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RESEARCH ARTICLE
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EFFICACY OF INFERIOR VENA CAVA COMPRESSIBILITY INDEX IN PREDICTING POST-SPINAL HYPOTENSION AND ITS CORRELATION WITH PERFUSION INDEX AND PLETH VARIABILITY INDEX IN INFRAUMBILICAL SURGERIES.

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Abstract

Background and Aims: Following infraumbilical surgery under spinal anaesthesia, post-spinal hypotension (PSH) is a frequent and important clinical consequence. It arises mainly from sympathetic blockade, causing peripheral vasodilation, venous pooling, and reduced cardiac output. Prompt identification of patients at higher risk enables timely preventive measures. This study examined the predictive efficacy of Inferior Vena Cava Collapsibility Index (IVC-CI) for PSH as well as the correlation between Pleth Variability Index (PVI), Perfusion Index (PI), and occurrence of hypotension. This prospective, double-blind, randomized observational study involved 100 ASA I–II patients between the ages of 18 and 60 who were under spinal anaesthesia for elective infraumbilical surgeries. Using preoperative ultrasound, patients were grouped as Group A (IVC-CI <40%) or Group B (IVC-CI ≥40%). Baseline PI, PVI, and haemodynamic parameters were recorded. The capacity of IVC-CI to predict PSH, as evaluated through sensitivity ,specificity and receiver operating characteristic (ROC) analysis, was primary result. Secondary outcomes were correlations between PI, PVI, and hypotension, as well as vasopressor use.

Results: Hypotension occurred in 64% of Group B compared with 12% of Group A ($p < 0.001$). An IVC-CI >40% predicted PSH with 84.21% sensitivity and 70.97% specificity (AUC = 0.867). Higher baseline PI (>3.5) and elevated PVI were significantly linked to hypotension. Vasopressor (ephedrine) requirement was also notably greater in Group B ($p < 0.01$).

Conclusion: Preoperative IVC-CI is reliable and non-invasive predictor of PSH. Both PI and PVI show a significant association with hypotension, supporting their use as adjuncts in perioperative risk assessment.

Keywords: Post-spinal hypotension, IVC-CI, Perfusion Index, Pleth Variability Index, Spinal anaesthesia, Infraumbilical surgery

Introduction

Infraumbilical procedures frequently result in hypotension, a well-known side effect of spinal anaesthesia. It results primarily from sympathetic nervous system blockade, which induces arterial and venous vasodilation, reduces venous return, and decreases cardiac output. These haemodynamic changes can compromise organ perfusion, thereby increasing perioperative risk, particularly in patients with limited cardiovascular reserve or in surgeries that further impair venous return.

To improve prevention and early detection of post-spinal hypotension, attention has shifted towards dynamic, non-invasive haemodynamic assessment tools. Static baseline measurements frequently fail to capture short-term fluctuations in cardiovascular status. For assessing fluid responsiveness and vascular tone in real time, the IVC-CI, PI, or PVI have become clinically significant metrics.

Respiratory variation in inferior vena cava (IVC) diameter is measured by the IVC-CI, which is obtained employing point-of-care ultrasonography. It is recognized as proxy for intravascular volume status and fluid responsiveness, helping doctors to predict hypotension risk prior to anaesthesia induction. The peripheral perfusion is reflected by the PI, which is the ratio of pulsatile to non-pulsatile blood flow and is measured by pulse oximetry. Higher baseline PI values generally indicate reduced vascular tone and may signal an increased susceptibility to hypotension after spinal anaesthesia. The PVI, which measures respiratory-induced changes in PI, provides additional insight into fluid responsiveness. Using these parameters together offers a comprehensive, real-time, non-invasive haemodynamic assessment. However, while each index has individual utility, few studies have explored their combined predictive value for PSH. The current research has been designed to determine diagnostic accuracy of IVC-CI in predicting PSH and to examine its relationship with PI and PVI among patients receiving spinal anaesthesia for infraumbilical surgery without preloading of intravenous crystalloids.

