Predictive effect of the difference of brachial artery peak velocity during the valsalva maneuver in different positions on supine hypotension syndrome of parturient after spinal anesthesia

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Research article

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Abstract

BACKGROUND: The effectiveness of predicting the incidence of supine hypotension syndrome (SHS) after spinal anesthesia was measured by ultrasonic measurement of the variation of brachial artery peak velocity in different positions of parturient.

METHODS: Parturient scheduled for elective cesarean section. ASAI or □, were divided into SHS group and no SHS group (SBP in the upper extremity decreased by>30 mmHg or decreased to<80 mmHg) after spinal anesthesia. To record HR, SBP, DBP, MAP of supine position and left lateral position before anesthesia, and to measure brachial artery peak velocity during the Valsalva maneuver by Ultrasonic. Calculate the differences of the above indexs before and after the transformation position. The receiver operating characteristic (ROC) curve was plotted to evaluate the predictive effect of each index on SHS after spinal anesthesia.

RESULTS: Among the 84 patients, 41 cases (48.81%) developed SHS after spinal anesthesia. brachial artery peak velocity maximum (Vpmax), brachial artery peak velocity minimum (Vpmin) and brachial artery peak velocity variation (ΔVp) were different before and after the transformation position. The difference in SHS group is significantly greater than non SHS group ($P<0.05$). The areas under ROC curve (AUC) of ΔVpmin, ΔΔVp, ΔVpmax, were 0.859, 0.794□0.614, 95%CI were 0.776□0.941, 0.689□0.899, 0491□0.736, and the cut-off values were 10.55cm/s, 5.98%, 8.40cm/s.

CONCLUSION: The difference of brachial artery peak velocity measured by ultrasonic in different positions of parturient during the Valsalva maneuver can effectively predict the occurrence of SHS, in which ΔVpmin≥10.55cm/s has better predictive effect.

Trial registration: China Clinical Trial Register ChiCTR1900022704, prospective registered on 23. April 2019.

1. Background

Supine hypotension syndrome (SHS) refers to a group of symptoms such as chest tightness, dizziness, nausea and vomiting in the supine position of late pregnant women. SBP decreases by 30 mmHg or below 80 mmHg. When change to left lateral position, the above symptoms are alleviated or disappeared[1]. The reason is that the huge uterus oppresses the inferior vena cava and squeezes the abdominal organs, resulting in a significant reduction in the volume of cardiac return blood.

Spinal anesthesia always provides a reliable result during caesarean section, but With the relaxation of abdominal muscles and uterine attachment ligaments after spinal anesthesia, uterine pressure on inferior vena cava is aggravated, could induce or aggravate SHS. How to effectively predict the occurrence of SHS after spinal anesthesia, Prepare the anesthesiologist well in advance, It is essential for the safety of mother and child during surgery.

The forced exhalation caused the pressure in the chest to surge during the early Valsalva maneuver, Which reduces venous reflux. Ventricular filling, diastolic end-volume, and internal vascular system regurgitation decreased[2]. According to the Frank-Starling mechanism, in preload dependent patients, their cardiac output depends primarily on venous reflux. The continuous increase in intrathoracic pressure must lead to a significant decrease in the stroke volume and arterial velocity during the early Valsalva maneuver. In contrast, for non-preload dependent patients, venous reflux is not a limiting factor for cardiac output, the impact of increased intrathoracic pressure on cardiac output is reduced.

With maternal from supine to left side, uterine pressure on the inferior vena cava and abdominal aorta reduced, bringing blood from the lower limbs and abdominal cavity back to the systemic circulation, left ventricular stroke volume increased, as the blood volume increases, can reduce the reduction of left ventricular stroke volume caused by increased intrathoracic pressure when the maternal's valsalus exhalation. Therefore, before the Spinal anesthesia, the change in left ventricular stroke volume during valsalus exhalation before and after maternal change body position can reflect the degree of pressure of the uterus on the lower vena cava and abdominal aorta. Does this have a predictive effect on supine hypotension syndrome after the Spinal anaesthesia, It's still to be studied.

Ultrasound measurement of brachial artery peak flow rate can reflect changes in left ventricular stroke volume, can be used to determine volume reactivity[3−4], and the operation method is easy to grasp, convenient, non-invasive. In this study, the changes of brachial artery peak velocity under different postures of maternity were measured by ultrasound, and the effectiveness of SHS after spinal anesthesia was predicted.

