Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 31s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Ultrasound Guided Inferior Vena Cava Collapsibility Index (IVCCI) as a Predictor of Hypotension in Pregnant Women Undergoing Lower Segment Caesarean under Spinal Anesthesia

Tasneem Fathima Ahmed[1], Rathna Paramaswamy[2], Lakshmi Ramakrishnan[3]

[1] Senior Resident, Department of Neuroanesthesia, Christian Medical College, Vellore, India.

ORCID Id: 0000-0001-6397-285X

[2] Professor, Department of Anesthesiology, Saveetha Medical College and Hospital, Chennai, India.

ORCID: 0000-0002-0784-6952

[3] Professor and HOD, Department of Anesthesiology, Saveetha Medical College and Hospital, Chennai, India.

ORCID- 0000-0003-4984-4688

[*]**Corresponding author:**

Tasneem Fathima Ahmed

Cite this paper as: Tasneem Fathima Ahmed, Rathna Paramaswamy, Lakshmi Ramakrishnan, (2025) Ultrasound Guided Inferior Vena Cava Collapsibility Index (IVCCI) as a Predictor of Hypotension in Pregnant Women Undergoing Lower Segment Caesarean under Spinal Anesthesia. *Journal of Neonatal Surgery*, 14 (31s), 673-679.

ABSTRACT

Background: Post-spinal hypotension (PSH) is a common complication seen during the intra-operative period in women posted for caesarean section under spinal anaesthesia. It poses risks to both mother and foetus. The Inferior Vena Cava Collapsibility Index (IVCCI) has emerged as a non-invasive tool for assessing volume status and may predict PSH.

Methods: In this prospective observational study, 123 term pregnant women scheduled for elective lower segment caesarean section under spinal anaesthesia were enrolled. Preoperative ultrasound was done to measure minimum and maximum IVC diameters, and IVCCI was calculated. Hemodynamic parameters were recorded every 5 minutes for 30 minutes post-spinal anesthesia. The primary outcome was the incidence of PSH and its association with IVCCI. ROC curve analysis was performed to determine predictive thresholds.

Results: PSH occurred in 58.5% of participants. IVCCI was significantly higher in patients who developed hypotension. An IVCCI >26.5% yielded a sensitivity of 94.4% and specificity of 27.5%, while a threshold of >36.5% improved specificity to 60.8% with sensitivity of 83.3%. ROC analysis demonstrated an AUC of 0.745 ($p < 0.001$), confirming moderate predictive accuracy. Heart rate and mean arterial pressure trends also differed significantly between hypotensive and normotensive groups.

Conclusion: IVCCI is a reliable, non-invasive predictor of post-spinal hypotension in parturients. Incorporating bedside IVC ultrasound into preoperative assessment may improve early identification and targeted management of high-risk patients.

Keywords: *Inferior vena cava, IVCCI, post-spinal hypotension, spinal anaesthesia, caesarean section*

1. INTRODUCTION

Spinal anaesthesia remains the preferred technique for elective caesarean sections due to its safety profile, rapid onset, and minimal fetal drug exposure compared to general anaesthesia.[(1)] However, one of its most common and clinically significant complications is post-spinal hypotension (PSH), which can lead to maternal discomfort, nausea, vomiting, and, more critically, compromised uteroplacental perfusion resulting in fetal acidosis and hypoxia.[(2)]

The physiological basis of PSH lies in the sympathetic blockade induced by spinal anaesthesia, leading to vasodilation, decreased preload, and bradycardia. These effects are magnified in pregnant women due to aorto-caval compression by the gravid uterus, especially in supine position.[(3)] The incidence of PSH in obstetric patients varies widely, reported between 7.4% and 74.1%, depending on definitions and prophylactic measures employed.[(3)]

Preventive strategies for PSH include fluid preloading or co-loading, left uterine displacement, and vasopressor use. Among vasopressors, phenylephrine and ephedrine are commonly used, with international consensus supporting phenylephrine as the first-line agent due to its efficacy and fetal safety profile.[4]

Despite these interventions, a universally effective prophylaxis for PSH remains elusive. Thus, identifying patients at high risk before anaesthesia becomes crucial for targeted hemodynamic management. One promising, non-invasive modality for such risk stratification is the Inferior Vena Cava Collapsibility Index (IVCCI), which can be measured using bedside ultrasound.[5]

IVCCI reflects intravascular volume status by assessing respiratory variations in IVC diameter. It has been validated in various clinical settings, including intensive care and emergency departments, as a predictor of fluid responsiveness.[6] Its application in obstetrics is still evolving, but early studies suggest a possible role in predicting PSH.[7, 8]

This study aims to evaluate the predictive value of IVCCI for post-spinal hypotension in full-term pregnant women undergoing elective caesarean section under spinal anaesthesia. We hypothesize that a higher preoperative IVCCI is associated with increased susceptibility to PSH.