Methods

This prospective, randomised, double-blind observational research has been performed after acquiring clearance from Institutional Ethics Committee (Ref. No. 355/D-26/2022) and securing written informed consent from each participant in their native language. Clinical Trials Registry of India registration number for the study is CTRI/2025/05/106581. There are 100 patients in all, both male and female, between the ages of 18 and 60, they are classified by the American Society of Anaesthesiologists (ASA) as having physical status I and II. Under spinal anaesthesia, all have been scheduled for elective infraumbilical surgical procedures. ASA grade III or IV patients were among the exclusion criteria, a body mass index (BMI) ≥40, infraumbilical masses or elevated intra-abdominal pressure, autonomic dysfunction, intracardiac shunts, peripheral vascular disease, chronic use of oral vasoactive medication, aortic stenosis, arrhythmias, or any contraindication to spinal anaesthesia. On the day before surgery, a comprehensive medical history was recorded, followed by a detailed general and systemic examination, including airway evaluation and inspection of the lumbar spine. As required by fasting specifications, patients were kept at zero per oral. Premedication consisted of intravenous midazolam 1mg and butorphanol 0.5mg, administered approximately 30min. Prior surgery. Upon arrival in the operating theatre, standard multiparameter monitoring has been initiated, recording baseline heart rate (HR), oxygen saturation (SpO_2), respiratory rate (RR), pleth variability index (PVI), mean arterial pressure (MAP), systolic and diastolic blood pressures (SBP, DBP), perfusion index (PI), as well as electrocardiography (ECG). Intravenous access was established using a 20G cannula without preloading. Preoperative assessment of IVC has been performed using a 3.5–5MHz curvilinear ultrasound probe in paramedian long-axis subcostal view. IVC diameter measurements were made during inspiration and expiration, 2–3cm distal to the right atrium in M-mode. The following formula has been employed to determine IVC-CI: IVC Collapsibility Index (IVC-CI)= [(dIVCmax − dIVCmin)/

dIVCmax × 100]. Three readings were taken at one-minute intervals, and mean value has been used for analysis. Based on the IVC-CI, patients were randomly assigned via a computer-generated sequence into 2 groups: Group A (IVC-CI <40%) or Group B (IVC-CI ≥40%). Ultrasound examination was performed by an anaesthesiologist trained in point-of-care ultrasound for IVC evaluation, while spinal anaesthesia has been managed through another anaesthesiologist blinded to the ultrasound findings. Spinal anaesthesia has been performed using 12–15 mg of 0.5% hyperbaric bupivacaine in L3–L4 interspace, followed by fluid co-loading. For the first 10 minutes, hemodynamic monitoring was done every minute. After that, it was done every 5 min. until 30 min., and then every 10 min. until procedure was finished. A drop in MAP of greater than 20% from baseline or an absolute MAP of < 60mmHg was considered hypotension. Intravenous ephedrine (5 mg) and a 250ml crystalloid bolus were used for it. Intravenous atropine (0.6 mg) was used to treat bradycardia, which is defined as an HR of < 50 beats per min.

Sample size calculation:

Required sample size has been determined utilizing prior study data, aiming for >85% statistical power and a 95% confidence level (α=0.05). The formulae used were: $n = Z\alpha/2^2 \times Sn(1-Sn)/d^2 \times P$ and $n = Z\alpha/2^2 \times Sp(1-Sp)/d^2 \times (1-P)$

Statistical analysis:

Data have been compiled in Microsoft Excel and processed employing SPSS version 20. Categorical data were compared employing Chi-square test, and continuous variables have been shown as mean ± standard deviation (SD) and examined utilizing Student's t-test. Through computing positive predictive value (PPV), negative predictive value (NPV), sensitivity, and specificity predictive performance of IVC-CI has been evaluated. Plotting receiver operating characteristic (ROC) curves revealed that good diagnostic accuracy was indicated by an area under the curve (AUC) >0.8.

