ISSN: 0975-3583,0976-2833 VOL15, ISSUE 8, 2024

ORIGINAL RESEARCH

Evaluating the efficacy of inferior vena cava collapsibility index and caval aorta index in anticipating the incidence of hypotension after spinal anaesthesia: A Clinical study

Prem Raj Nagarwal[1], Dr. Prachi Verma[2], Dr. Himani Marmat[3]

[1]Associate Professor, Department of Anaesthesiology, JNU Institute of Medical Sciences & Research Centre Jaipur (JNUIMSRC), Rajasthan, India.

[2]Associate Professor, Department of Anaesthesiology and Critical Care, Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India.

[3]Senior Resident, M.D. Medicine, Department of Medicine, Government Medical College, Ratlam, M.P., India

Corresponding Author:Dr. Prem Raj Nagarwal,

Associate Professor, Department of Anaesthiology, JNU Institute of Medical Sciences & Research Centre Jaipur (JNUIMSRC), Rajasthan, India. nagarwalprem70@gmail.com

Received: 19th June, 2024 Accepted: 14th July, 2024

Abstract:

Background

Spinal anesthesia is commonly used in various surgical procedures but is often associated with hypotension, which can lead to significant complications. The Inferior Vena Cava Collapsibility Index (IVCCI) and Caval Aorta Index (CAI) are potential predictors of fluid responsiveness and can help anticipate hypotension after spinal anesthesia. This study aims to evaluate the efficacy of IVCCI and CAI in predicting hypotension following spinal anesthesia.

Materials and Methods

A total of 100 patients scheduled for elective surgeries under spinal anesthesia were enrolled in this prospective clinical study. Preoperative IVCCI and CAI measurements were obtained using ultrasound. Spinal anesthesia was administered using 0.5% bupivacaine. Blood pressure was monitored every 5 minutes for 30 minutes post-anesthesia. Hypotension was defined as a systolic blood pressure decrease of more than 20% from baseline or below 90 mmHg. Statistical analysis was performed using logistic regression to assess the predictive value of IVCCI and CAI for hypotension.

Results

Out of 100 patients, 35 developed hypotension after spinal anesthesia. The mean IVCCI for the hypotensive group was 45%, compared to 25% in the non-hypotensive group ($p < 0.01$). The mean CAI was 0.8 in the hypotensive group and 0.6 in the non-hypotensive group ($p < 0.05$). Logistic regression analysis revealed that both IVCCI and CAI were significant predictors of hypotension, with IVCCI having a higher predictive accuracy (AUC = 0.85) compared to CAI (AUC = 0.78).

Conclusion

The Inferior Vena Cava Collapsibility Index and Caval Aorta Index are effective predictors of hypotension following spinal anesthesia. IVCCI, in particular, demonstrates superior predictive

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 8, 2024

accuracy. Incorporating these indices into preoperative assessments may enhance the management and prevention of hypotension, improving patient outcomes.

Keywords

Inferior Vena Cava Collapsibility Index, Caval Aorta Index, Hypotension, Spinal Anesthesia, Fluid Responsiveness, Ultrasound Predictors.

Introduction

Spinal anesthesia is a widely used technique for providing anesthesia during various surgical procedures, particularly in lower abdominal, pelvic, and lower limb surgeries. Despite its benefits, such as rapid onset and effective sensory and motor blockade, spinal anesthesia is frequently associated with hypotension, occurring in up to 30% of patients (1). Hypotension after spinal anesthesia is primarily due to sympathetic blockade, leading to vasodilation and a decrease in systemic vascular resistance and cardiac output (2). This hemodynamic instability can result in adverse outcomes, particularly in patients with compromised cardiovascular function (3).

Predicting hypotension following spinal anesthesia is crucial for implementing timely interventions to mitigate its effects. Traditionally, clinical parameters such as heart rate and blood pressure are used to guide fluid management, but these have limitations in accurately predicting hypotension (4). Recent advances in ultrasonography have provided non-invasive methods for assessing hemodynamic status, offering promising tools for predicting fluid responsiveness (5).

The Inferior Vena Cava Collapsibility Index (IVCCI) and Caval Aorta Index (CAI) are two such ultrasonographic indices that have gained attention for their potential utility in predicting fluid responsiveness and hypotension. The IVCCI is calculated by measuring the variation in the diameter of the inferior vena cava (IVC) during the respiratory cycle, with greater collapsibility indicating lower intravascular volume and potential fluid responsiveness (6). The CAI, on the other hand, involves the ratio of the diameters of the IVC to the aorta, providing another measure of volume status (7).

Previous studies have demonstrated the utility of IVCCI in predicting hypotension in various clinical settings, including critical care and emergency medicine (8,9). However, its application in the context of spinal anesthesia remains underexplored. Similarly, while the CAI has been shown to correlate with fluid responsiveness, its role in predicting hypotension after spinal anesthesia requires further investigation (10).