2. Methods

2.1 normal information

This study is a prospective, single-center, randomized controlled study. It was approved by the Institutional Ethics Committee (2017-102-01), Registration through clinical trials(ChiCTR1900022704), The study was conducted from May 2019 to September 2019. Each patient signed the informed consent form.The inclusion criteria were single fetal maternal undergoing elective cesarean delivery with spinal anesthesia,ASAI-II, patients with pregnancy-induced hypertension(PIH), gestational diabetes mellitus(GDM), unstable cardiac rhythm, contraindications of spinal anesthesia were excluded.

2.2 Anesthesia method

All maternal were performed routine monitoring of ECG, HR, BP, SpO_2 with no premedication, establishing upper extremity venous access, Sodium Potassium Magnesium Calcium and Glucose Injection were given intravenous to supple physiological need for $10ml \cdot kg^{-1} \cdot h^{-1}$. In the supine position for patients after a 5-min relaxation period before spinal anesthesia, HR, SBP, DBP, MAP, brachial artery peak velocity were measured. Wedge position pad was used to make body left 30 degrees, HR, SBP, DBP, MAP and brachial artery peak velocity were measured 5 minutes later. The difference between supine position and lateral position was calculated(Δ). Spinal anesthesia was performed at the L3-L4 intervertebral space, with the patient in the left lateral position. After successful puncture, 0.3% ropivacaine 3.5 ml (1% ropivacaine 1 mL + saline 2.5 ml) was injected, injection time 20 s, sensory blocking plane was controlled T6-8. Oxygen was routinely inhaled during surgery, atropine was given if HR�50 times/min; ephedrine was immediately injected and infusion was speeded up when SHS appeared. Supine hypotension syndrome is generally diagnosed with a decrease in systolic BP of at least 30 mmHg or a systolic blood pressure of less than 80 mmHg. All maternal By anesthesiologist were randomly divided into 2 groups according to the presence of SHS or absence of SHS during the operation.

2.3 Standard Valsalva maneuver and brachial artery peak velocity measurements

The Mylab Alpha type ultrasonic instrument and SL1543 type probe (3�13 MHz)was used in all ultrasonographical examinations. According to the literature[3], to find brachial artery by two-dimensional ultrasound 5 cm above the right elbow, to measure blood flow velocity by pulse Doppler, the angle of the sampling frame was consistent with the direction of the blood vessel, sampling location was located in the center of the arteries, sampling angle �60°. The Valsalva maneuver pressure monitoring device was composed of a whistle, connecting pipe, TE2000 type pressure gauge and so on. To conduct the Valsalva maneuver training after monitoring[5]: prescribing the parturient to start to bite the whistle and breathe out in a calm breathing state, maintaining pressure 30 mmHg(1mmHg = 0.133 kPa), releasing rapidly after 15 s and then breathing smoothly. To begin the study after the training standard. The parturient began the Valsalva maneuver, in the same time, brachial artery peak velocity spectrum was recorded within 15 s after the start of the Valsalva maneuver, then brachial artery peak velocity maximum(Vpmax) and minimum�Vpmin� value in the early expiratory phase were measured, taking the average of 3 measurements of 3 respiratory cycles, calculating the brachial artery peak velocity variation degree�ΔVp�. ΔVp=�Vpmax-Vpmin�/��Vpmax + Vpmin�/2�×100%. Calculating ΔVpmax, ΔVpmin, ΔΔVp, which were the difference of measured values of maternal between supine position and side-lying position. Ultrasound measurements were performed by the same experienced sonographer.

2.4 Data analysis

Data was analyzed using SPSS 17.0. All data were expressed as mean standard deviation, apaired t-test was used to compare the variables between the patient group and the control group. Evaluation of the prediction effect of each indicator on SHS by ROC curve, the most Youdon's index method determines the diagnostic threshold of each indicator. Statistical significance was set at P�0.05.

3. Results

In this study, double normal method is used to estimate the sample size. Eighty-seven maternal were enrolled in the study, among the maternal, Three cases developed SHS before spinal anesthesia, were excluded from the study.Finally, 84 pregnant women were enrolled, 41 cases(48.81%) developed SHS after spinal anesthesia(Fig. 1). There were no significant differences between the two groups regarding age, BMI, gestational week, and anesthesia block plane (P > 0.05) (Table1).

