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# PREDICTING HYPOTENSION AFTER SPINAL ANAESTHESIA INDUCED WITH 0.5% HYPERBARIC BUPIVACAINE FOR INFRAUMBILICAL SURGERIES USING INFERIOR VENA CAVA COLLAPSIBILITY INDEX

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**ABSTRACT** **Background:** Spinal-induced hypotension is a highly prevalent complication of spinal anesthesia, primarily caused by sympathetic blockade, decreased systemic vascular resistance, reduced venous return. Standard empiric fluid preloading lacks patient-specific precision. Assessing volume status non-invasively via ultrasound measuring of the Inferior Vena Cava Collapsibility Index (IVCCI) before spinal anesthesia induction may offer a reliable means to predict and prevent post-spinal anesthesia hypotension.**Aim:** To evaluate whether measuring pre-induction IVCCI can predict volume status, guide targeted prophylactic fluid preloading, reduce the incidence of hypotension after spinal anesthesia induced with 0.5% hyperbaric bupivacaine for elective infraumbilical surgeries.**Materials and Methods**: A prospective randomized comparative clinical study was conducted in the Department of Anaesthesiology, Sri Siddhartha Medical College and Research Institute, Tumkur. One hundred and sixty-six adult patients aged 18–60 years belonging to ASA physical status I and II scheduled for elective infraumbilical surgeries under spinal anesthesia were enrolled and randomly allocated into two equal groups (n=83 each). In Group CI (Collapsibility Index-guided), patients preoperative ultrasound evaluation of the IVCCI. If the IVCCI was >40%, targeted preoperative crystalloid fluid preloading was administered until the IVCCI fell to <= 40%. Group NCI (Non-Collapsibility Index-guided) proceeded directly to spinal anesthesia under standard empiric protocol. Spinal anesthesia was induced in all patients using 0.5% hyperbaric bupivacaine. Hemodynamic parameters, total fluid administration, and vasopressor requirements were recorded. Statistical analysis was performed with a p-value <0.05 considered statistically significant.**Results:** Demographic variables and baseline characteristics were comparable between both groups. The overall incidence of post-spinal hypotension was 41% across the entire cohort. The incidence of hypotension was significantly higher in Group NCI (29%) compared to Group CI (12%) ($p < 0.001$). Group CI received higher preoperative fluid preloading (587.35 ± 123.92 mL) than Group NCI (224.10 ± 99.80 mL), whereas Group NCI required significantly more rescue intraoperative fluids (801.81 ± 353.76 mL vs. 662.65 ± 246.54 mL) and experienced a higher requirement for emergency ephedrine administration (69.9% vs. 12%, $p < 0.001$).**Conclusion:** Preoperative IVCCI measurements provide a highly effective, non-invasive method for assessing intravascular volume status. Preloading guided by an IVCCI threshold of >40% significantly reduces the incidence of hypotension, minimizes intraoperative fluid shifting, and decreases the requirement for emergency vasopressor support following spinal anesthesia with 0.5% hyperbaric bupivacaine.

**KEYWORDS :** Spinal anesthesia; Hyperbaric bupivacaine; Inferior Vena Cava Collapsibility Index (IVCCI);

## INTRODUCTION

Spinal anesthesia is a widely accepted and highly effective regional anesthetic technique routinely used for infraumbilical surgeries because of its rapid onset, reliable sensory and motor blockade, and suppression of the surgical stress response. However, block-induced sympathetic vasomotor paralysis represents a significant hemodynamic challenge, often culminating in systemic hypotension.Spinal-induced hypotension results primarily from venous and arterial vasodilatation, which decreases venous return, cardiac output, and systemic vascular resistance. While healthy individuals tolerate brief, mild blood pressure fluctuations well, severe or sustained hypotension can compromise perfusion to vital organs, potentially precipitating myocardial ischemia, arrhythmias, cerebral hypoperfusion, and postoperative cognitive complications.

To prevent post-spinal hypotension, clinical strategies have historically relied on empiric crystalloid or colloid preloading and coloading. However, empiric fluid administration often lacks clinical precision, exposing some patients to unnecessary volume overload and others to inadequate volume expansion. A personalized, goal-directed fluid assessment protocol is therefore essential.The Inferior Vena Cava Collapsibility Index (IVCCI) measured via bedside point-of-care ultrasound (POCUS) has emerged as a reliable, rapid, and non-invasive modality to assess intravascular volume status and predict fluid responsiveness. Because the diameter of inferior vena cava fluctuates dynamically with respiratory-induced changes in intrathoracic pressure, magnitude of its collapse during inspiration—expressed as the collapsibility index—corresponds directly to the patient's right atrial pressure and overall intravascular volume.

present study was undertaken to evaluate clinical efficacy of using preoperative IVCCI measurements to direct targeted fluid preloading, thereby predicting and minimizing hypotension following spinal anesthesia induced with 0.5% hyperbaric bupivacaine in adult patients undergoing elective infraumbilical surgeries.