Observation and Results

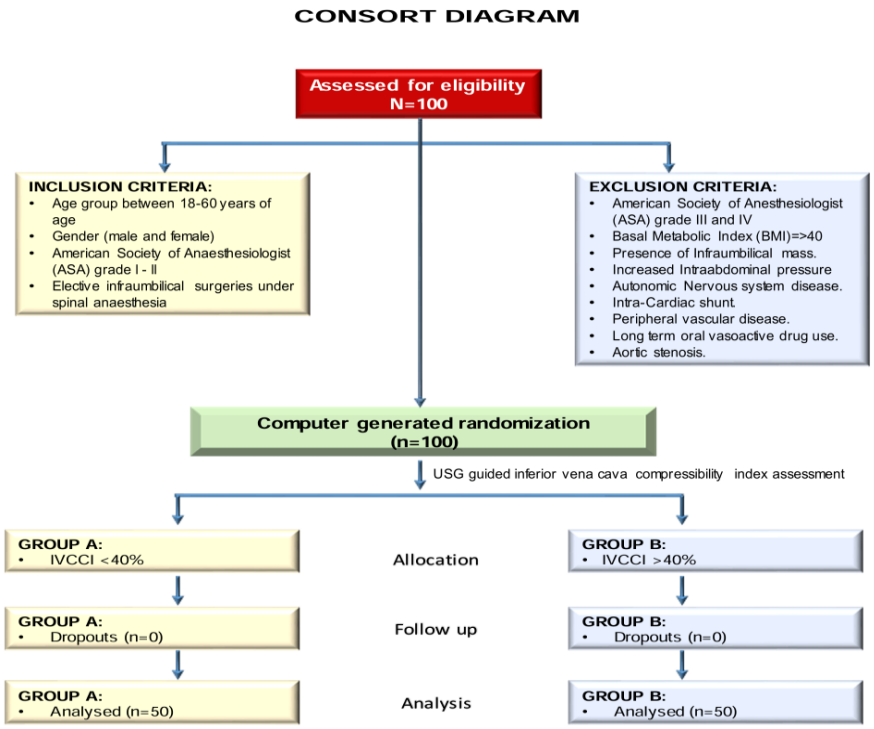


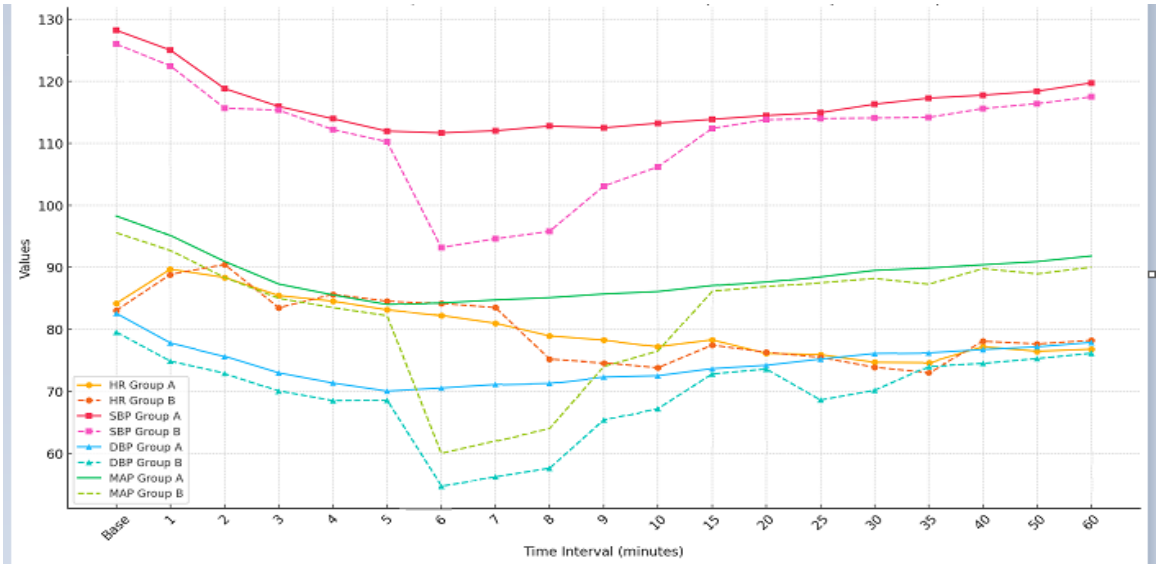
FIGURE-1: Consort Diagram showing patient flow through the study.

