THE USEFULNESS OF PERFUSION INDEX DERIVED FROM A PULSE OXIMETER IN PREDICTING HYPOTENSION FOLLOWING SPINAL ANESTHESIA FOR CESAREAN SECTION

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ABSTRACT

Hypotension is a frequent complication of spinal anesthesia. Decrease in peripheral vascular tone that occurs during pregnancy is one of the factors causing hypotension in patients undergoing cesarean section under spinal anesthesia. Perfusion index derived from pulse oximeter can be an easy and non-invasive measure of peripheral perfusion. This study was conducted to test the usefulness of pulse oximeter in predicting hypotension following spinal anesthesia for cesarean section. In this study, 247 parturients undergoing elective cesarean section under spinal anesthesia were included. Parturients who had baseline PI<3.5 were kept in Group I and parturients who had baseline PI>3.5 were kept in Group II. All the patients were given 0.5% bupivacaine heavy 2.2 ml for spinal anesthesia. In group I, 30 patients (23.62%) had hypotension whereas in Group II, 119 patients (100%) had hypotension. The episodes of hypotension were significantly lower in Group I as compared to Group II ($p<0.001$). The dose of mephentermine ($p<0.001$) used was also significantly lower in Group I as compared to Group II. Therefore, we concluded that a baseline PI>3.5 is a prediction of hypotension following spinal anesthesia in patients undergoing cesarean section.

KEYWORDS

Perfusion index, pulse oximeter, hypotension, spinal anesthesia, cesarean section

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INTRODUCTION

Spinal anesthesia is now the popular route of anesthesia in parturients for cesarean delivery.[1] Besides providing excellent intraoperative analgesia, it has decreased maternal morbidity and mortality as compared to general anesthesia.[2] Due to the physiological changes pregnant women become more sensitive to local anesthetics, less responsive to vasopressors and have lower mean arterial pressure (MAP) at term.[3] All these changes lead to profound hypotension in pregnant patients when given spinal anesthesia. In our context, the incidence of post spinal hypotension during cesarean section is reported to be up to 38%.[4] Prediction of hypotension by identifying patients at risk can be very useful as hypotension has adverse maternal as well as fetal outcomes.

We use non-invasive blood pressure cuffs as the standard practice to measure blood pressure during cesarean section. However, this often fails the timely detection of episodes of hypotension. Invasive method such as arterial cannulation for blood pressure measurement, can detect beat to beat variability in arterial pressure, but is neither feasible nor justified in patients undergoing cesarean section. Perfusion Index (PI) is the ratio of the pulsatile blood flow to the non-pulsatile static blood flow in a patient's peripheral vascular tissue. It reflects vasomotor tone. A lower PI indicates greater peripheral vasomotor tone where as a higher PI indicates lower vasomotor tone. Perfusion index can be measured using a pulse oximeter based on the amount of Infrared light absorbed.[5]

There are studies that have used PI to detect the likelihood of spinal anesthesia associated hypotension. Toyama *et al*[6] and Duggappa *et al*[7] studied PI as a predictor of hypotension in parturients undergoing cesarean section under spinal anesthesia. They found a PI value of 3.5 as a cutoff point to predict hypotension in their population. Very limited research has been done regarding its use for prediction of hypotension in our population. With the objective to determine whether a baseline PI >3.5 can predict the development of hypotension in our population, this research was conducted. A strong predictive probability if found can help us easily identify patients who are at risk of hypotension and be prepared with preventive measures such as early initiation of vasopressors.

MATERIALS AND METHODS

An observational analytical study was conducted in the department of Anesthesia at Nepal Medical College Teaching Hospital from 1st July, 2021 to 30th June, 2022. Ethical approval was obtained from the NMC Institutional Review Committee (Ref no. 051-077/078). An estimated sample size of minimum 116 patients in each group was calculated based on 81% sensitivity as per Toyama *et al*[6] within 95% confidence interval and a 7% margin of error. Informed written consent was obtained from all the participants. All the parturients in the age group of 18 – 35 years with term singleton pregnancy, whose height was in the range of 150-160cm, whose baseline systolic blood pressure was within 90-140mmHg and baseline diastolic blood pressure was within 60-90mmHg scheduled for elective cesarean section were included in the study. The exclusion criteria were refusal to participate in the study, BMI >35kg/m^2, Preeclampsia or Eclampsia and maternal history of cardiovascular or cerebrovascular disease. As suggested by Toyama *et al*,[6] we used a baseline PI value of 3.5 in this study. We hypothesized that parturients with a baseline PI value >3.5, had a higher incidence of post spinal hypotension.

