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Original Research Article

Predicting Hypotension in Patients Undergoing Lower Segment Caesarean Section Under Subarachnoid Block by Assessing Perfusion Index: A Prospective Observational Study

Dr. Ajay Krishnan A.R.[1], Dr. Rohini K.P.[2]

[1]Consultant Anaesthesiologist, Midas Hospital and Surgical Centre, Ollur, Thrissur, Kerala, India.
[2]Professor, Department of Anaesthesiology, Kerala Medical College, Cherpulassery, Palakkad, Kerala, India.

Corresponding Author
Dr. Ajay Krishnan A.R., Consultant Anaesthesiologist, Midas Hospital and Surgical Centre, Ollur, Thrissur, Kerala, India.

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ABSTRACT

Background: Patients undergoing LSCS (Lower Segment Caesarean Sections) frequently experience hypotension after spinal anaesthesia. Early detection of at-risk patients may enable prompt intervention and enhance outcomes for mothers and newborns. The development of hypotension after SAB (Subarachnoid Block) may be predicted by the perfusion index, a non-invasive metric obtained from pulse oximetry.

Methods: This prospective observational study was conducted at Daya General Hospital Limited, Thrissur, involving 100 parturients undergoing elective LSCS. Based on baseline PI, participants were split into two groups: Group 1 (PI ≤ 3.5; n = 50) and Group 2 (PI > 3.5; n = 50). Every patient was given Ringer's lactate for prehydration and 10 mg of 0.5% hyperbaric bupivacaine for spinal anaesthesia. After SAB, haemodynamic parameters were tracked during 60 minutes. A mean arterial pressure of less than 65 mmHg was considered hypotension. The groups were compared in terms of the frequency of hypotension, the need for vasopressors, haemodynamic parameters, newborn APGAR scores, the length of operation, and the frequency of nausea and vomiting. The chi-square test and unpaired Student's t-test were used for statistical analysis; $p < 0.05$ was deemed statistically significant.

Results: The demographic characteristics were comparable between the groups. The mean number of hypotensive episodes was significantly higher in Group 2 than in Group 1 (1.52 ± 1.39 vs. 0.32 ± 0.65; $p < 0.001$). Patients with baseline PI > 3.5 also required greater vasopressor support. No statistically significant differences were observed in neonatal APGAR scores, duration of surgery, or incidence of nausea and vomiting between the groups.

Conclusion: Baseline PI > 3.5 was significantly associated with an increased incidence of hypotension and higher vasopressor requirements following SAB for elective LSCS. PI may serve as a useful, non-invasive adjunct for identifying patients at increased risk of spinal anaesthesia-induced hypotension.

Keywords: Perfusion Index, Hypotension, Spinal Anaesthesia, Subarachnoid Block, Caesarean Section, Pulse Oximetry.

INTRODUCTION

Because of its quick onset, efficient sensory and motor blocking, and avoidance of airway manipulation associated with general anaesthesia, LSCS (Lower Segment Caesarean Sections) are frequently performed under spinal anaesthesia. However, hypotension following spinal anaesthesia is a frequent complication, primarily resulting from sympathetic blockade, peripheral vasodilatation, and reduced venous return. Maternal hypotension can lead to adverse effects such as nausea, vomiting, and dizziness, while reduced uteroplacental perfusion may compromise fetal oxygenation and contribute to umbilical arterial acidosis in neonates.[1] Early detection of parturients who

are more likely to experience post-spinal hypotension may enable prompt preventive measures and enhance the results for both mothers and newborns.

Physiological changes during pregnancy, including reduced systemic vascular resistance and alterations in cardiovascular regulation, influence maternal haemodynamic responses to spinal anaesthesia. At term, pregnant women may have relatively lower MAP (Mean Arterial Pressure) and increased sensitivity to the haemodynamic effects of local anaesthetics and vasopressors.[2] Consequently, the sympathetic blockade produced by spinal anaesthesia can precipitate a significant reduction in blood pressure in parturients undergoing LSCS.

NIBP (Non-Invasive Blood Pressure) monitoring is routinely used to assess intraoperative haemodynamic status. However, intermittent NIBP measurements may fail to detect rapid haemodynamic changes between consecutive readings and do not provide continuous beat-to-beat assessment of peripheral perfusion. Therefore, identifying reliable, non-invasive predictors of hypotension before the administration of spinal anaesthesia remains clinically important.

