Research Article

A Clinical Study: Comparison of Ultrasonographic Measures of Inferior Vena Cava Collapsibility Index and Change in Area of Internal Jugular Vein for Prediction of Hypotension During Induction of General Anaesthesia

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Abstract

Background: Post-induction hypotension (PIH) is a common complication of general anaesthesia. Ultrasonographic assessment of inferior vena cava collapsibility index (IVCCI) and internal jugular vein (IJV) area changes may help predict its occurrence. Aim: To compare the accuracy of IVCCI and IJV area change rate in predicting post-induction and severe post-induction hypotension. Materials and Methods: This prospective clinical study included 100 adult patients aged 18–65 years with ASA physical status I–II undergoing elective surgery under general anaesthesia. Pre-induction ultrasonographic measurements of IVC diameter and IJV cross-sectional area were obtained. IVCCI and IJV area change rate were calculated. Haemodynamic parameters were monitored following induction, and diagnostic accuracy was assessed using receiver operating characteristic (ROC) analysis. Results: Post-induction hypotension occurred in 73 (73%) patients, while severe hypotension occurred in 10 (10%) patients. IJV area change rate demonstrated the highest predictive accuracy for PIH, with an AUC of 0.80 (95% CI: 0.72–0.88), sensitivity of 78%, and specificity of 76% at a cut-off of >0.25. IVCCI showed an AUC of 0.76 (95% CI: 0.68–0.84), with sensitivity of 78% and specificity of 71% at a cut-off of >0.34. For severe PIH, IJV area change rate showed an AUC of 0.83, compared with 0.72 for IVCCI. Conclusion: IJV area change rate demonstrated better predictive performance than IVCCI for post-induction and severe hypotension. Both ultrasonographic parameters may serve as useful non-invasive bedside tools for preoperative haemodynamic risk assessment.

Keywords: Post-induction hypotension; Inferior vena cava collapsibility index; Internal jugular vein; Ultrasonography; General anaesthesia; Haemodynamic monitoring; Predictive accuracy.

1. Introduction

Post-induction hypotension (PIH) is a common complication of general anaesthesia that may lead to significant end-organ injury. Ultrasonographic assessment of the inferior vena cava collapsibility index (IVCCI) and internal jugular vein (IJV) area changes offers a non-invasive, rapid method for predicting PIH.

However, comparative evidence, particularly in the Indian population, remains limited. Therefore, this study aims to compare IVCCI and IJV area changes as predictors of PIH in adult ASA I–II patients undergoing elective surgery under general anaesthesia.

1.1 Aims Of The Study

This clinical study is aimed at comparing the inferior vena cava (IVC) versus internal jugular vein (IJV) ultrasonographic measurements in prediction for post-induction hypotension and prediction of severe post-induction hypotension after induction of general anaesthesia with the following objectives.

1.2 Primary Objective

To compare the accurateness of IVC and IJV variations in prediction of post-induction hypotension (defined as MAP < 20% of the baseline reading for 2 minutes or more).

1.3 Secondary Objectives

- To calculate the incidence of post-induction hypotension.

- To calculate the accuracy of IVC collapsibility index in predicting post-induction hypotension.
- To calculate the accuracy of change in area of IJV in prediction of post-induction hypotension.

2. Material And Methods

- After Approval from Institutional Ethical committee
- Written informed consent
- Age 18-65 years
- Patients of either sex
- ASA grade 1-2
- Elective general anaesthesia surgery

2.1 Exclusion criteria

- Patients presenting with major vascular disease
- Ejection fraction < 40%
- Unstable angina
- Respiratory distress
- Elevated intra-abdominal pressure
- Implanted pacemaker
- Patients with ASA grade more than 3
- Age more than 65 years and less 18 years
- Patient not consenting for participating in the study

2.2 Sample size estimation

Sample size was estimated using the Cleveland Clinic Risk Calculator Library, assuming an AUC of 0.74, null AUC of 0.50, prevalence of 0.63, $\alpha = 0.05$, and 80% power, yielding a required sample of 100 patients.

2.3 Groups allocation

Randomly selected, eligible patients were assigned for conduction of ultrasound-based measures of inferior vena cave or internal jugular vein readings.

3. Methodology

3.1 Patient Preparation

18G IV cannula secured; crystalloid infusion started at 10 mL/kg/h.
Baseline blood pressure and SpO_2 recorded.

3.2 Ultrasonographic Assessment

IVC and IJV assessed before induction using a 6–13 MHz Sonosite probe.
IVC: Maximum and minimum diameters measured; collapsibility index (CI) calculated.
IJV: Cross-sectional area measured in supine and Trendelenburg positions; percentage change calculated.