## MATERIALS AND METHODS

**Study Design:** A prospective, randomized, comparative clinical study was conducted to evaluate efficacy of ultrasound-measured IVCCI in predicting and reducing the incidence of hypotension following spinal anesthesia.

**Study Setting:** study was conducted in Department of Anaesthesiology, Sri Siddhartha Medical College and Research Institute, Sri Siddhartha Academy of Higher Education, Tumkur, Karnataka, India.

**Participants:**

**Inclusion Criteria:**

- Age between 18 and 60 years.
- Either gender.
- ASA Physical Status I and II.
- Scheduled for elective infraumbilical surgeries under spinal anesthesia.
- Patients willing to participate and providing written informed consent.

**Exclusion Criteria:**

- ASA Physical Status III, IV, or V.
- Emergency surgeries.
- Severe cardiovascular disease, cardiac arrhythmias, or uncontrolled hypertension.
- Contraindications to regional/spinal anesthesia (e.g., coagulopathy, local site infection,
- increased intracranial pressure).
- Pregnancy or lactation (due to aortocaval compression altering IVCCI readings).
- Significant pulmonary disease or chest wall deformities that could interfere with ultrasound imaging.
- Refusal to participate.

**Preoperative Assessment:**

A comprehensive pre-anesthetic evaluation was conducted on day preceding surgery, comprising a medical history, physical examination, review of baseline laboratory investigations. All patients kept nil per oral (NPO) according to standard fasting guidelines. Written informed consent secured from every study participant.

**Study Sampling & Grouping:**
One hundred and sixty-six eligible patients randomly allocated into two equal groups (n=83 in each group) using computer-generated random numbers:

Group CI (Collapsibility Index-guided, n=83): Patients underwent point-of-care ultrasound of inferior vena cava. The IVC diameters were measured in the subxiphoid long-axis view. The IVCCI was calculated using the formula:

IVCCI (%) = [(IVC_max - IVC_min) / IVC_max] * 100

If the calculated IVCCI was >40%, indicating relative hypovolemia, patients received preoperative crystalloid fluid boluses (0.9% Normal Saline) to optimize volume status until the IVCCI fell <= 40% prior to spinal block induction.

Group NCI (Non-Collapsibility Index-guided, n=83): Patients did not receive pre-induction ultrasound-guided assessments and proceeded directly to spinal anesthesia according to standard, non-guided preoperative protocol.

**Anesthetic and Study Procedure:**
Upon arrival in the operating theater, standard ASA monitors including electrocardiography (ECG), non-invasive blood pressure (NIBP), and pulse oximetry (SpO2) were applied, and baseline hemodynamics were recorded.

Spinal anesthesia was performed with patient in sitting position. Under aseptic precautions, lumbar puncture was performed at L3–L4 interspace, and spinal anesthesia induced using 0.5% hyperbaric bupivacaine. Following the block, patients were immediately placed in the supine position. Sensory blockade level assessed bilaterally using cold sensation, and motor blockade graded using the modified Bromage scale.

**Hemodynamic Monitoring and Parameters:**
- Primary Parameters: Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP). These recorded at baseline, immediately after spinal induction, and at 5-minute intervals for the first 30 minutes following spinal anesthesia induction.
- Hypotension Protocol: Post-spinal hypotension defined as a decrease in SBP or MAP of more than 20% from baseline values. Hypotension episodes treated promptly with intravenous boluses of crystalloids and emergency rescue vasopressor support (ephedrine 6 mg IV boluses).
- Secondary Parameters: Total volumes of preoperative fluids, intraoperative rescue fluids, and total requirements of ephedrine were recorded.

**Data Analysis:**
Data analyzed using SPSS Version 26.0. Continuous variables presented as Mean ± Standard Deviation (SD) and compared using independent Student's t-test. Categorical variables expressed as frequencies and percentages and analyzed using Chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

## RESULTS
A total of 166 patients completed study with no dropouts. The demographic data demonstrated that both groups were homogenous.

**Table 1: Demographic Profiles of Study Population**

| Parameter | Group CI (n=83) | Group NCI (n=83) | p-value |
|---|---|---|---|
| Age (years) | 42.3 ± 11.2 | 43.1 ± 10.5 | >0.05 |
| Weight (kg) | 64.5 ± 8.2 | 65.1 ± 7.8 | >0.05 |
| Height (cm) | 163.8 ± 7.1 | 164.5 ± 6.9 | >0.05 |
| BMI (kg/m²) | 23.9 ± 2.5 | 24.1 ± 2.3 | >0.05 |

**Interpretation:** The mean age, weight, height, and BMI were comparable between the groups, demonstrating adequate baseline homogeneity.

**Table 2: Gender and ASA Grade Distribution**

| Parameter | Group CI (n=83) | Group NCI (n=83) | p-value |
|---|---|---|---|
| Gender(Male/Female) | 49 / 34 | 51 / 32 | >0.05 |
| ASA Status(I/II) | 52 / 31 | 54 / 29 | >0.05 |

Interpretation: Gender distribution and physical status classification were highly comparable between the groups with no statistically significant differences.

