Section: Anaesthesia

Original Research Article

PERFUSION INDEX AS A PREDICTOR OF DEVELOPMENT OF HYPOTENSION AFTER SPINAL ANAESTHESIA IN CAESAREAN SECTION

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ABSTRACT

Background: The perfusion index serves as a valuable tool for evaluating perfusion dynamics and is currently under consideration as a non-invasive approach to identify the potential onset of hypotension after a subarachnoid block (SAB). The current study sought to investigate the relationship between baseline perfusion index in parturients and the extent of hypotension experienced during spinal anaesthesia for Caesarean delivery, as well as to determine if baseline perfusion index could serve as a predictor for this hypotension.

Material and Methods: A group of 30 expectant mothers scheduled for elective caesarean delivery was chosen for the study. The perfusion index was assessed while the participants were in a supine position, utilising a designated pulse oximeter probe affixed to the left index finger of each parturient to maintain consistency in the recorded PI values. Maternal non-invasive blood pressure, heart rate, and perfusion index were documented at one-minute intervals from the time of spinal injection until delivery, followed by recordings at two-and-a-half-minute intervals until the conclusion of the surgical procedure.

Results: The findings indicate a notable reduction in systolic arterial pressure (SAP) following spinal injection in parturients, regardless of whether they had high or low baseline pulse indices (PI). However, those with elevated baseline PI experienced more pronounced decreases in SAP at the 4, 5, and 6-minute marks post-injection compared to their counterparts with lower baseline PI. Parturients exhibited significant reductions in mean arterial pressure (MAP) following spinal injection, regardless of whether they had high or low baseline perfusion index (PI). Notably, those with elevated baseline PI experienced a more pronounced drop in MAP five minutes post-injection compared to their counterparts with lower baseline PI.

Conclusion: The study found that baseline PI measured at the finger is associated with the extent of arterial pressure reduction during spinal anaesthesia for Caesarean delivery. A baseline PI cut-off point of 3.5 may serve as a useful indicator for identifying parturients who are at risk for hypotension in this context.

Key Words: Caesarean Section, Hypotension, Mean Arterial Pressure, Perfusion index.

INTRODUCTION

Hypotension that occurs after spinal anaesthesia is primarily due to the sympathetic blockade and a reduction in cardiac output.[1] Pregnant women exhibit heightened sensitivity to local anaesthetics, diminished responsiveness to vasopressors, and experience a lower mean arterial pressure (MAP) as they approach term.[2] Consequently, women in labour may experience significant hypotension after

undergoing central neuraxial blockade during a lower segment caesarean section (LSCS).

The standard approach for monitoring intraoperative haemodynamics is through non-invasive blood pressure (NIBP) measurement. Nonetheless, this method is unable to measure beat-to-beat variation in perfusion dynamics, which restricts its overall efficacy. The reduction in peripheral vascular tone leads to blood volume being retained in the extremities prior to the administration of spinal anaesthesia. Additionally, the sympathetic blockade associated with spinal anaesthesia exacerbates this pooling of blood.[3] Consequently, individuals in labour who exhibit low baseline vascular tone might face a heightened risk of experiencing hypotension following spinal anaesthesia.

The perfusion index (PI) represents the ratio of pulsatile to non-pulsatile blood flow within peripheral vascular tissue. This measurement is obtained through a pulse oximeter, which assesses the absorption of infrared light to determine blood flow dynamics.[4] Therefore, perfusion index (PI) serves as a valuable tool for evaluating perfusion dynamics and is currently being explored as a non-invasive approach to predict the potential onset of hypotension after a subarachnoid block (SAB).[5-7] Numerous studies conducted in the past have utilized the perfusion index to evaluate haemodynamic parameters. Nevertheless, there is a scarcity of data concerning its application in predicting the occurrence of hypotension resulting from central neuraxial blockade.

This study sought to investigate the relationship between baseline pulse index in parturients and the severity of hypotension experienced during spinal anaesthesia for Caesarean delivery, as well as to determine if baseline pulse index could serve as a predictor for this hypotension.