Patients in both groups had similar baseline clinical appearances and demographics, with no statistically significant differences observed in age, ASA grade, sex distribution, body mass index (BMI), or baseline vital signs (Table 1).

TABLE-1:Combined comparison of baseline characteristics among Group A (IVC-CI < 40%) and Group B (IVC-CI ≥ 40%).

Parameter	Group A (IVCCI < 40%)	Group B (IVCCI > 40%)	p-value	Significance
Mean Age (years)	37.64 ± 14.20	34.50 ± 8.78	0.187	NS
Gender (M/F)	20 / 30	17 / 33	0.534	NS
BMI (kg/m²)	23.06 ± 2.69	23.04 ± 2.41	0.969	NS
ASA Grade (I/II)	26 / 24	23 / 27	0.548	NS
Heart Rate (beats/min)	83.18 ± 7.90	82.04 ± 6.90	0.222	NS
Systolic BP (mmHg)	127.12 ± 6.17	127.00 ± 7.91	0.161	NS
Diastolic BP (mmHg)	83.58 ± 9.39	82.56 ± 10.52	0.187	NS
Mean Arterial Pressure (mmHg)	98.27 ± 7.77	97.57 ± 9.49	0.761	NS
Respiratory Rate (breaths/min)	19.50 ± 1.95	19.16 ± 2.05	0.183	NS
Oxygen Saturation (SpO_2 %)	100.00 ± 0.34	99.97 ± 0.17	0.328	NS

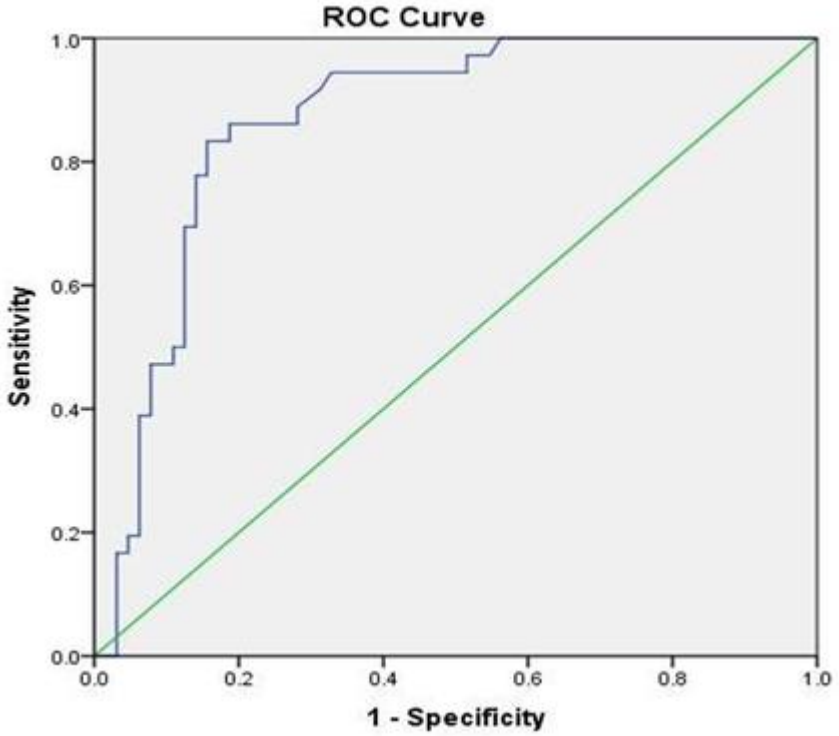
During the intraoperative period, initial haemodynamic trends were similar between the two groups. Heart rate values in the first five minutes after spinal anaesthesia did not differ significantly. From the eighth to the tenth minute, however, Group B displayed a statistically significant decrease in heart rate compared with Group A (p=0.006, p=0.016, & p=0.011, respectively). Beyond tenth minute, heart rates stabilised and no further significant differences were recorded. Bradycardia occurred in 4% of patients in Group A and 10% in Group B, difference that has not been statistically significant (p=0.239) (Graph 1). In a cohort of 100 patients, intraoperative MAP, SBP, and DBP have been assessed and compared among Group A (IVCCI < 40%) and Group B (IVCCI > 40%). During the baseline period and up to the fifth minute after spinal anaesthesia, no significant differences have been observed among two groups in any of the hemodynamic parameters (p>0.05). From sixth to tenth minute, however, Group B experienced a notable decrease in SBP, DBP, and MAP (p < 0.05). Hemodynamic stability was progressively restored after the fifteenth minute through prompt intervention with intravenous fluid boluses and, when necessary, vasopressor administration (ephedrine 5 mg IV boluses). Consequently, by this stage, the differences in blood pressure among groups have no longer statistically significant (p>0.05), as illustrated in Graph 1.



