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ORIGINAL RESEARCH

Perfusion index as an early predictor of postspinal hypotension in elective lower segment cesarean section

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ABSTRACT

Background and aims: Early detection of hypotension benefits in deciding on preventative measures, safe anesthesia for the mother, and improved outcomes for the newborn. Reduced cardiac output from blood pooling in blocked body parts and decreased vascular resistance from sympathetic blockade cause hypotension after spinal anesthesia for Caesarean section. Peripheral perfusion dynamics resulting from variations in peripheral vascular tone have been evaluated using the perfusion index (PI) obtained from a pulse oximeter. This study aims to determine whether the baseline perfusion index can be used to predict hypotension following spinal anaesthesia in a caesarean section. **Methods:** In this prospective double blind observational study,140 patients were enrolled.PI and blood pressure, heart rate were monitored at baseline. every 3 minutes for the first fifteen minutes and then every 5 minutes until the end of the surgery, after administering spinal anaesthesia with 10mg hyperbaric bupivacaine. The incidence of hypotension was compared with baseline PI.ROC curve was plotted for PI and prediction of hypotension. **Results:** There was a significant association between baseline PI and hypotension. In our study, it was observed that the patients with baseline cut off of PI>3.8 the risk of hypotension was high in the first 10-12 minutes following spinal anaesthesia.The sensitivity and specificity for the 3.8 cut off of PI were 88.6% and 69.2% respectively. **Conclusion:** Our study found that a baseline PI cut off of 3.8 has higher predictability for hypotension risk within the first 10-12 minutes following spinal anaesthesia.

Keywords: Perfusion Index, Pregnancy, Postspinal hypotension, Lower segment caesarean section.

INTRODUCTION

Lower segment caesarean section (LSCS) is a common surgical procedure performed to deliver babies in cases where vaginal delivery poses a risk to the mother or child. The administration of spinal anaesthesia is the preferred anesthetic technique for elective caesarean sections due to its rapid onset, effective analgesia, and minimal exposure to general anesthesia, which can be beneficial for both the mother and the newborn. Despite its advantages, spinal anaesthesia is associated with certain complications, among which postspinal hypotension (PSH) is one of the most significant. 'PSH is defined as a decrease in systolic blood pressure of more than 20% from baseline or a systolic blood pressure of less than 100 mmHg'. It occurs in approximately 60-70% of cesarean deliveries under spinal anesthesia and can have deterious effects on both the mother and the fetus.

Hypotension following spinal anaesthesia is primarily due to the sympathetic blockade, leading to vasodilation and reduced venous return. The resultant decrease in cardiac output can compromise placental perfusion, leading to fetal acidosis and adverse neonatal outcomes. Maternal symptoms can include nausea, vomiting, dizziness, and in severe cases, loss of consciousness. Therefore, the timely prediction and management of PSH are crucial in improving maternal and neonatal outcomes. Traditional methods for predicting PSH, such as baseline hemodynamic measurements, have shown limited predictive value. Hence, there is a need for reliable and non-invasive predictors that can facilitate early intervention.

A healthy pregnancy is marked by a reduction in systemic vascular resistance, resulting from decreased

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vascular tone (1,2,3). Near term, pregnant women exhibit lower mean arterial pressure, increased sensitivity to local anaesthetics, and a reduced response to vasopressors (4). Consequently, this makes parturients more prone to significant hypotension after receiving central neuraxial blockade for lower segment cesarean section (LSCS) (5). Various strategies have been employed to prevent hypotension. Some studies suggest that co-loading with crystalloids and colloids is more effective than preloading (5).

The perfusion index (PI) is a non-invasive, simple, and continuous parameter derived from the photoplethysmographic signal obtained from pulse oximetry. ‘PI represents the ratio of pulsatile blood flow to non-pulsatile or static blood in peripheral tissues and provides an indirect measure of peripheral perfusion’. It has been increasingly used in various clinical settings to assess peripheral circulation and the effectiveness of therapeutic interventions. The utility of PI in predicting hemodynamic changes during spinal anaesthesia has been a subject of growing interest.“The Perfusion Index (PI) is a relative measure of pulse strength at the monitoring site. It is obtained from the plethysmographic waveform produced by the pulse oximeter probe. PI represents a numerical value indicating the strength of the infrared (IR) signal returning from the monitoring site. It is calculated using the following formula (6).'"AC represents the pulsatile component of the infrared signal, corresponds to the light absorbed by the pulsating arterial inflow and the pulse oximeter waveform amplitude'. 'DC signifies the non-pulsatile component of the infrared signal, absorbed by the skin, other tissues, and the non-pulsatile vascular site blood volume expressed in percentage'.