Parturients were kept NPO for solid food for 6 hours and clear fluids for 2 hours before the surgery. We excluded the patients if NPO hour exceeded 8 hours. In the operating room, chest electrodes, pulse oximeter and blood pressure cuff were attached to the patient. Intravenous access was obtained with an 18 G cannula. Pulse oximeter probe was attached to the cannulated hand and blood pressure monitoring cuff was attached to the opposite hand. Baseline NIBP, Heart rate and PI were recorded with the parturients in the supine position. Those parturients who had a baseline PI <3.5 were enrolled in Group I and those patients who had a baseline PI>3.5 were enrolled in Group II. Co loading was done with lactated Ringer's solution (10ml/kg). Maintenance fluid was calculated (using Holliday Segar formula, as per body weight) and was replaced. Sub arachnoid block was performed in sitting position with hyperbaric bupivacaine 0.5% 2.2 ml at the rate of about 0.2ml/sec. Then the parturients were returned to supine position with a left lateral tilt of 15 degree. The upper sensory block level was checked by assessing the loss of cold sensation with alcohol swabs. Those parturients in whom subarachnoid block had to be repeated due to inadequate level of anesthesia were excluded from the study. Maternal NIBP, HR, and PI was recorded at one and 3 minutes after subarachnoid block and at 5 min intervals thereafter until 45 minutes. Hypotension was defined as a decrease in MAP of > 20% from the baseline.[8] If MAP decreased below this level, a bolus of mephentermine 5mg was given as a rescue medication. At the time of hypotension, level of block was also assessed. If the level of block was higher than T4, the parturients were

excluded from the study. Total episodes of hypotension and total dose of mephentermine used in every parturient was recorded. If the heart rate was less than 55 bpm, a bolus of 0.6mg atropine was given. Immediately after delivery of the baby, 3 IU of oxytocin was given as IV bolus. Thereafter, 10 IU inj. Oxytocin was given as a separate intravenous infusion. Parturients who required additional oxytocin or inj. Ergometrine were excluded from the study.

Data was entered in an excel spreadsheet and analyzed using SPSS version 16. Demographic parameters are presented in median with interquartile range. Comparison of Heart rate, systolic, diastolic and mean arterial pressure between two groups was done using independent sample t-test. Number of episodes of hypotension was compared using Chi-Square test and Mann-Whitney U test was applied to find the significance of dose of mephentermine used in the two groups.

RESULTS

During the study period 251 parturients were included in the study. Five parturients had to be excluded from the study for inadequate level of spinal block and a block level higher than T4. There were 247 patients for final analysis: 127 patients in Group I and 119 patients in Group II. The demographic parameters (age, weight and height) were comparable between two groups (Table 1).

Table 1: Demographic parameters

Demographic parameter (IQR)	Group I (127)	Group II (119)
Age in years median (IQR)	30 (27-32)	26 (24-30)
Height in cm median (IQR)	156 (154-157)	156 (155-157)
Weight in Kg median (IQR)	69 (64-74)	70 (66-74)

Intraoperative heart rate at 1st, 5th, 25th, 35th, and 45th minutes was significantly higher in Group II as compared to Group I (Fig. 1). None of the patients had bradycardia (HR< 55bpm). Intraoperative systolic blood pressure measured at different intervals showed significantly lower blood pressure in Group II as compared to Group I (p<0.05) (Fig. 2). Similarly, diastolic blood pressure was also significantly lower at all the time intervals in Group II as compared to Group I (p value <0.05) (Fig. 3). Mean arterial pressure also showed significantly lower values in Group II in comparison to Group I (p value<0.05) (Fig. 3).