This study aims to evaluate the efficacy of the Inferior Vena Cava Collapsibility Index and Caval Aorta Index in predicting the incidence of hypotension following spinal anesthesia. By determining the predictive accuracy of these indices, this study seeks to enhance preoperative risk assessment and improve the management of patients undergoing spinal anesthesia.

Materials and Methods

Study Design and Participants

A total of 100 patients scheduled for elective surgeries under spinal anesthesia were enrolled. Inclusion criteria included patients aged 18-65 years, ASA physical status I or II, and those undergoing surgeries expected to last less than 2 hours. Exclusion criteria included patients

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 8, 2024

with a history of cardiovascular disease, obesity (BMI > 30 kg/m²), pregnancy, or any contraindications to spinal anesthesia.

Preoperative Assessment

All patients underwent a standard preoperative assessment, including a detailed medical history, physical examination, and routine laboratory tests. Baseline hemodynamic parameters, including heart rate and blood pressure, were recorded. Ultrasonographic measurements of the Inferior Vena Cava Collapsibility Index (IVCCI) and Caval Aorta Index (CAI) were performed using ultrasound machine.

Measurement of IVCCI and CAI

The IVCCI was calculated by measuring the maximum and minimum diameters of the inferior vena cava (IVC) during a respiratory cycle using the subcostal view. IVCCI was determined using the formula:

IVCCI=IVCmax−IVCminIVCmax×100\text{IVCCI} = \frac{\text{IVC}_{\text{max}} - \text{IVC}_{\text{min}}}{\text{IVC}_{\text{max}}} \times 100IVCCI=IVCmaxIVCmax −IVCmin×100

The CAI was calculated as the ratio of the diameter of the IVC to the diameter of the abdominal aorta (AA) at the level of the renal veins. Measurements were taken during end-expiration.

Anesthetic Technique

Spinal anesthesia was administered in the lateral position using a 25-gauge Quincke needle at the L3-L4 interspace. A standard dose of 12.5 mg of 0.5% hyperbaric bupivacaine was injected into the subarachnoid space. Patients were then positioned supine, and hemodynamic parameters were monitored every 5 minutes for the first 30 minutes after spinal anesthesia.

Definition of Hypotension

Hypotension was defined as a decrease in systolic blood pressure of more than 20% from baseline or a systolic blood pressure below 90 mmHg at any time within 30 minutes after the administration of spinal anesthesia.

Statistical Analysis

Data were analyzed using SPSS 23.

Results

Patient Demographics and Baseline Characteristics

A total of 100 patients were included in the study, with 45 males and 55 females. The mean age was 45 ± 12 years, and the mean body mass index (BMI) was 24.8 ± 3.2 kg/m². There were no significant differences in demographic characteristics between the hypotensive and non-hypotensive groups.

Incidence of Hypotension

Out of the 100 patients, 35 (35%) developed hypotension following spinal anesthesia. The mean time to onset of hypotension was 12 ± 5 minutes.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 8, 2024

Ultrasonographic Measurements

The mean IVCCI in the hypotensive group was 45% ± 8%, significantly higher than the 25% ± 6% observed in the non-hypotensive group ($p < 0.01$). The mean CAI was 0.8 ± 0.1 in the hypotensive group compared to 0.6 ± 0.1 in the non-hypotensive group ($p < 0.05$).

Predictive Accuracy of IVCCI and CAI

Receiver operating characteristic (ROC) curve analysis showed that IVCCI had a higher predictive accuracy for hypotension, with an area under the curve (AUC) of 0.85 (95% CI: 0.77-0.93), compared to CAI, which had an AUC of 0.78 (95% CI: 0.69-0.87).

Logistic Regression Analysis

Logistic regression identified IVCCI as an independent predictor of hypotension (odds ratio [OR] 1.12, 95% CI: 1.05-1.20, $p < 0.01$), while CAI was also a significant predictor (OR 1.09, 95% CI: 1.02-1.16, $p < 0.05$).

Tables

Table 1: Patient Demographics and Baseline Characteristics

Characteristic	Total (n=100)	Hypotensive (n=35)	Non-hypotensive (n=65)	p-value
Age (years)	45 ± 12	46 ± 11	44 ± 12	0.52
Male, n (%)	45 (45%)	16 (46%)	29 (45%)	0.92
Female, n (%)	55 (55%)	19 (54%)	36 (55%)	0.88
BMI (kg/m²)	24.8 ± 3.2	24.5 ± 3.1	25.0 ± 3.3	0.42

Table 2: Ultrasonographic Measurements and Hemodynamic Parameters

Parameter	Hypotensive (n=35)	Non-hypotensive (n=65)	p-value
IVCCI (%)	45 ± 8	25 ± 6	<0.01
CAI	0.8 ± 0.1	0.6 ± 0.1	<0.05
Time to hypotension (min)	12 ± 5	N/A	N/A

Table 3: Predictive Accuracy of IVCCI and CAI

Index	AUC (95% CI)	Sensitivity (%)	Specificity (%)
IVCCI	0.85 (0.77-0.93)	82	78
CAI	0.78 (0.69-0.87)	74	70

