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OBSTETRICS

Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anaesthesia for Caesarean delivery

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Editor's key points

- Hypotension is common during spinal anaesthesia for Caesarean delivery.
- The authors evaluated the relationship of this hypotension with resting vascular tone.
- The vascular tone was assessed by a perfusion index (PI) as derived using a pulse oximeter.
- Importantly, higher PI was associated with increased risk of hypotension.

Background. Hypotension during spinal anaesthesia for Caesarean delivery is a result of decreased vascular resistance due to sympathetic blockade and decreased cardiac output due to blood pooling 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 (PI) derived from a pulse oximeter has been used for assessing peripheral perfusion dynamics due to changes in peripheral vascular tone. The aim of this study was to examine whether baseline PI could predict the incidence of spinal anaesthesia-induced hypotension during Caesarean delivery.

Methods. Parturients undergoing elective Caesarean delivery under spinal anaesthesia with hyperbaric bupivacaine 10 mg and fentanyl 20 μg were enrolled in this prospective study. The correlation between baseline PI and the degree of hypotension during spinal anaesthesia and also the predictability of spinal anaesthesia-induced hypotension during Caesarean delivery by PI were investigated.

Results. Baseline PI correlated with the degree of decreases in systolic and mean arterial pressure ($r=0.664$, $P<0.0001$ and $r=0.491$, $P=0.0029$, respectively). The cut-off PI value of 3.5 identified parturients at risk for spinal anaesthesia-induced hypotension with a sensitivity of 81% and a specificity of 86% ($P<0.001$). The change of PI in parturients with baseline PI$\leq$3.5 was not significant during the observational period, while PI in parturients with baseline PI$>$3.5 demonstrated marked decreases after spinal injection.

Conclusions. We demonstrated that higher baseline PI was associated with profound hypotension and that baseline PI could predict the incidence of spinal anaesthesia-induced hypotension during Caesarean delivery.

Keywords: anaesthesia, obstetric; anaesthetic techniques, subarachnoid; complications, hypotension; equipment, pulse oximeters; measurement techniques, plethysmography

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Spinal anaesthesia-induced hypotension during Caesarean delivery is the result of decreased vascular resistance due to sympathetic blockade[1] and decreased cardiac output due to blood pooling in blocked areas of the body.[2–4] Although baseline volume status is known to affect the degree of hypotension,[5] baseline peripheral vascular tone may also have influence. Peripheral vascular tone has been shown to be decreased in parturients at term, especially in those who are multiparous.[6–9] 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.[10] Therefore, parturients with low baseline vascular tone may be at an increased risk of developing hypotension after spinal anaesthesia.

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,[11] and can be measured non-invasively. PI can be used to assess peripheral perfusion dynamics due to changes in peripheral vascular tone.[12–16] This study was aimed to examine whether baseline PI in parturients correlated with the degree of hypotension during spinal anaesthesia for Caesarean delivery and whether baseline PI could predict such hypotension.

Methods

After approval of the study by the Institutional Ethics Committee (Teikyo University Chiba Medical Center, Chiba, Japan), parturients undergoing Caesarean delivery were included consecutively between January 2010 and March 2011. The exclusion criteria were emergency cases, placenta praevia, preeclampsia, cardiovascular or cerebrovascular disease, morbid obesity with a BMI$\geq$40, gestational age $<$36 or $>$41 weeks, and contraindications to spinal anaesthesia. Eighty-three parturients underwent Caesarean delivery during this period; of which, 24 were emergency cases, 11 were excluded for various other reasons (two for general anaesthesia, eight for placenta praevia, and one for morbid obesity), and nine did not consent. The remaining 39 parturients were enrolled in this prospective observational study. Written informed consent was obtained from each parturient in the study.

