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Article

Correlation Between Internal Jugular Vein Collapsibility Index and Inferior Vena Cava Collapsibility Index by Point-of-Care Ultrasound for Estimation of Central Venous Pressure

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ABSTRACT

Background: Accurate assessment of central venous pressure (CVP) is essential for managing critically ill patients. Ultrasound-guided measurement of the internal jugular vein (IJV) and inferior vena cava (IVC) collapsibility index (CI) offers a non-invasive method for estimating CVP. This study aimed to correlate IVC and IJV collapsibility indices with invasively measured CVP. **Objective**: To assess the correlation between the internal jugular vein collapsibility index and IVC collapsibility index using point-of-care ultrasound (POCUS) for estimation of CVP. **Methods**: This cross-sectional study was conducted at the Department of Anesthesia, National Hospital Lahore, over a six-month period (26th July 2024 to 26th January 2025). A total of 61 ICU-admitted patients with an inserted CVP catheter were enrolled. IJV and IVC measurements were taken using bedside ultrasound, recording maximum and minimum diameters and cross-sectional areas (CSA) during respiratory cycles. **Results**: The mean age of patients was 64.62 ± 16.21 years, with a mean CVP of 13.66 ± 6.06 cm H_2O. The IJV collapsibility index at a cutoff of >10.2 cm^2 showed a sensitivity of 42.9%, specificity of 15.8%, and an overall accuracy of 34.4%, with a negative correlation of -0.641 with CVP. The IVC collapsibility index at a cutoff of >26.5 cm^2 showed 26.2% sensitivity, 36.8% specificity, and 29.5% overall accuracy, with a negative correlation of -0.570 with CVP. **Conclusion**: Both IVC and IJV collapsibility indices serve as beneficial non-invasive markers for assessing CVP. However, the IJV collapsibility index demonstrates a stronger correlation and may offer a more reliable prediction of CVP changes, serving as a valuable adjunct in fluid management for critically ill patients.

Keywords: Central venous pressure, internal jugular vein, inferior vena cava, collapsibility index, ultrasound, non-invasive, critical care, fluid management, diagnostic accuracy, sensitivity, specificity

INTRODUCTION

Although intravenous fluids are advised for critically ill ICU patients, higher volumes of fluids have been linked with adverse outcomes in such patients (1). In the management of fluid therapy, the critically ill ICU patient's volume status must be ascertained (2). At times, it becomes even more difficult, particularly through physical examination alone (3). Various non-invasive and invasive methods of volume determination are available (4). Static and dynamic indices are two general haemodynamic parameters that are predictive of fluid response (5). Central venous pressure (CVP) and inferior vena cava (IVC) diameter measurement by sonography are frequently used parameters in volume status determination (6).

One alternative to IVC for indirectly measuring CVP is the assessment of various properties of the internal jugular vein (IJV). The height of jugular vein pulsation has been a topic of investigation in clinical practice as an indicator of CVP and right atrial pressure, although it is not considered sensitive (7).

Point-of-care ultrasound (POCUS) is an accessible tool that holds the potential to enable physicians to identify signs of venous congestion from the bedside (8). As an objective measure of physiological and haemodynamic indicators of fluid status, tolerance, and responsiveness, POCUS is emerging as an excellent non-invasive bedside diagnostic modality (9). According to one study, an IJV anteroposterior collapsibility index (AP-CI) ≤24.8% at

30° served as an accurate predictor of a CVP ≥8 mmHg, with sensitivity and specificity of 100% and 97.1%, respectively. The IJV cross-sectional area collapsibility index at 30° demonstrated a stronger correlation with CVP (r = –0.56, P < 0.001), suggesting that in patients with cirrhosis, IJV POCUS may be a more accurate predictor of CVP than IVC-based assessments (10). The highest correlations observed between IJV collapsibility index and CVP at 30° were r = –0.583 (CSA-CI) and r = –0.559 (diameter-CI), while the correlation between IVC-CI and CVP was r = –0.540 (7).