Table 1
Comparison of general conditions between two groups of maternal($\bar{x} \pm s$)

Parameters	cases (number)	Age (years)	BMI (kg/m^2)	Gestational week (weeks)	Sensory blockade plane (T)
Non-SHS group	43	30.95 ± 5.62	29.78 ± 4.17	38.82 ± 1.7	6.92 ± 0.8
SHS group	41	31.36 ± 4.37	30.20 ± 4.76	38.91 ± 1.8	6.89 ± 0.7

There was no significant difference in ΔSBP, ΔDBP, ΔMAP, ΔHR between the two groups before and after the body position change (P > 0.05). The ΔVpmax, ΔVpmin and ΔΔVp of the SHS group were significantly higher than those of the non-SHS group (P < 0.05) (Table 2,Fig. 2,3).

Table 2
Comparison of changes in maternal hemodynamics between the two groups($\bar{x} \pm s$)

Parameters	cases (number)	ΔVp_{max} (cm/s)	ΔVp_{min} (cm/s)	ΔΔVp (%)	ΔSBP (mmHg)	ΔDBP (mmHg)	ΔMAP (mmHg)	ΔHR (Times/min)
Non-SHS group	43	7.23 ± 5.42	6.92 ± 3.92	3.60 ± 2.51	8.09 ± 5.61	8.37 ± 6.32	6.98 ± 6.35	3.63 ± 2.28
SHS group	41	12.60 ± 11.57^a	17.22 ± 9.48^a	8.59 ± 5.61^a	8.80 ± 6.39	8.02 ± 8.41	8.12 ± 6.71	4.59 ± 2.81

Compared with non-SHS group, $^a P < 0.05$

ROC curve evaluation:ΔVpmin, ΔΔVp predicts that the area under the receiver operating characteristic curve (AUC) of SHS is greater than other indicators, AUC of ΔVpmin was larger (Table 3,Fig. 4).

Table 3
The accuracy of ΔVp_{min}, $\Delta\Delta Vp$,ΔVp_{max},predicting SHS

Parameters	Diagnostic threshold	AUC	95%CI	Sensitivity(%)	Specificity（%）
ΔVp_{min}(cm/s)	10.55	0.859	0.776～0.941	78.0	88.4
$\Delta\Delta Vp$(%)	5.98	0.794	0.689～0.899	70.7	88.4
ΔVp_{max}(cm/s)	8.40	0.614	0.491～0.736	56.1	67.4
ΔSBP(mmHg)	7.50	0.527	0.402～0.651	48.8	58.1
ΔDBP(mmHg)	6.50	0.429	0.305～0.554	39.0	44.2
ΔMAP(mmHg)	9.50	0.576	0.453～0.699	26.8	79.1
ΔHR (Times/min)	2.50	0.608	0.487～0.729	80.5	39.5

4. Discussion

The full-term pregnancy developed severe supine hypotension resulting from inferior vena cava and abdominal aorta compression by the uterus, probable cause of both maternal and fetaldeath[6]. How to predict the incidence of supine hypotension syndrome (SHS), and to take appropriate prevention and intervention measures in advance was essential for maternal and fetal safety.

As reported in the literature[6, 7], weight can indirectly reflect the size of the uterus in pregnancy, and to estimate fetal weight through the ultrasonic measurement of fetal double top diameter can predict the size of the gravid uterus directly, both were the SHS risk factors. However ,there were more risk factors affecting the occurrence of SHS(eg, fetal position, inferior vena cava variation), predicting the occurrence of SHS based on risk factors was lack of feasibility in clinical work.

