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Prediction of Hypotension During Neuraxial Anesthesia in Patients with Pregnancy-Induced Hypertension Through Subclavian Vein Collapsibility Index

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Abstract: *Objective:* To explore and evaluate the predictive value of subclavian vein collapsibility index (SCV-CI) on hypotension during neuraxial anesthesia in patients with pregnancy-induced hypertension (PIH). *Methods:* Pregnant women with PIH who underwent elective cesarean section in our hospital from January to July 2021 were selected as the research subjects. Patients who experienced hypotension during anesthesia were included into the hypotension group, whereas patients who had a normal blood pressure during anesthesia were included in the normotensive group. The SCV-CI was then calculated for three respiratory cycles, the average value was taken as the base value, and the patient was monitored for another 20 minutes. The blood pressure, heart rate, blood oxygen saturation, and SCV-CI of the patients were measured, and the incidence of maternal nausea and vomiting and cord blood gas were recorded. Then, a correlation analysis was conducted on the relationship between subclavian vein collapsibility index and hypotension. A receiver operating characteristic curve was drawn to seek the threshold value of subclavian vein collapsibility index for post-anesthesia hypotension. *Results:* There was no significant difference in systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) between the two groups before anesthesia ($P > 0.05$). After anesthesia, the above indexes (SBP, 103.25 ± 12.48 mmHg; DBP, 58.94 ± 7.46 mmHg; and HR, 52.96 ± 6.48 beats/min) were significantly lower than those of the normal blood pressure group, and the difference was statistically significant ($P < 0.05$). In comparison, the SCV-CI in the hypotension group was 35.82 ± 4.93% greater than that in the normal blood pressure group (23.85 ± 5.27%), and the incidence of nausea and vomiting in the hypotension group (40.0%) was significantly higher than that in the normotensive group (10.53%), and the difference was statistically significant ($P < 0.05$). The area under the curve of SCV-CI prediction against hypotension in patients with PIH under neuraxial anesthesia was 0.825 (95% CI: 0.762–0.893, $P < 0.001$), the cut-off value was 25.68%, the predictive sensitivity was 92.68%, and the specificity was 81.24%. *Conclusion:* SCV-CI has a good predictive value for the occurrence of hypotension in patients with PIH during neuraxial anesthesia.

Keywords: Subclavian vein collapsibility index; Pregnancy-induced hypertension; Neuraxial anesthesia; Hypotension

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1. Introduction

General anesthesia in obstetrics has been improving, but spinal anesthesia is still the preferred technique in cesarean section. This is because spinal anesthesia avoids some risks of general anesthesia, and patients with pregnancy-induced hypertension (PIH) can stay awake and participate in the childbirth process, which promotes early bonding with newborns and breastfeeding, and is helpful in postoperative pain control [1]. After spinal anesthesia, the fetus and uterus presses against the inferior vena cava and (or) the abdominal aorta, and the blood returned to the heart decreases drastically, resulting in a decrease in cardiac output, which is the main cause of hypotension or supine position syndrome [2,3]. After spinal anesthesia, blood vessels below the sympathetic nerve block plane dilates, and muscle relaxation aggravates venous dilation, all of which results in reduced cardiac blood return and reduced cardiac displacement [4]. Therefore, an early prediction of hypotension after spinal anesthesia in patients with PIH is important to ensure a smooth delivery [5]. In this research, pregnant women with PIH who underwent elective cesarean section in our hospital from January to July 2021 were selected as the research subjects, and the relationship between subclavian vein collapsibility index SVC-CI on hypotension in PIH patients during neuraxial anesthesia.

2. Materials and methods

2.1. General information

After the study was approved by the ethics committee, 68 pregnant women with pregnancy-induced hypertension who underwent elective cesarean section in our hospital from January to July 2021 were selected as research subjects. The patients with contraindication of intraspinal anesthesia and those who are deemed not suitable for the study were discharged. Cases with intraspinal anesthesia level lower than T6, which meant that the anesthesia was not effective, were excluded. Patients who needed to change the anesthesia method were not included in the statistics.

2.2. Method

All subjects of this research fasted for 6 hours (food) and 2 hours (drink) before the operation. They received sedative and antispasmodic therapy before the operation. After entering the operating room, their blood pressure, electrocardiogram (ECG), and oxygen saturation were monitored. All puerperae involved in this research were treated with combined spinal epidural anesthesia, L3-4 space puncture. They also received subarachnoid injection of 14-15mg 0.5% ropivacaine. A tunneled epidural catheter of 3–4 cm was inserted, and controlled anesthesia was injected into plane T6-T4. At the beginning of anesthesia, the patients were given rapid fluid supplement of 10 mL/kg. 0.3mg atropine were administered to patients with heart rate lower than 50 times/minute, and patients with blood pressure below 20% of the normal value was considered as post-anesthesia hypotension and was included in the hypotension group (n = 30), and norepinephrine was injected to maintain their blood pressure. Patients with blood pressure above 20% of the baseline value without the need for vasopressors were included in the normotensive group (n = 38).