GRAPH-1:

A comparison was carried out for hemodynamic variables—heart rate (HR), SBP, DBP, and MAP—between Group A (IVC-CI < 40%) and Group B (IVC-CI > 40%) across multiple time points after administration of spinal anaesthesia.

In this prospective analysis, intraoperative hypotension occurred more frequently in Group B (IVCCI > 40%), affecting 64% of patients, compared with only 12% in Group A (IVCCI < 40%). The difference has been highly statistically significant (p=0.001). The research also assessed predictive value of IVCCI for intraoperative hypotension. IVCCI demonstrated sensitivity of 84.21%, indicating strong capability in identifying patients who developed hypotension, and a specificity of 70.97%, reflecting a moderate ability to recognize those who remained normotensive. ROC curve analysis showed an AUC of 0.867, with 95% CI of 0.79–0.93, confirming its robust diagnostic accuracy in predicting hypotension after spinal anaesthesia, as illustrated in Graph 2. In Group B = 4% of patients experienced nausea and vomiting, compared to 0% in Group A (p=0.153), a difference that was not statistically significant.



X-axis: 1 – Specificity (False Positive Rate); Y-axis: Sensitivity (True Positive Rate).

GRAPH-2: Receiver Operator Characteristic (ROC) curve for predictability of hypotension post spinal anaesthesia using Inferior Vena Cava Compressibility Index (IVCCI) in Group A (IVCCI < 40%) and Group B (IVCCI ≥ 40%).

In this study, all 100 participants were classified into two subgroups according to their intraoperative hemodynamic response: a normotensive group (n = 62) and a hypotensive group (n = 38) following spinal anaesthesia. The Perfusion Index (PI) was monitored over time in both groups to evaluate its usefulness in predicting post-spinal hypotension. At baseline and at 1 minute after anaesthesia, PI values did not differ significantly among groups (p>0.05). From 2-10 minutes, however, patients who developed hypotension showed markedly higher PI values, with the most significant differences occurring between the 3rd and 8th minute (p < 0.001). Beyond the 20-minute point, PI measurements in the two groups no longer showed statistically significant differences, as detailed in Table 2.

TABLE-2: Comparison of trend of Perfusion Index in patients who are normotensive and hypotensive in both Group A and Group B

