Indian Journal of Clinical Anaesthesia 2024;11(3):289–294

Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical Anaesthesia

Journal homepage: www.ijca.in

Original Research Article

Role of Pleth variability index and perfusion index for predicting hypotension following spinal anaesthesia in patients undergoing caesarean section

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ARTICLE INFO

Article history:
Received 13-02-2024
Accepted 17-06-2024
Available online 30-08-2024

Keywords:
Pleth variability index
Perfusion index
Hypotension
Spinal anaesthesia
Caesarean section

ABSTRACT

Background & Aims: Pleth variability index and perfusion index are noninvasive continuous hemodynamic monitors that can assess peripheral vascular tone and intravascular volume status and thus can predict hypotension following spinal anaesthesia. Spinal anaesthesia is the choice of anaesthesia in caesarean sections. Approximately 70% of patients will develop hypotension after spinal anaesthesia, which can lead to maternal and fetal complications. Thus, the Pleth Variability Index (PVI) and perfusion index (PI) allow the identification of patients with an increased susceptibility to hypotension following spinal anaesthesia.

Materials and Methods: This prospective observational study was conducted in a tertiary care centre with 102 obstetric patients undergoing spinal anaesthesia for caesarean section in the age group of 18-35 years who were full term with ASA≤ grade II, BMI 35kg/m^2. Pleth variability index and Perfusion index were measured before and after spinal anaesthesia. The data was analysed using ROC and multiple linear regression models using SPSS software.

Results: In the hypotension group PVI and PI at one minute is higher than without the hypotension group. PVI at one minute is an independent factor for predicting hypotension following spinal anaesthesia (P=0.039). ROC analysis of baseline and one-minute PVI showed only one-minute PVI can predict hypotension with an AUC-0.633(95% CI-0.492-0.774) and an optimal cut-off value of 19.5. ROC analysis of baseline and one-minute PI revealed both baseline and one-minute PI could predict hypotension with AUC-0.507 (95% CI 0.378-0.636) and 0.540 (95% CI 0.410-0.682) respectively. The optimal cut-off of baseline PI for predicting hypotension is 2.5 with a sensitivity of 51.4%, specificity of 61.5% and one-minute PI is 4.5 with a sensitivity of 60.8% and specificity of 53.8%.

Conclusion: Baseline PVI is not a predictor of hypotension and one-minute PVI ≥19.5 can predict hypotension following spinal anaesthesia. One minute PI ≥ 4.5 is more sensitive in predicting hypotension than Baseline PI ≥2.5.

Keymessage: The Pleth Variability Index and Perfusion Index are noninvasive monitors which can predict hypotension following spinal anaesthesia in cesarean sections.

1. Introduction

Caesarean delivery is the most common obstetric surgical procedure and Spinal anaesthesia (SA) is the primary anaesthetic choice for patients undergoing caesarean

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https://doi.org/10.18231/j.ijca.2024.057

deliveries. It eliminates the use of general anaesthesia and the possible hazards involved with managing the airway in pregnant women.[1] However, SA can lead to hypotension in approximately 70% of patients.[2] Hypotension may lead to adverse effects like nausea, vomiting and dizziness in the mother and fetal hypotension, umbilical artery acidosis and hypoxemia in the newborn.[3] Sympathetic blockade, peripheral pooling of blood and decreased cardiac output following spinal anaesthesia lead to hypotension.[4] Which is more profound in pregnant patients because of mechanical and hormonal factors.[1] Pregnant women are less responsive to vasopressors which may again lead to complications. Pregnant women, especially multiparous, have decreased peripheral vascular tone at term. Peripheral vascular tone and baseline volume status can affect the degree of hypotension.[5] Parturients with low peripheral vascular tone have more pooling of blood in peripheries and may be at increased risk of developing hypotension. An ability to identify those who would suffer from hypotension following spinal anaesthesia would allow anesthesiologists to take appropriate measures to prevent maternal and fetal complications. According to ASA standard monitoring, Non-invasive blood pressure monitoring is used to assess intraoperative hemodynamics. But it would not give beat-to-beat variability in hemodynamics. PVI and PI are simple and noninvasive indices of hemodynamics that can be automatically and continuously measured using a specialised finger pulse oximeter.

