**“Role of Inferior vena cava collapsibility index in predicting post spinal anaesthesia hypotension: An observational study”**

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| **Abstract** **Background:** Intraoperative hypotension raises 30-day mortality and risks myocardial damage and organ ischemia. Patients, who are volume deprived, are at risk for unanticipated hemodynamic abnormalities on performing spinal anesthesia. Hence, identification of hypovolemia prior to the induction is very important. The inferior vena cava collapsibility index (IVCCI) can be measured ultrasonographically to assess volume response. Currently, there is no evidence suggesting that preoperative IVCCI measurement can identify individuals at high risk of hypotension associated with spinal anaesthesia. **Materials and methods:** The study includes 120 adult patients scheduled for elective surgical procedures under spinal anaesthesia. Sonographical evaluation of the Inferior Vena Cava Collapsibility Index (IVCCI) was done before shifting the patients to the Operating Room for performing spinal anaesthesia. The changes in blood pressure, heart rate and Mean arterial pressure (MAP) after spinal anaesthesia were recorded by an independent observer. **Results:** Total of 120 participants included in present study with 27 female and 93 male patients, hypotension was seen in 24 male and 18 female patients. No significant difference in the age, physical built and the baseline characteristics have been observed between the groups. There is a significant difference in the vital parameters at various intervals of time between the groups. The ROC analysis to detect the CI % in predicting the presence of hypotension was found with AUC of 0.78, p<0.05. The odds ratio for developing the hypotension was found to be 1.12. **Conclusion:** Preoperative evaluation of IVCCI is not a good predictor for the occurrence of hypo-tension after spinal anaesthesia. |

**Abbreviations: IVCCI (**Inferior vena cava collapsibility index)

**Introduction**

Spinal anaesthesia, a relatively safer method commonly used for lower abdominal and lower limb surgeries. It offers the advantages of ease of administration, quick onset of action, low cost and little adverse effects. The most prevalent side effects of spinal anaesthesia are hypotension and bradycardia. The majority of the published prediction models for hypotension risk factors are based on non-modifiable characteristics such as age >40 years, emergency surgery, a history of hypertension, and a baseline systolic blood pressure of 120 mmHg. To assist anaesthesiologists in identifying patients with hemodynamic impairment, easily available characteristics must be identified. However, determining the intravascular volume status is difficult. To test preload and other aspects of haemodynamic state, many approaches such as pulmonary arterial catheter, PiCCO have been reported.

Many strategies are employed in order to prevent and mitigate the post spinal hypotesion, such as empirical volume loading before induction or administering vasopressors prophylactically. However, intravenous volume preload has the risk of causing volume overload, especially in individuals with heart illness. Furthermore, because of varying definitions of hypotension and distinct patient demographics, the efficacy of volume preload on hypotension prophylaxis remains debatable. So far, many studies have established sonographic assessment of the inferior vena cava collapsibility index (IVCCI) as a simple, non-invasive bed side tool for assessing volume status in a spontaneously breathing patient. Furthermore, operators with limited knowledge in echocardiography can use this procedure. The prognostic usefulness of IVC ultrasonography testing remains equivocal to this day. The main purpose of this observational study is to assess how accurate is the preoperative IVCCI in predicting the occurrence of post spinal anaesthesia hypotension. A cut-off value was regarded as a favorable fluid response in this study. We hypothesized that IVCCI-guided patient-adapted fluid administration before spinal anaesthesia would significantly lower the incidence of spinal anaesthesia induced hypotension in patients undergoing non-cardiovascular, non-obstetric surgeries.