PI (Time)	Normotensive (n=62) Mean ± SD	Hypotensive (n=38) Mean ± SD	t-value	p-value	Significance
Baseline	2.532 ± 1.101	3.35 ± 1.25	-1.020	0.310	NS
1 min	2.757 ± 1.089	3.50 ± 1.30	-1.010	0.325	NS
2 min	2.875 ± 1.186	3.85 ± 1.279	-3.750	0.001	S
3 min	2.849 ± 1.247	4.00 ± 1.33	-4.250	<0.001	S
4 min	2.865 ± 1.309	4.10 ± 1.40	-4.300	<0.001	S
5 min	2.849 ± 1.286	4.15 ± 1.40	-4.750	<0.001	S
6 min	2.854 ± 1.338	4.25 ± 1.45	-4.800	<0.001	HS
7 min	2.600 ± 1.073	3.80 ± 1.50	-4.500	<0.001	HS
8 min	2.465 ± 1.003	3.50 ± 1.25	-4.200	<0.001	HS
9 min	2.331 ± 0.932	2.85 ± 0.75	-2.850	0.005	S
10 min	2.294 ± 1.118	3.45 ± 1.40	-4.350	<0.001	S
15 min	1.995 ± 0.949	2.55 ± 1.30	-2.350	0.021	S
20 min	1.932 ± 0.949	2.30 ± 1.30	-1.500	0.138	NS
25 min	1.956 ± 0.635	2.10 ± 1.30	-0.700	0.487	NS
30 min	1.854 ± 0.548	2.00 ± 1.25	-0.750	0.456	NS
35 min	1.768 ± 0.559	1.75 ± 0.90	0.300	0.765	NS
40 min	1.697 ± 0.676	1.70 ± 1.30	0.000	1.000	NS
50 min	1.599 ± 0.515	1.60 ± 1.25	0.000	1.000	NS
60 min	1.581 ± 0.504	1.55 ± 1.30	0.250	0.803	NS

S – Significant ($p < 0.005$); NS – Non-Significant ($p > 0.05$); HS – Highly Significant ($p < 0.001$)

The Pleth Variability Index (PVI) pattern was also analyzed in two subgroups: 38 patients who experienced hypotension after spinal anaesthesia and 62 who remained normotensive. During the first 6 minutes post-anaesthesia, PVI values were notably higher in the hypotensive group. Even at baseline, the mean PVI in this group has been significantly greater than that of the normotensive group ($p=0.028$). From 7th minute onward, differences in PVI among groups were no longer statistically significant ($p>0.05$), as presented in Table 3.

TABLE NO.-3: Comparison of trend of Pleth Variability Index in patients who are normotensive and hypotensive in both Group A and Group B

PVI (Time)	Normotensive (n=62) Mean ± SD	Hypotensive (n=38) Mean ± SD	t-value	p-value	Significance
Baseline	18.20 ± 3.50	21.36 ± 2.19	-1.850	0.028	S
1 min	17.80 ± 2.80	21.24 ± 3.58	-2.950	0.005	S
2 min	17.65 ± 2.50	20.36 ± 2.59	-3.120	0.003	S
3 min	17.90 ± 3.00	20.78 ± 3.34	-2.890	0.006	S
4 min	18.00 ± 3.40	20.36 ± 3.37	-2.450	0.018	S
5 min	17.55 ± 2.40	20.02 ± 4.16	-2.180	0.034	S
6 min	17.70 ± 2.00	20.28 ± 3.73	-2.710	0.009	S
7 min	18.74 ± 2.88	19.80 ± 4.05	-1.272	0.067	NS
8 min	18.14 ± 3.83	18.26 ± 3.62	-0.139	0.434	NS
9 min	18.92 ± 3.23	18.44 ± 3.47	0.645	0.115	NS
10 min	17.03 ± 3.01	16.94 ± 3.81	0.361	0.102	NS
15 min	16.50 ± 3.17	16.96 ± 3.94	0.499	0.401	NS
20 min	15.98 ± 3.29	17.28 ± 4.11	0.708	0.112	NS
25 min	15.72 ± 4.42	16.76 ± 4.42	0.701	0.215	NS
30 min	14.08 ± 3.14	15.34 ± 4.91	0.491	0.301	NS

PVI (Time)	Normotensive (n=62) Mean ± SD	Hypotensive (n=38) Mean ± SD	t-value	p-value	Significance
35 min	16.94 ± 3.39	15.92 ± 4.55	0.705	0.282	NS
40 min	17.47 ± 3.65	16.36 ± 5.22	0.391	0.124	NS
50 min	16.63 ± 3.34	15.86 ± 4.87	0.269	0.188	NS
60 min	18.44 ± 3.309	18.91 ± 2.761	0.548	0.236	NS

S – Significant ($p < 0.005$); NS – Non-Significant ($p > 0.05$); HS – Highly Significant ($p < 0.001$)

In our study, no instances of respiratory depression, pruritus, urinary retention, back pain, total spinal block, neurological deficits, or local anaesthetic toxicity were observed in either group.

