophylactic vasopressor administration.[4,6]

The PI, obtained from pulse oximetry, is calculated as the ratio of pulsatile to non-pulsatile blood flow and reflects peripheral vascular tone.[1] Baseline PI has been shown to predict hypotension following spinal anaesthesia. Toyama et al. reported that higher baseline PI values were associated with an increased risk of hypotension after spinal anaesthesia.[7]

A study by Lal J et al showed that parturients with baseline PI >3.5 measured at the finger are at higher risk of developing hypotension during spinal Anaesthesia for caesarean section compared to those

Corresponding Author:
Dr. Robin Khapung
Email: robinkhapung@hotmail.com

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with baseline PI ≤3.5.[3] Study by Malavika et al. showed that a baseline perfusion index value > 4.25 is associated with a higher incidence of hypotension following spinal Anaesthesia in elective LSCS.[8] A study by Duggappa et al. showed that a baseline perfusion index >3.5 is associated with a higher incidence of hypotension following spinal Anaesthesia in elective LSCS[9] Study by Harde et al showed that baseline PI> 2.9 can predict post-spinal hypotension in LSCS with high sensitivity and specificity.[10] This variation may be due to the use of a different definition for hypotension, such as MAP thresholds, Systolic Blood pressure thresholds, or percentage increase from baseline. When definitions change, the measured incidence and the "best" PI threshold also change.[4,11]

A study conducted by Thapa et al. at Nepal Medical College, Nepal, showed that Parturients with baseline PI > 3.5 are at higher risk of developing hypotension following spinal Anaesthesia than those with baseline PI <3.5.[12] A study by Pradhan et al. at Paropakar Hospital, Kathmandu, showed that a higher baseline PI index (>3.5) is associated with a higher incidence of hypotension and requires vasopressor support following spinal Anaesthesia in elective LSCS.[13]

This study was designed to evaluate the utility of perfusion index as an early indicator of spinal anaesthesia–induced hypotension in parturients undergoing LSCS at a tertiary care centre in rural Nepal.

METHODS

This prospective observational study was conducted at the Karnali Academy of Health Sciences (KAHS), a tertiary-level healthcare institution in rural Nepal, following ethical clearance from the Institutional Review Committee (IRC) (Reference No. 081/082/05) between September 2024 and August 2025.

Parturients aged 18–40 years, American Society of Anesthesiologists[14] – Physical status ASA-PS I–II, undergoing elective LSCS under spinal anaesthesia, were included. Exclusion criteria were hypotensive disorders requiring vasopressors preoperatively, cardiac disease, arrhythmias, contraindications to spinal anaesthesia, and refusal of consent.

All eligible participants underwent a thorough pre-anaesthetic evaluation. Demographic variables, including age, height, and weight, were recorded along with detailed medical and obstetric history, clinical examination findings, and relevant laboratory investigations. After ensuring adequate fasting (six hours for solids and two hours for clear fluids), intravenous pantoprazole 40 mg and ondansetron 4 mg were given in the preoperative room. Standard monitoring was done and preoperative baseline heart rate (HR), non-invasive blood pressure (BP), electrocardiogram (ECG), oxygen saturation (SpO_2), and PI were documented.

Baseline PI values were measured in a standardized manner using a multiparameter patient monitor with a dedicated pulse oximeter probe (Mindray ePM12M; Mindray Bio-Medical Electronics Co. Ltd., Shenzhen, China). PI is dynamic, and it can change with factors such as vascular tone, intravascular volume, temperature, stress, probe placement, and patient movement.[15] The probe was consistently placed on the left index finger to minimize inter-site variability. Measurements were obtained at rest, with minimal movement, in a comfortable supine position with a 15-degree left uterine displacement to prevent aortocaval compression. The average of three PI readings taken at five-minute intervals was considered the baseline PI value.

Based on baseline PI, participants were stratified into two groups using a cut-off value of 3.5. Parturients with a baseline PI ≤3.5 were assigned to Group A, while those with a PI >3.5 were categorized as Group B. This classification was derived from previously published literature evaluating PI as a predictor of spinal-induced hypotension.[10]

In the operating theatre, patients were administered Lactated Ringer's solution at a rate of 10 mL/kg. Spinal anaesthesia was performed by an anaesthesiologist who was blinded to the baseline PI values and study grouping. Under strict aseptic precautions, spinal Anaesthesia was administered in the sitting position at the L2–L3 or L3–L4 intervertebral space using a 26-gauge Quincke spinal needle. A fixed intrathecal dose of 10 mg of 0.5% hyperbaric bupivacaine was injected.

Following spinal Anaesthesia, patients were positioned supine with a wedge placed under the right hip until delivery of the neonate. Sensory blockade was assessed every 2 minutes with a cold swab, and the surgical incision was permitted once a sensory level of T4 was achieved.

