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Pulse Oximeter- A Visionary to Augur Hypotension at a Glance
A Clinical Study Conducted in a Tertiary Care Institution in South India

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Abstract
Background: *Hypotension during spinal anesthesia for cesarian delivery is a result of decreased vascular resistance due to sympathetic blockade and decreased cardiac output due to pooling of blood in blocked areas of the body. Change in baseline peripheral vascular tone due to pregnancy may affect the degree of such hypotension. The perfusion index derived from pulse oximeter has been used for assessing peripheral perfusion dynamics due to changes in peripheral vascular tone.*
Aim: *To examine whether baseline perfusion index could predict the incidence of spinal anesthesia induced hypotension during caesarean delivery.*
Methods: *154 pregnant females in the gestational age group 36-40 weeks who are undergoing elective cesarian delivery with no comorbidities have been enrolled in this study. We collected the data using structured proforma and interpreted using ROC analysis to find optimal cut off value of baseline PI for prediction of hypotension*
Results: *Baseline PI correlated with the percentage decrease in mean arterial pressure ($r=0.662; p=0.000$). The cut-off PI value of 2.65 identified parturients at risk for spinal anaesthesia-induced hypotension with a sensitivity of 91.6%, specificity of 70.4%, positive predictive value of 78.4%, negative predictive value 87.7% and accuracy of 81.8%. Baseline PI correlated with no of episodes of hypotension and no of times vasopressors used ($p<0.005$). Percentage of decrease in MAP correlated with parturient height and baseline MAP ($p < 0.05$).*
Conclusions: *Baseline PI is associated with degree of hypotension after spinal anaesthesia for caesarean delivery. Baseline PI >2.65 can predict hypotension after spinal anaesthesia for caesarean delivery.*
Keywords: *perfusion index; pulse oximeter; measuremet techniques, subarachnoid; complications.*

Introduction

Spinal anaesthesia-induced hypotension during Caesarean delivery is the result of sympathetic blockade and decreased cardiac output due to blood pooling in extremities of the body. Normal pregnancy is characterized by a decrease in systemic vascular resistance and increases in total blood volume and cardiac output particularly after 30 weeks of gestation and more blood volume will be trapped in extremities due to the pregnancy-induced decrease in venous tone. Decreased peripheral vascular tone results in blood volume being trapped in the extremities even before spinal anaesthesia, and the sympathetic blockade with spinal anaesthesia would further increase the blood pooling. Therefore, it is likely that parturients with low baseline vascular tone are more at risk to develop hypotension during spinal anaesthesia than those with relatively higher baseline vascular tone.

The perfusion index (PI) derived from a pulse oximeter is calculated as the ratio of the pulsatile blood flow to the non pulsatile blood in peripheral tissue, and can be measured noninvasively. PI can be used to assess peripheral perfusion dynamics due to changes in peripheral vascular tone. This study is aimed to examine whether baseline PI in parturients correlated with the degree of hypotension during spinal anaesthesia for Caesarean delivery and whether baseline perfusion index could predict such hypotension.

Aim

The aim of the study is to find the validity of baseline perfusion index in predicting the incidence of hypotension after spinal anaesthesia for caesarean delivery in pregnant females with gestational age between 36 and 40 weeks admitted for elective caesarean delivery at SAT Hospital, Govt. Medical College, Trivandrum.