Several studies have suggested that PI can serve as an early indicator of sympathetic blockade and subsequent hypotension following spinal anesthesia. A decline in PI indicates peripheral vasodilation, which precedes a drop in blood pressure. Consequently, monitoring PI may allow for the early detection of PSH, enabling prompt and proactive management. This is particularly relevant in the context of LSCS, where maintaining stable hemodynamics is critical for the well-being of both the mother and the fetus (7).

Previous research has demonstrated a correlation between changes in PI and the occurrence of hypotension during spinal anaesthesia. For instance, studies have shown that a significant decrease in PI following spinal block is predictive of subsequent hypotension. There is a need to validate the predictive value of PI in a larger cohort of pregnant women undergoing LSCS and to establish standardized thresholds for PI changes that can reliably forecast PSH.

Moreover, the relationship between baseline PI values, demographic factors (such as age, body mass index, and preexisting conditions), and the incidence of PSH warrants further investigation. Understanding these associations could enhance the predictive accuracy of PI and guide individualized patient management.

METHODS AND METHODOLOGY

This prospective observational study was performed in a tertiary care centre in the Department of Anaesthesiology, B.L.D.E.U.'s Shri B.M Patil Medical College, Hospital and Research Centre, Vijayapura, Karnataka. After receiving clearance from the institutional ethical clearance committee[BLDE(DU)/IEC/776/2022-23].Parturients undergoing elective caesarean section under spinal anaesthesia. Patients in the age group of 20-35 years pertaining to American Society of Anesthesiology 2 were included in the study in a number of one fourty(140). Patients with placenta previa , gestational diabetes mellitus, cardiovascular or cerebrovascular disease, and patients who are contraindicated to spinal anesthesia were omitted from the study. The primary goal of the research was to evaluate the baseline perfusion index as a predictor of hypotension in parturients undergoing elective lscs under spinal anaesthesia.The second goal was to evaluate the trend of PI before and after ephedrine administration.Informed consent was taken before the procedure. On the day of the procedure, the parturients were premedicated with Inj. ondansetron 4 mg IV in the preoperative room, following a sufficient fasting period of six hours for solids and two hours for liquids. Baseline values were recorded and the ECG, non-invasive blood pressure monitor, and pulse oximeter were used.Following their transfer to the operating room, all parturients received 500 ml of Ringers lactate solution and maintenance IV fluids at a rate of 10 ml/kg/hr. Standard monitors were also attached.Baseline parameters like HR, SBP, DBP, MAP, SPo2, and baseline PI was noted.An anesthesiologist blind to the study protocol and baseline characteristics administered spinal anesthesia. Under strict aseptic measures, spinal anesthesia was administered in a sitting posture using a 25 G Quincke's spinal needle at the L3-L4 interspace with 10 mg of 0.5% hyperbaric bupivacaine.A wedge was then positioned beneath the parturients' right hip and buttocks, putting them in a supine position.A cold swab was used to assess the sensory block, and surgery was initiated after the T6 level was reached.Over the course of the first fifteen minutes of the experiment, the following parameters were recorded: pulse rate, PI, mean arterial blood pressure, diastolic blood pressure, systolic blood pressure (SBP), and SPo2. After that, these parameters were collected every five minutes.After the infant was extracted, oxytocin injection (10 units slow IV) was administered.Decrease in SBP by 20% from baseline is defined as hypotension for this study and a rescue dose of vasopressor injection ephedrine 6mg was given.PI measured before and after ephedrine.A heart rate less than 60 beats per minute is

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called bradycardia.A bolus of atropine 0.5mg is administered if hypotension is associated with bradycardia.Collected data was entered in Microsoft Excel 16, for further statistical analysis, Categorical data were expressed interms of frequency and proportion, while quantitative data were expressed interms of mean and standard deviation. The chi-square test of association were applied to find association between the variables. ANOVA was used to find mean difference of quantitative data among the variables. The recover operating curve was used to find out cut off value of perfusion index and also to find out sensitivity and specificity. P-value <0.05 were considered as statistically significant. Statistical analysis was done with the help of statistical software SPSS version 25.