Haemodynamic variables, including HR, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), SpO_2, and PI, were recorded at five-minute intervals for the first 30 mins following spinal anaesthesia and subsequently at ten-minute intervals until completion of surgery. If the surgery lasted less than 30 minutes, the variables were recorded in the post-operative ward for at least 30 minutes after spinal Anaesthesia.

Hypotension was defined as either a reduction in MAP below 65 mmHg or a decrease in SBP greater than 25% from baseline. Episodes of hypotension were managed initially with intravenous fluids, followed by Mephentermine 6 mg intravenously when required. The total volume of intravenous fluids administered and cumulative vasopressor dosage were recorded.

Bradycardia was defined as a heart rate less than 50 beats per minute and was treated with intravenous atropine 0.6 mg. Following delivery and clamping of the umbilical cord, oxytocin 10 units diluted in 500 mL of normal saline was infused over 30 minutes as per institutional practice.

The occurrence of adverse events such as nausea, vomiting, shivering, bradycardia, or other complications was documented and managed according to standard institutional guidelines.

Sample size was estimated using a correlation-based predictive model as described by Harde et al.[10] The sample size was calculated using the formula

$$N=((Z\alpha+Z_\beta)/c)2 + 3$$

where $Z\alpha$ corresponds to a two-sided significance level of 0.05 (1.96), Z_β represents 80% statistical power (0.842), and C is the expected correlation coefficient. Using a correlation coefficient of 0.443 reported in the reference study, the minimum required sample size was calculated to be 43 participants per group.

Data were analyzed using the Statistical Package for Social Sciences (SPSS) software, version 20. Continuous variables were assessed for normality and reported as mean ± standard deviation or median and interquartile range, while categorical variables were presented as frequencies and percentages. The independent-samples t-test or Mann-Whitney U Test was used to compare continuous variables, and the chi-square test was used for categorical data. Correlation between MAP and PI, and systolic blood pressure and PI were observed using Spearman's rho. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 86 patients were included in the study. The patient's median age was 27 (25-29) years. The median Height of the enrolled patients was 155cm (152-158). The median weight of the participants was 65(62-70) kg. Similarly, the median gestational age was 41 weeks (39-42). The comparison of the parameters between Group A and Group B is shown in Table 1. All baseline characteristics (height, weight, gestational age, heart rate, SBP, DBP, MAP) show no statistically significant differences, with p-values ranging from 0.110 to 0.600.

A total of 27(31.4%) had hypotension post spinal anaesthesia. For hypotension, 10 (11.6%) received a single dose of inj. Mephentermine (i.e. 6 mg), 11(12.8%) got 2 doses (i.e.12 mg) and 6(7%) got three doses (i.e. 18 mg). After administration of mephentermine, MAP increased to >65 mmHg.

Similarly, 2(2.3%) had vomiting post-spinal Anaesthesia. Three (3.5%) had bradycardia intraoperatively for which inj. Atropine 0.6 mg was given, which corrected bradycardia.

Table 1. Baseline characteristics by PI group (PI ≤3.5 vs PI >3.5)

Variable	Group A(PI≤3.5)	Group B(PI>3.5)	P value
Age (in years)	27(24-28)	27.93(26-30)	0.600*
Height (in cm)	155(151-158)	155(153-158)	0.929*
Weight (in kg)	64(60-70)	65(63-72)	0.110*
Gestational age (in weeks)	40(39-42)	41(39-44)	0.210*
Baseline heart rate (in bpm)	89(80-95)	89(81-97)	0.554*
Baseline SBP (in mm Hg)	125.03±11.243	126±13.41	0.299**
Baseline DBP (in mm Hg)	82(73-87)	82(75-90)	0.412*
Baseline MAP (in mm Hg)	92.86±10.26	94.81±12.17	0.255**

*Mann-Whitney U Test, **Independent T test

The association between the baseline perfusion index and hypotension post-spinal Anaesthesia in patients undergoing LSCS was significant (p < 0.001) (Table 2).

Table 2. Association of baseline perfusion index with hypotension post spinal anaesthesia

Perfusion index	Hypotension		Chi-square value	P value
	Yes n (%)	No n (%)		
<=3.5	11(12.8%)	48(55.8%)	14.187	<0.001
>3.5	16(18.6%)	11(12.8)		

The association between the perfusion index and patient parity was calculated, and no association was found between the initial PI and patient parity. (Table 3)

Table 3. Association between the perfusion index and parity of the patient

Perfusion index	Parity		Chi-square value	P value
	Multi	Primi		
<=3.5	31(36%)	28(32.6%)	0.337	0.644
>3.5	16(18.6%)	11(12.8%)		

The association between the perfusion index and the patient's caesarean section history was calculated, and no association was found between the initial PI and the patient's Caesarean section. (Table 4)