Brachial artery peak velocity can reflect changes in left ventricular stroke volume, can judge capacity reactivity effectively[3, 4].When maternal forced expiratory, intrathoracic pressure increased, leading to venous reflux and left heart filling reduction[8], with capacity insufficient, the increased intrathoracic pressure can cause an increased degree of declined left ventricular stroke volume[9]. With Maternal from supine to left side, the uterus to the inferior vena cava and abdominal aorta oppression mitigated, bringing blood from the lower limbs and abdominal cavity back to the systemic circulation, this effect was equivalent to fast infusion of liquid to the parturient, if the heart had a capacity of reactivity, left ventricular stroke volume would be increased accordingly. At the same time, with the increase of blood volume, could reduce the degree of left ventricular stroke volume decline caused by increased intrathoracic pressure when maternal forced expiratory. Therefore, this study calculated brachial artery peak velocity difference in the expiratory phase before and after the body positions, to reflect the uterus oppression of the abdominal aorta and inferior vena cava, thus to predict the degree of compression of the uterus on related blood vessels after spinal anesthesia, and to predict possible SHS. The study indicated ΔVpmin、ΔΔVp could effectively predict the SHS after spinal anesthesia.

The study developed SHS judgement criteria according to literature reports[1], and plotted the ROC curve of ΔSBP,ΔDBP, ΔMAP, ΔHR and ultrasound measurement indicators ΔVpmax, ΔVpmin, ΔΔVp before and after the body positions, evaluated appeal indicators to predict the accuracy of SHS after spinal anesthesia. The larger the AUC, the higher the diagnostic accuracy of the index. AUC greater than 0.7 indicated that the indicator had excellent diagnostic accuracy[10]. The results indicated that the variation of brachial artery peak velocity measured by ultrasonic measurement in different positions of parturient had better diagnostic accuracy than difference between Blood pressure and heart rate, among them, ΔVpmin ≥ 10.55 cm/s had a good predictive effect on SHS after spinal anesthesia, sensitivity 78.0%, specificity 88.4%.

Although the difference of brachial artery peak velocity measured by ultrasonicduring the Valsalva maneuver in different positions of parturient can effectively predict the occurrence of SHS, this method required early training of maternal Valsalva maneuver and spend some time, it was not applicable to patients with acute caesarean section. In the follow-up study, we would further adjust the research method and look for a more practical approach to clinical practice.

5. Conclusions

In summary, the difference of brachial artery peak velocity measured by ultrasonic in different positions of parturient during the Valsalva maneuver can effectively predict the occurrence of SHS, in which $\Delta Vp_{min} \geq 10.55$ cm/s has better predictive effect, and allow the anesthesiologist to be fully prepared in advance. It provides a non-invasive, accurate and effective method to ensure maternal and child safety during the perioperativeperiod.

Abbreviations

SHS: supine hypotension syndrome; ROC: receiver operating characteristic; AUC Area under curve; Vpmax: brachial artery peak velocity maximum; Vpmin: brachial artery peak velocity minimum; ΔVp: brachial artery peak velocity variation; ΔSBP: SBP difference between supine position and lateral position; ΔDBP: DBP difference between supine position and lateral position; ΔMAP: MAP difference between supine position and lateral position; ΔHR: HR difference between supine position and lateral position; ΔVpmax: Vpmax difference between supine position and lateral position; ΔVpmin: Vpmin difference between supine position and lateral position; ΔΔVp: ΔVp difference between supine position and lateral position

Declarations

Ethics approval and consent to participate

Ethics approval was granted by the Ethics Committee of Cangzhou Central Hospital, 16 Xinhua West Road, Cangzhou, China 061001. 22.12.2017.

We conduct our study in compliance with recognized international standards, including the principles of the Declaration of Helsinki. All experiments and data collection were performed with prior informed consent to participate. Written consent to participate in the study were obtained from each participant.

Consent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available from the corresponding author. The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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No funding was provided.

Authors' contributions

M.Q.and T.L. participated in the conception and design of the study.M.Q.,T.L.,J.L.,L.Y. performed the experiments,

collected and recorded the data.J.L.performed the ultrasonographic measurement.M.Q. analyzed the data and drafted the article.T.L.and L.Y. participated in the revision of the article. All authors have read and approved the final article.

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Not applicable.

