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ORIGINAL ARTICLE

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Role of pleth variability index for predicting hypotension after spinal anesthesia for cesarean section

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ABSTRACT
Background: Hypotension is frequently observed after spinal anesthesia for cesarean section and can be detrimental to both mother and baby. We investigated the role of the pleth variability index for predicting hypotension after spinal anesthesia for cesarean section.
Methods: Eighty-five parturients undergoing elective cesarean section under spinal anesthesia were enrolled. We recorded pleth variability index and perfusion index before anesthesia, and blood pressure, heart rate and pulse oxygen saturation before and after anesthesia. The association between baseline pleth variability index and perfusion index with hypotension after spinal anesthesia was explored using multivariate analysis.
Results: Hypotension occurred in 42 parturients. Baseline pleth variability index was higher in parturients who experienced hypotension than in those who did not ($P < 0.05$), although there was no difference in baseline perfusion index. The area under the receiver operating characteristic curve was 0.66 for baseline pleth variability index for the prediction of hypotension ($P < 0.05$). Baseline pleth variability index was significantly related to the incidence of hypotension ($P = 0.017$), but was not significantly related to the magnitude of the decrease in systolic blood pressure. Baseline perfusion index was not significantly related to the magnitude of the decrease in systolic blood pressure.
Conclusion: Greater baseline pleth variability index was associated with hypotension after spinal anesthesia for cesarean section, but may not be a clinically useful predictor.

Keywords: Pleth variability index; Perfusion index; Cesarean section; Spinal anesthesia; Hypotension

Introduction

Hypotension is a common complication of spinal anesthesia for cesarean section. It is caused mainly by peripheral vasodilation and is usually associated with a compensatory increase in cardiac output.[1,2] The occurrence of hypotension after spinal anesthesia may have a partial relationship with the intravascular volume before spinal anesthesia. Therefore, monitoring techniques that evaluate intravascular volume may predict the occurrence of hypotension and help guide fluid therapy and vasopressor prophylaxis. Previous studies have confirmed that pulse pressure variation and stroke volume variation can determine the necessity of fluid therapy to improve the outcomes in mechanically ventilated patients.[3–5] Non-invasive parameters have particularly aroused attention; for example, respiratory variations in pulse oximeter plethysmographic waveform amplitude, which have close association with stroke volume variation, are extremely sensitive to changes in preload.[6–8]

Pleth variability index (PVI) is the variable parameter of perfusion index (PI) during the respiratory cycle. It represents the ventilation-induced respiratory changes in PI, using the maximum and minimum PI values over a given period of time, and is calculated from the percentage difference between the two parameters:

$$\mathrm{PVI} = (\text{maximum PI} - \text{minimum PI})/\text{maximum PI} \times 100\%$$

PVI reflects the respiratory variations in pulse oximeter plethysmographic waveform amplitude, and can be instantly and continuously monitored and recorded. Previous studies have demonstrated that PVI may reflect intravascular volume, with higher values of PVI associated with lower intravascular volume.[9–13]

The aim of this study was to investigate the association of PVI before spinal anesthesia with the occurrence of hypotension after anesthesia and to determine whether PVI may be a useful tool to aid in the prediction and prevention of hypotension after spinal anesthesia for cesarean section.

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Methods

The study was approved by the Medical Ethics Committee of Obstetrics and Gynecology Hospital of Fudan University, Shanghai, China, and was registered at http://www.chictr.org/usercenter/index/ (reg.no. ChiCTR-ONC-12002215). Written informed consent was obtained from all participants. Eighty-five women undergoing elective cesarean section under spinal anesthesia were enrolled in this prospective observational study. Exclusion criteria included obesity (body weight >115 kg), height <152 cm, diabetes mellitus, hypertension, heart disease, multiple pregnancy, breech presentation, age <18 or >40 years, and presence of painful uterine contractions.

