PRE-OPERATIVE ULTRASONOGRAPHIC EVALUATION OF INFERIOR VENA CAVA COLLAPSIBILITY INDEX AS A PREDICTOR FOR HYPOTENSION AFTER SPINAL ANAESTHESIA

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ABSTRACT

Postspinal anaesthesia hypotension is a common side effect and can lead to significant morbidity and mortality. Inferior venacava collapsibility index (IVC-CI) and diameter of the inferior venacava (IVC) are two widely used parameters for assessing the intravascular volume status. In this study, we evaluated inferior vena cava collapsibility before surgery topredict hypotension after spinal anaesthesia. In this hospital based observational study, 80 patients aged 18-60 years of ASA physical status I and II undergoing surgery below umbilicus under spinal anesthesia. The IVC-CI and IVC diameter were measured using ultrasound pre-operatively. After administering spinal anaesthesia, haemodynamic data were collected till 18 min. Our general objective was to evaluate the predictive value of IVC-CI for detecting post-spinal hypotension and specific objectives were to to measure IVC diameter, calculate IVC-CI, measure MAP, SBP, DBP. We constructed the receiver operator characteristic (ROC) curves for IVCCI and obtained the best cut-off values. The post spinal hypotension occurred in 18 (22.5%) patients. IVC-CI had a sensitivity of 18.0%, a specificity of 76.0% and a positive predictive value of 18.0%, negative predictive value of 76.0% for predicting hypotension following spinal anesthesia at a cut off value of >42.0%. The IVC-CI had poor diagnostic accuracy for prediction of hypotension after spinal anesthesia for surgery below umbilicus.

KEYWORDS

Inferior venacava collapsibility index, inferior vanacava diameter, postspinal hypotension, spinal anesthesia

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INTRODUCTION

Spinal anaesthesia is frequently used for surgery below umbilicus. Postspinal anaesthesia hypotension is a common side effect with an incidence of 15.3 to 33.0% that may result in organ hypoperfusion and ischaemic events.[1-3] Hypotension occurs because of vasodilation due to preganglionic sympathetic fiber blockade resulting in peripheral vasodilatation.

Prevention of an undesired hypotensive event has a key role in avoiding such events. To date, available prediction models used for estimation of the risk of hypotension after spinal anesthesia are mostly based on nonmodifiable factors (e.g., age, comorbidities).[4] There is a need to identify variables that can help clinicians recognize patients with modifiable factor, such as those with impaired preload.

Recently, ultrasound has come up as a new modality to predict the intravascular volume status of patients undergoing surgery. There are many methods for assessing intravascular volume status preoperatively (Central venous pressure measurements, esophageal Doppler Ultrasound, pulmonary arterialcatheterization, and transesophageal echocardiography).[5-8] Still, most of them are invasive, time-consuming. The ultrasound-guided measurement of the diameter of the inferior venacava (IVC) can indirectly assess the intravascular volume.[9,10]

In this study, we hypothesized that preoperative inferior venacava collapsibility index (IVC-CI) assessment is a good predictor of intraoperative hypotension within twenty minutes of giving spinal anesthesia in patients undergoing elective surgery. The general objective of the study was to evaluate the ultrasonographic guided IVC-CI for prediction of hypotension after spinal anesthesia while the measurement of IVC diameter, MAP, SBP, DBP and calculation of IVC-CI were the specific objectives.

MATERIALS AND METHODS

This is a hospital based observational study conducted in Nepal Medical College Teaching Hospital (NMCTH), Kathmandu from July 2024-december 2024. All patients undergoing both elective and emergency surgery under spinal anesthesia, who fulfilled inclusion criteria were enrolled for the study. The patients aged 18-60 years with surgery below umbilicus under spinal anesthesia with ASA physical status I and II were included in the study while the patients with known hypersensitivity / contraindication to spinal anesthesia; pregnant patients; patients with BMI >40 $kg.m^{-2}$; those with any intra-abdominal tumors or the patients who refuse to participate were excluded from the study.