While the gold standard for CVP measurement remains catheter-based, it is invasive, time-consuming, and requires trained personnel. The IJV collapsibility index, however, offers a promising non-invasive alternative for estimating CVP or fluid status in ICU patients, especially when measured at a 30° head elevation. The objective of this study, therefore, is to assess the correlation between IJV-CI and IVC-CI to determine which method provides a better estimation of CVP. The broader goal is to inform the development of non-invasive monitoring strategies and enhance patient care in critical care settings by exploring these ultrasound-derived indices. The outcomes of this research may have significant clinical implications by potentially reducing reliance on invasive procedures and improving the safety and efficiency of CVP assessment in critically ill patients.

MATERIALS AND METHODS

This was a cross-sectional study conducted at the Department of Anesthesia, National Hospital Lahore. The duration of the study spanned six months, from 26th July 2024 to 26th January 2025, following the approval of the research proposal. A consecutive sampling technique was employed. The sample size of 61 patients was estimated using a correlation coefficient of 0.353 between the IJV collapsibility index and the IVC collapsibility index, with a 95% confidence level and 80% power of the test, calculated using the correlation formula (10). Patients included in the study were those aged over 18 years and admitted to the ICU with an indwelling central venous pressure (CVP) catheter for clinical indications. Patients were excluded if they were on mechanical ventilation, had a history of neck or chest surgery or radiotherapy, pulmonary hypertension, tricuspid regurgitation, deep venous thrombosis in the upper limbs, or were pregnant. The study commenced after obtaining approval from the local ethics committee of the National Hospital Lahore (NHMC/HR/1045). Written informed consent was obtained from all patients or their legal guardians. CVP was measured using a central venous catheter (CVC) inserted via the subclavian vein or internal jugular vein (IJV), and a transducer was used for pressure measurement. For ultrasound assessment, a linear vascular transducer (7–13 MHz, 38 mm) was used for IJV imaging, and a phased array probe (1–5 MHz, 21 mm) was used for IVC imaging. IJV measurements were taken on the right side with the patient in a supine position and the head elevated to 30°. The maximum and minimum anteroposterior (AP) diameters and cross-sectional areas (CSA) were recorded over four respiratory cycles. The collapsibility index (CI) was calculated using the formula: ((Maximum diameter or CSA – Minimum diameter or CSA) / Maximum diameter or CSA) × 100%.

IVC measurements were performed with the patient in a supine position. Measurements were obtained from the subxiphoid region, approximately 2 cm below the hepatic veins, capturing maximum and minimum AP diameters across four breathing cycles. The CI was derived using the same formula. The predefined cutoff values were as follows: for CVP ≤10 cm H_2O, the IJV CSA-CI at 0° was >14.1, IJV diameter-CI at 0° was >10.2, IJV CSA-CI at 30° was >19.0, IJV diameter-CI at 30° was >10.2, and IVC-CI at 0° was >26.5. Data were entered and analyzed using SPSS version 26. Continuous variables such as IJV and IVC diameters were summarized using mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Pearson's correlation coefficient was used to assess the association between IJV and IVC collapsibility indices. Diagnostic metrics including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to evaluate the predictive accuracy of the IJV collapsibility index for estimating CVP. A p-value less than 0.05 was considered statistically significant.

RESULTS

The patients' mean age was 64.62 ± 16.21 years, with an age range from 24 to 99 years. The average weight was 76.64 ± 16.18 kg, while the mean height was 5.62 ± 0.19 feet. The mean heart rate was 88.38 ± 20.10 beats per minute, and the mean arterial pressure averaged 88.16 ± 17.29 mmHg. Central venous pressure (CVP) had a mean of 13.66 ± 6.06 cm H_2O, ranging from 2.00 to 29.00 cm H_2O.

Table 1: Descriptive Statistics of Demographic and Hemodynamic Parameters

Parameter	Mean	S.D.	Range	Minimum	Maximum
Age (years)	64.62	16.21	75.00	24.00	99.00
Weight (kg)	76.64	16.18	57.00	45.00	102.00
Height (feet)	5.62	0.19	0.80	5.10	5.90
Heart rate (min)	88.38	20.10	84.00	54.00	138.00
Mean arterial pressure	88.16	17.29	72.00	50.00	122.00
CVP (cm H_2O)*	13.66	6.06	27.00	2.00	29.00
IJV diameter (CSA)**	15.28	8.78	27.00	2.00	29.00
IVC (CSA)***	26.14	6.59	19.90	17.10	37.00

