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**Original article**

# Assessing the Utility of Ultrasonographic Vein Collapsibility Index in Anticipating Hypotension during Spinal Anesthesia for Cesarean Sections

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**Abstract**

**Background and Objectives:** Hypotension following spinal anesthesia, termed Post Spinal Anesthesia Hypotension (PSAH), is a common occurrence in anesthetic practice, particularly in the context of cesarean sections. Utilizing ultrasound as a secure and uncomplicated technique for hemodynamic monitoring has gained prominence. This study aimed to evaluate the effectiveness of pre-operative measurements of the Inferior Vena Cava Collapsibility Index (IVCCI) and Internal Jugular Vein Collapsibility Index (IJVCI) in predicting PSAH.

**Methods:** In this cross-sectional blinded study, 76 pregnant females scheduled for elective cesarean section were included. They were categorized into two groups based on the presence of PSAH: (1) 37 cases with PSAH; and (2) 39 cases without PSAH. All participants underwent ultrasound-guided assessments of IVCCI and IJVCI. The predictive potential of these parameters for PSAH was scrutinized.

**Results:** Both groups exhibited non-significant differences in demographic characteristics. Nevertheless, IVCCI demonstrated mean values of 37.62% and 28.36%, whereas IJVCI showed mean values of 47.82% and 32.79% in cases with and without PSAH, respectively. For IVCCI, employing a threshold of 32.5% yielded a sensitivity and specificity of 85.2% and 92.7%, respectively, for predicting PSAH, with an overall diagnostic accuracy of 88.6%.

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IJVCI, with a cut-off value of 39%, exhibited a sensitivity and specificity of 84.2% and 83.4%, respectively, in predicting the same complication.

**Conclusion:** IVCCI and IJVCI emerged as effective and dependable tools for predicting PSAH in pregnant women undergoing cesarean section, with a slight advantage for IVCCI in terms of specificity and overall accuracy.

**Key Words:** Ultrasonography, Spinal Anesthesia, Inferior Vena Cava, Cesarean Section

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## Introduction

Post spinal anesthesia hypotension (PSAH) is a common occurrence in daily obstetric anesthesia practice, with reported incidences reaching up to 71%. This phenomenon is attributed to reduced preload, a consequence of the gravid uterus exerting pressure on the inferior vena cava (IVC), and subsequent decreased systemic vascular resistance and vascular dilation following spinal anesthesia [1,2].

Pregnant individuals experiencing prenatal hypovolemia face an elevated risk of cardiovascular collapse, and PSAH poses potential risks for both maternal and fetal well-being. Therefore, pre-anesthetic identification of fluid deficit may serve as a preventive measure against a critical decline in blood pressure during surgery [3].

Advancements in hemodynamic monitoring devices have been notable, with ultrasound emerging as a safe and straightforward technique for such monitoring. Anesthesiologists employing point-of-care ultrasound, as indicated by various studies, have found ultrasonography measurements of the inferior vena cava (IVC) or internal jugular vein (IJV) useful in gauging intravascular volume. The transabdominal measurement of IVC diameters presents a complication-free method. By utilizing these diameters, the Inferior Vena Cava Compressibility Index (IVCCI) can be calculated, proving to be a reliable approach for assessing the volume status of patients [4-9].

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A scarcity of studies exists that compares the efficacy of IVCCI and IJVCI in predicting PSAH during cesarean section. Consequently, we undertook this study to evaluate the effectiveness of pre-operative IVCCI and IJVCI in predicting PSAH.

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## Material and Methods

This cross-sectional blinded study included adult pregnant female cases, aged 25 to 35 years, with class I or II American Society of Anesthesiologists (ASA) physical status, undergoing elective cesarean section under subarachnoid block. Informed consent was obtained from all participants prior to the study. Exclusion criteria included cases with emergency conditions, uncontrolled systemic comorbidities (cardiovascular, respiratory, or renal), patients anticipating massive intraoperative loss (placenta accreta or placenta previa), and those who received preload of intravenous fluids.

The study comprised two groups based on the incidence of PSAH: with PSAH (37 cases) and without PSAH (39 cases). Patients were admitted a day before surgery and commenced fasting at 12:00 a.m. A thorough anesthesia examination was conducted the night before surgery in the operating room, including regular hemodynamic monitoring with three-lead electrocardiography, pulse oximetry, and non-invasive blood pressure measurement.