RESULTS

A total of 140 patients fulfilling the inclusion criteria were analyzed in this study.

Table 1: Demographic characteristics

Parameters	Mean	Std. Deviation
Age(years)	26.02	3.60
Weight(kilogram)	60.68	3.91
Height(centimeter)	155.98	0.662
Gestational Age (weeks)	36.94	1.219

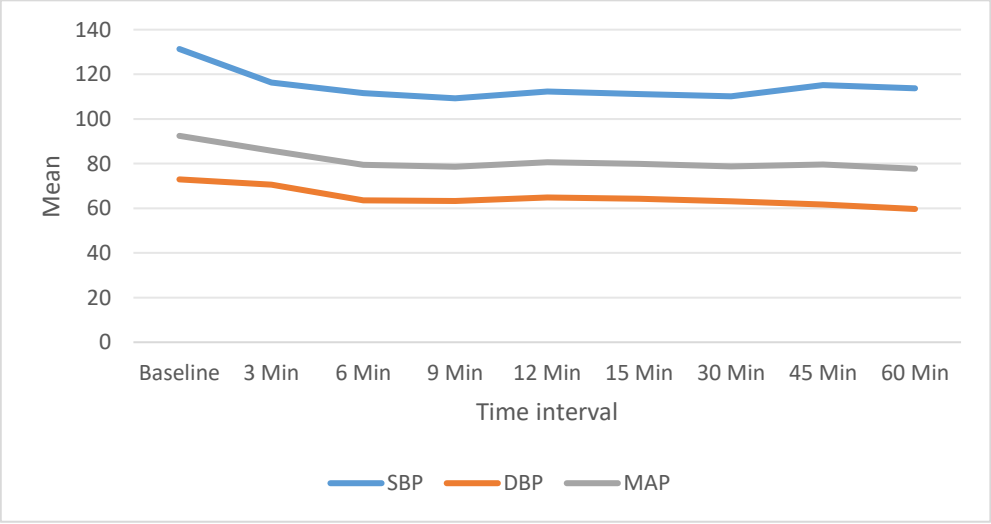
Mean distribution of demographic parameters like age, weight, height and gestational age, in the present study minimum age was 20 years and maximum were 35 years, patients with minimum weight of 55 kg and maximum of 68kg, minimum height of 145cm and maximum of 157cm, minimum gestational age of 36 weeks and maximum of 40 weeks.(Table 1).

Table 2: Association between hypotension and PI

Hypotension	PI Interval			Chi-square	P-value
	≥3.8	≤3.8	Total		
Yes	52(78.80)	29(39.20)	81(57.90%)	22.43	<0.001
No	14(21.20)	45(60.80%)	59(42.10%)		
Total	66(100%)	74(100%)	140(100%)		

Association between hypotension and perfusion index were statistically significant.Of the 140 patients, 66 were with PI > 3.8 out of which 52 patients had hypotensive episodes.29 out of 74 patients in whom PI was less than or equal to 3.8 also had hypotensive episodes as shown in above table (Table 2).

Figure 1: Comparision of SBP,DBP,MAP at different time intervals



It was observed that at baseline mean SBP was 125.75 but after spinal it was decreased to in the interval of mean SBP of 115.32.It was observed that at baseline mean DBP was 70.87 , but after spinal it was decreased to in the interval of mean SBP of 59.68 to 70.54 .It was observed that at baseline mean MAP was 88.1 but after spinal it was decreased to in the interval of mean SBP of 78.2 to 77.1.And difference from baseline to at different intervals of time were statistically highly significant,(p-value<0.01) (Figure 1).

'Table 3: Requirement of ephedrine and intravenous fluids and number of episodes of hypotension.'