Inspection of subclavian vein collapsibility index: Before anesthesia, a high-frequency linear array probe was placed on the sagittal plane of the right midclavicular line perpendicular to the long axis of the subclavian vein for the best effect. The diameter and cross-sectional area of the right subclavian vein at the end of inspiratory and expiratory processes were then measured. Then, the SCV-CI was measured. The procedure was repeated for three respiratory cycles were recorded and their average values were taken as the basis value, followed by continuous monitoring for 20 minutes.

2.3. Observation indicators

The changes of hemodynamic indexes (systolic blood pressure [SBP], diastolic blood pressure [DBP], and heart rate [HR]), the subclavian vein collapsibility index (SCV-CI) of the patients, and the incidence of nausea and vomiting were recorded. A receiver operating characteristic (ROC) curve was drawn to analyze the relationship between SCV-CI and hypotension.

2.4. Statistical processing

SPSS26.0 was used to perform statistical analysis, and a *t* test was carried out on the measurements, and a chi-square test was also performed on the count data. A receiver operating characteristic (ROC) curve was plotted to determine the cut-off value of SCV-CI for post-anesthesia hypotension.

3. Results

3.1. Comparison of hemodynamic indicators between the two groups

There was no significant difference in systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) between the two groups before anesthesia ($P > 0.05$). During anesthesia, The SBP, DBP, and HR in hypotensive group were significantly lower than those in the normotensive group (SBP, 103.25 ± 12.48 mmHg; DBP, 58.94 ± 7.46 mmHg; HR, 52.96 ± 6.48 beats/min), and the difference was statistically significant ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of hemodynamic indicators between the two groups of patients (mean ± s)

Group	SBP (mmHg)		DBP (mmHg)		HR (times/min)	
	Before anesthesia	After anesthesia	Before anesthesia	After anesthesia	Before anesthesia	After anesthesia
Hypotension group (*n* = 30)	147.92 ± 13.58	103.25 ± 12.48	92.68 ± 8.73	58.94 ± 7.46	78.85 ± 7.43	52.96 ± 6.48
Normotensive group (*n* = 38)	148.04 ± 14.26	121.09 ± 12.35	92.09 ± 9.57	68.47 ± 8.15	78.26 ± 7.68	64.52 ± 6.13
t	2.318	6.792	2.574	7.458	2.907	8.126
P value	> 0.05	0.012	> 0.05	0.006	> 0.05	0.001

3.2. Comparison of SCV-CI and incidence of nausea and vomiting between the two groups

The SCV-CI in the hypotensive group was 35.82 ± 4.93%, which was greater than that in the normotensive group 23.85 ± 5.27%, and the incidence of nausea and vomiting in hypotensive patients (40.0%) was significantly higher than that that of the normotensive group (10.53%), and the difference was statistically significant ($P < 0.05$), as shown **Table 2**.

Table 2. Comparison of subclavian vein collapsibility index and incidence of nausea and vomiting between the two groups

Group	*n*	SCV-CI (%)	Incidence rate of nausea and vomiting (%)
Hypotension group	30	35.82 ± 4.93	12 (40.0)
Normotensive group	38	23.85 ± 5.27	4 (10.53)
χ^2/ *t*		8.219	9.675
P		0.001	0.000

3.3. The predictive value of SCV-CI on hypotension in patients with PIH who underwent neuraxial anesthesia

The area under the ROC curve of SCV-CI in predicting hypotension in patients with PIH under neuraxial anesthesia was 0.825 (95% CI: 0.762–0.893, $P < 0.001$), the cut-off value was 25.68%. Besides, the predictive sensitivity of SCV-CI against hypotension was 92.68%, and the specificity was 81.24%, as shown in **Figure 1**.