The ratio of pulsatile to non-pulsatile blood flow in peripheral tissue is represented by the non-invasive perfusion index (PI), which is obtained from pulse oximetry. The relative absorption of infrared light by pulsatile and non-pulsatile blood components can be used to assess it, which indicates variations in peripheral perfusion and vascular tone.[3] PI has gained attention as a potential predictor of hypotension following spinal anaesthesia, with previous studies investigating its utility in identifying parturients at risk of developing this complication.[4-6]

Maternal cardiovascular adaptation during a typical pregnancy is facilitated by decreased systemic vascular resistance, increased blood volume, and cardiac output. The degree of peripheral vasodilatation varies among individuals and may influence baseline PI values. A higher baseline PI may indicate reduced peripheral vascular tone, suggesting an increased susceptibility to further vasodilatation following spinal anaesthesia. The resulting sympathetic blockade may lead to venous pooling, reduced venous return, and subsequent hypotension.

Therefore, evaluating preoperative PI may help identify parturients at risk of hypotension following spinal anaesthesia for LSCS and facilitate the implementation of appropriate preventive measures.

Aims and Objectives

This study aims to assess the relationship between the occurrence of hypotension after SAB (Subarachnoid Block) in patients undergoing LSCS (Lower Segment Caesarean Section) and the baseline perfusion index (PI). Comparing the occurrence of hypotension between patients with a baseline PI < 3.5 and those with a baseline PI > 3.5 is the main goal. The secondary goals are to compare the two groups' SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure), and MAP (Mean Arterial Pressure), determine the total doses of vasopressors needed to treat hypotension, and assess newborn outcomes using APGAR scores.

MATERIALS AND METHODS

Study Design

This study was conducted as a prospective observational study at Daya General Hospital Limited, Thrissur, Kerala, from June 2022 to May 2023, following approval from the Institutional Ethics Committee and Research Committee. The study aimed to evaluate the correlation between baseline perfusion index (PI) and the incidence of hypotension following subarachnoid block in patients undergoing LSCS.

Inclusion and Exclusion Criteria

The study included parturients aged 20–35 years with a gestational age of 36–41 weeks, height between 145 and 180 cm, singleton pregnancy, ASA (American Society of Anesthesiologists) physical status grade II, and a BMI (Body Mass Index) ≤ 40 kg/m². Written informed consent was obtained from all participants, and only those who achieved a sensory block up to the T6 level were included. Parturients with ASA physical status grades III or IV, placenta previa, pre-eclampsia, cardiovascular or cerebrovascular disease, gestational diabetes mellitus, or morbid obesity were excluded. Patients who refused to participate, had an overdistended uterus or multiple pregnancy, had contraindications to spinal anaesthesia, required additional uterotonic agents or additional surgical interventions, or failed to

achieve a sensory block up to the T6 level were also excluded.

Sample Size Calculation

Based on a study conducted by Duggappa D, Lokesh M, Dixit A et al.,[7] using correlation 0.416, with 95% confidence level and 80% power, number of patients enrolled is calculated as:

$n = [Z1-\beta + Z1-\alpha/2]^2 / [r^2 / (1-r^2)]$

r: correlation coefficient

Z1-α/2: desired confidence level

1-β: Power

n = 46

(Approximately 50 patients to be included in each group) Therefore, a total of 100 patients has to be enrolled in this study.

Data Collection Procedure

All eligible parturients provided written informed consent before data collection began. During the preoperative evaluation, pertinent medical history, prior anaesthesia and surgical history, comorbidities, drug use, and allergies were noted, along with demographic information such as age, weight, and height. Before spinal anaesthesia was administered, baseline physiological parameters were measured, such as pulse rate, SBP, DBP, MAP, peripheral oxygen saturation (SpO_2), and perfusion index (PI). A pulse oximeter fitted to the left index finger was used to test the PI while the patient was supine. Patients were split into two groups based on their initial PI: Group 1 (PI < 3.5) and Group 2 (PI > 3.5). Ten milligrams of 0.5% hyperbaric bupivacaine were used to induce spinal anaesthesia after prehydration with Ringer's lactate. After five minutes, the block's sensory level was evaluated, and patients who failed to reach a T6 sensory block were disqualified from the trial. For the first 20 minutes after spinal anaesthesia, haemodynamic measures such as NIBP, HR (Heart Rate), RR (Respiratory Rate), and SpO_2 were measured every 2 minutes. After that, they were recorded every 5 minutes until 60 minutes. The incidence of hypotension, defined as MAP < 65 mmHg, and the requirement for vasopressor administration were documented. Episodes of bradycardia, defined as HR < 55 beats/min, and their management were also recorded. The maximum cephalad spread of the sensory block was assessed at 20 minutes. Following delivery, neonatal APGAR scores were recorded at 1 and 5 minutes. The duration of surgery and the occurrence of nausea and vomiting were documented. The study did not include patients who needed extra uterotonic medications or surgical procedures.