2. METHODS

Study Objective

The objective of this study was to evaluate the ability of IVCCI to predict PSH in term pregnant women undergoing elective caesarean section by assessing the correlation between IVCCI and hemodynamic parameters (heart rate and mean arterial pressure).

Study Design and Setting

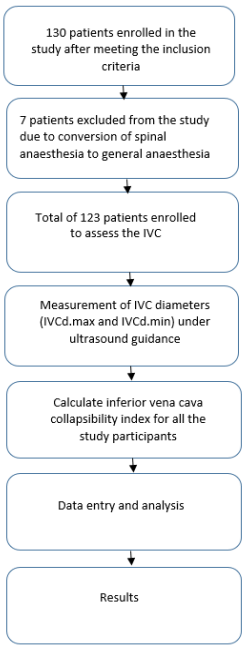
We conducted a prospective, observational study at Saveetha Medical College and Hospital, Chennai, India, over a six-month period from December 2020 to June 2021. Ethical approval was obtained from the Institutional Review Board and Ethics Committee before participant recruitment.

Participants

A total of 123 pregnant women with singleton, full-term gestation scheduled for elective lower segment caesarean section under spinal anaesthesia were enrolled. Inclusion criteria included age between 20 and 40 years and American Society of Anaesthesiologists (ASA) physical status I or II. Exclusion criteria were pregnancy-induced hypertension, cardiac disease, multiple gestations, ASA physical status ≥ III, contraindications to neuraxial anaesthesia, drug allergies, or refusal to participate.

Sample size was calculated based on previously reported sensitivity and specificity values for IVCCI (Singh et al., 2019), using a confidence level of 95% and 10% precision, resulting in a minimum requirement of 91 participants.

Figure.1. CONSORT flow chart



Preoperative Scanning

All participants underwent a pre-anaesthetic evaluation, and informed written consent was obtained. Ultrasound-guided measurement of the inferior vena cava (IVC) was performed in the left lateral decubitus position using a low-frequency (2–5 MHz) curvilinear transducer. The IVC was visualized in the subxiphoid sagittal view. Measurements were taken 1 cm distal to the hepatic vein-IVC junction. Maximum and minimum diameters were recorded during expiration and inspiration, respectively. IVCCI was calculated using the following formula:

$$\text{IVCCI}\ (\%) = \left(\frac{\text{IVCd}_{\text{max}} - \text{IVCd}_{\text{min}}}{\text{IVCd}_{\text{max}}} \right) \times 100$$

Intraoperative Period

Upon arrival in the operating room, standard ASA monitors were applied, and baseline heart rate (HR), non-invasive blood pressure (NIBP), and oxygen saturation (SpO_2) were recorded. Participants were co-loaded with Ringer's lactate solution (15 ml/kg) at the time of spinal anaesthesia. Spinal anaesthesia was administered in the sitting position at the L3–L4 interspace using 2.0 mL of 0.5% hyperbaric bupivacaine. A Crawford wedge was placed under the right iliac crest to provide left uterine displacement until delivery.

Hemodynamic parameters (HR and mean arterial pressure (MAP) were recorded every 5 minutes for 30 minutes following spinal induction. Hypotension was defined as systolic blood pressure <100 mmHg or a MAP decrease >25% from baseline. Ephedrine 6 mg IV bolus was administered as needed to treat hypotension.

Statistical Analysis

Data were analyzed using IBM SPSS version 20. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Comparisons between groups (hypotension vs. no hypotension) were performed using the unpaired Student's *t*-test for continuous variables. ROC curve analysis was conducted to assess the diagnostic accuracy of IVCCI in predicting PSH, with sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) calculated at different IVCCI cut-offs. A p-value of <0.05 was considered statistically significant.

3. RESULTS

1.Demographic Details

Age and body mass index (BMI) was analyzed using frequency analysis and percentage analysis. Majority of the patients were less than 30 years of age (76.5%) and had a BMI of more than 30.

Table 1. Demographic details

Demographic Details		Number	Percentage (%)
Age	<30 years	94	76.5
	>30 years	29	23.5
BMI	<18.5	0	0
	18.5-24.9	11	8.9
	25-29.9	51	41.5
	>30	61	49.5

2. Hemodynamic Parameters Post Spinal Anesthesia

To assess the effects of spinal anesthesia on cardiovascular status, heart rate (HR) and mean arterial pressure (MAP) were measured at regular intervals post spinal anesthesia. These parameters were compared between participants who developed post-spinal hypotension (PSH) and those who did not.