Target sample was obtained based on the results (sensitivity and specificity) of IVC-CI of <50.0% in predicting the development of significant hypotension.[11] With, Expected sensitivity of predicting hypotension from earlier study 39.0%,[11] 95.0% confidence interval and 10.0% allowable error, the minimum sample size is 76. Hence, the sample size to be taken was 80.

After the Institutional Review Committee (IRC) of NMCTH approval, the patients who met the inclusion criteria underwent pre-anesthetic assessment a day prior to the surgery. Anesthetic procedure were explained to the patient. Informed consent were obtained. Patients was kept NPO as per the ASA fasting guidelines.

All IVC measurements were performed in the supine position before administering spinal anesthesia using a SAMSUNG PT60A ultrasonography machine. All IVC measurements were performed by a single anesthesiologist fully trained in ultrasound who had at least 2 years of experience in this field.

The measurements of IVC diameter were carried out via subcostal approach in B-mode using a long-axis view of the IVC at end-expiration, just proximal to the junction of the hepatic veins that lie approximately 0.5 to 3.0 cm proximal to the ostium of the right atrium (RA). IVC-CI was calculated using the following equation: IVC-CI = ((IVCexpiratory − IVCinspiratory)/IVCexpiratory) × 100%.[12-14] In operating room, heart rate (HR), mean blood pressure (MBP), peripheral oxygen saturation were measured before spinal anesthesia and defined as baseline readings. An 18 gauge i.v. cannula was inserted and no fluid load will be administered to any of the patients before spinal anesthesia. Ringer lactate was infused at 10ml/kg/hr after spinal anesthesia.

An anesthesiologist who was not involved in the study administered spinal anesthesia with a 25-gauge Quincke needle. A dose of 12 to 15 mg of 0.5% heavy bupivacaine (depending on the surgery and the patient's constitution) was injected intrathecally, when the free flow of cerebrospinal fluid was obtained at L3-L4 level. After injection, patients were immediately positioned in the supine position. Meanwhile, non-invasive blood pressure measurements were performed every 3min, and other vital parameters were recorded continuously during the period following spinal anesthesia.

The sensory block level was evaluated with a pinprick test by an anesthetist who was not involved in the study, with the aim of a T8-T6 level block (Fig. 1).

An episode of hypotension was defined as a decrease in the MBP by more than 20.0% of the baseline value or any recorded period of MBP <65 mmHg during the period following spinal anesthesia. Severe hypotension was defined as MBP <55 mmHg. Episodes of hypotension was treated using 5 mL/kg of crystalloids infused within 15 min. After 2 min of persistent hypotension or MBP <55 mmHg, appropriate vasoactive drug (mephentermine 3 mg, phenylephrine 100 µg) was administered every 2 min depending on improvement in the patient's condition. Any complications such as nausea and vomiting, discomfort, shivering, or allergic reactions were noted and managed accordingly.