MATERIALS AND METHODS

The prospective observational study was conducted at Department of Anesthesia, Tertiary Care Teaching Institute of India for the duration of 1 year. After approval of the study by the Institutional Ethics Committee, Parturients undergoing elective caesarean delivery under ASA grades I and II were included. A total of 30 parturients posted for elective caesarean delivery were selected.

Exclusion Criteria

- Emergency cases.
- Placenta previa.
- Preeclampsia.
- Cardiovascular or cerebrovascular disease.
- Contraindications to spinal anaesthesia.

We hypothesised that parturients with higher baseline PI would have a higher incidence of hypotension. Anticipating equal distribution of baseline PI on either side of cut-off point of 3.5 suggested in a study by Toyama et al.[8] Keeping the confidence interval at 95%, a minimum of 30 parturients would be required, to achieve a power of 80%, if the same result had to be reproduced.

Parturients with placenta praevia, preeclampsia, cardiovascular or cerebrovascular disease, gestational diabetes, body mass index ≥40, gestational age < 36 or >41 weeks, contraindications to spinal anaesthesia and those requiring emergency LSCS were excluded from the study. Standard monitoring with electrocardiography, automated NIBP, and pulse oximetry (SpO2) was performed for baseline values and intraoperative monitoring. The perfusion index was measured in the supine position using a specific pulse oximeter probe which was attached to the left index finger of all parturients to ensure uniformity in measured PI values.

Each parturient was given an infusion of 500 ml Ringer Lactate as pre-hydration before spinal anaesthesia via an i.v. Cannula. After the pre-hydration, lactated Ringer's solution was infused until the end of surgery. Standard monitoring with electrocardiography, automated non-invasive arterial pressure (NIAP) measurement, and pulse oximetry was performed. Spinal anaesthesia was given in sitting position at L3-L4 space with inj Bupivacaine 0.5% heavy 2 ml and a sensory block of T6 level was achieved.

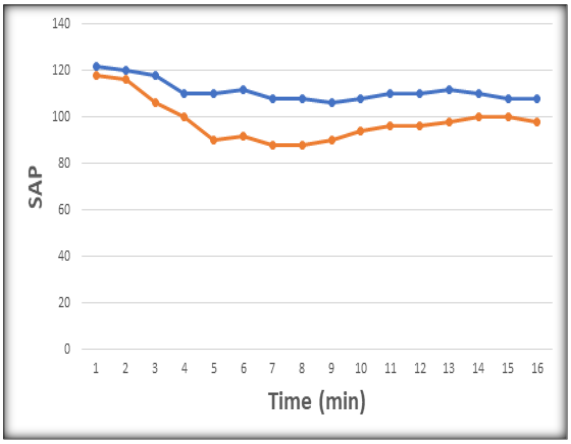
Maternal NIBP, HR, and PI were recorded at 1 min intervals between the spinal injection and delivery and then at 2.5 min intervals until the end of surgery. Hypotension was defined as a decrease in SAP ≤ 25% from baseline. When SAP decreased to this level, a bolus of 6mg Mephentermine was given as a rescue medication, keeping the decrease within SAP≤25% from baseline. Rescue Mephentermine was given in the same manner if the patient complained of faintness, dizziness, nausea, or vomiting even if the decrease in SAP from baseline was ≤25%.

Statistical Analysis

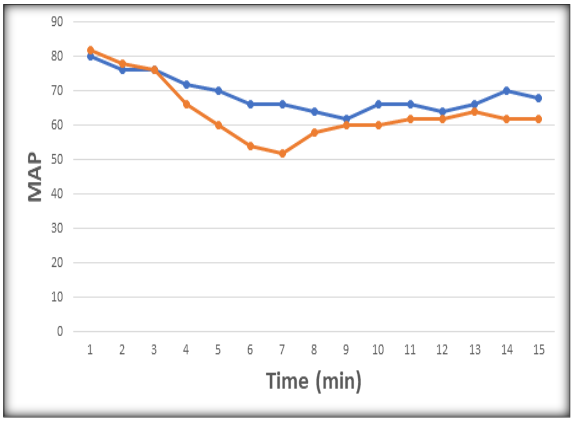
The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2019) and then exported to data editor page of SPSS version 19 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were described as means and standard deviations or median and interquartile range based on their distribution. Qualitative variables were presented as count and percentages. For all tests, confidence level and level of significance were set at 95% and 5% respectively.