At baseline (0 minutes), HR and MAP values were not significantly different between groups. However, significant changes emerged at 5 and 10 minutes:

- Heart rate was significantly higher in the PSH group at 5, 10, and 15 minutes ($p < 0.05$), suggesting a compensatory response to hypotension.

- MAP was significantly lower in the PSH group at 5 and 10 minutes ($p < 0.01$), reflecting the onset of hypotension.

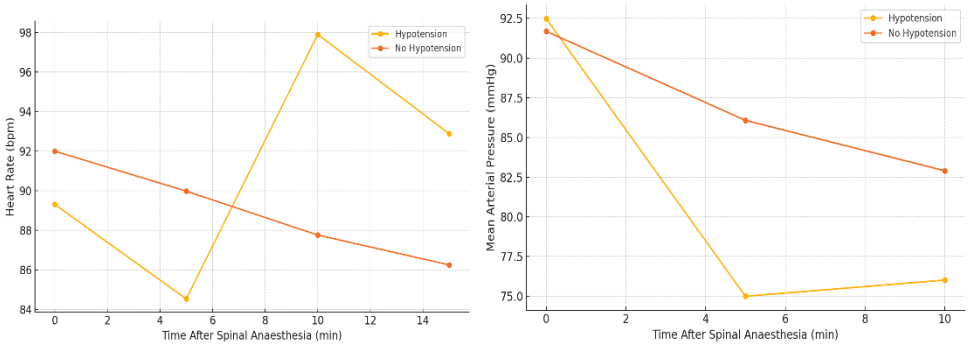
Table 2. Heart Rate Comparison Between Groups

Time (min)	Hypotensive Group (Mean ± SD)	Non-Hypotensive Group (Mean ± SD)	P-value
0	89.31 ± 14.08	92.00 ± 13.40	0.288
5	84.53 ± 16.95	89.98 ± 11.63	0.04
10	97.90 ± 14.01	87.76 ± 11.32	<0.001
15	92.88 ± 9.89	86.25 ± 14.80	0.004

Table 3. Mean Arterial Pressure Comparison Between Groups

Time (min)	Hypotensive Group (Mean ± SD)	Non-Hypotensive Group (Mean ± SD)	P-value
0	92.49 ± 9.74	91.69 ± 11.10	0.673
5	74.99 ± 13.14	86.08 ± 13.07	<0.001
10	76.01 ± 12.35	82.90 ± 12.04	0.003

Figure 2. Heart Rate and Mean Arterial Pressure Trends After Spinal Anesthesia



Heart rate was significantly higher in the hypotensive group at 5-, 10-, and 15-minutes post-spinal anesthesia. MAP dropped significantly in the hypotension group at 5 and 10 minutes compared to the non-hypotensive group.

3. Incidence and Management of Hypotension

Out of 123 participants, 72 women experienced PSH while 51 women did not. The overall incidence of PSH in this study is 58.5 %.

To manage hypotension, intravenous ephedrine was administered in bolus doses of 6 mg as needed and 52.8% of patients received 1 bolus while 5.6% received 2 boluses.

4.Induction to delivery time

The mean induction-to-delivery time was approximately 15 minutes, indicating efficient surgical progression post-anesthesia.

5. IVC Ultrasound Measurements

The IVC diameter was measured during end-inspiratory phase (IVCd min) and end-expiratory phase (IVCd max) of respiratory cycles, and the means were 10.48 mm and 18.45 mm respectively.

Table 4. Mean and standard deviation of IVC diameters among the study participants

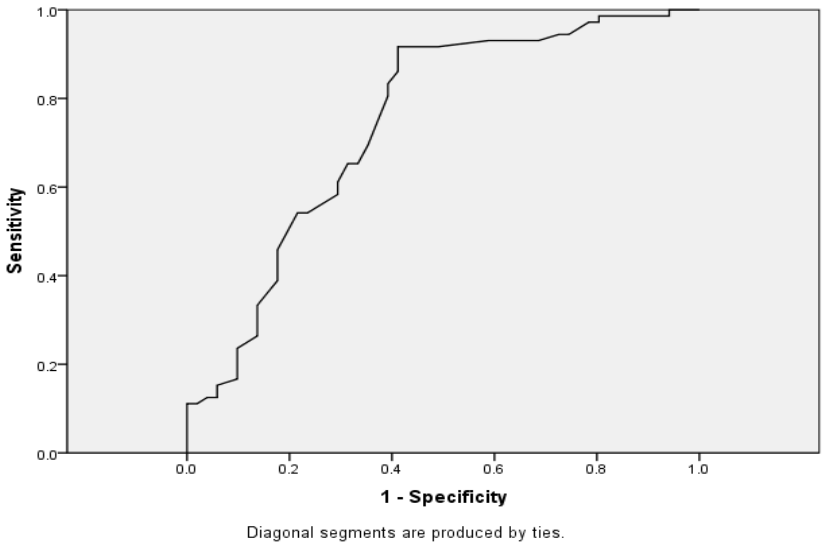
IVC Diameter (mm)	**Mean**	**Median**	**Std.Deviation**	**Range**	**Minimum**	**Maximum**
IVCd min	10.4880	9.7200	4.38002	21.01	3.31	24.32
IVCd max	18.1523	17.9200	4.82153	22.20	8.80	31.00