Subject

This study was conducted on Pregnant females with gestational age between 36 and 40 weeks for elective caesarean delivery at SAT Hospital, Govt. Medical College, Trivandrum. Pregnant females with gestational age between 36 and 40 weeks for elective caesarean delivery were included. Patients for emergency caesarean section Patients with pre eclampsia, cardiovascular or cerebrovascular disease, morbid obesity Gestational age less than 36 weeks and more than 40 weeks were excluded from the study. Parturients undergoing Caesarean delivery under spinal anaesthesia satisfying inclusion and exclusion criteria was included in the study. Written informed consent was obtained from each parturient in the study. Standard monitoring with electrocardiography, automated non-invasive arterial pressure (NIAP) measurement, and pulse oximetry using MINDRAYS mutiparameter monitor was used. The cuff of an automated NIAP device was attached to the right arm. The pulse oximeter probe was attached to the left index finger.ECG leads were attached. Baseline MAP, SBP, heart rate (HR), and PI will be recorded in the supine position. Average of three PI values taken 5 minutes apart was considered as baseline PI value. Each parturient was given a preloading of 15-20 ml/kg normal saline/Ringer lactate before spinal anaesthesia via an i.v. cannula 16 or 18 guage. Under strict aseptic precautions, lumbar subarachnoid block was be given in right lateral decubitus position using a 25 guage Quincke spinal needle in L3-4 space with 0.5 % Bupivacaine (HEAVY) 2 ml. The parturient was returned to the supine position with a left lateral tilt of 15° to facilitate left uterine displacement. MAP, SBP will be recorded at 1 min intervals between the spinal injection and delivery and then at 2.5 min intervals until the end of surgery. Ringer's lactate/normal saline was administered at a rate of 100 ml/10 min. The level of sensory block was checked 5 min after the spinal injection with a cold swab. Maximum cephalad spread was checked 20 min after lumbar subarachnoid block. If T6 sensory level was not achieved after 20 min, they were excluded from the study. Hypotension is defined as a decrease in mean arterial pressure>30% from baseline. (Miller's anaesthesia- 8th edition chapter 56,page no 1713). Vasopressors EPHIDRINE/PHENYL EPHRINE was used to treat hypotension. No of episodes of

hypotension and no of times vasopressors used were noted. Injection oxytocin 5 units was given as bolus IV dose following baby extraction and Oxytocin infusion was started at a rate of 200 mU/min. Patients who required additional oxytocics and/or additional surgical interventions were excluded from the study.

(a) Research design: Hospital based Observational study with diagnostic test evaluation

(b) Study setting

Teritiary care setting; Sree Avittom Thirunal (SAT) hospital division of Department of Anaesthesiology, Medical College, Trivandrum

(c) Study period: Eighteen months

(d) Research subjects: Pregnant females with gestational age between 36 and 40 weeks for elective caesarean delivery at SAT Hospital, Govt. Medical College, Trivandrum.

Inclusion criteria

Pregnant females with gestational age between 36 and 40 weeks for elective caesarean delivery

Exclusion criteria

- Patients who are not willing for the study.
- Patients for emergency caesarean section
- Patients with pre eclampsia, cardiovascular or cerebrovascular disease, morbid obesity
- Gestational age less than 36 weeks and more than 40 weeks.

Technique

Parturients undergoing Caesarean delivery under spinal anaesthesia satisfying inclusion and exclusion criteria was included in the study.

Written informed consent was obtained from each parturient in the study.

Standard monitoring with electrocardiography, automated non-invasive arterial pressure (NIAP) measurement, and pulse oximetry using MINDRAYS mutiparameter monitor was used. The cuff of an automated NIAP device was attached to the right arm. The pulse oximeter probe was attached to the left index finger.ECG leads were attached. Baseline MAP, SBP, heart rate (HR), and PI will be recorded in the supine position. Average of three PI values taken 5 minutes apart was considered as baseline PI value. Each parturient was given a preloading of 15-20 ml/kg normal saline/Ringer lactate before spinal anaesthesia via an i.v. cannula 16 or 18 guage.