3.3 Anaesthesia and Intubation

- General anaesthesia induced, followed by mask ventilation at MAC 0.7–0.8.
- Endotracheal intubation performed after 3 minutes.
- Difficult intubation requiring prolonged airway instrumentation led to exclusion.

3.4 Intraoperative Monitoring

- Heart rate, MAP, and SpO_2 recorded at baseline and at 0, 1, 2, 3, 4, 5, 7, 10, 15, and 20 minutes after induction.
- IV fluid and vasopressor requirements documented.

3.5 Haemodynamic Events and Management

- **Hypotension:** MAP decrease >20% from baseline; treated with IV fluid bolus.
- **Severe hypotension:** MAP decrease >40%; IV mephentermine 6 mg bolus administered, with repeat treatment if

persistent.

- **Bradycardia:** HR < 55 BPM was managed with Inj.Atropine (0.01 mg/kg)
  Demographic data: (age – gender – comorbidities – current medications) were routinely collected
  Incidence of hypotension, incidence of prolonged hypotension and incidence of bradycardia was determined.

3.6 Ultrasound Technique

Ultrasound assessment was performed before induction of general anaesthesia using a **Sonosite 6–13 MHz probe**.

- **IVC Ultrasound :** Patient positioned supine (0°); probe placed in the subxiphoid region. IVC visualized in the longitudinal plane near its junction with the right atrium. Measurements obtained **2–3 cm distal to the hepatic vein junction**. Maximum diameter during expiration (dIVCmax) and minimum diameter during inspiration (dIVCmin) were measured using 2D ultrasound/M-mode. IVC collapsibility index (CI) calculated as:

$$\mathrm{CI} = \frac{dIVC_{\max} - dIVC_{\min}}{dIVC_{\max}} \times 100$$

- **IJV Ultrasound :Supine measurement**
  Patient maintained supine with the head in a neutral position.IJV identified lateral to the carotid artery using transverse scanning, with minimal probe pressure. Cross-sectional area measured at end-expiration.

- **Trendelenburg measurement :** Table tilted 15–30° head-down; 1–2 minutes allowed for venous redistribution. IJV area remeasured at the same site and at end-expiration.

IJV area change rate calculated as:

$$\frac{\mathrm{Area}_{\mathrm{Trendelenburg}} - \mathrm{Area}_{\mathrm{supine}}}{\mathrm{Area}_{\mathrm{Trendelenburg}}} \times 100$$

4. Result

Table 2.1 – Hemodynamic characteristics

Parameter	Value
Inferior vena cava	
Maximum diameter (mm)	15.8 [11.6, 19.3]
Minimum diameter (mm)	9.8 [7.0, 13.6]
Collapsibility index	0.42 [0.20, 0.47]
Internal jugular vein	
Supine area (mm²)	10.2 [6.9, 14.1]
Trendelenburg area (mm²)	14.4 [9.4, 18.7]
Change rate	0.25 [0.11, 0.44]
Baseline mean arterial pressure (mmHg)	82 [60, 110]
Baseline heart rate (bpm)	80 [71, 89]
Incidence of post-induction hypotension	73 (73%)
Incidence of severe post-induction hypotension	10 (10%)
Incidence of bradycardia	12 (12%)
Time to hypotensive episode (minutes)	2 [1, 4]

Source table reproduced with original measures and values

Table 2.2 – Hemodynamic characteristics in hypotensive and non-hypotensive patients

Parameter	Non-hypotension (n = 27)	Hypotension (n = 73)	P-value
Inferior vena cava			
Maximum diameter (mm)	15.6 [13.9, 17.7]	16.1 [11.6, 19.3]	**0.327**
Minimum diameter (mm)	11.7 [9.7, 13.6]	9.4 [7.0, 11.0]	**<0.001***
Collapsibility index	0.25 [0.20, 0.30]	0.42 [0.33, 0.47]	**<0.001***
Internal jugular vein			
Supine area (mm²)	9.5 [6.9, 14.1]	10.4 [7.1, 14.0]	**0.284**
Trendelenburg area (mm²)	12.0 [9.4, 18.5]	14.8 [12.2, 18.7]	**0.047***
• Change rate	0.20 [0.11, 0.27]	0.29 [0.25, 0.44]	**<0.001***
Baseline mean arterial pressure (mmHg)	82 [60, 109]	82 [61, 110]	**0.891**
Baseline heart rate (bpm)	80 [68, 89]	80 [62, 89]	**0.982**