RESULTS

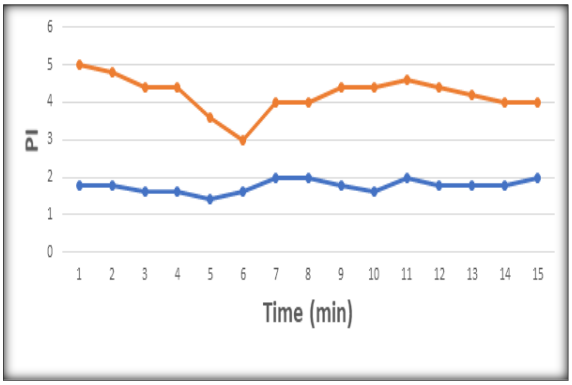
Patient characteristic and obstetric characteristics are presented in Table 1. 18 parturients (60%) developed hypotension. [Table 1]



Graph 1



Graph 2



Graph 3: Summary of the changes in SAP, MAP, and PI from baseline through 15 min after the induction of spinal anesthesia (SP). Data are presented as mean. Time, minutes after spinal injection

SAP decreased significantly after spinal injection in parturients with both high and low baseline PI, parturients with high baseline PI had larger decreases in SAP 4, 5, and 6 min after spinal injection than those with low baseline PI. (Graph 1) While parturients also showed marked decreases in MAP after spinal injection in parturients with both high and low baseline PI, parturients with high baseline PI had a larger decrease in MAP 5 min after spinal injection than those with low baseline PI. The change of PI in parturients with low baseline PI was not significant throughout the observational period, while PI in parturients with high baseline PI demonstrated marked decreases after spinal injection. ($p \leq 0.05$)

Table 1: Patient characteristic and obstetric characteristics. Data are presented as mean (range) for age, mean (SD), median (range), or number of subjects

Variables	Number
Age (yr) (mean±SD)	34.02±4.56
Height (cm) (mean±SD)	158.92±15.32
Weight (kg) (mean±SD)	64.02±12.64
Gravidity (n) (mean±SD)	2.12±0.22
Parity (n) (mean±SD)	2.01±0.11
Gestational age (weeks)	37.12±8.55

DISCUSSION

The principle of SpO2 relies on two light sources that emit wavelengths of 660nm and 940nm. The pulsatile component signifies the variations in arterial blood volume occurring between the source and the detector. The non-pulsatile component originates from connective tissue, bone, and the venous compartment. The reduction in systemic vascular resistance during pregnancy leads to an elevated perfusion index, attributed to an increase in the pulsatile component resulting from vasodilation. The induction of sympathectomy through spinal anaesthesia is likely to lead to a further reduction in peripheral vascular tone, resulting in increased pooling and hypotension. Pulse index can serve as an effective method for the early prediction of hypotension.

It is not uncommon to observe hypotension after the administration of spinal anaesthesia during a caesarean delivery.[9] A definitive monitoring system to predict the likelihood of developing hypotension is currently lacking, which hinders the ability to implement additional precautions. Research has sought to assess the effectiveness of the perfusion index as a predictor of hypotension after spinal anaesthesia in caesarean sections.[8] A healthy pregnancy is marked by a reduction in systemic vascular resistance, an increase in total blood volume, and an elevation in cardiac output.[9,10] The decrease in systemic vascular resistance can differ among parturients due to a range of influencing factors.[11,12] The reduction in tone is expected to lead to elevated perfusion index values, attributed to an increase in the pulsatile component resulting from vasodilatation. The induction of a sympathectomy through spinal

anaesthesia leads to a notable reduction in peripheral vascular tone, resulting in increased pooling and hypotension. Women in labour who present with a high baseline perfusion index may experience reduced peripheral vascular tone, placing them at an increased risk for hypotension after receiving spinal anaesthesia. The perfusion index has been utilised in research by Mowafi et al. to identify intravascular injection of an epinephrine-containing epidural test dose, thereby confirming its effectiveness in detecting vasoconstriction.5 Ginosar et al. showed that an increase in PI after epidural anaesthesia serves as a clear and reliable marker for sympathectomy.[6] A recent study conducted by Yokose et al.[13] revealed that PI lacked predictive value for hypotension in parturients undergoing LSCS after SAB. The observed discrepancy can be linked to several methodological variations, including the definition of hypotension, the use of colloids for co-loading, and the approach taken to calculate baseline PI.