For IJVCI measurement patients were positioned supine, and the right IJV was examined with the linear vascular transducer positioned two cm superior to the right sternoclavicular joint in the transverse plane of the neck. Doppler examination identified the IJV, and measurements were recorded for four respiratory cycles. Anteroposterior maximum and minimum diameters were determined, and IJVCI was calculated using the formula: (Maximum diameter - lowest diameter/maximum diameter) 100% [10].

For IVCCI measurement, a curvilinear probe was placed longitudinally over the subxiphoid region, and IVC measurements were estimated just distal to the entrance of hepatic veins into IVC. Internal anteroposterior IVC diameters were measured at their highest and lowest values after expiration and inspiration. IVCCI was calculated using the same formula as for IJV.

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Following ultrasound measurements, patients were positioned supine, and spinal anesthesia was administered using 2.5 mL hyperbaric bupivacaine 5% and 20 mcg fentanyl into the L 2 - 3 or L 3 - 4 intervertebral space. Simultaneously, all patients received a co-load of ringer lactate solution (10 - 12 mL/kg over 15 minutes). Surgery commenced when the sensory block reached the T6 level.

Throughout the procedure, heart rate and mean arterial pressure (MAP) were recorded every 3 minutes for the first 15 minutes. Ephedrine (6 mg increment) and Ringer lactate solution were used to treat hypotension, defined as a decrease in MAP of more than 20% of its basal value or MAP 65 mmHg (250 mL bolus). The dosage of ephedrine was recorded, and bradycardia (heart rate less than 50 beats per minute) was treated with an intravenous infusion of atropine (0.6 mg).

Data entry and analysis were performed using SPSS software version 21 for windows. Data were tested for normality, and quantitative data were expressed as mean and standard deviation. Frequency and percentage were used for categorical variables. The chi-square test, Mann-Whitney U test, and independent samples t-test were employed to compare groups. Receiver operating characteristic (ROC) curve analysis demonstrated diagnostic accuracy, with a significance level set at $P < 0.05$.

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## Results

The majority of the included cases belonged to ASA class I. There were no significant differences observed in demographic parameters between the two study groups (Table 1).

No substantial disparity was observed in the heart rate measurements between the two groups. Nonetheless, instances within the PSAH group exhibited a tendency toward elevated heart rates compared to the other group, although this difference did not achieve statistical significance. In terms of blood pressure, no notable distinction was discerned between the two groups with respect to the baseline measurement (Table 2).

PSAH cases showed significantly higher IVCCI and IJVCI values than non-PSAH cases (Table 3). The IVCCI, with a cut-off of 32.5%, demonstrated a sensitivity of 85.2% and specificity of 92.7% for predicting PSAH, yielding a diagnostic accuracy of 88.6%. Similarly, the IJVCI, with a cut-off value of 39%, exhibited a sensitivity of 84.2% and specificity of 83.4% for predicting the same complication (Table 4).

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**Table 1: Clinico-demographic profile of study patients**

| Variables | Patients with PSAH (n = 37) | Patients Without PSAH (n = 39) | P Value |
|---|---|---|---|
| Age, in years | 27.12 ± 2.225 | 26.18 ± 4.004 | 0.43 |
| BMI, in kg/m² | 30.21 ± 3.142 | 29.92 ± 3.724 | 0.79 |
| ASA grade I | 31 (83.78) | 35 (89.74) | 0.65 |
| ASA grade II | 6 (16.22) | 4 (10.26) | |

**Table 2: Heart rate and MAP in relation to the presence of PSAH in patients.**

| Variables | Patients with PSAH (n = 37) | Patients Without PSAH (n = 39) | P Value |
|---|---|---|---|
| **Heart rate (beats per minute)** | | | |
| Basal | 99.2 ± 13.4 | 94.8 ± 8.2 | 0.65 |
| 3 minutes | 110.2 ± 15.1 | 106.3 ± 8.9 | 0.07 |
| 6 minutes | 115.5 ± 17.7 | 107.4 ± 10.0 | 0.05 |
| 9 minutes | 117.3 ± 17.2 | 108.1 ± 10.4 | 0.10 |
| 12 minutes | 115.8 ± 18.3 | 110.0 ± 11.1 | 0.19 |
| 15 minutes | 114.4 ± 17.8 | 111.2 ± 12.3 | 0.20 |
| **MAP (mmHg)** | | | |
| Basal | 99.6 ± 13.0 | 95.2 ± 8.6 | 0.61 |
| 3 minutes | 110.8 ± 14.8 | 105.5 ± 9.1 | 0.08 |
| 6 minutes | 116.2 ± 16.5 | 108.2 ± 9.8 | 0.04 |
| 9 minutes | 116.8 ± 18.2 | 109.1 ± 11.5 | 0.08 |
| 12 minutes | 114.7 ± 17.1 | 110.3 ± 12.0 | 0.16 |
| 15 minutes | 113.2 ± 17.5 | 111.8 ± 13.2 | 0.19 |