6.Predictive Value of IVCCI

To determine the Sensitivity, Specificity, Positive Predictive Value (PPV), and Negative Predictor Value of IVCCI with the incidence of hypotension, the Receiver Operator Characteristic (ROC) curve analysis was used.

IVCCI% to predict PSH was 0.74 (95% CI 0.65, 0.83) and it has shown that the best cut-off value that showed significant sensitivity and specificity values was if IVCCI (%) ranges between 16.5 and 26.5%. With a standard error of 0.47 and p-value at <0.001, the ROC analysis was found to be significant

Figure.3. ROC Curve Analysis



Based on data from previous studies, the thresholds for IVCCI cut-off was kept at >36.5% and >26.5%. The incidence of post spinal hypotension (n=60) has decreased significantly, with a p-value of <0.001, when compared to the cut-off values kept at 26.5% (n=68).

IVCCI **>36.5%** could predict post spinal hypotension with **83.3% sensitivity**, 60% specificity.

IVCCI **>26.5%** could predict post spinal hypotension with a high **94.4% sensitivity**, but very low specificity (27.5%) Both thresholds demonstrated statistically significant predictive value ($p < 0.001$).

4. DISCUSSION

Our findings indicate that IVCCI is a clinically useful non-invasive parameter for assessing volume status and identifying patients at risk of hypotension following spinal anaesthesia.

The overall incidence of PSH in our study was 58.5%, consistent with previous reports that document a wide range (7.4% to 74.1%), likely reflecting variation in definitions, prophylactic strategies, and patient characteristics.[9] Despite prophylactic co-loading with crystalloids and the use of left uterine displacement, hypotension remained prevalent, underscoring the need for predictive tools to tailor management.

We found that an IVCCI threshold of >26.5% offered high sensitivity (94.4%) but poor specificity (27.5%), while a higher threshold of >36.5% improved specificity (60.8%) with a trade-off in sensitivity (83.3%). These findings align with those of Airapetian et al., who showed that IVCCI values above 40% are predictive of fluid responsiveness in spontaneously breathing patients.[10] Although originally developed for use in critical care and emergency settings, our study supports the extension of this tool to obstetric anaesthesia, a field where fluid balance is critical and invasive monitoring is limited.

The predictive value of IVCCI has been debated in obstetric populations. Singh et al. reported poor diagnostic accuracy of IVCCI for PSH in term pregnant women, citing confounding factors such as gestational aortocaval compression.[11] However, other studies—such as that by Salama et al.—support our results, demonstrating significant predictive value of both IVCCI and IVC:Ao ratio, with IVCCI showing a sensitivity of 84% and specificity of 77% at a threshold of 44.7% (12). Our intermediate thresholds (26.5% and 36.5%) offer more clinically pragmatic cut-offs while maintaining statistically significant predictive power.

Interestingly, heart rate and mean arterial pressure trends in our study revealed significantly higher heart rates and lower MAPs in hypotensive patients at 5- and 10-minutes post-spinal. This supports the hypothesis that sympathetic blockade, compounded by reduced venous return, precipitates compensatory tachycardia and subsequent hemodynamic instability. These observations are in line with previous work showing that baseline autonomic tone and vascular compliance affect susceptibility to PSH.[13,14]

Ultrasound-based IVCCI assessment has several advantages—it is rapid, non-invasive, reproducible, and feasible in obstetric populations without need for advanced operator training. In the context of limited-resource settings or cases where rapid fluid assessment is required, it may offer practical value beyond subjective clinical judgment.[15]

Despite these strengths, our study has limitations. It was a single-centre study with a modest sample size, and did not evaluate inter-observer variability. Furthermore, only elective cases were included, limiting the generalizability to emergency caesarean deliveries. Future multicentre trials with broader patient inclusion criteria and incorporation of additional dynamic indices (e.g., carotid flow time or internal jugular vein collapsibility) could strengthen predictive modelling.