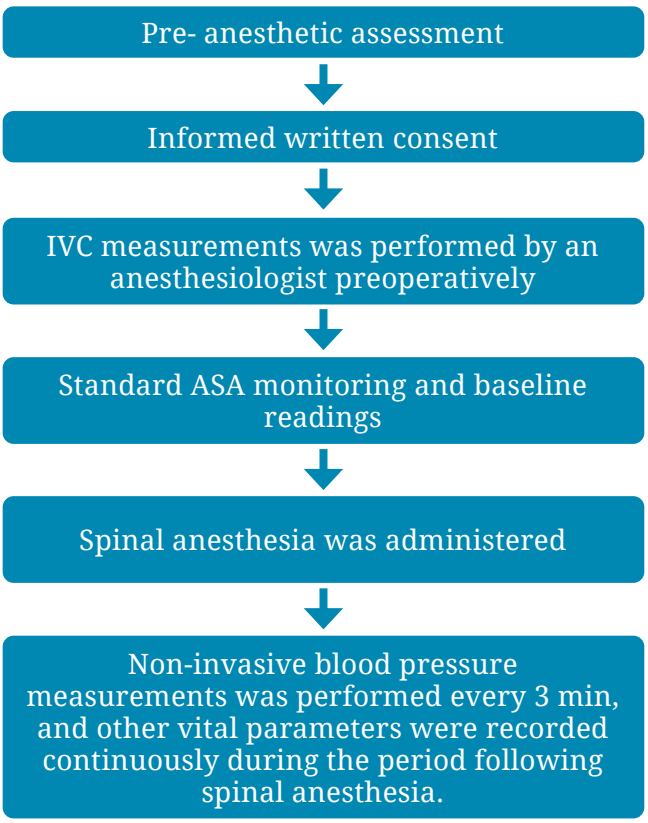

Fig. 1: Graphic representation of study design and procedure

Statistical analysis: Data analysis was performed by using SPSS-16. Mean±standard deviation (SD) was calculated for age. The student's t-test was applied for demographic and hemodynamic variables like age, weight, heart rate, blood pressure, and mean arterial pressure. The Chi-square test was used to see the association between the groups for categorical variables like gender, ASA physical status. Receiver operating characteristic (ROC) curves was used to assess the diagnostic value of IVCCI for predicting PSAH. The interclass correlation coefficients (ICCs) and their 95.0% confidence intervals (CI) were calculated to assess the degree of reliability. P-value was considered statistically significant if less than 0.05.

RESULTS

Eighty patients were enrolled in this study. Among the 80 patients, 55 were male (68.0%), and 25 were female (32.0%). Fourteen patients were ASA I (17.5%), and 66 were ASA II (82.5%). The mean age was 41.92 years, with a standard deviation of 14.53. After spinal anesthesia, 18 (22.5%) patients developed hypotension. ASA II patients developed hypotension more often than ASA I patients (P- value >0.05). Among these, sixteen patients received mephentermine and two patients improved with bolus intravenous fluid only. No significant difference was

Table 1: Demographic variables

Variables	Combined (n=80)	Normotensive (n=62)	Hypotensive (n=18)	P-Value
Age (years)	42±14.5	39±14.72	52±8.11	<0.05
Weight (kg)	60.38±10.20	60±10.44	63±9.38	0.37
Male sex, n (%)	55 (68%)	40 (64%)	15(81%)	>0.05
ASA (I/II)	14/66	14/48	0/18	0.07
Baseline SBP, mmHg	130.62±13	131.25±13	128.36±13	0.52
Baseline MAP, mmHg	99.18±9.11	99.28±9	99±10	0.89
Baseline HR, beats/min	82.14±17.26	80.20±15.70	89±21.37	0.22
dIVC, mm	18.72±14.17	19.12±16	17.31±5	0.54
IVC-CI, %	27.77±16.66	28.10±17.56	26.60±13.62	0.76

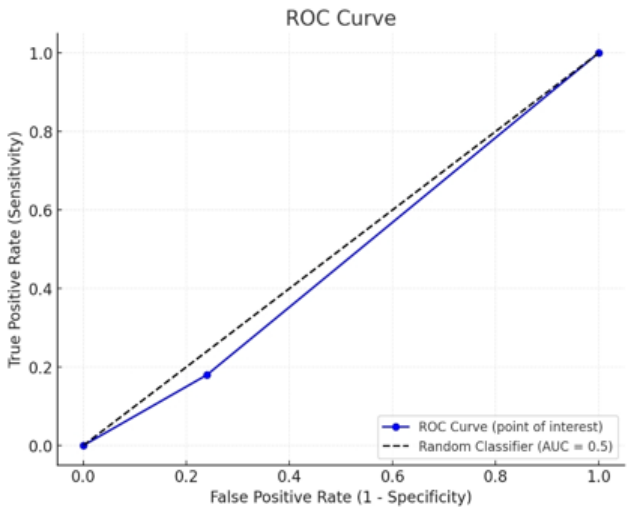

Fig. 2: Receiver operating characteristic curves showing the ability of collapsibility index of inferior venacava to predict hypotension following spinal anesthesia. The point of interest on the curve corresponds to the (true positive rate, false positive rate) value of (0.24, 0.18).

observed in baseline MAP between patients who develop hypotension and those with hemodynamic stability (P =0.89). Patients who developed hypotension had both dIVC and IVC-CI smaller with p value >0.05. IVC-CI has week relationship for predicting hypotension following spinal anesthesia (r =-0.15). Side effects like nausea, vomiting, shivering, allergic reaction were not appreciated in any patients.