PARAMETER	PI≤ 3.8	PI≥3.8	P value
Dose of ephedrine in mg	0	6	< 0.001

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Fluid requirement in ml	921.21	1161.34	<0.001
Episodes of hypotension			
0	36	16	<0.001
1	24	15	
2	11	25	
3	3	7	
4	0	3	

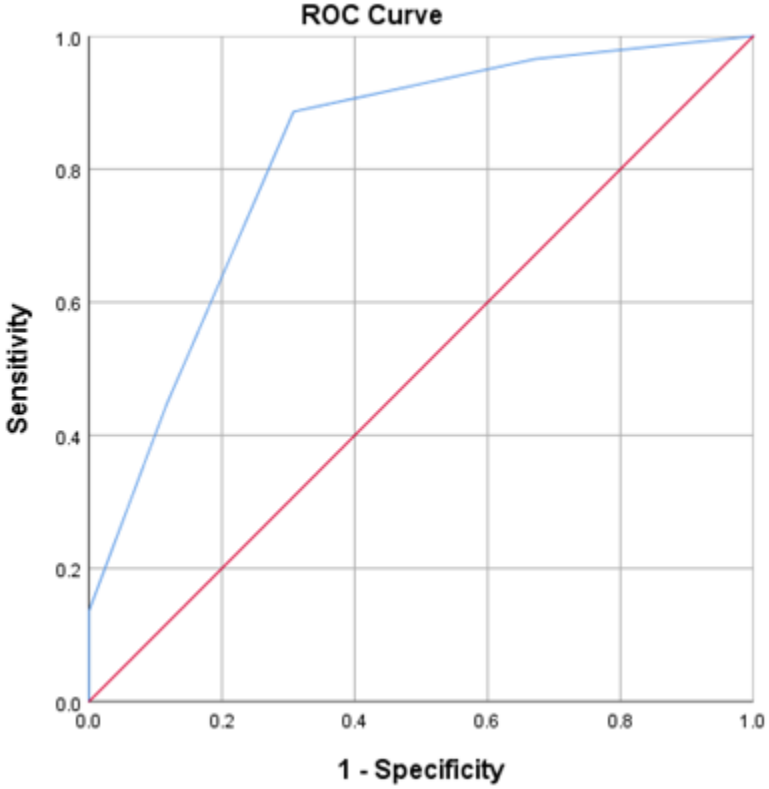
Mean dosage of ephedrine usage in patients with PI≤3.8 was 0mg ang 6 mg in patients with PI≥3.8.The amount of IV fluids required in patients with PI ≤3.8 was lower than inpatients with PI≥3.8.We found highly significant correlation between baseline PI,total dose of ephedrine used and total fluids used.Among all major number of episode were 1 and 2 among patients with PI >3.8, maximum number of episode were 2 followed by 1, 3 and 4 and this association between number of hypotension episode and baseline PI was statistically highly significant as shown in Table 3.

Table 4: ROC curve to find cut-off value of PI to predict hypotension

ROC Curve	Values
AUC	0.832
Std Error	0.41
P-value	<0.0001
95% CI	
Lower Bound	0.748
Upper Bound	0.899
Sensitivity	88.6
Specificity	69.2
Cut-off Value	3.8

'The Roc yielded 3.8 as a more appropriate cut off with a well balanced sensitivity of 88.6% and specificity of 69.2%.The area under the curve was 0.832 (Table 4).'

Figure 2: ROC curve to find cut-off value of PI to predict hypotension



DISCUSSION

Pregnancy is characterized by increased metabolic demands. Cardiovascular changes are particularly significant because they interact with the effects of central neuraxial blockade. Hormonal influences lead to peripheral vasodilation, resulting in reduced systemic vascular resistance (8).The enlarged uterus during pregnancy poses a risk of compressing the

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vena cava, which decreases venous return and cardiac output as the pregnancy progresses (9). Significant hypotension results from the sympathetic blockade brought on by spinal anaesthesia, which accentuates the decrease in venous return and systemic vascular resistance. Additionally, adrenergic downregulation during pregnancy increases vasopressor demand (10).

Pulse oximetry is one the American Society of Anesthesiologists (ASA) basic monitors and is used for all the cases.Because vasodilatation causes an increase in the pulsatile component, this decrease in tone will correlate with greater perfusion index values. Further reduction in peripheral vascular tone, increased pooling, and hypotension will result after the induction of sympathectomy under spinal anaesthesia irrespective of the type of anaesthesia. In the study we have used the perfusion index (PI), a non-invasive tool for predicting hypotension. Toyoma et al (11). conducted the first study on predicting hypotension with PI in lower segment cesarean section (LSCS), finding a positive correlation between decreased arterial blood pressure during spinal anesthesia and baseline PI. Their study's ROC curve identified a cutoff value of 3.5 for baseline PI, above which the risk of hypotension increased.