**Table 3: The IVCCI and IJVCI in relation to the presence of PSAH in patients.**

| Variables | Patients with PSAH (n = 37) | Patients Without PSAH (n = 39) | P Value |
|---|---|---|---|
| Maximum IJV diameter | 1.10 ± 0.324 | 1.05 ± 0.225 | 0.16 |
| Minimum IJV diameter | 0.61 ± 0.121 | 0.65 ± 0.145 | 0.024 |
| IJVCI (%) | 47.82 ± 8.249 | 32.79 ± 6.987 | <0.05 |
| Maximum IVC diameter | 1.36 ± 0.198 | 1.37 ± 0.180 | 0.26 |
| Minimum IVC diameter | 1.15 ± 0.109 | 1.03 ± 0.117 | <0.05 |
| IVCCI (%) | 37.62 ± 6.082 | 28.36 ± 4.736 | <0.05 |

**Table 4: The diagnostic characteristics for IVCCI and IJVCI in forecasting PSAH.**

| Variables | IJVCI | IVCCI |
|---|---|---|
| AUC | 0.905 | 0.945 |

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| | | |
|---|---|---|
| P value | <0.05 | <0.05 |
| Diagnostic point | 39 | 32.5 |
| Sensitivity (%) | 84.2 | 85.2 |
| Specificity (%) | 83.4 | 92.7 |
| PPV (%) | 80.8 | 91.3 |
| NPV (%) | 59.2 | 87.5 |
| Accuracy (%) | 84.2 | 88.6 |

## Discussion

While PSAH is generally well tolerated by healthy individuals, with symptoms limited to nausea, vomiting, and lightheadedness, it can significantly affect patients with pre-existing cardiovascular risk factors. Identifying patients at high risk of severe hypotension is crucial for anesthetists to prepare and personalize treatment [11, 12].

The incidence of PSAH in our study was 48.68%, and another studies reported a similar high incidence (4). Varying reports suggest an incidence ranging from 7.4% to 74.1% in different series, primarily due to variations in the definition of hypotension across studies [6,12].

Our findings indicated that cases with PSAH had a significantly higher IVCCI than those without PSAH. IVCCI, with a cut-off value of 32.5%, exhibited a sensitivity of 85.2% and specificity of 92.7%. In another study, IVCCI's sensitivity and specificity in predicting hypotension in pregnant women were reported as 60.9% and 35.5% with a cut-off of 25.64% and 69.6% and 23.5% with a cut-off of 20.4%, respectively [6]. Other reports suggested an optimal cut-off value of 43% with sensitivity and specificity of 78.6% and 91.7%, respectively [13]. IVCCI, validated as a reliable predictor of fluid receptivity, demonstrated a 35% reduction in PSAH incidence in a previous randomized controlled trial [14-19].

Similarly, cases with PSAH in our study had a significantly higher IJVCI than those without PSAH. Previous research suggested that IJVCI values above 39% had sensitivity and specificity of 87.5% and 100% in predicting hypovolemia in critically ill patients [20]. The cut-off values, varying between studies, may be attributed to population differences, radiological experiences, or statistical tests used.

Our results indicate that both IVCCI and IJVCI are reliable markers for predicting PSAH occurrence, with a slight superiority for IVCCI. Anesthesiologist experience, center policy, and patient characteristics should guide the preferred technique, considering factors such as the difficulty of assessing IVCCI in obese individuals and cases with excess intraabdominal gases. IJVCI, requiring less image acquisition time than IVC, may be preferable in certain situations [10, 21].

While our study has limitations, including its single-center design and relatively small sample size, it underscores the need for further research with larger cohorts. Additionally, exclusion of individuals with sensory blocks higher than T4 limits the generalizability of our findings.

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## Conclusion

IVCCI and IJVCI prove to be effective and dependable tools for predicting PSAH in pregnant women undergoing cesarean section, with IVCCI showing a slight advantage in terms of specificity and accuracy. A higher collapsibility index is associated with a reduced volume status.

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