5. CONCLUSION

Ultrasound-guided measurement of the inferior vena cava collapsibility index (IVCCI) provides a simple, non-invasive, and reliable method for predicting post-spinal hypotension in term parturients undergoing elective caesarean section. IVCCI thresholds >26.5% and >36.5% were associated with a significantly increased risk of hypotension, with the latter offering a better balance of sensitivity and specificity. Implementation of preoperative IVC scanning may allow for individualized fluid and vasopressor strategies, ultimately enhancing maternal hemodynamic stability and fetal safety.

REFERENCES

[1] Yeoh, S. B., Leong, S. B., & Heng, A. S. (2010). Anaesthesia for lower-segment caesarean section: Changing perspectives. *Indian Journal of Anaesthesia*, 54(5), 409–414.

[2] Šklebar, I., Bujas, T., & Habek, D. (2019). Spinal anaesthesia-induced hypotension in obstetrics: Prevention and therapy. *Acta Clinica Croatica*, 58(Suppl 1), 90.

[3] Bishop, D. G. (2014). Predicting spinal hypotension during Caesarean section. *Southern African Journal of Anaesthesia and Analgesia*, 20(4), 14–17.

[4] Kinsella, S. M., Carvalho, B., Dyer, R. A., Fernando, R., McDonnell, N., Mercier, F. J., ... & Vercueil, A. (2018). International consensus statement on the management of hypotension with vasopressors during caesarean section under spinal anaesthesia. *Obstetric Anesthesia Digest*, 38(4), 171–172.

[5] Zhang, J., & Critchley, L. A. (2016). Inferior vena cava ultrasonography before general anesthesia can predict hypotension after induction. *Anesthesiology*, 124(3), 580–589.

[6] Airapetian, N., Maizel, J., Alyamani, O., Mahjoub, Y., Lorne, E., Levrard, M., ... & Dupont, H. (2015). Does inferior vena cava respiratory variability predict fluid responsiveness in spontaneously breathing patients? *Critical Care*, 19(1), 1–8.

[7] Singh, Y., Anand, R. K., Gupta, S., Chowdhury, S. R., Maitra, S., Baidya, D. K., & Singh, A. K. (2019). Role of IVC collapsibility index to predict post spinal hypotension in pregnant women undergoing caesarean section. *Saudi Journal of Anaesthesia*, 13(4), 312–317.

[8] Salama, E. R., Refaat, R. H., & Soliman, M. A. (2018). Pre-operative inferior vena cava collapsibility index

and IVC to aorta diameter index as predictors for post spinal anaesthesia hypotension.

[9] Hartmann, B., Junger, A., Klasen, J., Benson, M., Jost, A., Banzhaf, A., et al. (2002). The incidence and risk factors for hypotension after spinal anaesthesia induction: An analysis with automated data collection. *Anesthesia & Analgesia*, 94, 1521–1529.

[10] Airapetian, N., Maizel, J., Alyamani, O., et al. (2015). Does inferior vena cava respiratory variability predict fluid responsiveness in spontaneously breathing patients? *Critical Care*, 19(1), 1–8.

[11] Singh, Y., Anand, R. K., Gupta, S., et al. (2019). Role of IVC collapsibility index to predict post spinal hypotension in pregnant women undergoing caesarean section. *Saudi Journal of Anaesthesia*, 13(4), 312–317.

[12] Salama, E. R., Refaat, R. H., & Soliman, M. A. (2018). Pre-operative inferior vena cava collapsibility index and IVC to aorta diameter index as predictors for post spinal anaesthesia hypotension. *[Study included in thesis]*

[13] Bishop, D. G., Cairns, C., Grobbelaar, M., & Rodseth, R. N. (2017). Heart rate variability as a predictor of hypotension following spinal for elective caesarean section: A prospective observational study. *Anaesthesia*, 72, 603–608.

[14] Riley, E. T., Cohen, S. E., Rubenstein, A. J., & Flanagan, B. (1995). Prevention of hypotension after spinal anesthesia for cesarean section: six percent hetastarch versus lactated Ringer's solution. *Anesthesia & Analgesia*, 81, 838–842.

[15] Chowdhury, S. R., Baidya, D. K., Maitra, S., et al. (2022). Assessment of role of inferior vena cava collapsibility index and variations in carotid artery peak systolic velocity in prediction of post-spinal anaesthesia hypotension in spontaneously breathing patients: An observational study. *Indian Journal of Anaesthesia*, 66(2), 100–105.