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Figures

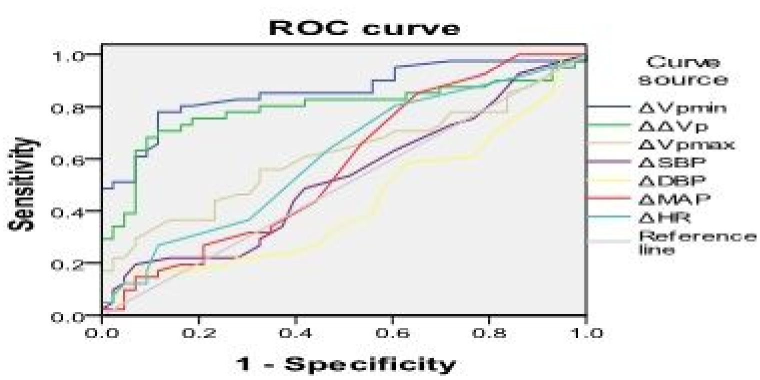

Figure 1

ROC curve of ΔVpmin, ΔΔVp, ΔVpmax, ΔSBP, ΔDBP, ΔMAP, ΔHR predicting SHS

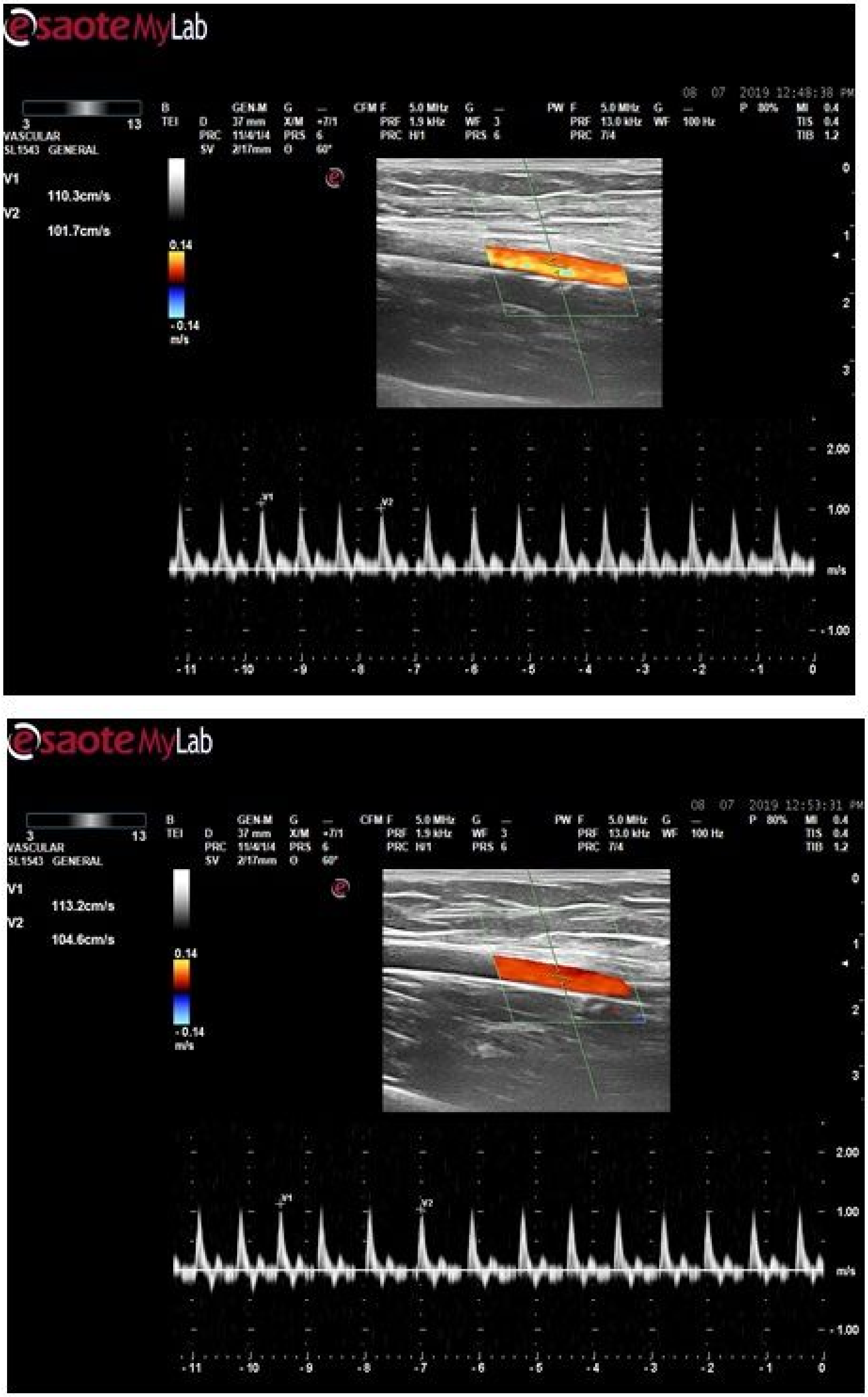

Figure 2

Brachial artery peak velocity of parturientinsupine position and left lateral position from non-SHS group