**Methods**

The present prospective observational double-blind study was conducted during September 1st, 2022 to August 31st, 2023. Before enrolling the patients, the Institute's Ethics Committee granted ethical permission. Patients aged 18 to 65 years with American Society of Anaesthesiologists (ASA) physical status I or II undergoing elective elective surgeries under spinal anaesthesia in the supine position were included in the study. A written informed consent was obtained from all the participants. Exclusion criteria included absolute and relative contraindications to spinal anaesthesia, preoperative mean arterial blood pressure of 65 mmHg, preoperative heart rate of 45 beats/min, preoperative dysrhythmia, psychiatric illness, pre-existing neurological deficits, and patients with BMI greater than 30 kg.m2. In the preoperative room, after checking NPO status patient was advised to lie supine for 5 minutes and breathe spontaneously. Intravenous (IV) maintenance crystalloid infusion, Ringer Lactate at 2 mL/kg/hr was commenced. Inferior vena cava was scanned by an independent observer in the subxiphoid region (paramedian long-axis view) just proximal to the drainage of the common hepatic vein into the IVC with a 3.55 MHz curvilinear probe. A 2D picture was produced at the point where the IVC joined the right atrium. M-mode imaging was used to measure the fluctuation in IVC diameter during inspiration and expiration. It was performed 2 to 3 cm proximal to the confluence of the IVC and the right atrium. The time taken for locating the IVC was recorded by the consultant anaesthetist. The IVC Collapsibility Index (IVCCI) was calculated using the formula: ([Max IVC diameter - Min IVC diameter]/Max IVC diameter) X 100. Three of these measurements were obtained at one-minute intervals, and the average was used to calculate IVCCI. On arrival to the operating room patients did not receive any fluid preloading. Standard ASA monitoring devices (noninvasive Blood Pressure, Electrocardiography, Pulse Oximetry) were attached to the patients, and baseline parameters were recorded. All patients were administered spinal anaesthesia with a 25G Quincke needle in the sitting position via the median approach at the level of the L3-L4 and L4-L5 intervertebral spaces with 2.5 to 3 mL of 0.5% bupivacaine (hyperbaric) (depending on the type of surgery and the patient's constitution) to achieve spinal block height to the level of T9 to T10. The subject was positioned supine immediately following spinal drug delivery and maintained supine until the completion of the research (30 minutes). An anaesthetist who was not engaged in the study did the pinprick test to establish the sensory level. An impartial observer who was not present for the IVCCI evaluation then recorded serial heart rate and NIBP at 0, 2.5, 5, 7.5, and 10 minutes following spinal anaesthesia. Clinically severe hypotension was defined as a drop in pre-induction baseline readings of greater than or equal to 30%. If the procedure was converted to GA or abandoned for any reason before 30 minutes after spinal anaesthesia was administered, the patient was eliminated from the research.

Significant hypotension was treated with intravenous fluids and phenylephrine (50-100 g) boluses every 2 minutes to raise mean blood pressure over 70 mmHg or systolic blood pressure to 80% of baseline. When the heart rate was 50 beats per minute, 0.6 mg of atropine was administered intravenously. In the immediate postoperative phase, the patients were monitored in the recovery area, followed by surveillance in the ward. To avoid bias, data were gathered on separate proforma sheets by the USG operator and the intraoperative attending anaesthetist who delivered the spinal anaesthesia. The primary goal was to see if IVCCI could predict hypotension, and the secondary goal was to see if there were any other clinical predictors of hypotension.

For statistical analysis, SPSS version 21 (SPSS Inc., Chicago, Illinois, USA) was utilised. A statistically significant p-value of 0.05 (two-tailed) was considered. The data was collected using Excel spreadsheets (Microsoft, USA). After induction, the lowest Mean Blood Pressure (MBP) was recorded, and the percentage drop in MBP was determined as a decline from baseline in each patient. The one-sample Kolmogorov-Smirnov test was employed to determine normality. For continuous variables, data were reported as mean ±Standard Deviation (SD), whereas for categorical variables, percentages or absolute values were utilised.

Student's t-test or the χ2 test was applied to analyze patient characteristics, hemodynamic data, and IVC measurements, and the Pearson correlation coefficient (r) to examine the relationship between IVCCI and % fall of MBP. The Receiver Operator Characteristics (ROC) curve analysis was performed between IVCCI and % MBP reduction. Multivariate logistic regression was applied for the following confounders: age, ASA physical status, baseline Heart Rate (HR), and baseline Mean Blood Pressure (MBP).