These results suggest that both the Inferior Vena Cava Collapsibility Index and the Caval Aorta Index are effective in predicting hypotension following spinal anesthesia, with IVCCI showing superior predictive performance. Incorporating these measurements into preoperative assessments could improve the management of patients undergoing spinal anesthesia by allowing for better anticipation and prevention of hypotensive events.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 8, 2024

Discussion

The findings of this study demonstrate that both the Inferior Vena Cava Collapsibility Index (IVCCI) and Caval Aorta Index (CAI) are effective predictors of hypotension following spinal anesthesia. Our results align with previous research highlighting the potential of ultrasonographic indices to assess fluid responsiveness and predict hemodynamic instability (1,2).

The IVCCI showed a significant association with the development of hypotension, with a higher mean IVCCI observed in hypotensive patients compared to non-hypotensive patients. This finding supports previous studies that have identified IVCCI as a reliable indicator of intravascular volume status and fluid responsiveness in critically ill patients (3,4). The high predictive accuracy of IVCCI (AUC = 0.85) suggests its utility as a preoperative screening tool to identify patients at risk of hypotension after spinal anesthesia. This is consistent with Feissel et al.'s study, which demonstrated that IVCCI could predict fluid responsiveness with an AUC of 0.84 in mechanically ventilated patients (5).

The CAI also showed a statistically significant difference between hypotensive and non-hypotensive groups, with an AUC of 0.78. Although the CAI was a less robust predictor than IVCCI, it still provided valuable information about patients' hemodynamic status. Kircher et al. reported that the CAI is a useful adjunct for assessing intravascular volume, particularly when combined with other indices (6). The CAI’s utility in this context may be enhanced by integrating it with additional clinical parameters to improve the overall predictive model.

Incorporating IVCCI and CAI measurements into routine preoperative assessments can enhance the management of patients undergoing spinal anesthesia. By identifying those at higher risk for hypotension, anesthesiologists can implement preventive measures, such as preloading with intravenous fluids or using vasopressors, to mitigate hemodynamic instability. This proactive approach could reduce the incidence of hypotension-related complications, improving patient outcomes (7).

This study has several limitations. First, the sample size was relatively small and limited to a single institution, which may affect the generalizability of the results. Future multicenter studies with larger sample sizes are necessary to validate these findings. Second, the study focused only on ASA I and II patients, excluding those with significant comorbidities who might have different hemodynamic responses to spinal anesthesia. Additionally, while ultrasound measurements were performed by experienced operators, interobserver variability was not assessed, which could impact the reproducibility of the results.

Conclusion

Both the Inferior Vena Cava Collapsibility Index and Caval Aorta Index are effective in predicting hypotension following spinal anesthesia, with IVCCI demonstrating superior predictive accuracy. Implementing these indices into preoperative assessments can improve the management and prevention of hypotension, enhancing patient safety and outcomes. Further research is needed to explore the integration of these indices into comprehensive predictive models that consider additional patient-specific factors.

References

1. Carpenter RL, Caplan RA, Brown DL, Stephenson C, Wu R. Incidence and risk factors for side effects of spinal anesthesia. Anesthesiology. 1992;76(6):906-16.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 8, 2024

2. Greene NM. Physiology of spinal anesthesia. Baltimore: Williams & Wilkins; 1981.

3. Brull R, Macfarlane AJ, Chan VW. Spinal, epidural, and caudal anesthesia. In: Miller RD, editor. Miller's Anesthesia. 8th ed. Philadelphia: Elsevier Saunders; 2015. p. 1684-720.

4. Marquez J, Boscan P, Grubb T, et al. Agreement between pulse pressure variation and pleth variability index for the prediction of fluid responsiveness in anesthetized dogs. J Vet Emerg Crit Care. 2013;23(3):346-50.

5. Vieillard-Baron A, Chergui K, Augarde R, et al. Cyclic changes in right ventricular output impedance during mechanical ventilation. J ApplPhysiol (1985). 2003;95(5):2333-41.

6. Feissel M, Michard F, Mangin I, et al. Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients. Intensive Care Med. 2004;30(9):1740-6.

7. Kircher BJ, Himelman RB, Schiller NB. Noninvasive estimation of right atrial pressure from the inspiratory collapse of the inferior vena cava. Am J Cardiol. 1990;66(4):493-6.

8. Muller L, Bobbia X, Toumi M, et al. Respiratory variations of inferior vena cava diameter to predict fluid responsiveness in spontaneously breathing patients with acute circulatory failure: need for a cautious use. Crit Care. 2012;16(5)

9. Barbier C, Loubières Y, Schmit C, et al. Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients. Intensive Care Med. 2004;30(9):1740-6.

10. Resnick J, Cydulka RK. Use of ultrasound to assess intravascular volume in children undergoing elective surgery. J Ultrasound Med. 2005;24(4):423-6.