Table 2: Episodes of Hypotension

Group	Episodes of hypotension	Number of parturients (%)
Group I (n=127)	0	97 (76.4)
	1	22 (17.3)
	2	6 (4.7)
	3	2 (1.6)
Group II (n=119)	1	3 (2.5%)
	2	5 (4.2%)
	3	8 6.7%)
	4	23 (19.3%)
	5	17 (14.3%)
	6	28 (23.5%)
	7	17 (14.3%)
	8	13 (10.9%)
	9	1 (0.8%)
	10	3 (2.5%)
	11	1 (0.8%)

r_s 0.78 p<0.001

Table 3: Dose of Mephentermine used

Parameter	Group I (127)	Group II (119)
Dose of Mephentermine in mg, median (IQR, minimum–maximum)	0.00 (0-0, 0-15)	30 (20-35,5-55)

r_s 0.88 p<0.001

In group I, 30 patients (23.62%) had hypotension whereas in Group II, 119 patients (100%) had hypotension. In Group I, 22 patients (17.3%) had one episode of hypotension, 6 patients (4.7%) had two episodes of hypotension and 2 patients (1.6%) had three episodes of hypotension. In Group II, three patients (2.5 %) had 1episode, 5 patients (4.2%) had 2 episodes, 8 patients (6.7%) had 3 episodes, 23 patients (19.3%) had 4 episodes, 17 patients (14.3%) had 5 episodes, 28 patients (23.5%) had 6 episodes, 17 patients (14.3%) had 7 episodes, 13 patients (10.9%) had 8 episodes, 1 patient (0.8%) had 9 episodes, 3 patients (2.5%) had 10 episodes, 1 patient (0.8%) had 11 episodes (Table 2).