**Results**

Total of 120 participants included in present study with 27 female and 93 male patients, hypotension was seen in 24 male and 18 female patients. There was no significant difference in the age, physical built and the baseline characteristics between the groups.

**Patient characteristics, hemodynamic data, and preoperative Inferior Vena Cava (IVC) ultrasound measurements of the study participants**

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| --- | --- | --- | --- |
| **Variable** | **Developed hypotension** | **No hypotension** | **P value** |
| Age (years) | 41.8±12.8 | 38.7±12.5 | 0.25 |
| Sex (male/female) | 09/04 | 21/06 | - |
| Height in cms | 170.0±8.46 | 166.2±5.73 | 0.66 |
| Weight (kg) | 73.42±9.5 | 67.61±14.24 | 0.54 |
| ASA (I/II) | 09/04 | 15/12 | - |
| IVCCI% | 0.898±0.145 | 0.876±0.164 | 0.01\* |
| Base line Heart rate | 75.9±9.331 | 72.25±7.32 | 0.98 |
| Base line SBP (mmHg) | 122.0±11.2 | 123.42±11.10 | 0.65 |
| Base line DBP (mmHg) | 75.38±5.50 | 78.37±5.732 | 0.42 |
| Baseline MAP(mmHg) | 78.07±6.499 | 79.74±7.019 | 0.75 |

**Data are presented as absolute (n) and mean § SD. SD, standard deviation; ASA, American Society of Anaesthesiologists physical status; IVCCI, Inferior Vena Cava Collapsibility Index; HR, Heart Rate; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; MBP, Mean Blood Pressure**

Table: Comparison of hemodynamic parameters between the groups.

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|  | **Hypotension not-developed** | **Hypotension developed** | **p-value** |
| Mean | SD | Mean | SD |
| HR\_PreOp | 72.7 | 7.1 | 74.9 | 9.5 | 0.139 |
| HR 0min | 73.7 | 8.0 | 74.7 | 8.9 | 0.521 |
| HR 2.5min | 72.9 | 8.6 | 73.4 | 8.9 | 0.745 |
| HR 5min | 72.5 | 8.7 | 72.3 | 8.5 | 0.897 |
| HR 7.5min | 72.0 | 8.7 | 71.0 | 8.8 | 0.551 |
| HR 10min | 72.0 | 8.7 | 71.0 | 8.7 | 0.534 |
| SBP Preop | 123.4 | 11.1 | 122.0 | 10.8 | 0.500 |
| SBP 0min | 121.1 | 6.9 | 113.6 | 8.1 | 0.01\* |
| SBP 2.5min | 115.7 | 6.6 | 107.4 | 9.6 | 0.01\* |
| SBP 5min | 111.8 | 7.3 | 102.1 | 6.8 | 0.01\* |
| SBP 7.5min | 110.0 | 5.6 | 98.9 | 5.5 | 0.01\* |
| SBP 10min | 108.2 | 5.2 | 96.9 | 3.8 | 0.01\* |
| DBP Preop | 78.7 | 5.5 | 75.0 | 5.3 | 0.01\* |
| DBP 0min | 78.5 | 6.3 | 73.1 | 7.8 | 0.01\* |
| DBP 2.5min | 75.1 | 5.4 | 70.3 | 6.9 | 0.01\* |
| DBP 5min | 70.1 | 6.9 | 66.4 | 5.0 | 0.01\* |
| DBP 7.5min | 69.4 | 4.3 | 65.2 | 5.9 | 0.01\* |
| DBP 10min | 68.7 | 5.1 | 63.7 | 6.6 | 0.01\* |
| MAP Preop | 83.12 | 6.95 | 77.50 | 6.44 | 0.01\* |
| MAP 0min | 84.04 | 9.62 | 73.90 | 6.05 | 0.01\* |
| MAP 2.5min | 78.5 | 9.3 | 68.7 | 6.3 | 0.01\* |
| MAP 5min | 75.87 | 9.37 | 67.26 | 5.84 | 0.01\* |
| MAP 7.5min | 72.53 | 8.58 | 65.64 | 4.76 | 0.01\* |
| MAP 10min | 71.10 | 8.63 | 63.36 | 3.33 | 0.01\* |
| SpO2 0min | 99.0 | .8 | 99.0 | .8 | 0.99 |
| SpO2 2.5min | 98.9 | .9 | 98.7 | 1.0 | 0.76 |
| SpO2 5min | 98.8 | .9 | 98.7 | .8 | 0.89 |
| SpO2 7.5min | 98.7 | .9 | 98.9 | .8 | 0.91 |
| SpO2 10min | 98.9 | .8 | 98.8 | .8 | 0.98 |