ROC curve Analysis: ROC curve analysis showed that IVC-CI had a sensitivity of 18.0%, a specificity of 76.0% and a positive predictive value of 18.0%, negative predictive value of 76.0% for predicting hypotension following spinal anesthesia at a cut off value of >42.0%. The AUC was 0.408 (Fig. 2). Hypotension occurred in 14 of the 62 patients with IVCCI <42.0%.

DISCUSSION

In this study we evaluated inferior vanacava collapsibility as a predicator for hypotension after spinal anesthesia. Post-spinal anesthesia hypotension is one of the most common side effects of spinal anesthesia. Hypotension occurs due to decreased systemic vascular resistance because of sympatholysis and decreased cardiac output because of reduced venous return. Post-spinal anesthesia hypotension may be associated with nausea, vomiting, syncope, dizziness, aspiration, cardiac arrhythmias, cardiac arrest, and even death. Intraoperative hypotension has been found to correlate with post-operative mortality.[15]

Ultrasonographic assessment of the inferior vena cava collapsibility index (IVC-CI) and inferior venacava diameter is easy to perform, non-invasive, time-efficient, and readily available as well. The ultrasonographic measurement of IVC-CI as predictors of fluid responsiveness has been extensively studied in different patient populations, predominantly in the critically ill patients.

In our study, we found that IVC-CI were not good predictor of post spinal hypotension like the study conducted by Roy *et al.*[16] In their study, the percentage decrease in MBP and IVC-CI revealed linear relationship that denotes a progressive increase in IVC-CI does not necessarily cause a more progressive fall in BP. The ROC curve analysis for predicting post-spinal hypotension did not demonstrate good diagnostic accuracy as the area under the curve was 0.46. Similarly, in the study done by Chowdhury *et al*[17] out of the 50 patients, 17 (34.0%) patients developed post spinal hypotension and the IVC-CI predicted post spinal hypotension with poor sensitivity and specificity in both groups which was near to our study finding. In another study, by Ceruti *et al*[18] relative risk reduction of hypotension was 35.0% between IVC-Ultrasound guided volume management-group and a control group with no IVCUS assessment. IVC collapsibility index was correlated with the amount of fluid administered (r^2=0.32), but not to predict postspinal anaesthesia hypotension, which supports our study findings.

However, in a research done by Ni *et al*[19] ROC curve analysis revealed that IVC-CI had a sensitivity of 83.9%, a specificity of 76.3%, and a positive predictive value of 84.0% for predicting postspinal anesthesia hypotension at a cut-off point of >42.0%. The area under the curve (AUC) was 0.834. The reason behind different finding from our study can be due to the IVC ultrasound-guided fluid therapy while we administed 10 mL kg^{-1} of Ringer lactate as maintainance fluid without any specific USG-guided endpoint of fluid therapy. Our study finding can be explained by multifactorial reasons. First, maintenance fluid might have prevented hypotension in hypovolemic patients. Second, the IVC-CI is also determined by the patient's respiratory effort and pattern. The diaphragmatic descent can compress the IVC and can cause reduction of the IVC diameter during inspiration in abdominal breathing as compared to thoracic breathing and falsely elevate the IVCCI. This can happen in anxious pre-operative patients.

For healthy adult patients, the IVC-CI had poor diagnostic accuracy for prediction of hypotension after spinal anesthesia. However, further studies with larger sample sizes are suggested particularly in elderly patients and in patients with pre-existing cardiovascular diseases. The limitations of this study include small sample size, invasive monitoring of blood pressure would have provided more precise data and the correlation of PSH was not assessed with the type of surgery which might be a confounding factor.

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