Table 4. Association between the perfusion index and history of caesarean section

Perfusion index	Caesarean section history		Chi-square value	P value
	Yes	No		
<=3.5	20(23.3%)	39(45.3%)	0.003	0.959
>3.5	18(20.9%)	9(10.5%)		

The trend in MAP over time for the baseline PI showed higher MAP in patients with baseline PI < 3.5 and lower MAP in those with baseline PI > 3.5. The PI >3.5 group demonstrated a lower early MAP profile than the PI ≤3.5 group during the initial 30-minute period. (Figure 1)

The correlation between the patient's mean MAP over 30 minutes and the perfusion index was calculated. The normality testing for perfusion index showed a non-normal distribution, and that of MAP was normal. So, Spearman's rho was used to calculate the correlation. There was a negative moderate correlation (Spearman's rho(r)=-0.373). As perfusion index increases, MAP decreases, and vice versa. This finding was statistically significant (p-value = 0.001). (Figure 2))

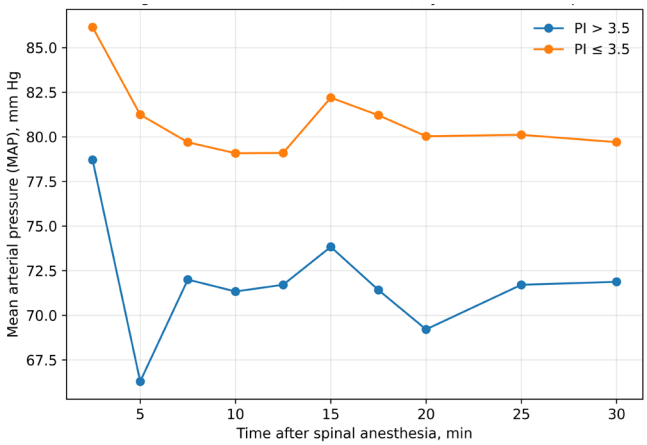

Figure 1: MAP trend by PI group

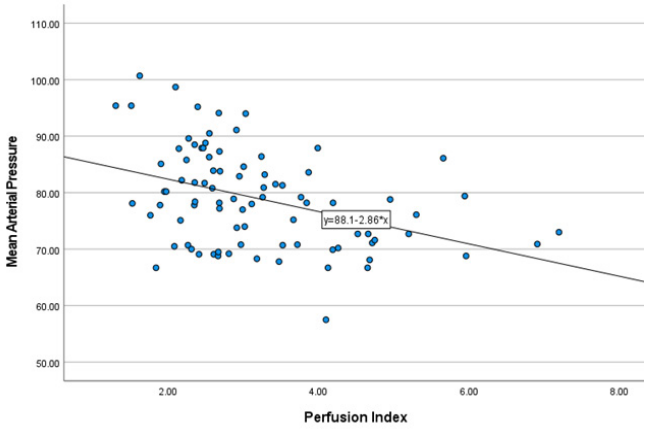

Figure 2: Correlation of mean arterial pressure with perfusion index

The correlation between the patient's mean SBP over 30 minutes and the perfusion index was calculated. The normality testing for perfusion index showed a non-normal distribution, and that of SBP was normal. So, Spearman's rho was used to calculate the correlation. There was a negative moderate correlation (Spearman's rho(r)=-0.368). As perfusion increases, SBP decreases, and vice versa. This finding was statistically significant (p-value = 0.001). (Figure 3)

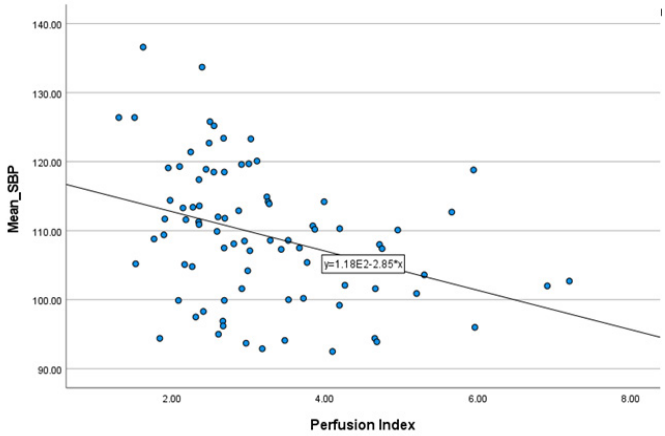

Figure 3: Correlation of the mean SBP of the patient with the perfusion index

DISCUSSION

This prospective study evaluated baseline PI as an early, non-invasive indicator of spinal anaesthesia–induced hypotension among 86 term parturients undergoing elective LSCS in a resource-limited setting. Hypotension was associated with PI >3.5 than in those with PI ≤3.5 (p <0.001). All the baseline indices were comparable between the two groups.