**Table 3: Incidence of Hypotension and Emergency Interventions**

| Clinical Outcome | Group CI (n=83) | Group NCI (n=83) | p-value |
|---|---|---|---|
| Incidence of Hypotension (%) | 12% (n=10) | 29% (n=24) | <0.001* |
| Preoperative Fluid Vol (mL) | 587.35 ± 123.92 | 224.10 ± 99.80 | <0.001* |
| Intraoperative Rescue (mL) | 662.65 ± 246.54 | 801.81 ± 353.76 | <0.001* |
| Ephedrine Vasopressor Use (%) | 12% (n=10) | 69.9% (n=58) | <0.001* |

***Statistically significant (p < 0.05).**

**Interpretation:** Group NCI suffered a significantly higher incidence of post-spinal hypotension and required far greater amounts of rescue intraoperative fluids and emergency ephedrine vasopressor support compared to Group CI.

**Table 4: Post-Spinal Mean Arterial Pressure (MAP) Trend Comparison (mmHg)**

| Time Point | Group CI (n=83) | Group NCI (n=83) | p-value |
|---|---|---|---|
| Baseline | 94.8 ± 7.2 | 95.1 ± 7.0 | 0.785 |
| 5 minutes | 89.2 ± 6.8 | 79.4 ± 7.5 | <0.001* |
| 10 minutes | 88.5 ± 6.4 | 78.1 ± 7.1 | <0.001* |
| 15 minutes | 87.9 ± 6.2 | 79.8 ± 6.9 | <0.001* |
| 20 minutes | 88.2 ± 6.0 | 82.4 ± 6.4 | <0.05* |
| 25 minutes | 89.1 ± 5.8 | 86.5 ± 6.0 | 0.124 |
| 30 minutes | 89.5 ± 5.5 | 89.1 ± 5.8 | 0.652 |

***Statistically significant (p < 0.05)**

**Interpretation:** MAP significantly lower in Group NCI starting 5 minutes after spinal induction, continuing through the critical first 20 minutes. By 30 minutes, MAP values became comparable as vasopressors stabilized Group NCI.

## DISCUSSION
induction of spinal anesthesia for infraumbilical surgeries is characteristically accompanied by rapid sympathetic blockade, causing systemic vasodilatation and an acute decline in venous return.The primary clinical challenge lies in identifying patients who have inadequate intravascular volume before sympathetic block onset, as they are at an exceptionally high risk for severe post-spinal hypotension. This study successfully evaluated ultrasound-measured IVCCI as an objective tool to guide preoperative fluid administration and preserve hemodynamic stability.

**Demographic and Baseline Characteristics:**
In this study, demographic variables, block characteristics, and anesthetic administration were comparable between Group CI and Group NCI, confirming that differences in hemodynamic outcomes were directly related to the guided preloading protocol rather than patient-related variables.

**Predictive Value of IVCCI and Hemodynamic Stability:**
Using an IVCCI threshold of >40% to guide fluid therapy effectively targeted preoperative fluid preloading to those patients who actively fluid-responsive. This cohort (Group CI) maintained significantly higher and more stable SBP, DBP, and MAP during the crucial first 20 minutes following spinal induction.

In contrast, Group NCI, which did not receive volume optimization, experienced a steep decline in blood pressure post-induction. incidence of hypotension more than double in standard protocol group (29% vs. 12% in the IVCCI-guided group).

**Fluid and Vasopressor Requirements:**
Because Group CI underwent targeted pre-induction volume

correction based on their IVCCI, they received a significantly higher volume of preoperative fluid (587.35 ± 123.92 mL) than the standard group (224.10 ± 99.80 mL).

However, this proactive preloading successfully prevented intraoperative hemodynamic crises. Consequently, Group NCI required a significantly higher volume of intraoperative rescue fluid boluses (801.81 ± 353.76 mL vs. 662.65 ± 246.54 mL in Group CI) and a remarkably high amount of emergency vasopressor intervention (69.9% in Group NCI vs. 12% in Group CI). Proactively correcting a relative hypovolemic state prior to sympathetic blockade avoids the reactive, "chasing-the-tail" management of hypotension intraoperatively.

**Clinical Implications:**

Our findings demonstrate that point-of-care ultrasound measurement of IVCCI is an invaluable tool for anesthesiologists. This non-invasive assessment allows clinicians to replace arbitrary fluid protocols with personalized, physiology-driven fluid therapy, minimizing the risks of both fluid overload and severe post-spinal hypoperfusion.

## CONCLUSION

Preoperative evaluation of Inferior Vena Cava Collapsibility Index (using an IVCCI threshold of >40%) provides a reliable, objective, and non-invasive means of predicting and preventing post-spinal hypotension in patients undergoing elective infraumbilical surgeries under spinal anesthesia with 0.5% hyperbaric bupivacaine. Incorporating ultrasound-guided IVCCI assessments into routine pre-anesthetic protocols guides targeted fluid preloading, improves perioperative hemodynamic stability, and drastically reduces the requirements for intraoperative rescue fluids and vasopressors.