Under strict aseptic precautions, lumbar subarachnoid block was be given in right lateral decubitus position using a 25 guage Quincke spinal needle in L3-4 space with 0.5 % Bupivacaine (HEAVY) 2 ml. The parturient was returned to the supine position with a left lateral tilt of 15° to facilitate left uterine displacement. MAP, SBP will be recorded at 1 min intervals between the spinal injection and delivery and then at 2.5 min intervals until the end of surgery. Ringer's lactate/normal saline was administered at a rate of 100 ml/10 min. The level of sensory block was checked 5 min after the spinal injection with a cold swab. Maximum cephalad spread was checked 20 min after lumbar subarachnoid block. If T6 sensory level was not achieved after 20 min, they were excluded from the study. Hypotension is defined as a decrease in mean arterial pressure>30% from baseline. (Miller's anaesthesia- 8th edition chapter 56, page no 1713). Vasopressors EPHIDRINE/PHENYL EPHRINE was used to treat hypotension. No of episodes of hypotension and no of times vasopressors used were noted. Injection oxytocin 5 units was given as bolus IV dose following baby extraction and Oxytocin infusion was started at a rate of 200 mU/min. Patients who required additional oxytocics and/or additional surgical interventions were excluded from the study.

Sampling

Sample size is 137

Sample size was calculated as below,

Total number of positive cases = 4PQ/l2

P = Sensitivity

Q = 1 – P (100-P if P is taken as a percentage)

l = 5 – 10 (l shows precision) here it is taken as 10

In the study "Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anaesthesia for Caesarean delivery" by S. Toyama*, M. Kakumoto, M. Morioka, K.

Matsuoka, H. Omatsu, Y. Tagaito, T. Numai and M. Shimoyama Department of Anesthesiology, Teikyo University Chiba Medical Center, 3426-3 Anesaki, Ichihara-City, Chiba 299-0111, Japan) (British Journal of Anaesthesia 111 (2): 235–41 (2013) the cut off value PI value of 3.5 identified parturients at risk for spinal anaesthesia induced hypotension with a sensitivity of 81% and specificity of 86% Substituting in the formula, Total number of True positive (TP) cases = 4 x 81x 19 / 10 x 10 = 61.56

In a prospective study of hypotension after spinal anesthesia for cesarean section at Siriraj Hospital: incidence and risk factors, Part 2J Med Assoc Thai. 2008 May;91(5):675-80.

Incidence of hypotension was 65.1%

The sample size is calculated to be around =TP/PREVALENCE= 61.56*100/65=94

No of true negative cases = 4P2Q2/l2

P2= SPECIFICITY

Q2= 1-P2

No of true negative (TN) cases=4x 86x 14/100= 48.16

Total Cases=TN/ (1- PREVALENCE)=(48.16/35)x 100=137

Out of the total cases calculated using sensitivity and specificity separately, 137 is the higher value and hence was taken as the sample size. In this study 170 parturients who were willing to participate in the study were enrolled according to inclusion and exclusion criteria. 16 of them were discarded due to inadequate sensory block or requirement of additional oxytocics. Data analysis was done in the remaining 154 parturients.

Sampling technique

Every patient eligible for the study was included.

h) Data collection tools

Structured data collection proforma

Data analysis:

Data will be entered into Microsoft excel sheet. Analysis of data will be done using SPSS software. Qualitative data are expressed in proportion and percentage and quantitative data expressed as mean and standard deviation. Karl Pearson correlation coefficient test and ANOVA test are were used for statistical analysis. For all statistical evaluations, a two tailed probability of value $p<0.05$ was considered significant. To test the ability of baseline PI to predict spinal anaesthesia induced hypotension in Caesarean delivery areas under the receiver operating characteristic (ROC) curves of hypotension was calculated and the optimal cut-off point is obtained from the closest point to the left upper corner on the ROC curve. Sensitivity, specificity, positive predictive value, negative predictive value, accuracy was calculated.

Limitations of the study: study has several limitations. Hemodynamic parameters such as cardiac output and systemic vascular resistance were not measured.