** Central venous pressure (CVP) in cm H_2O ** Collapsibility index for IJV diameter (cross-sectional area) *** Collapsibility index for IVC (cross-sectional area)*

The collapsibility index for the internal jugular vein (IJV) had a mean cross-sectional area (CSA) of 15.28 ± 8.78 cm^2, while the inferior vena cava (IVC) had a mean CSA of 26.14 ± 6.59 cm^2. Among the diagnoses, the most common conditions were acute kidney injury (27.87%) and combined medical illnesses (19.67%), followed by end-stage renal disease (16.39%) and septic shock (13.11%). Regarding

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the diagnostic accuracy of the collapsibility index, an IJV cutoff of >10.2 cm^2 showed a sensitivity of 42.9%, specificity of 15.8%, and overall accuracy of 34.4%, with a correlation coefficient of -0.641. The IVC CI, using a threshold of >26.5 cm^2, demonstrated a sensitivity of 26.2%, specificity of 36.8%, and an overall accuracy of 29.5%, with a correlation coefficient of -0.570. These correlation values indicate moderate to strong negative relationships, suggesting that as the collapsibility index increases, CVP tends to decrease. A negative correlation implies that a higher collapsibility index corresponds to a lower CVP, meaning that more collapsible veins are associated with lower central venous pressure.

Table 2: Comparison and Diagnostic Accuracy of IJV and IVC Taking CVP as Gold Standard

Parameter	CVP ≤10	CVP >10	Sensitivity	Specificity	PPV	NPV	Overall Accuracy	Correlation
IJV >10.2	13	37	42.9%	15.8%	52.9%	11.1%	34.4%	-0.641
IJV ≤10.2	6	5						
IVC >26.5	7	14	26.2%	36.8%	47.8%	18.4%	29.5%	-0.570
IVC ≤26.5	12	28						

The IJV collapsibility index (-0.641) demonstrates a stronger inverse relationship with CVP compared to the IVC collapsibility index (-0.570), indicating that IJV collapsibility is a more reliable indicator of CVP changes than IVC collapsibility.

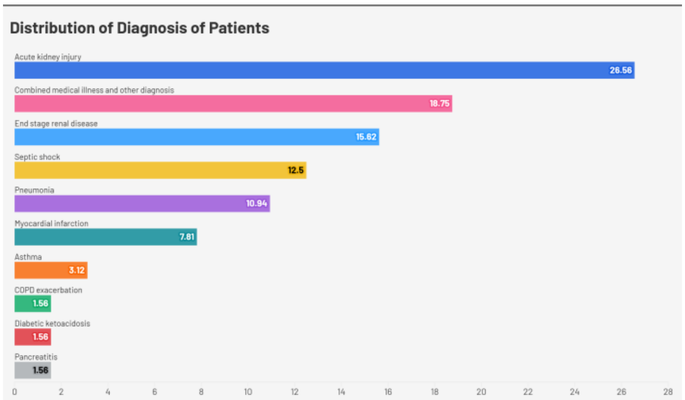

Figure 1: Distribution of Diagnosis of Patient

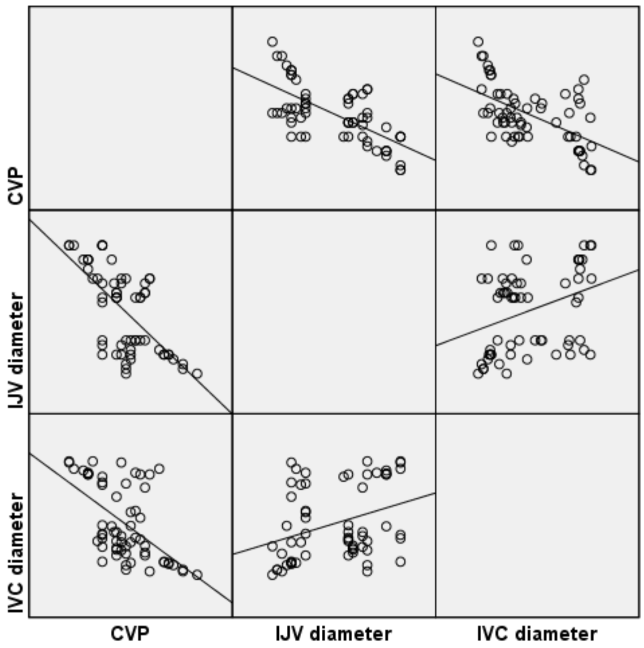

Figure 2: Scatter Plot Showing Negative Correlation between Central Venous Pressure (CVP) and Collapsibility Index for IJV Diameter (CSA) and IVC (CSA)