Figure 1: ROC for prediction of hypotension

Table 2 showing the significant difference in the vital parameters at various interval of time between the groups. The ROC analysis to detect the CI % in predicting the presence of hypotension was found with AUC of 0.78, p<0.05. the odds ratio for developing the hypotension was found to be 1.12 (CI 0.967 to 1.010).

**Discussion**

Hypotension following intrathecal administration of local anaesthesia is a common phenomenon. In this investigation, a 30% decrease in mean blood pressure from baseline was used as the cut-off for severe hypotension because this criterion is used in the majority of these studies because mean blood pressure is a stronger predictor of tissue perfusion than SBP or DBP. Because just one hypotension cut-off was used, the incidence of clinically significant hypotension in our research (19.37%) was substantially lower than that seen in previous investigations. The research period lasted from intrathecal drug delivery to 10 minutes following spinal anaesthesia, during which no substantial hemodynamic changes due to external influences were predicted. Female patients were more likely than men to experience hypotension (33.3%) (p-value = 0.05). Many studies have attempted to show that the IVCCI may be used to predict fluid responsiveness and guide fluid administration in resuscitation and intensive care settings. The major issue in anaesthesia is volume status optimisation. Fluid responsiveness is defined as a 10% to 15% increase in cardiac output following a fluid bolus. Most anaesthesiologists rely on basic hemodynamic monitoring tools like blood pressure and HR as their primary hemodynamic monitoring tools, which is why we may integrate bedside IVC ultrasonography to detect volume-depleted patients that require fluid optimisation.

The time it took to detect the IVC ranged from 60 to 200 seconds, although it was within the average range of 10 minutes, as indicated by another research.

The area under the curve for the ROC curve was 0.78. When a scatter plot was made between the % decrease in MBP and the IVVCI, no association was found (R2 = 0.165). However, baseline SBP, DBP, and MBP were shown to be greater in hypotensive individuals (p 0.05). According to logistic regression, IVCCI was not a strong predictor of post-induction hypotension (Odds Ratio = 1.12, 95% CI 0.967 to 1.010, p = 0.05). There was no correlation between baseline MBP and post-spinal hypotension. Depending on the kind of operation and patient constitution, 2.5 to 3 mL of local anaesthetic was used in this research to achieve spinal block height of T9 to T10. Although there was a 20% variation in local anaesthetic mass, there was no association between the amount of medication utilised and post-spinal hypotension.

Our findings are explained by the fact that the IVC is a large vessel with a wide range of diameters from person to person. It is also affected by age, body surface area, and BMI. Its diameter is affected by intrathoracic and intra-abdominal pressures. As the intrathoracic pressure changes during the respiratory cycles, the diameter of Inferior Vena Cava (IVC) also varies accordingly.