Statistical Analysis

The SPSS (Statistical Package for the Social Sciences) was used to analyse the data after it had first been placed into a Microsoft Excel spreadsheet. While qualitative data were displayed as percentages and frequencies, quantitative data were given as mean ± standard deviation (SD). The unpaired Student's t-test was used to analyse continuous variables, while the Chi-square test was used to compare categorical variables. Statistical significance was defined as a p-value of < 0.05.

RESULTS

Characteristic	PI ≤ 3.5 (n=50)	PI > 3.5 (n=50)	P-Value
Age 20–25 years, n (%)	15 (30%)	16 (32%)	
Age 26–30 years, n (%)	28 (56%)	20 (40%)	
Age 31–35 years, n (%)	7 (14%)	14 (28%)	
Mean age (years), mean ± SD	26.8 ± 3.4	27.5 ± 3.6	0.312
Height (m), mean ± SD	1.6136 ± 0.0755	1.6126 ± 0.0738	0.947
Weight (kg), mean ± SD	76.36 ± 9.901	78.12 ± 9.621	0.371
Normal BMI (18.5–22.9), n (%)	1 (2%)	0 (0%)	
Overweight BMI (23–24.9), n (%)	30 (60%)	26 (52%)	
Obese BMI (>25), n (%)	19 (38%)	24 (48%)	
Total participants, n (%)	50 (100%)	50 (100%)	
BMI distribution, overall p value			0.393

Table 1. Consolidated Demographic and BMI Characteristics

The mean age was 26.8 ± 3.4 years in the PI ≤ 3.5 group and 27.5 ± 3.6 years in the PI > 3.5 group (P = 0.312). Height, weight and BMI distribution also showed no

statistically significant differences between the groups (all reported p-values > 0.05). P-values for age, height, weight and BMI are those reported in the source. Percentages and categories are reproduced as presented.

Time	PI ≤ 3.5 (mean ± SD)	PI > 3.5 (mean ± SD)	P-Value	Significance
Baseline	116.20±12.66	112.72±10.33	0.135	Non-significant
2 min	107±13.61	101.06±14.39	0.037	Significant
4 min	107.54±14.37	103.02±13.48	0.108	Non-significant
6 min	110.28±14.63	106.96±12.12	0.220	Non-significant
8 min	111.46±12.55	106.44±12.32	0.046	Significant
10 min	111.28±13.82	106.18±9.34	0.033	Significant
12 min	112.62±11.98	105.94±11.27	0.005	Significant
14 min	111.82±10.69	106.22±10.72	0.010	Significant
16 min	110.62±10.64	106.94±10.06	0.079	Non-significant
18 min	110.36±9.42	106.12±8.73	0.022	Significant
20 min	109.60±7.79	106±9.85	0.046	Significant
25 min	107.88±7.61	106.72±8.99	0.488	Non-significant
30 min	107.60±6.63	107.12±8.61	0.756	Non-significant
35 min	108.27±6.60	108.58±6.83	0.816	Non-significant
40 min	109.58±8.85	107.28±7.46	0.213	Non-significant
45 min	111.81±9	109.10±6.71	0.171	Non-significant
50 min	108.21±5.82	110.23±4.05	0.176	Non-significant
55 min	107.12±7.03	111.13±4.66	0.064	Non-significant
60 min	111.80±6.97	110.17±4.23	0.527	Non-significant

Table 2. Comparison of Systolic Blood Pressure

SBP differed significantly between the groups at 2, 8, 10, 12, 14, 18 and 20 minutes. Differences at baseline and at the other recorded time points were not statistically significant. SBP values are in mmHg.