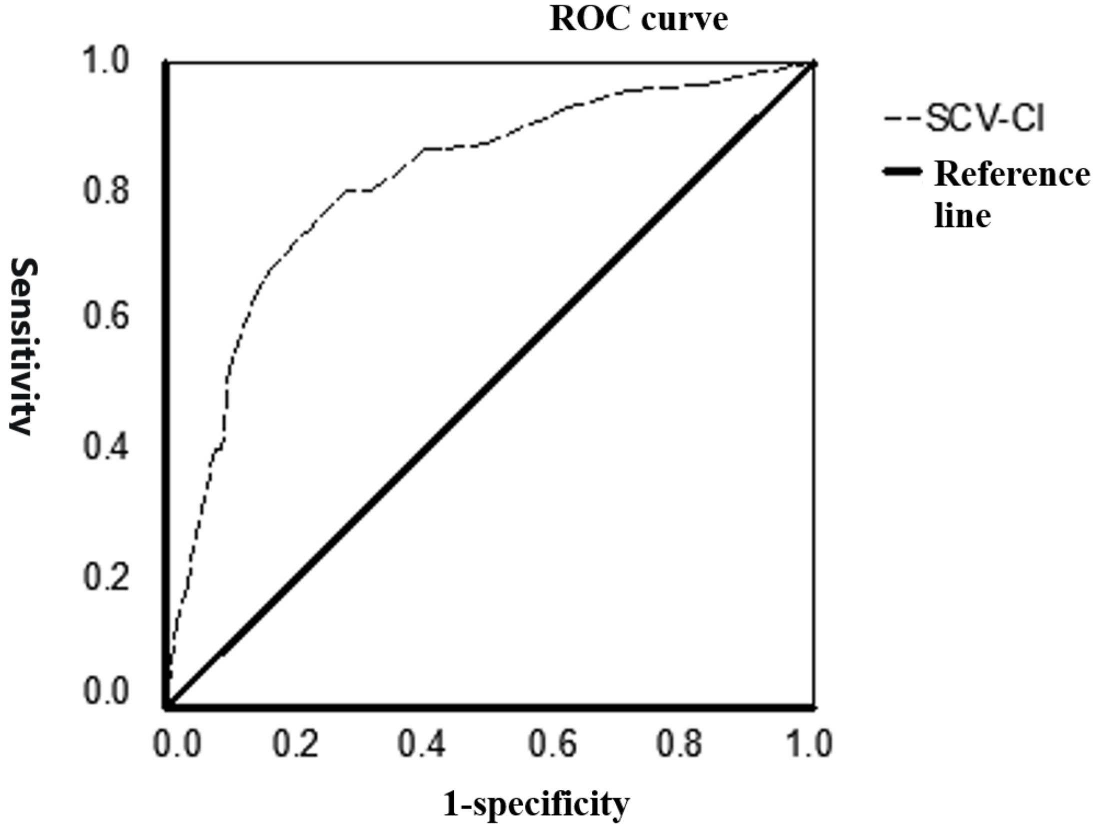

Figure 1. ROC curve of SCV-CI for predicting hypotension after neuraxial anesthesia in patients with PIH

4. Discussion

During spinal anesthesia for cesarean section in patients with PIH, the probability of hypotension is high, and it is harmful to the patients. There are many reasons for intraoperative hypotension, and many of the reasons are unexpected, and there are currently no clear and effective prediction methods. The method and mechanism of hypotension in cesarean section are also unclear., the most common and effective methods for the prevention and treatment of hypotension during neuraxial anesthesia for cesarean section are fluid infusion and vasoactive drugs [6,7].

Ultrasonic measurement of the inferior vena cava (IVC) has been widely recommended as a method for volume assessment. Because of its repeatability and accessibility, ultrasonic measurement of inferior vena cava diameter, maximum diameter at the end of respiration and collapse index in the state of spontaneous respiration is highly recognized by emergency, intensive care and anesthesiologists. In addition to measuring the inferior vena cava, the subclavian vein can also be measured [8]. Measuring collapsibility index is more sensitive than measuring vein width. The subclavian vein collapse index and inferior vena cava collapse index in shock patients were higher than those in non-shock patients [9,10]. The subclavian vein collapse index was positively correlated with the inferior vena cava collapse index [11]. The study [12] reported that for patients at high risk of complications caused by intraoperative hypovolemia and hypotension, the measurement of SCV-CI can provide clinically useful information. Before anesthesia, a high-frequency linear array probe was placed on the sagittal plane of the right midclavicular line perpendicular to the long axis of the subclavicular vein for the best effect. The diameter and cross-sectional area of the right subclavicular vein at the end of inspiratory and expiratory processes were then measured. The results showed that there were no significant differences in SBP, DBP and HR between the two groups before anesthesia. During anesthesia, the SBP, DBP, and HR in hypotensive group were significantly lower than those in the normotensive group (SBP, 103.25 ± 12.48 mmHg; DBP, 58.94 ± 7.46 mmHg; HR, 52.96 ± 6.48 beats/min), and the difference was statistically significant ($P < 0.05$). The SCV-CI in the hypotensive group was 35.82 ± 4.93% greater than that of the normotensive group 23.85 ± 5.27%, and the incidence of nausea and vomiting in hypotensive patients (40.0%) was significantly higher than that in the normotensive group (10.53%). The area under the curve of SCV-CI predicting hypotension in patients with pregnancy-induced hypertension under neuraxial anesthesia was 0.825 (95% CI: 0.762–0.893, $P < 0.001$), the cut-off value was 25.68%, the predictive sensitivity was 92.68%, and the specificity was 81.24%.

Therefore, SCV-CI has a good predictive value for the occurrence of hypotension in patients with PIH who undergo neuraxial anesthesia. Hence, it can be used to guide the prevention and control measures of hypotension in patients with PIH after caesarean section. However, because this study was single-centered with a small sample size, the conclusions of the study may be biased, and it may be better to combine other indicators to predict the occurrence of hypotension in patients with PIH who undergo neuraxial anesthesia.

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Disclosure statement

The author declares no conflict of interest.

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