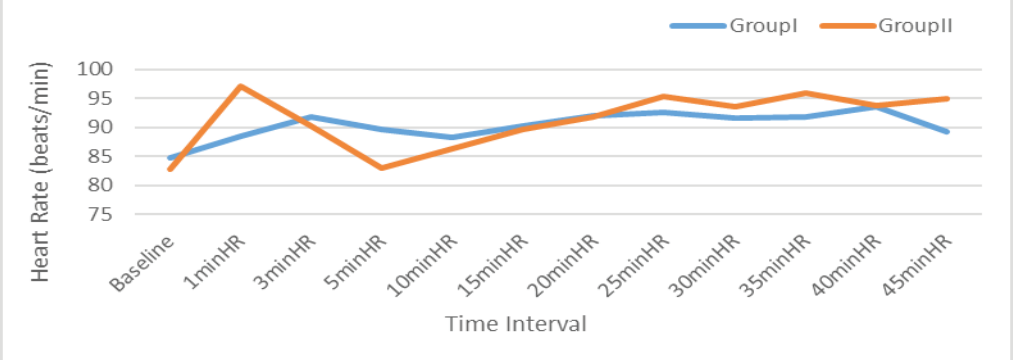

Fig. 1: Intraoperative Heart Rate

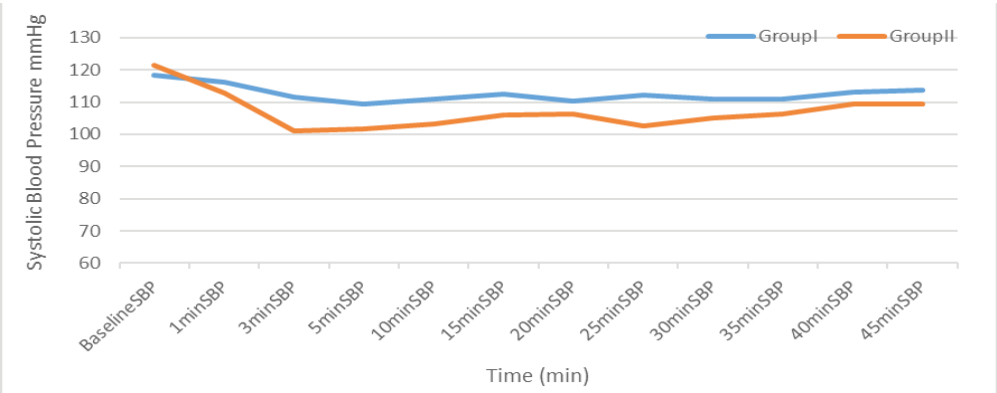

Fig. 2: Intraoperative Systolic Blood Pressure

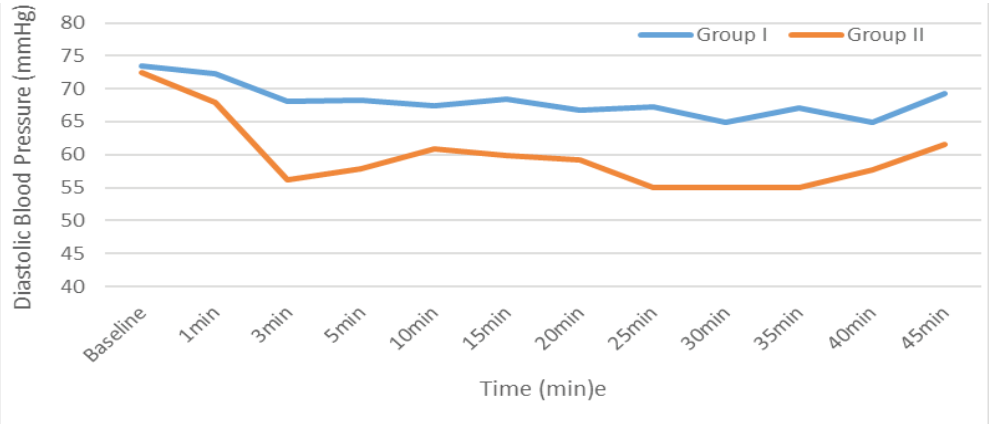

Fig. 3: Intraoperative Diastolic Blood Pressure

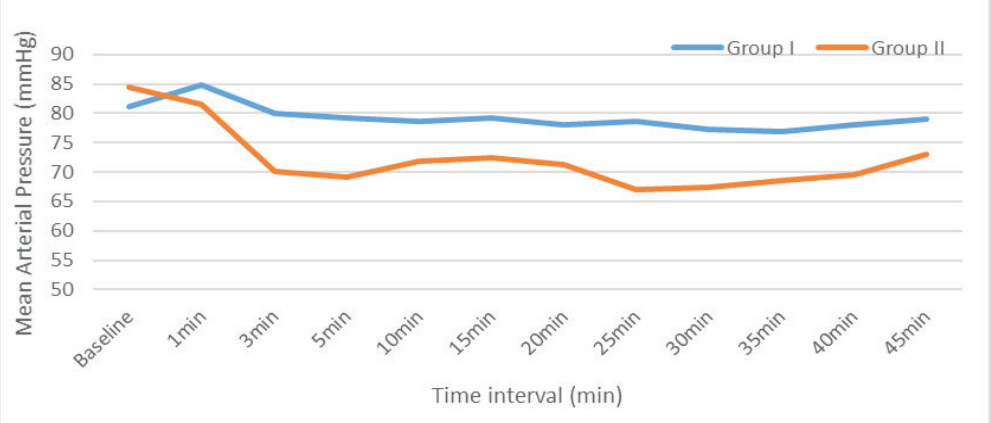

Fig: 4: Intraoperative Mean Arterial Pressure

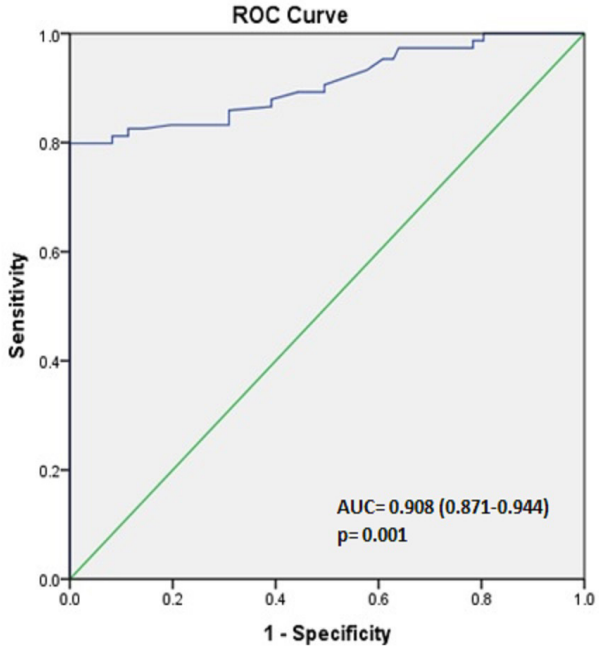

Fig.5: ROC curve: Baseline PI against incidence of hypotension

The correlation between baseline PI >3.5 and number of episodes of hypotension was highly significant (r_s 0.78 p< 0.01)

Median mephentermine used in Group I was 0 mg (IQR, min-max: 0-0mg, 0-15mg). In Group II it was 30 mg (IQR, min-max: 20-35 mg, 5-55 mg). Mephentermine administered in Group I was significantly less as compared to Group II (p<0.001) (Table 3).

The ROC curve showed a balanced 80% sensitivity and specificity. The area under the ROC (AUC) is 0.908.

DISCUSSION

In this study, we found that the parturients who had a baseline PI more than 3.5, the number of episodes of intraoperative hypotension and dose of mephentermine used to maintain blood pressure was higher. During pregnancy there is decrease in peripheral vascular tone that results in pooling of blood in the extremeties.[9-11] Spinal anesthesia causes a further decrease in peripheral vascular tone which contributes to hypotension. PI by assessing peripheral perfusion dynamics can detect vascular tone.[12-16] Parturients who have lower baseline peripheral vascular tone are expected to be at higher risk of developing hypotension following spinal anesthesia. Although peripheral perfusion can be measured by other methods including clinical signs, central to toe temperature difference, laser Doppler and capillary microscopy, use of pulse oximeter for PI monitoring is cost effective, easy to perform and has no risk or contraindications.[6]

Besides vascular resistance, intravascular volume status also affects the degree of hypotension after spinal anesthesia. In this study fluid required for coloading and maintenance was calculated as per body weight. Hypotension if occurred was treated by mephentermine only, fluid bolus was not given. All the patients were kept NPO for solid food for 