Time	PI ≤ 3.5 (mean ± SD)	PI > 3.5 (mean ± SD)	P-Value	Significance
Baseline	70.30±8.38	72.22±10.87	0.325	Non-significant
2 min	64.46±10.30	62.08±15.29	0.364	Non-significant
4 min	62±9.48	59.76±11.20	0.283	Non-significant
6 min	63.56±9.55	59.58±9.43	0.039	Significant
8 min	65.62±10.15	60.76±11.69	0.029	Significant
10 min	64±9.36	60.68±9.48	0.081	Non-significant
12 min	63.78±11.70	60.34±11.37	0.139	Non-significant
14 min	62.76±10.67	58.62±10.24	0.051	Non-significant
16 min	65.60±9.49	60.04±10.41	0.006	Significant
18 min	64.66±8.18	60.60±9.85	0.027	Significant
20 min	65.54±7.46	58.74±11.32	0.001	Significant
25 min	63.20±8.11	58.72±11.70	0.029	Significant
30 min	62.98±7	61.70±8.32	0.408	Non-significant
35 min	64.67±6.70	63.17±6.49	0.263	Non-significant
40 min	65.63±8.19	64.33±7.97	0.480	Non-significant
45 min	63.08±7.06	64±7.50	0.617	Non-significant
50 min	63.50±7.79	64.86±6.89	0.532	Non-significant
55 min	62.53±8.17	65.40±7.51	0.309	Non-significant
60 min	64.20±5.51	66.42±6.50	0.397	Non-significant

Table 3. Comparison of Diastolic Blood Pressure

DBP differences were statistically significant at 6, 8, 16, 18, 20 and 25 minutes. The differences at baseline and all other recorded time points were not statistically significant. DBP values are in mmHg.

Time	PI ≤ 3.5 (mean ± SD)	PI > 3.5 (mean ± SD)	P-Value	Significance
Baseline	84.94±8.92	85.38±9.64	0.813	Non-significant
2 min	78.38±10.49	74.56±14.34	0.132	Non-significant
4 min	76.90±10.57	73.84±10.99	0.159	Non-significant
6 min	79.36±10.17	75.02±9.15	0.027	Significant
8 min	80.62±9.40	75.66±10.84	0.016	Significant
10 min	79.18±10.03	75.52±7.77	0.044	Significant
12 min	79.50±11.43	75.36±10.08	0.058	Non-significant
14 min	79.06±9.59	73.94±8.95	0.007	Significant
16 min	80±9.01	75.26±8.81	0.009	Significant
18 min	79.74±7.72	75.20±7.87	0.004	Significant
20 min	79.78±6.94	74.16±9.42	0.001	Significant
25 min	77.84±6.92	75.32±8.13	0.098	Non-significant
30 min	77.64±6.01	76.50±6.88	0.380	Non-significant
35 min	78.96±5.90	77.90±5.13	0.346	Non-significant
40 min	80.05±7.53	78.19±6.45	0.243	Non-significant
45 min	78.83±6.73	78.69±6.10	0.928	Non-significant
50 min	78.17±5.75	79.73±4.61	0.314	Non-significant
55 min	77±6.54	80.33±4.89	0.111	Non-significant
60 min	79.90±3.54	80.50±4.72	0.737	Non-significant

Table 4. Comparison of Mean Arterial Pressure

MAP was significantly different between the groups at 6, 8, 10, 14, 16, 18 and 20 minutes. No statistically significant difference was reported at baseline or at the remaining time points. MAP values are in mmHg.

Outcome	PI ≤ 3.5 (mean ± SD)	PI > 3.5 (mean ± SD)	P value	Significance
Number of hypotension episodes	0.32 ± 0.65	1.52 ± 1.39	<0.001	Highly significant

Table 5. Comparison of Hypotension Episodes

The mean number of hypotension episodes was higher in the PI > 3.5 group (1.52 ± 1.39) than in the PI ≤ 3.5 group (0.32 ± 0.65), with a highly statistically significant difference (P < 0.001).

Outcome	PI ≤ 3.5 (mean ± SD)	PI > 3.5 (mean ± SD)	P-Value	Significance
Vasopressor given (mephentermine)	1.92 ± 3.92	9.12 ± 8.33	<0.001	Highly significant

Table 6. Comparison of Vasopressor Use

Mean vasopressor use was higher in the PI > 3.5 group (9.12 ± 8.33) than in the PI ≤ 3.5 group (1.92 ± 3.92). The difference was highly statistically significant (P < 0.001).

Outcome	PI ≤ 3.5 (n=50)	PI > 3.5 (n=50)	P-Value	Significance
Duration of surgery (min), mean ± SD	50.86 ± 9.73	50.70 ± 12.79	0.944	Non-significant
APGAR at 1 minute, mean ± SD	8.56 ± 0.907	8.50 ± 0.84	0.732	Non-significant
APGAR at 5 minutes, mean ± SD	9.02 ± 0.77	8.76 ± 0.80	0.100	Non-significant
Nausea/vomiting: Yes, n (%)	2 (4%)	6 (12%)	0.140	Non-significant
Nausea/vomiting: No, n (%)	48 (96%)	44 (88%)		
Total participants, n (%)	50 (100%)	50 (100%)		

Table 7. Consolidated Perioperative and Neonatal Outcomes

Duration of surgery, APGAR scores at 1 and 5 minutes, and nausea/vomiting did not differ significantly between the two groups. Nausea/vomiting was reported in 2 (4%) participants in the PI ≤ 3.5 group and 6 (12%) in the PI > 3.5 group (P = 0.140).