Our hypothesis was that the Pleth Variability Index (PVI) and Perfusion Index (PI) might evaluate the maternal volume status and peripheral vascular tone. This would enable the identification of patients who are more likely to experience hypotension after receiving spinal anaesthetic for caesarean delivery.

2. Materials and Methods

This prospective observational study was conducted in the Tertiary Care Institute after appropriate approval of the ethical committee (IEC-EC/131/2019) and necessary trial registration (CTRI - CTRI/2020/08/027177) from March 2020 to August 2021. Sample size Is calculated by using buderers formula, based on previous study "Pleth variability index can predict spinal anaesthesia-induced hypotension in patients undergoing caesarean delivery".[5] Prevalence of hypotension = 64% (0.64), Sensitivity = 78.1%(0.78).

Specificity = 83.3%(0.83)At 95% confidenceinterval,

$$Sample\ size\ (n) = \frac{4\ x\ 0.78\ x\ 0.21}{(0.1)^2 X\ 0.64} = 102$$

102 subjects between the age group of 18-35 years and gestational age more than 37 weeks undergoing spinal anaesthesia for caesarean section were included in the study after obtaining informed consent. Subjects having American society of Anaesthesiology physical status >III, BMI >35 kg/ m2, Haemoglobin <7 g/dl and contraindication for spinal anaesthesia were excluded. All patients underwent general physical examination and routine investigation according to the institutional protocol. Patients were kept nill per mouth for 8 hours prior to surgery. In the operating room, ASA Standard monitors were attached. BaselinePVI, PI, HR, BP and SPO2 were measured in a supine position with a 15° left lateral tilt to prevent aortocaval compression. PVI and PI are automatically and continuously measured using a Masimo-finger pulse oximeter in the index finger.IV line secured with 20 G intravenous catheter. Infusion Ringer lactate was started. Antiemetic inj. ondansetron 4 mg IV was admininstered. Spinal anaesthesia was given with 25G Quincke's spinal needle in a sitting position with 10 mg 0.5% Inj. heavy bupivacaine and 20 mcg Inj.Fentanyl is under the standard protocol of the institution. Spinal level, HR, SBP, MAP, SPO2, PVI & PI measured every minute for an initial 10 minutes and then every 5 minutes up to 30 minutes in a supine position with a 15° left lateral tilt. The sensory level was checked using a spirit swab for a cold sensation. The assessment of motor blockade was done using a modified Bromage scale. The surgery commenced once the T6 dermatomal level was achieved. After baby extraction inj. oxytocin was administered according to institutional protocol. Hypotension is defined as SBP < 90mmHg/ 20% fall from baseline/MAP <65 mmHg. Hypotension was treated with Inj. Ephedrin 6 mg bolus & Fluid bolus of RL @10-15ml/kg.

Data entry was done in Microsoft Excel 2016 and analysed using IBM SPSS Statistics 22. Categorical data was represented as frequencies and percentages and the continuous data was represented as mean and median. The data was tested for normal distribution by Kolmogorov–Smirnov test. In variables with normal distribution, group comparison was done with an independent sample t-test. The Mann-Whitney U test was employed to analyse quantitative data that did not follow a normal distribution. Analysed by the ROC curve, the screening effectiveness of the PI and PVI in predicting hypotension after spinal anaesthesia in parturient was assessed. A p-value below 0.05 was taken to be statistically significant.

3. Results

Out of 102 subjects 2 were excluded because of inadequate spinal level and converted into general anaesthesia.

Thus, total number of subjects included in the study is 100.