** indicates statistical significance (p < 0.05)*

Source table reproduced with original group values and p-values

Table 3 – Accuracy of IVC and IJV parameters in predicting PIH

Parameter	AUC (95% CI)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI) | Cut-off value
Inferior Vena Cava					
Maximum diameter	0.53 (0.44–0.63)	68 (57–78)	42 (28–57)	70 (59–80)	**39 (26–54) | ≤16.0 mm**
Minimum diameter	0.68 (0.59–0.77)	73 (62–82)	62 (46–76)	80 (69–89)	**52 (38–66) | ≤10.4 mm**
Collapsibility index	0.76 (0.68–0.84)	78 (67–87)	71 (55–84)	85 (75–92)	**60 (45–74) | >0.34***
Internal Jugular Vein					
Supine area	0.55 (0.46–0.64)	72 (61–82)	40 (27–55)	72 (60–81)	**42 (28–57) | ≤11.2 mm²**
Trendelenburg area	0.64 (0.55–0.73)	69 (58–79)	61 (45–75)	78 (67–87)	**49 (36–63) | >13.8 mm²**
Change rate	0.80 (0.72–0.88)	78 (67–87)	76 (61–87)	87 (77–94)	**62 (48–75) | >0.25***

** Identified cut-off values for predicting hypotension for clinical implementation. AUC: area under ROC curve; CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value.*

All source diagnostic metrics, confidence intervals and cut-offs retained

Table 4 – Accuracy of IVC and IJV parameters in predicting severe PIH

Parameter	AUC (95% CI)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI) | Cut-off value
Inferior Vena Cava					
Maximum diameter	0.56 (0.48–0.64)	72 (43–92)	48 (39–58)	13 (7–22)	**94 (85–98) | ≤16.2 mm**
Minimum diameter	0.64 (0.54–0.74)	78 (49–95)	52 (42–62)	15 (8–25)	**96 (87–99) | ≤9.3 mm**
Collapsibility index	0.72 (0.62–0.81)	86 (57–98)	64 (54–73)	20 (11–32)	**98 (91–100) | >0.40***
Internal Jugular Vein					
Supine area	0.57 (0.47–0.66)	67 (38–88)	51 (41–61)	13 (7–23)	**93 (84–98) | ≤9.9 mm²**
Trendelenburg area	0.61 (0.51–0.70)	70 (42–90)	58 (48–68)	15 (8–26)	**95 (86–98) | >14.6 mm²**
Change rate	0.83 (0.75–0.91)	88 (62–98)	75 (65–83)	27 (16–41)	**98 (93–100) | >0.29***

** Identified cut-off values for predicting severe hypotension for clinical implementation. AUC: area under ROC curve; CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value.*

All source diagnostic metrics, confidence intervals and cut-offs retained

5. Discussion

There was a high incidence of PIH, with 73% of patients experiencing hypotension (MAP decrease >20% from baseline) with 10% of those patients experiencing severe hypotension (MAP decrease >40% from baseline).
The incidence of PIH was easily managed by giving IV fluid within no time.

Internal jugular vein (IJV) change rate demonstrated positive predictive ability for both hypotension and severe hypotension, with area under ROC curve values of 0.80 and 0.83 respectively.

IJV change rate >0.25 was determined as the optimal cut-off value for predicting hypotension, providing a sensitivity of 78% and specificity of 76%, with a high positive predictive value of 87%.

IVCCI showed good predictive accuracy for hypotension with an AUC of 0.76 and optimal cut-off value of >0.34 (sensitivity 78%, specificity 71%).

IVCCI and IJV change rate add a good predictive value for prediction of post induction hypotension but when compared to each other, IJV change rate results were better.

IVCCI (sensitivity 86% and specificity 64%) and IJV change rate (sensitivity 88% and specificity 75%) showed good accuracy in predicting post induction severe hypotension.

IJV change rate was the best predictor of PIH (AUC 0.80; cut-off >0.25), followed by **IVCCI** (AUC 0.76; cut-off >0.34).
Our findings agree with **Altiparmak et al. (2019)**, who reported an IJV change-rate cut-off of approximately 0.28, and **Zhang and Critchley (2016)**, who demonstrated the predictive value of IVCCI.

5.1 Physiological basis

Increased IVC collapsibility and IJV area variation may indicate reduced venous filling, predisposing patients to hypotension following anaesthesia-induced vasodilation.
For severe PIH, IJV change rate showed the highest accuracy (AUC 0.83; sensitivity 88%; NPV 98%), although its low PPV (27%) warrants cautious interpretation.

5.2 Clinical implication

Dynamic IJV and IVC ultrasound measurements may help identify high-risk patients and guide individualized haemodynamic management.

6. Conclusion

IJV change rate outperformed IVCCI in predicting post-induction hypotension. Both are useful bedside ultrasound tools for pre-induction risk assessment and haemodynamic management.

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