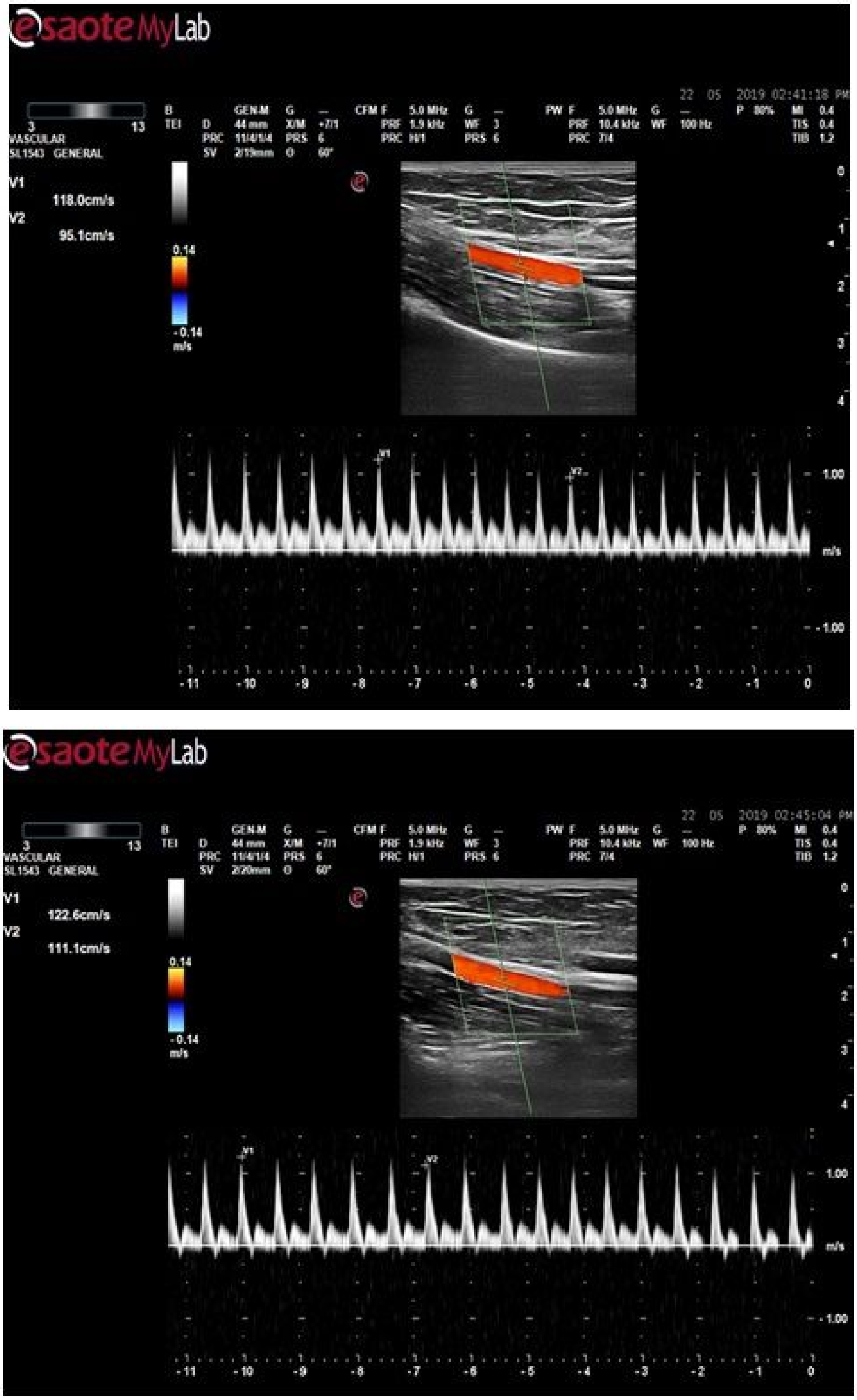

Figure 3

Brachial artery peak velocity of parturientinsupine position and left lateral position from SHS group