In the present study we have included 140 patients, to evaluate the baseline perfusion index as a predictorof hypotension in parturients undergoing elective LSCS under spinal anaesthesia. .In the present study from the systolic blood pressure, it was observed that 62.9% of the patients observed with hypotension. ROC cure showed area under curve for PI to predict hypotension was 0.821, with p-value<0.001, with a sensitivity of 88.6% and specificity of 69.2% and cut-off value in our study was found to be 3.8. Also mean SBP was 125.75 and SD of 9.016, but after spinal it was decreased to in the interval of mean SBP of 115.32 and difference from baseline to at different intervals of time were statistically highly significant. Mean MAP was 88.1 and SD of 0.883, but after spinal it was decreased to in the interval of mean MAP of 77.71 to 85.79 and difference from baseline to at different intervals of time were statistically highly significant. In the study by **Zainab M. Attia et al** observed that, MAP decreased significantly all times after spinal anaesthesia compared to pre spinal. Present results were in competence with Toyama et al (11). who reported a marked decreases in MAP after spinal injection in parturient with both high and low baseline PI.

Association between hypotension episodes and PI interval was statistically highly significant. In above table it showed that, of 66 patients with PI more than 3.8. 53% of the patients were with number of hypotension episode 2 to 4 and among patients with PI ≤3.8 out of 74 patients 92% of the patients had 0 to 2 episode of hypotension.In the present study, patient with episode 2 and 1 ephedrine was used followed by in episodes 3 and 4. Also we have observed there is positive correlation between hypotensive episodes and total dose of ephedrine used(r=0.71, p-value<0.001)and total IV fluids used . A higher requirement of vasopressor was seen in parturient with baseline PI>3.8. A study by **Duggappa et al,** on Spearman's rank correlation they found highly significant correlation between baseline PI >3.8 and number of episodes of hypotension (r= 0.416, P < 0.001)showing a sensitivity of 69.84% and a specificity of 89.29%, these results are similar to our study. In Group I (PI<3.5), the median ephedrine usage was 0 mg, while in Group II (PI>3.5), it was 6 mg . Group I required less IV fluids than Group II (12). In the study conducted by **Jabarulla, et al** plotted the ROC curve to find out cut-off value of baseline PI and it was observed to be 1.7 with a sensitivity of 75% and specificity of 71% and it was statistically significant (p-value=0.006) (13). A more recent study by **Mallawaarachchi et al (14).** correlated the trend in PI with the degree of hypotension, finding a significant relationship between increasing PI values and the incidence of hypotension, and concluded that the response to vasopressors could be quickly assessed using this value.**Harde, et al**,in their study they have explained that pregnancy is associated with increased total blood volume and a decrease in systemic vascular resistance resulting in reduced vascular tone, which corresponds to an increase in pulsatile component and higher PI values (15). In the same study, the ROC curve demonstrated an AUC of 0.917 . The study established a new cutoff for baseline PI >2.9, predicting post-spinal hypotension with a sensitivity of 83.08% and specificity of 96.06%. Study done by **Thapa et al** studied that, In Group I, 30 patients (23.62%) experienced low blood pressure, while in Group II, all 119 patients (100%) experienced hypotension. Also in our study we have found there is positive correlation (r=0.42, p-value<0.001) PI >3.8 and number of episodes and this correlation between them found statistically significant. In the same study by Thapa et al observed that the correlation between baseline PI >3.5 and number of episodes of hypotension was highly significant (r = 0.78 p< 0.01).

CONCLUSION

The perfusion index (PI) was observed to increase significantly and more rapidly in parturients experiencing significant hypotension, likely due to sympathetic blockade. The response to ephedrine can be quickly evaluated by changes in PI, aiding in the decision-making process for additional ephedrine doses. PI can serve as a predictor of hypotension in parturients undergoing caesarean section with spinal anaesthesia. Our study found that a baseline PI cut-off of 3.8 has higher predictability for hypotension risk within the first 10-12 minutes following spinal anaesthesia.

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