6 to 8 hours. We excluded the patients in whom NPO hour was more than 8 hours as longer NPO hours might affect intravascular volume by increasing fluid deficit. So, we can assume that the intravascular volume status was comparable in both the groups. We used a fixed volume of intrathecal bupivacaine in all the patients as the study population height was in the range of 150cm-160cm. As the block height is also determined by the volume of intrathecal drug given. We excluded the patient who had a block level higher than T4 as it can be the cause of hypotension. All the parturients received fixed dose of syntocinon as uterotonics. Patients who required additional dose of syntocinon or methylergometrine were excluded from the study as it can influence the PI value.

Higher perfusion index value means the parturient had a lower baseline peripheral vascular tone which was further reduced by spinal anesthesia. Hence, hypotension occurred more frequently and a higher dose of Mephentermine was required. In such patients prophylaxis with vasopressor that directly addresses the decrease in systemic vascular resistance if considered could have reduced episodes of hypotension. Our findings are different from that of Yokose *et al* who studied PI measured before the induction of spinal anesthesia in prediction of hypotension.[17] In their study they found no correlation between PI values and hypotension in parturients undergoing cesarean section under spinal anesthesia. They defined hypotension as systolic blood pressure <80mmHg but our definition was a decrease in MAP of >20% from the baseline.

Our study has several limitations. Only healthy parturients were enrolled in this study. The parturients with hypertension and heart disease, in whom the prediction of hypotension is of utmost importance were excluded from the study. We studied only a single baseline PI value, changes in serial PI values and its association with hypotension was not studied. PI values can be easily changed by patient

movement and increased sympathetic activity, which despite our effort was inevitable. Further studies comparing PI values with invasive and accepted tools of hemodynamic monitoring need to be done to prove its accuracy.