Photoplethysmographic analysis is sensitive to patient movement, and PI is decreased due to sympathetic stimulation due to several factors such as stress , anxiety, systemic and local pathological factors, which in turn induces peripheral vasoconstriction. In this study, baseline PI values were recorded with utmost care to avoid patient movement, especially while recording baseline values and all patients were counselled before taking them up for surgery to allay anxiety. Baseline values of PI and hemodynamic parameters were obtained with parturients in the supine position, whereas a 15 degree left lateral table tilt was applied after spinal injection. In pregnant women, the supine position is known to be associated with significant aortocaval compression by the gravid uterus, reducing venous return, cardiac output, and arterial pressure, and we cannot rule out its effect on the baseline values. PI values might vary when measured with different types of monitors. However in this study only MINDRAYS multiparameter monitor was used. Baseline PI varies beat to beat and hence it was difficult to determine an accurate value. Hence average of three values measured 5 minutes apart was considered as the baseline PI.

Observation and Results

170 parturients were selected for study after applying inclusion and exclusion criteria. Among them 8 were excluded because their upper sensory

block did not reach T6. Another 8parturients were excluded because of additional oxytocins requirements. Total 16 parturients were excluded. Analysis was done on the remaining 154 parturients. 85 percent of study population is in the age group 20-29 with mean age of 25.

Majority of study population is having gravidity 1 and parity 0. BMI of the study population ranges from 15.6 to 40.9 with a mean of 28.3.Baseline PI ranged from 0.8 to 9.2

With mean value of 3.61.Baseline HR ranges from 56 to 114 with mean of 86.Baseline SBP ranges from 90 to 168 with a mean of 119.Baseline MAP ranges from 65to128 with a mean of 83.

ANOVA test was used for comparison of baseline PI with number of episodes of hypotension ($p<0.05$) and no of times vasopressors used ($p<0.05$).Higher baseline PI was associated with more episodes of hypotension. Higher baseline PI was associated with more times of vasopressor use.

ROC Analysis

The ROC analysis revealed that baseline PI was suitable for detecting parturients at risk for hypotension (AUC=0.859). The baseline cut-off point that predicted hypotension as determined by ROC analysis was 2.65 with sensitivity of 91.6%, specificity of 70%, positive predictive value of 78.4%,negative predictive value of 87.7% and accuracy of 81.8%.

From a previous similar study the best cutoff value of Baseline PI for prediction was obtained as 3.5.In my study cutoff value of PI 3.5 gives a sensitivity of 81.9%, specificity of 74.6 and accuracy of 78.6%.

The patient characteristic and obstetric characteristics were compared according to the Baseline PI cut-off point of 2.65 determined by the above ROC analysis.

97parturients (63%) had baseline PI>2.65 and hypotension was observed in 76 of those parturients (78%). 57 parturients (27%) had baseline PI<2.65 and hypotension was observed in 7 of those parturients (12%).

Discussion

The perfusion index (PI) derived from a pulseoximeter is the ratio of the pulsatile blood flow to then on pulsatile blood in peripheral tissue, and can be measured non-invasively. PI can be used to assess changes in peripheral vascular tone. Normal pregnancy is characterized by a decrease in systemic vascular resistance and increases in total blood volume and cardiac output. Pregnant women, particularly after 30weeks of gestation, have more blood volume pooled in extremities due to the pregnancy-induced decrease in vasculartone. The sympathetic blockade caused by spinal anaesthesia in healthy pregnant women can further increase the pooling of blood, resulting in more trapped blood in the extremities compared with non-pregnant women. However, the degree of decrease in vasculartone in parturients may vary depending on the gravidity, parity of pregnancy and other factors. Therefore parturients with low baseline vascular tone are more at risk to develop hypotension during spinal anaesthesia than those with relatively higher baseline vasculartone. This study was aimed to examine whether baseline Piinparturients can be correlated with the degree of hypotension after spinal anaesthesia for Caesarean delivery and whether baseline PI can predict hypotension after spinal anaesthesia for caesarean delivery. 170 parturients were selected for study after applying inclusion and exclusion criteria. Among them 8 were excluded because their upper sensory block did not reachT6.Another 8 parturients were excluded because of additional oxytocin requirements. Total 16 parturients were excluded. Analysis was done on the remaining 154 parturients.85 percent of study population is in the age group 20-29 with mean age of 25. Majority of study population is having gravidity 1 and parity 0.Baseline PI ranges from 0.8to9.2 with a mean of 3.61.BMI of the study population ranges from 15.6to40.9 with a mean of 28.BaselineHR ranges from 56to114 with mean of 86.Baseline SBP ranges from 90 to 168 with a mean of 119.Baseline MAP ranges from 65 to 128 with a mean of 83.