DISCUSSION

Sympathetic blockade, which causes peripheral vasodilation and decreased systemic vascular resistance, is the main cause of hypotension that frequently occurs after spinal anaesthesia during LSCS. In addition to causing umbilical arterial acidosis in infants, this hypotension may have negative consequences on mothers, including nausea, vomiting, and dizziness.[1] There is currently no conclusive monitoring method that can accurately anticipate when hypotension will occur, which emphasises the necessity for further steps to identify individuals who are at risk and put suitable preventive measures in place.

NIBP monitoring is the usual technique for evaluating intraoperative haemodynamic state in pregnant women undergoing LSCS. Its incapacity to continually track beat-to-beat changes in peripheral perfusion dynamics, however, limits its efficacy.

The ratio of pulsatile to non-pulsatile blood flow in peripheral vascular tissue is known as the perfusion index (PI). A pulse oximeter based on the relative absorption of infrared light is used to measure it.[3] Therefore, PI can serve as a useful indicator of peripheral perfusion and haemodynamic changes. Several previous studies have investigated the role of PI in assessing haemodynamic parameters. However, limited evidence is available regarding its usefulness in predicting hypotension following central neuraxial blockade.

The goal of the current investigation was to ascertain if parturients receiving elective LSCS could develop hypotension after spinal anaesthesia if their baseline PI was more than 3.5.

The usefulness of PI was examined by Ginosar et al.[4] who found that it was a more sensitive, earlier, and clearer sign of epidural-induced sympathectomy. In a similar vein, Mowafi et al.[5] showed that PI was a trustworthy substitute for conventional haemodynamic criteria in determining the intravascular injection of an epidural test dose. A greater baseline PI was linked to profound hypotension, and baseline PI could predict the occurrence of spinal anesthesia-induced hypotension after caesarean delivery, according to Toyama S, Kakumoto M, Morioka M et al.[8]

Additionally, Xu Z et al.[9] came to the conclusion that PI might be used as a more sensitive, objective, and early signal for determining the onset of caudal block. In contrast, Yokose M, Mihara T, Sugawara Y et al.[10] found that pre-anaesthetic heart rate could be a predictive factor for spinal anaesthesia-related hypotension, whereas other parameters derived from pulse oximetry and heart rate variability were not predictive. These discrepancies may be attributable to methodological differences among studies, including variations in the definition of hypotension, rapid infusion of colloids as a co-load following spinal anaesthesia, and the methods used to calculate representative baseline PI values.

A baseline PI > 3.5 was shown to be very statistically significantly correlated with the frequency of hypotension events in the current investigation. Patients with a baseline PI > 3.5 experienced more episodes of hypotension and required greater vasopressor support than those with a baseline PI ≤ 3.5. Furthermore, a statistically significant association was observed between a baseline PI > 3.5 and the likelihood of developing hypotension following spinal anaesthesia.

These findings are consistent with the studies conducted by Toyama S, Kakumoto M, Morioka M et al.[8] Duggappa DR, Lokesh MP, Dixit A et al.[7] and Varghese R et al.[11] The results confirm that baseline PI may be useful as a non-invasive predictor of hypotension brought on by spinal anaesthesia in parturients having elective LSCS.

Limitations

Movement, temperature, psychological stress, and worry are some of the elements that affect the perfusion index and may raise sympathetic activity. It can be difficult to control these variables in patients who are awake. To reduce patient movement, baseline PI measurements were meticulously collected in the current investigation. Additionally, all patients received appropriate preoperative counselling to alleviate anxiety and minimize sympathetic stimulation before surgery.

CONCLUSION

The present study concludes that a baseline perfusion index (PI) > 3.5 is significantly associated with an increased incidence of

hypotension and higher vasopressor requirements following subarachnoid block for elective lower segment caesarean section. Therefore, PI may serve as a simple, non-invasive and useful adjunct for identifying parturients at increased risk of spinal anaesthesia-induced hypotension. However, further studies with larger sample sizes are required to establish its predictive accuracy and clinical applicability.

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