Table 1: Patient characteristic

Parameter (n=100)	Mean	SD
Age (in years)	25.98	3.31
Height (in cm)	157.83	2.79
Weight (in kgs)	61.24	6.13
BMI (Kg/m^2)	24.60	2.17
Hb (g\dL)	11.27	1.24

Table 2: Baseline parameters

Baseline vitals	Mean	SD
SPO2 (%)	99.52	0.80
Pulse rate (bpm)	90.33	13.46
Systolic blood pressure (mmHg)	119.52	12.65
Diastolic blood pressure (mmHg)	75.34	11.24
Mean arterial blood pressure (mmHg)	90	11
PVI	22.08	7.41
PI	3.28	2.54

Table 3: Comparison of base line parameters and PVI and PI at one minute in subjects with hypotension and no hypotension (Independent T-test)

Parameters (n=100)	Hypotension	No hypotension	P value
Baseline heart rate	92.85± 12.493	83.15 ±14.039	0.502
Baseline systolic blood pressure	118.20± 9.960	120.85±14.748	0.08
Baseline diastolic pressure	74.22±10.835	77.62± 10.778	0.717
Baseline mean arterial pressure	88.89± 9.878	92.04±11.619	0.096
Baseline PVI	21.892 ±7.7893	23.031 ± 5.7655	0.280
PVI at 1 minute	19.30 ± 5.017	17.85 ± 7.298	0.039
Baseline PI	3.118 ±2.0129	3.750 ± 3.7043	0.21
PI at one minute	5.142 ± 2.0549	5.123 ± 3.0229	0.132

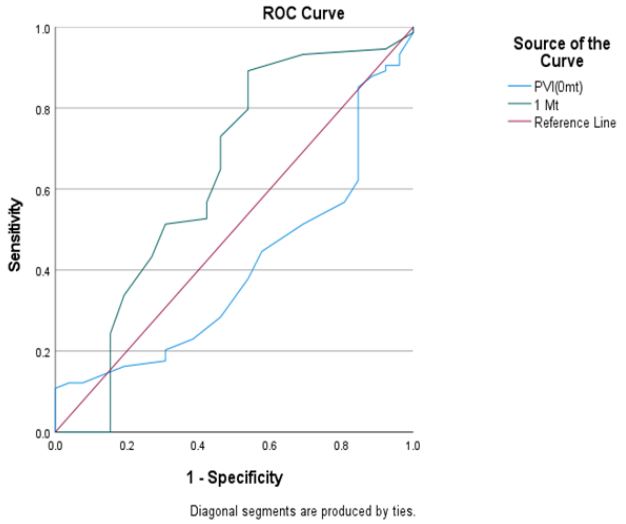

Figure 1: Roc curve analysis of baseline PVI and one-minute post spinal PVI in predicting hypotension following spinal anaesthesia

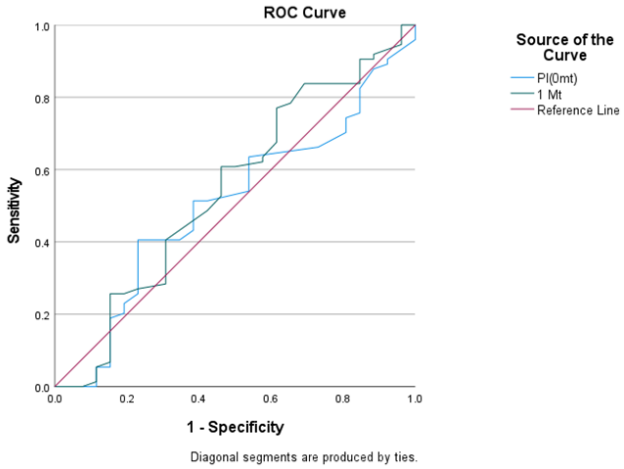

Figure 2: ROC curve analysis of baseline PI and one-minute PI in predicting hypotension following spinal anaesthesia

Out of 100 patients, 74% of patients developed at least one episode of hypotension following spinal anaesthesia. In the hypotension group PVI and PI at one minute is higher than without the hypotension group. A comparison of PVI at one minute in patients with hypotension and no hypotension showed that PVI at one minute is an independent factor for predicting hypotension (p=0.039) (Table 3). ROC analysis of baseline and one-minute PVI for predicting hypotension showed one-minute PVI can predict hypotension, AUC-0.633(95% CI-0.492-0.774) with optimal cut-off value for PVI at one minute for predicting hypotension is 19.5 with a sensitivity of 51.4%, specificity of 69.2% and positive predictive valve -82% (Figure 1). ROC analysis of baseline and one minute PI for predicting hypotension revealed both baseline [AUC-0.507 (95% CI 0.378-0.636)] and one minute PI [AUC-0.540 (95% CI 0.410-0.682] can predict hypotension (Figure 2). The optimal cut-off of baseline PI for predicting hypotension is 2.5 with a sensitivity of 51.4% and specificity of 61.5% and for one minute PI is 4.5 with a sensitivity of 60.8% and specificity of 53.8%.