This prospective observational study revealed a correlation between higher baseline PI and a more significant reduction in arterial pressure. The analysis revealed that the baseline PI demonstrated a strong sensitivity and specificity in predicting hypotension induced by spinal anaesthesia during Caesarean delivery. George et al. found a notable relationship between pulse index (PI) and a reduction in systemic arterial pressure. They established a baseline PI of 3.6 as their threshold, achieving a sensitivity of 80% and a specificity of 60%.[14] Arghese carried out a comparable study and found a correlation result with an area under the curve of 0.911, maintaining the same baseline PI of 3.5, which yielded a sensitivity of 86.6% and a specificity of 93.3%.[15] The hypotension associated with spinal anaesthesia primarily arises from a reduction in systemic vascular resistance, which is caused by the blockade of preganglionic sympathetic fibres. The influence of preoperative sympathetic activity and volume status on the extent of hypotension is well-documented.

Parturients exhibiting low baseline vascular tone may face a heightened risk of developing hypotension during spinal anaesthesia compared to those with a comparatively higher baseline vascular tone. A healthy pregnancy involves a reduction in systemic vascular resistance, alongside increases in total blood volume and cardiac output. Notably, pregnant women, especially those beyond 30 weeks of gestation, experience a greater volume of blood pooling in their extremities, a result of the pregnancy-related decrease in vascular tone.[16,17] Research utilising plethysmography has shown a decrease in peripheral vascular tone throughout a healthy pregnancy.[14-17] As a result, the implementation of a sympathectomy through spinal analgesia in healthy pregnant women is believed to enhance blood pooling, leading to a greater accumulation of blood in the extremities compared to their non-pregnant counterparts. Consequently, strategies such as colloid preloading, coloading, and the application of mechanical measures for lower limb compression that elevate central blood volume have shown effectiveness in decreasing the occurrence of hypotension during spinal anaesthesia for Caesarean delivery.[18-20] The extent to which vascular tone decreases in women during childbirth can differ based on the number of pregnancies and various other influencing factors.[21] Consequently, individuals in labour who exhibit low baseline vascular tone may face a greater risk of experiencing hypotension during spinal anaesthesia compared to those with a relatively higher baseline vascular tone. The measurement of peripheral vascular tone through plethysmography presents challenges, as the technique is invasive and not easily accessible for clinical management in elective situations. Conversely, non-invasive plethysmographic pulse wave monitoring is commonly integrated into pulse oximeters, making it easily accessible for everyday applications. The compensatory increases in sympathetic nervous system activation and systemic vascular resistance in non-blocked areas of the body, which are crucial for maintaining systemic perfusion pressures, are diminished under spinal anaesthesia. Consequently, the observed decrease in perfusion index (PI) after spinal injection in parturients with a high baseline PI likely indicates a reduction in preload caused by blood pooling in the lower body, rather than an increase in vascular tone resulting from compensatory sympathetic vasoconstriction. Research indicates that parturients exhibiting high baseline peripheral indices may experience reduced peripheral vascular tone in comparison to those with lower baseline values. This condition potentially increases their susceptibility to spinal anaesthesia-induced hypotension, as it may lead to greater blood pooling in the lower extremities.

The study's limitation lies in its small sample size, which restricts the ability to generalise the findings effectively. Given that the research was carried out in a single institution, caution is advised when extrapolating the findings to the broader population.

CONCLUSION

We demonstrated that baseline PI measured at the finger correlated with the degree of decrease in arterial pressure during spinal anaesthesia for Caesarean delivery, and a baseline PI cut-off point of 3.5 could be used to identify parturients at risk for such hypotension. PI may be a very useful tool to predict hypotension during spinal anaesthesia for Caesarean delivery in everyday practice.

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