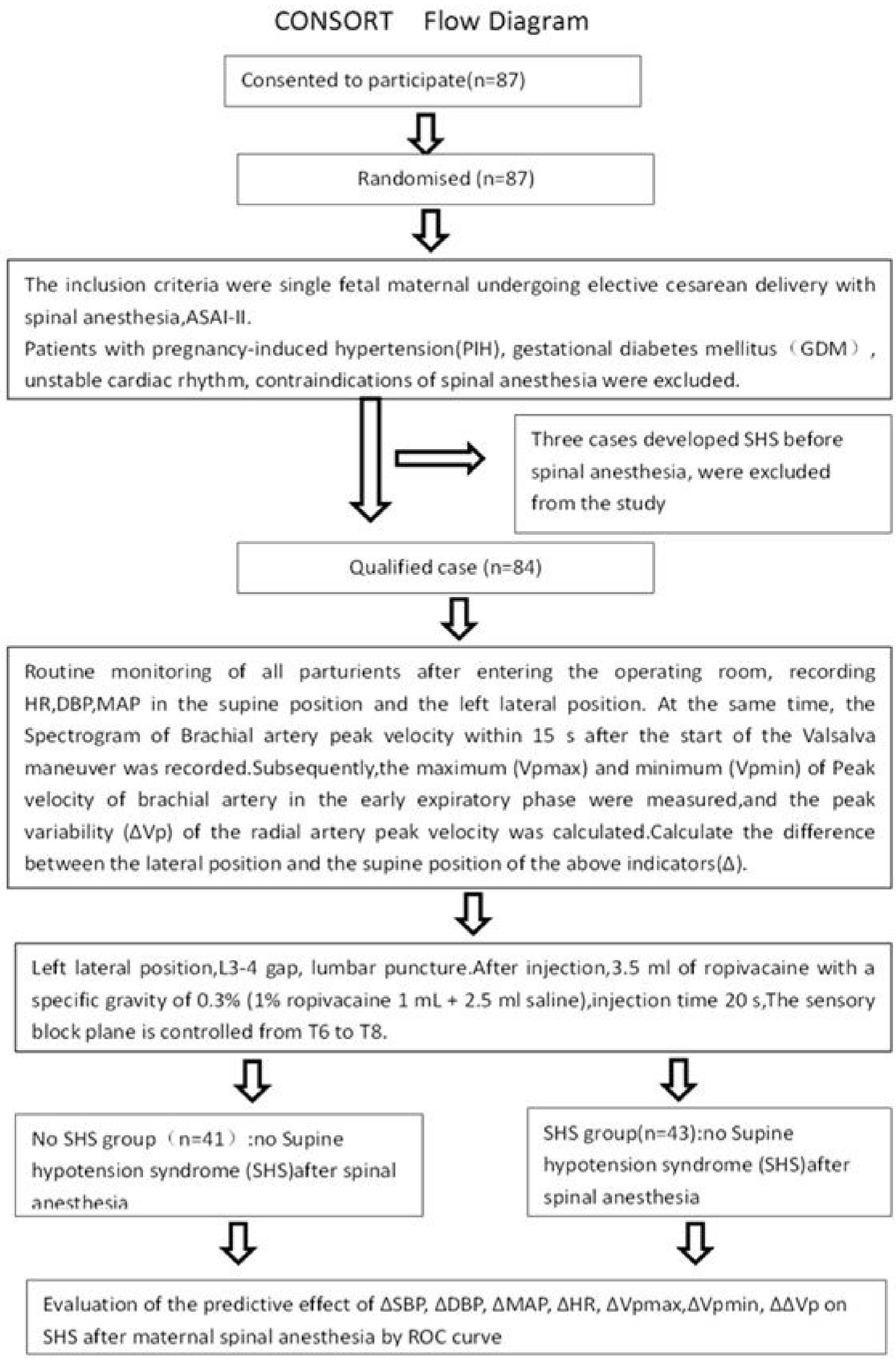

Figure 4

CONSORT Flow Diagram

Supplementary Files

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