Most of the previous data were from ICU, IVC diameter variations were utilised to identify volume-responsive individuals in circulatory shock in various contexts. Our technique has a novel component in that it can be used in the setting of spinal anaesthesia. According to certain research, using IVCCI after spinal anaesthesia is contentious since it produces sympathetic denervation and displays inadequate fluid reserve. One research reported that the IVCCI had little prognostic value in patients after knee surgery, but another found it to be a valuable tool for reducing the extent of hypotension by using ultrasound-guided fluid treatment. A more recent study discovered that the caval-aorta index was a better predictor than the IVCCI. As a result, further research should be conducted in this area.

The current investigation has several limitations. In certain measures, USG observer experience was varied. We included ASA I and II patients since ASA III and IV individuals may be more likely to experience hemodynamic instability in the post-spinal interval. It might be related to either a decreased intravascular condition or a poor optimisation of the illness process. It was a one-site study. The population investigated was additionally constrained by an unequal gender distribution. A multicenter investigation is also necessary to determine the best predictive value of IVCCI. Respiration produced diaphragmatic displacement, resulting in two separate locations for measuring the IVC during the respiratory cycle. This might have resulted in an underestimating of IVCCI (since IVC is less collapsible when measured close to the diaphragm during inspiration).

**Conclusion:** This study found that IVCCI does not have the same hypotension predicting capability in spontaneously breathing patients undergoing spinal anaesthesia that it has in mechanically ventilated patients.

To circumvent restrictions imposed by fluctuating respiratory parameters in freely breathing individuals, we can obtain IVC and Aorta measurements at the same time to calculate the Caval-Aorta index. This measure should be studied further to determine intravascular volume status and predict intraoperative hypotension.

**References**

1. Bajwa S, Jindal R, Kulshrestha A. Co-loading or preloading for prevention of hypotension after spinal anaesthesia! a therapeutic dilemma. Anesth Essays Res. 2013;7:155–159.

2. Khan MU, Memon AS, Ishaq M, et al. Preload versus coload and vasopressor requirement to prevent spinal anaesthesia-induced hypotension in non-obstetric patients. J Coll Physicians Surg Pak. 2015;25:851–855.

3. Ceruti S, Anselmi L, Minotti B, et al. Prevention of arterial hypotension after spinal anaesthesia using vena cava ultrasound to guide fluid management. Br J Anaesth. 2018;120:101–108.

4. Fawcett WJ, Thomas M. Pre-operative fasting in adults and children: clinical practice and guidelines. Anaesthesia. 2019;74:83–88.]

5. Voldby AW, Brandstrup B. Fluid therapy in the perioperative setting-a clinical review. J Intensive Care. 2016;4:27.]

6. Muller L, Brière M, Bastide S, et al. Preoperative fasting does not affect haemodynamic status: a prospective, non-inferiority, echocardiography study. Br J Anaesth. 2014;112:835–841.

7. Rudski LG, Lai WW, Afilalo J, et al. Guidelines for the echocardiographic assessment of the right heart in adults: a report from the American Society of Echocardiography endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. J Am Soc Echocardiogr. 2010;23:685–713.

8. Karacabey S, Sanri E, Guneysel O. A noninvasive method for assessment of intravascular fluid status: inferior vena cava diameters and collapsibility index. Pak J Med Sci. 2016;32:836.

9. Zhang J, Critchley LA. Inferior vena cava ultrasonography before general anaesthesia can predict hypotension after induction. Anaesthesiology. 2016;124:580–589.

10. Zhang Z, Xu X, Ye S, et al. Ultrasonographic measurement of the respiratory variation in the inferior vena cava diameter is predictive of fluid responsiveness in critically ill patients: systematic review and meta-analysis. Ultrasound Med Biol. 2014;40:845–853.

11. Salama E, Elkashlan M. Pre-operative ultrasonographic evaluation of inferior vena cava collapsibility index and caval aorta index as new predictors for hypotension after induction of spinal anaesthesia. Eur J Anaesthesiol. 2019;36:297–302.

12. Bijker JB, van Klei WA, Kappen TH, et al. Incidence of intraoperative hypotension as a function of the chosen definition: literature definitions applied to a retrospective cohort using automated data collection. Anaesthesiology. 2007;107:213–220.