PI is obtained from the pulse oximeter plethysmographic waveform and reflects the ratio of the pulsatile to non-pulsatile components of the signal (AC/DC). It therefore provides an indirect bedside estimate of peripheral perfusion and vascular tone at the monitoring site.[15] During pregnancy, baseline vascular tone is physiologically reduced to accommodate the expanded circulating volume, thereby increasing the tendency for peripheral pooling.[11] Spinal anaesthesia produces sympathetic blockade, causing further vasodilation and reduced venous return, thereby worsening pooling and increasing the risk of hypotension.[11] On this basis, a higher baseline PI likely reflects a more vasodilated state before anaesthesia; when spinal sympathectomy occurs, the fall in preload and MAP may be greater consistent with the lower early MAP pattern observed in our high-PI group.

Our study identified that a total of 27(31.4%) had hypotension post spinal anaesthesia. A study done in Ethiopia by Shitemaw et al showed the rate of hypotension among patients undergoing CS was 64%.[16] A prospective study by Lal J in India among females undergoing LSCS showed a hypotension incidence of 40% in the baseline PI ≤3.5 group, compared with 73.3% in the PI >3.5 group.[3] A study by Lamichhane et al. in Kathmandu found that the rate of hypotension among females undergoing LSCS was 41.88%.[17] A study by Gautam et al. showed that spinal Anaesthesia induced hypotension among 11.5% of females undergoing LSCS.[18] Possible reasons for the different incidence rates include differences in measurement methods, the operational definition of hypotension, and the clinical setting.

This study showed that the association between the baseline perfusion index and hypotension post-spinal Anaesthesia in patients undergoing LSCS was significant. A study by Duggappa et al. showed that a PI >3.5 was associated with a higher incidence of hypotension (81.3%), increased vasopressor requirements, and haemodynamic instability, including elevated heart rate and reduced blood pressure.[9] A 2023 meta-analysis of studies on parturients undergoing elective CS reinforced this, reporting a pooled sensitivity of 0.81, specificity of 0.75, and Area Under Curve(AUC) of 0.84 for PI predicting post-spinal hypotension with cut-off 3.5.[11] In contrast to this finding, Yokose et al. found no predictive value of PI for LSCS hypotension.[19] Most studies on this topic showed that PI > 3.5 is associated with a higher hypotension rate, except one. This difference could be due to the difference in the definition of hypotension after spinal Anaesthesia.

This study showed no association between the baseline perfusion index and a history of LSCS. No studies were found to compare this finding. This suggests that PI reflects current physiological vascular status rather than obstetric background, supporting its role as an independent physiological marker for hypotension risk assessment.

This study showed a negative correlation between baseline PI, MAP, and SBP. A study by Jana et al. showed a similar finding and, in addition, found that oxytocin use increases MAP.[20] Similarly, the study by Harde et al. showed that PI was negatively correlated with MAP and SBP.[10]

It was conducted at a single centre with a moderate sample size, so the findings may not reflect all settings. Blood pressure was measured at intervals, so short episodes of hypotension may have been missed. Also, a single baseline PI value can change with factors such as movement, stress/anxiety, temperature, and probe conditions, thereby introducing additional variability. Future multicentre studies with standardized PI measurement protocols and PI-guided preventive strategies are needed to determine whether this approach improves maternal haemodynamic outcomes and reduces vasopressor requirements.

CONCLUSION

Baseline perfusion index is a non-invasive marker that can help predict spinal anaesthesia–induced hypotension in parturients undergoing elective caesarean section. In this study, PI >3.5 was associated with a higher incidence of hypotension, lower early mean arterial pressure trends, and a negative correlation between PI and MAP. These findings support the use of baseline PI for early identification of high-risk patients and anticipatory haemodynamic management.

DECLARATIONS

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Author Contribution

RK took the lead in defining the work, reviewing important content, giving final approval, reaching agreements on all aspects, and managing journal correspondence. SB helped with review, approval, and agreement; RMS and SS contributed to review, approval, and agreement as well; AP and AA took part in approval and agreement; PKG, PSL, and KCC were involved in review, approval, and agreement; and NB focused on approval and agreement. The details table shows that RK and SB led in conception, design, collecting literature, data analysis, and interpretation. RMS and SS supported these areas, while AP and AA helped with literature and analysis. PKG contributed to most categories, PSL managed literature, analysis, and interpretation, and KCC and NB assisted with literature and analysis.

Conflict of Interest

The main author of the article is one of the members of the editorial team. He has no role in any of the editorial processes of the article.

Ethical Approval

Ethical approval was obtained from IRC KAHS with ref no: 081/082/05

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Consent /Assent

Informed written consent was obtained from all the participants before data collection.

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None.

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