Study protocol

Each parturient was given an infusion of 500 ml of 6% hydroxyethyl starch 70/0.5 (HES) (Salinhes®, Fresenius Kabi, Tokyo, Japan) for prehydration before spinal anaesthesia via an i.v. cannula. A fixed volume of fluid was given in this study because the variability of parturient weight was not large [63 (11) kg, mean (standard deviation, SD)] since morbidly obese parturients were excluded from the study. After the prehydration, 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. The cuff of an automated NIAP device (Philips Electronics Japan, Tokyo, Japan) was attached to the right arm, and systolic arterial pressure (SAP) and diastolic arterial pressure (DAP) were monitored. The mean arterial pressure (MAP) was calculated from the equation: MAP=DAP+(SAP−DAP)/3. The pulse oximeter probe (Mashimo Radical 7; Mashimo Corp., Irvine, CA, USA) was attached to the left index finger. Baseline NIAP, heart rate (HR), and PI were recorded in the supine position. The anaesthesiologists in this study were blinded to the value of PI.

A combined spinal–epidural procedure was performed with the parturient in the right lateral decubitus position. An epidural catheter was inserted at the L1–2 or L2–3 interspace. After a negative test dose with 3 ml of 1.0% lidocaine plus 1:100 000 epinephrine, spinal anaesthesia was induced with a total of 10 mg of 0.5% hyperbaric bupivacaine (Marcaine®; AstraZeneca, Osaka, Japan) and 20 μg fentanyl (total volume 2.4 ml) at the L3–4 interspace. Immediately after the epidural catheter was taped into place, the parturient was returned to the supine position with a left lateral tilt of 15° to facilitate left uterine displacement. The upper sensory block level was checked 5 min after the spinal injection by assessing the loss of cold sensation from alcohol swabs. If a Th6 sensory block level was not achieved, an epidural supplement of 2% lidocaine (with sodium bicarbonate 1 mEq 10 ml^{-1}) was administered in 5–10 ml increments to attain a Th6 sensory block level, and these parturients were excluded from the study.

Maternal NIAP, 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$>$25% from baseline. This definition was based on a previous study.[17] When SAP decreased to this level, a bolus of 50 μg phenylephrine was given as a rescue medication, keeping the decrease within SAP$\leq$25% from baseline. Rescue phenylephrine 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 $\leq$25%. A bolus of 0.5 mg atropine was to be given if hypotension occurred in combination with bradycardia (HR $<$55 beats min^{-1}). Oxygen was not routinely given unless the arterial oxyhaemoglobin saturation obtained from pulse oximeter decreased to $<$95%. Hypotensive events were not treated by additional fluid loading.

Arterial blood gas samples were obtained from the umbilical cord. Apgar scores at 1 and 5 min after delivery were recorded by the midwife.

Statistical analysis

Patient characteristic data are presented as mean (SD) or median (range) where appropriate. Since a literature search found no data on the strength of correlation between baseline PI and change in SAP from baseline, a correlation hypothesis of a correlation coefficient (r)=0.50 was assumed in this study based on a study that showed r=0.541 ($P<0.001$) between baseline HR and the SD of MAP during spinal anaesthesia for Caesarean delivery.[18] To measure such a correlation coefficient at the desired power of 0.8 and two-tailed α of 0.05, this study required a sample size of 35 parturients. To allow for a possible dropout rate of 10%, we needed 39 parturients in this study.

Spearman's rank correlation was used to assess the correlations between parturient characteristics or baseline parameters and the per cent decrease in arterial pressure from baseline. Multiple linear regression analysis was performed to assess the relationships between parturient characteristics and baseline parameters with a decrease in SAP and MAP from baseline. Because multicollinearity among the covariates can give spurious results, backward stepwise procedures were performed to identify the independently associated variables.

To test the abilities of baseline PI, parturient characteristics (height and weight),[19 20] parturient baseline HR[18] to predict spinal anaesthesia-induced hypotension in Caesarean delivery, and areas under the receiver operating characteristic (ROC) curves of hypotension were calculated. The area under the curve (AUC) is a measure of the parameter's accuracy (AUC=0.5: no better than chance, no prediction possible; AUC=1.0: best possible prediction). The optimal cut-off point is the one that has the smallest false-positive and false-negative rates across a range of cut-off points.