No premedication was given. The temperature in the operating room was maintained at 22°C. Patients were placed supine with 15° left lateral tilt achieved using a wedge under the right buttock. Electrocardiograph (ECG), oxygen saturation (SpO_2), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and heart rate (HR) were monitored by one anesthesiologist (S/5 Anesthesia Monitor, GE Healthcare, Helsinki, Finland). The probe of a Masimo Radical 7 (Masimo Corp., Irvine, CA, USA) was placed on the right index finger to measure PVI and PI, which were recorded by one nurse. The anesthesiologists were blinded to PVI and PI values. Mean values were recorded at 3-min intervals for three consecutive times to determine their baseline. Peripheral vein catheterization on the right hand was then performed but no prehydration was given. Hydroxyethyl starch solution 500 mL was infused at the rate of 0.4 mL/kg/min, then lactated Ringer's solution was infused at the same rate until the end of surgery. Combined spinal–epidural anesthesia was administered with patients in the left lateral position at the L3-4 vertebral interspace. A 16-gauge Tuohy needle was placed in the epidural space using loss of resistance to saline, then a 25-gauge Whitacre spinal needle was inserted through the Tuohy needle until the dura mater was punctured. Once free flow of clear cerebrospinal fluid (CSF) was observed in the spinal needle, 0.5% isobaric bupivacaine 10 mg (2 mL) was diluted with CSF to 2.5 mL, then injected over 15–30 s. After placement and fixation of an epidural catheter, patients were placed supine with 15° left lateral tilt, and oxygen was given via facemask at 5 L/min. SpO_2, SBP, DBP, MAP and HR were recorded minutely for 10 min. The sensory block level to cold was monitored every three minutes (1, 4, 7 and 10 min) using alcohol swabs and was recorded at 10 min. Hypotension was defined as SBP <80% of baseline and was treated with intravenous phenylephrine 100 μg as required. Intravenous atropine 0.3 mg was given for sinus bradycardia <50 beats/min. For patients with inadequate sensory block, 1% lidocaine was given through the epidural catheter. Surgery was allowed to start when the sensory block reached the T6 level; if this level was not achieved patients were excluded from the study.

Statistical analysis

In a preliminary trial of 30 parturients we found the standard deviation of baseline PVI was 5.3 and the incidence of hypotension 50% after spinal anesthesia using bupivacaine 10 mg. With one-tailed α of 0.05, in order to achieve a difference of no less than 3 in baseline PVI between two equal groups, we calculated that a total sample size of 78 was needed to attain the desired power of 80%. To allow for potential exclusions, a total of 85 patients were included.

Graphpad Prism 5 (GraphPad Software, Inc, La Jolla, CA, USA) and R software 2.15.1 (http://www.R-project.org) were utilized for statistical analysis. Results were expressed as mean ± standard deviation (SD) or median [interquartile range] as appropriate. Data were assessed for normal distribution using normality plots and the Kolmogorov–Smirnov test. Normally-distributed numerical variables were compared between groups by Student's independent samples t test. Non-normally-distributed data were compared between groups by the Wilcoxon rank sum test. The area under the receiver operating characteristic (ROC) curve was used to assess the ability of baseline PVI to predict hypotension with optimal threshold value determined by the point of maximum sum of sensitivity and specificity. A multiple logistic linear regression model was used to explore the relationship of baseline PVI with the incidence of hypotension and multiple linear regression models were used to explore the relationships of baseline PVI and PI with the degree of decrease in SBP. The controlled covariates were baseline SBP, baseline HR and baseline PI. All statistical tests were two-sided with $P < 0.05$ considered statistically significant.

Results

Three parturients were excluded because of an inadequate level of spinal anesthesia. Patient characteristics and baseline mean PVI and PI values are shown in Table 1. Hypotension occurred in 42 of the 82

Table 1 Patient characteristics and baseline data of 82 patients

Age (years)	29.3 ± 6.1
Weight (kg)	74.3 ± 9.3
Height (cm)	162 ± 6.1
Body mass index (kg/m^2)	29.2 ± 7.6
Baseline pleth variability index	20.6 ± 5.9
Baseline perfusion index	5.6 ± 0.6

Data are mean ± SD.