Discussion

The findings of this study demonstrate that a preoperative IVCCI exceeding 40% serves as reliable, non-invasive indicator for predicting hypotension following spinal anaesthesia (SAIH). Based on IVCCI measurements, patients have been divided into 2 groups. Hypotension occurred in 64% of individuals with IVCCI > 40% (Group B), compared to just 12% in those with IVCCI < 40% (Group A), a statistically significant difference (p=0.001). These findings strongly support predictive value of elevated IVCCI for post-spinal anaesthesia hypotension.

The findings for Group A of our study are consistent with those reported in earlier research, including those by Devi et al., Ni Ti et al., & Ayyanagouda et al., where hypotension rates ranged between 15%–20% following fluid optimization. Similarly, Ozdemir et al. reported a 52% hypotension rate in patients with smaller IVC diameters (suggestive of higher IVCCI), closely matching our Group B. The marginally increased incidence of hypotension in our Group B (64%) could be attributed to the lack of preoperative fluid optimization, in contrast to many earlier studies where fluid boluses were given before spinal anaesthesia to lower IVCCI. This methodological difference illustrates importance of proactive volume optimization and highlights clinical utility of incorporating IVC ultrasound into the preoperative assessment. This study not only supports existing evidence but also addresses a key gap by documenting the natural progression of hypotension in patients with high IVCCI who did not receive preloading. This reinforces IVCCI as practical, non-invasive tool to guide individualized fluid management or improve perioperative outcomes.

In this prospective research of 100 patients, those with IVCCI >40% (Group B) experienced significant reductions in SBP, DBP, and MAP between the 6th and 10th minutes post-spinal anaesthesia ($p < 0.05$), reflecting early hypotension due to hypovolemia and sympathetic blockade. Baseline blood pressures and those recorded within the initial five minutes were similar in both groups. By the 15th minute, hemodynamic stability was restored through fluid resuscitation and the use of vasopressors. These findings are in agreement with the results reported by Szabó, Zhang, Ozdemir, Ceruti, and Devi, all of which support IVCCI >40% as reliable predictor of post-spinal hypotension. They also highlight 6–10-minute window as a critical period for intervention.

The average ephedrine requirement was markedly higher in Group B comparing Group A (18.00 ± 6.27 versus 6.25 ± 2.16; $p = 0.001$), indicating increased vasopressor requirements in the high-IVCCI group. Similar trends were noted by Ceruti et al. (2017) and Devi et al. (2021), confirming higher vasopressor demand among patients with elevated IVCCI.

With sensitivity of 84.21%, specificity of 70.97%, and AUC of 0.867 (95% CI: 0.79-0.93; $p < 0.001$), IVCCI demonstrated high level of diagnostic accuracy in predicting PSH. These findings are consistent with previous research findings. Lal et al. (2023) reported a sensitivity of 81%, specificity of 90%, and an AUC of 0.828 at an IVCCI cutoff ≥43.5%. Ni et al. (2022) reported sensitivity and specificity of 83.9% and 76.3%, respectively, for IVCCI >42%, with an AUC of 0.834. Elbadry et al. (2022) found a sensitivity of 84.6% and specificity of 93.1% at lower cutoff (IVCCI >33%) in obstetric patients. Bortolotti et al. (2018) reported 93% sensitivity and 88% specificity (AUC 0.93) in patients with cardiac arrhythmias. Despite variability in cutoff thresholds