4. Discussion

Spinal anaesthesia is the choice of anaesthesia for caesarean sections and hypotension is one of the most common complications following spinal anaesthesia. The primary cause of hypotension after spinal anaesthesia is the inhibition of preganglionic sympathetic fibres, resulting in decreased systemic vascular resistance (SVR) and accumulation of blood in the lower extremities. This leads to a decrease in cardiac output and mean arterial pressure.5 The combined effect of spinal anaesthesia and pregnancy-related changes leads to a greater decrease in systemic vascular resistance and more pooling of blood in peripheries. Hypotension will lead to severe maternal and fetal complications. Early detection and treatment can reduce these complications. Many hemodynamic parameters have been studied for the prediction of hypotension, but none of them could definitely predict hypotension. For routine caesarean section non-invasive blood pressure monitors are used to measure the blood pressure. It does not give us a beat analysis of blood pressure. The degree of hypotension following spinal anaesthesia depends on pre-spinal sympathetic activity, peripheral vascular tone and volume status.[5] Parturients with low baseline vascular tone are more prone to hypotension as compared to parturients with high vascular tone.[6] The perfusion index is a calculation of the ratio between pulsatile blood flow and non-pulsatile blood flow in the peripheral vascular tissue. It is determined by measuring the amount of infrared light absorbed using a pulse oximeter.[7] This ratio measures alterations in peripheral vascular resistance and can evaluate the dynamics of peripheral perfusion and vascular tone.[8–10] Limited studies have demonstrated that an increase in PI is an early indicator that spinal anesthesia has initiated peripheral vasodilation which typically occurs prior to the anesthetic effect.[11,12] The PVI quantifies variations in PI that happen across the respiratory cycles. The PVI measurement enables the assessment of intravascular volume, with a higher PVI indicating a stronger likelihood of fluid response. It allows for evaluation of intravascular volume, and a higher PVI is associated with greater responsiveness to fluid volumes. Many factors can affect PI and PVI like psychological stress, anxiety, hypothermia, administration of cold IV fluids, patient movement, use of cautery, use of vasopressors, external light and nail paints Earlier studies have shown that PVI predicts fluid responsiveness in mechanically ventilated patients.[13] But in spontaneously breathing patients tidal volume and respiratory rates and thus cardiopulmonary interactions are more variable and this can lead to difficulty in assessing fluid responsiveness.[14] Spontaneous breathing will be preserved under spinal anaesthesia and many studies showed that PVI and PI are easy and non-invasive methods in the early prediction of hypotension following spinal anaesthesia.[3,5,11,14,15] PVI may be less accurate in the evaluation of intravascular volume and fluid responsiveness in spontaneously breathing patients because of changes in respiratory rate and tidal volume. Physiological changes in pregnancy like larger tidal volume, increased respiratory rate, deep thoracic respiration, larger blood volume, larger stroke volume, high heart rate and cardiac output may result in different cardiopulmonary interactions in parturient compared with non-pregnant women.