In conclusion, PI can be used to predict hypotension in pregnant patients undergoing cesarean section under spinal anesthesia. Parturients with baseline PI> 3.5 are at higher risk of developing hypotension following spinal anesthesia as compared to parturients with baseline PI<3.5.

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REFERENCES

1. Riley ET, Cohen SE, Macario A, Desari JB, Ratner EF. Spinal versus epidural anaesthesia for caesarean section: A comparison of time efficiency, costs, charges, and complications. *Anesth Analg* 1995; 80: 709-12.
2. Rudra A, Mondal M, Acharya A, Nayak S, Mukherjee S. Anesthesia related maternal mortality. *J Indian Med Assoc* 2006; 104: 312-6.
3. Gaiser R. Physiological changes of pregnancy. In: Chestnut DH, editor. Chestnut's Obstetric Anaesth: Principles and Practice. 5th ed. Philadelphia: Mosby Elsevier Publishing; 2014,15-38.
4. Sharma N. Incidence of postspinal hypotension during cesarean section. *J Inst Med* 2005; 27: 31-3.
5. Carpentier PH. New techniques for clinical assessment of the peripheral microcirculation. *Drugs* 1999; 59: 17-22.
6. Toyama S, Kakumoto M, Morioka M. Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anesthesia for cesarean delivery. *Br J Anaesth* 2013; 111: 235-41.
7. Duggappa DR, Lokesh M, Dixit A, Paul R, Raghavendra Rao RS, Prabha P. Perfusion index as a predictor of hypotension following spinal anesthesia in lower segment caesarean section. *Indian J Anaesth* 2017; 61: 649-54.
8. Klohr S, Roth R, Hofmann T, Rossaint R, Heesen M. Definitions of hypotension after spinal anesthesia for caesarean section: literature search and application to parturients. *Acta Anaesthes Scandinavica* 2010; 54: 909-21.
9. Barwin BN, Roddie IC. Venous distensibility during pregnancy determined by graded venous congestion. *Am J Obstet Gynecol* 1976; 125: 921-3.
10. Sakai K, Imaizumi T, Maeda H *et al*. Venous distensibility during pregnancy. Comparisons between normal pregnancy and preeclampsia. *Hypertension* 1994; 24: 461-6.
11. Ajne G, Ahlborg G, Wolff K, Nisell H. Contribution of endogenous endothelin-1 to basal vascular tone during normal pregnancy and preeclampsia. *Am J Obstet Gynecol* 2005; 193: 234-40.
12. Mowafi HA, Ismail SA, Shafi MA, Al-Ghamdi AA. The efficacy of perfusion index as an indicator for intravascular injection of epinephrine-containing epidural test dose in propofol anesthetized adults. *Anesth Analg* 2009; 108: 549-53.
13. Ginosar Y, Weiniger CF, Meroz Y *et al*. Pulse oximeter perfusion index as an early indicator of sympathectomy after epidural anesthesia. *Acta Anaesthesiol Scand* 2009; 53: 1018-26.
14. Lima AP, Beelen P, Bakker J. Use of a peripheral perfusion index derived from the pulse oximetry signal as a noninvasive indicator of perfusion. *Crit Care Med* 2002; 30: 1210-3.
15. Zaramella P, Freato F, Quaresima V *et al*. Foot pulse oximeter perfusion index correlates with calf muscle perfusion measured by near-infrared spectroscopy in healthy neonates. *J Perinatol* 2005; 25: 417-22.
16. Takahashi S, Kakiuchi S, Nanba Y, *et al*. The perfusion index derived from a pulse oximeter for predicting low superior vena cava flow in very low birth weight infants. *J Perinatol* 2010; 30: 265-9.
17. Yokose M, Mihara T, Sugawara Y, Goto T. The predictive ability of non-invasive haemodynamic parameters for hypotension during caesarean section: A prospective observational study. *Anesth* 2015; 70: 555-62.