(33%–50%), likely due to differences in patient demographics and methodologies, the overall evidence supports IVCCI's strong predictive value for PSH.
Heart rate was measured at various time intervals during surgery, and baseline values illustrate no significant difference among Group A or Group B (p=0.222), and most intervals showed no significant differences. However, Group B exhibited a significant transient bradycardia at the 8th, 9th, and 10th minutes post-spinal anaesthesia (p = 0.006–0.016), likely due to exaggerated sympathetic blockade in hypovolemic individuals. Group A maintained stable heart rates throughout. Bradycardia occurred more frequently compared to Group A (4%), in Group B (10%). But this difference (p=0.239) was not statistically significant. These findings are in agreement with those of Kansiz et al., who reported stable heart rates in patients with IVCCI <44.5%, and Ozdemir et al., who observed more bradycardia in patients with IVC diameter <1.5 cm. Elbadry et al. also noted a significant heart rate drop at the 6th minute in hypotensive patients post-spinal anaesthesia. It is noteworthy that limited research has explored heart rate variability in high-IVCCI patients without fluid preloading, as the majority of prior studies incorporated preloading in their protocols.
Throughout the observation period, respiratory rate (15–18 breaths/min) and oxygen saturation (SpO_2) remained steady and similar in both groups (p > 0.05), suggesting absence of respiratory compromise.

Our study also showed that patients with IVCCI >40% demonstrated significantly higher perfusion index (PI) values from 2 minutes post-spinal anaesthesia, peaking around 8–10 minutes and remaining elevated up to 15 minutes before normalizing by 20 minutes. Patients who developed hypotension showed a similar early rise in PI, supporting its value as a predictive marker. The time-dependent trend suggests an early vasodilatory response, particularly in hypovolemic patients. These findings were comparable with Kumar et al. (2024), Toyama et al. (2013), Duggappa et al. (2017), and Nandini et al. (2022), who also reported that elevated baseline or early PI values predicted hypotension. The prolonged PI elevation in our study may be attributed to the lack of fluid preloading, which could have enhanced the PI response due to uncorrected hypovolemia. The inclusion of IVCCI as a dynamic preoperative marker complements PI and helps explain the pronounced and sustained vasodilatory trend.

In addition, patients with an IVCCI greater than 40% demonstrated significantly elevated Pleth Variability Index (PVI) values from baseline up to 6 minutes after spinal anaesthesia, with the highest values observed in those who experienced hypotension. This supports the view that IVCCI, as a marker of hypovolemia, influences PVI dynamics during the early anaesthetic phase. However, the loss of statistical significance beyond 6 minutes suggests that PVI's predictive utility is limited to a narrow time window. These findings are in line with Kansiz et al., who also found IVCCI to be a strong predictor of hypotension while noting the limited reliability of PVI in isolation. Similarly, Küpeli İ et al. observed elevated PVI in hypovolemic patients, though intergroup differences diminished after anaesthesia. In contrast, Kuwata and Abdelhamid reported variable PVI cutoffs with differing diagnostic accuracies. These discrepancies may be attributed to differences in patient characteristics, anaesthetic techniques, and measurement timing. Overall, our results indicate that although PVI can function as an early warning marker, its accuracy improves when combined with dynamic parameters such as IVCCI, PI, or PPV.

Conclusion

The findings of this study confirm that a preoperative IVCCI exceeding 40% is dependable, non-invasive indicator for predicting post-spinal hypotension. Combining IVCCI screening with intraoperative monitoring of PI and PVI offers a dynamic and individualised approach to identifying high-risk patients. This integrated strategy supports timely intervention, minimizes hypotension-related risks, and enhances overall perioperative safety.

Limitations

This research has certain limitations. As it has been conducted at single centre, the results may not be fully applicable to wider populations or varied healthcare environments. While the sample size was adequate for statistical analysis, a larger cohort would enhance the robustness of the conclusions and facilitate more comprehensive subgroup evaluations. The exclusion of high-risk patients, such as those with ASA III/IV status, cardiovascular disease, or on vasoactive medications, limits applicability to more complex clinical scenarios. Furthermore, the reliability of PVI may be affected by inconsistent respiratory patterns in spontaneously breathing patients. The study focused exclusively on immediate intraoperative hypotension and did not evaluate long-term postoperative outcomes. Lastly, the use of operator-dependent ultrasound introduces variability in the measurement of IVCCI, potentially affecting reproducibility.

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Conflict of Interest
The author declares no conflict of interest.

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