In our study, 74% of participants had at least one episode of hypotension. Hypotension is defined by systolic blood pressure < 90 mmHg or a 20% fall from baseline systolic blood pressure or mean arterial pressure < 65 mmHg. Parturient with high baseline PI shows a marked decrease in SBP and MAP in a study by S. Toyama et al.[15] In their study, the AUC of ROC of baseline PI for predicting hypotension was 0.866 and the cutoff baseline PI for predicting hypotension was 3.5 with a sensitivity of 81% and specificity of 86%. In the Lal J et al. study, patients with PI more than 3.5 had a 73.3% incidence of hypotension as compared to the group with PI less than 3.5 and the ROC curve yielded 73.3% sensitivity and 76.67% specificity for baseline PI in predicting hypotension.[16] In a study by Joseph George et al a baseline PI of > 3.6 showed a significant correlation with hypotension following spinal anaesthesia with a specificity of 80% and a low sensitivity of 40%.[17] In M Arslan et al. study there is no ability of baseline PI to predict hypotension following spinal anaesthesia.[6]

In our study, one-minute PI is a little higher in the hypotension group than without the hypotension group.

The baseline PI cut-off that predicts hypotension as determined by ROC analysis is 2.5 with a sensitivity of 51.4% and 61.5% specificity and for one minute PI was 4.5 with a sensitivity of 60.8% and 53.8% specificity.

In a study by M Arslan et al., PVI at one minute was higher in patients with hypotension (20.8±5.8) than in the non-hypotension (18.6 ±6.9) group following spinal anaesthesia in caesarean deliveries. The area under ROC for post-spinal PVI in predicting hypotension is 0.663 (95% CI-0.530- 0796) optimal cut-off for post-spinal PVI was 18.5. In our study also one-minute PVI was greater in patients who developed hypotension and there was not much difference in baseline PVI in patients who developed hypotension and no hypotension. One minute PVI cut-off that predicted hypotension as determined by ROC analysis was 19.5 with sensitivity of 51%, specificity of 69%, positive predictive valve -82% with area under ROC for post spinal PVI in predicting hypotension is 0.633 (95%CI-0.492-0.774). The results of our study are comparable with a study by M Arslan et al. that only post-spinal PVI was found to be predictive of hypotension.

However, a study by Kuwata S et al. and S. Sun et al. showed baseline PVI can also predict hypotension following spinal anaesthesia. In a study by Kuwata S et al, the

area under the ROC curve for baseline PVI in predicting hypotension following spinal anaesthesia was 0.751 (95% CI-0.597-0.904) and for post-spinal PVI was 0.793 (95% CI-0.570-0.892) optimum threshold for post spinal PVI for predicting hypotension was 18%.

In S. Sun et al. study area under the ROC curve was 0.66 (95% CI-0.53-0.78) for baseline PVI in predicting hypotension following spinal anesthesia and the optimal cut-off was 23.5% with a sensitivity of 47.5% and specificity of 87.5%. [18]

The results of our study are comparable with the study by M Arslan et al. that only post-spinal PVI was found to be predictive of hypotension.

5. Limitations

Larger sample sizes may be required for accurate results. We did not use parameters such as stroke volume, or calculation of total peripheral resistance as it needed invasive procedures like an invasive arterial line or central line which were inappropriate for a caesarean section. Factors which increase sympathetic activities in patients like anxiety cannot be fully avoided, as they may lead to changes in peripheral vascular resistance. Movement of the patient, operation theatre temperature and use of vasopressors also result in errors in the measurement.

6. Conclusion

PVI and PI are simple and non-invasive methods to predict hypotension following spinal anaesthesia. From our study baseline PI of < 2.5 has less incidence of hypotension and valve ≥2.5 has more incidence of hypotension. One minute PI < 4.5 had less incidence of hypotension and value ≥4 .5 had more incidence of hypotension. The AUC of ROC is greater for one minute PI in predicting hypotension. In our study baseline PVI is not a predictor of hypotension following spinal anaesthesia.

One minute PVI of < 19.5 have less incidence of hypotension and a value ≥19.5 has more incidence of hypotension.

7. Sources of Funding

Nil.

8. Conflicts of Interest

Nil.

9. Data Availability

The data of this study are available from the corresponding author, Paul, upon reasonable request.

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Cite this article: Paul A, Hemantkumar I, Saji DA, Kavipriya S, Patil M. Role of Pleth variability index and perfusion index for predicting hypotension following spinal anaesthesia in patients undergoing caesarean section. *Indian J Clin Anaesth* 2024;11(3):289-294.