In this prospective observational study with diagnostic test evaluation it was demonstrated that higher baseline PI was associated with greater decrease in mean arterial pressure ($p<0.05$),greater episodes of hypotension($p<0.05$) and increased times of vasopressor use ($p<0.05$).It was demonstrated that lower parturient height is associated with greater decrease in mean arterial pressure.($p<0.05$).It was demonstrated that lower baseline MAP was associated with greater decrease in mean arterial pressure ($p<0.05$). From ROC analysis AUC was obtained as 0.859.AUC is >0.5 Hence prediction is possible. Best cut off of baseline PI for prediction of hypotension after spinal anaesthesia was obtained as 2.65 with a sensitivity of 91.6%, specificity of 70.4%, PPV of 78.4%,NPV of 87.7% and accuracy of81.8%

In a previous similar study **"**Perfusion index derived from a pulseoximeter can predict the incidence of hypotension during spinal anaesthesia for Caesarean delivery" by S.Toyama*, M. Kakumoto, (British Journal of Anaesthesia 111(2):235–41(2013) the best cutoff value of baseline PI for predicting hypotension by ROC analysis was 3.5 with a sensitivity of 81% and specificity of 86%. In our study, cutoff point of baseline PI of 3.5 gives a sensitivity of 81.9%, specificity of 81.9% accuracy of 78.6%.

Other patient factors and baseline parameters like age, weight, BMI, gravidity, parity, gestational age, baseline HR baseline SBP were not associated with degree of hypotension after spinal anaesthesia for caesarean delivery.

There were limitations in the study. Hemodynamic parameters such as cardiac output and systemic vascular resistance were not measured. Plethysmographic signal analysis is sensitive to patient movement, and PI is also decreased in case of sympathetic activation by several factors such as stress and anxiety or other systemic and local pathological causes, which in turn cause peripheral vasoconstriction which can give false, PI values. In my study, baseline values of PI and haemodynamic parameters were obtained with parturients in the supine position, whereas a15 degree left lateral table tilt was applied after spinal injection. In pregnant women, the supine position is Known to be associated with significant aortocaval compression by the gravid uterus, reducing venous return, cardiac output, and arterial pressure, and its effect on the baseline values could not be ruled out. PI values might vary when measured with different types of monitors. However in this study only MINDRAYS multi parameter monitor was used. Baseline PI varies be at to be at and hence it was difficult to determine an accurate value.

Despite these limitations, the study demonstrated that baseline PI was correlated with the development of hypotension during spinal anaesthesia for Caesarean delivery and baseline PI can predict the hypotension. From this study it was found out that a PI value of >2.65can predict hypotension after spinal anaesthesia for caesarean delivery.

Conclusion

The study demonstrated that higher baseline PI is associated with degree of hypotension after spinal anaesthesia for caesarean delivery and baseline PI can predict the incidence of spinal anaesthesia induced hypotension.

From this study it was found out that Baseline PI value of >2.65 can predict hypotension after spinal anaesthesia for caesarean delivery.

Lower parturient height is associated with greater degree of hypotension after spinal anaesthesia for caesarean delivery.

Lower baseline MAP is associated with greater degree of hypotension after spinal anaesthesia for caesarean delivery.

Higher baseline PI is associated within creased episodes of hypotension and increased vasopressor use after spinal anaesthesia for caesarean delivery.

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