DISCUSSION

This study aimed to assess the correlation between internal jugular vein (IJV) and inferior vena cava (IVC) collapsibility indices (CI) in estimating central venous pressure (CVP) using point-of-care ultrasound (POCUS). The mean CVP was 13.66 ± 6.06 cm H_2O, ranging from 2.00 to 29.00 cm H_2O. The mean IJV cross-sectional area (CSA) was 15.28 ± 8.78 cm^2, while the mean IVC CSA was 26.14 ± 6.59 cm^2. The IJV collapsibility index demonstrated 42.9% sensitivity, 15.8% specificity, and 34.4% overall accuracy, whereas the IVC collapsibility index showed 26.2% sensitivity, 36.8% specificity, and 29.5% overall accuracy. These relatively low sensitivity and specificity values are inconsistent with the findings reported by Jassim et al., who observed higher diagnostic performance using a cutoff of >14.1 at 0°, with sensitivity and specificity ranging from 73–82%, and an even higher accuracy at a cutoff of >19 at 30°, where sensitivity and specificity reached 83% (11). The disparity in findings may be attributed to variability in patient characteristics or differences in measurement techniques. Moreover, patient-specific variables such as respiratory effort, intra-abdominal hypertension, and underlying cardiovascular disease can influence collapsibility measurements and should be taken into account. Supporting this notion, a recent Turkish study evaluated the predictive value of IJV-CI in forecasting postspinal hypotension following elective surgery, reporting sensitivity and specificity of 64% and 63.6%, respectively, at a cutoff of 22.6% (AUC = 0.709). In comparison, our study found a lower sensitivity and specificity of 42.9% and 15.8%, respectively, at a cutoff of >10.2 cm^2. This suggests that clinical settings and patient profiles may influence diagnostic thresholds. Nonetheless, both studies affirm the utility of IJV-CI as a non-invasive monitoring parameter, particularly for predicting haemodynamic instability (12).

Our study demonstrated a significant negative correlation between both venous collapsibility indices and CVP, with the IJV-CI showing a stronger correlation (r = -0.641) than the IVC-CI (r = -0.570). These findings indicate that greater collapsibility of the IJV and IVC corresponds to lower CVP values, reinforcing the potential of IJV-CI as a more reliable non-invasive tool for assessing fluid status. A comparative study conducted in Qatar by Jassim et al. reported similar results, showing strong negative correlations between CVP and both IVC-CI (r = -0.540, P = 0.0001) and IJV-CI (r = -0.583 for CSA, r = -0.559 for diameter). Their findings suggest that while IVC-CI can serve as a backup when IJV imaging is not feasible (e.g., in patients with neck trauma or post-surgical changes), IJV-CI—particularly at a 30° head elevation—is preferable as a non-invasive bedside estimate of CVP (13).

Similarly, a study conducted in the surgical ICU of Lahore General Hospital found significant negative correlations between IVC-CI and CVP, with stronger associations in spontaneously breathing patients (r = -0.899) compared to those on mechanical ventilation (r = -0.725), highlighting the influence of respiratory variability on IVC-CI reliability. These findings are consistent with our observed correlation of -0.570 between IVC-CI and CVP (13). Another prospective observational study reported high correlations between CVP and both IJV-CI and IVC-CI, with the strongest correlation found between CVP and IVC-CI (r = -0.541), followed by IJV CSA-CI at 30° (r = -0.453). In comparison, the higher correlation in our study between IJV-CI and CVP (r = -0.641) supports the notion that IJV-CI may be more suitable than IVC-CI under certain clinical conditions (14).

However, not all findings align with our results. In a study of 60 patients, Kumar et al. reported weak negative correlations between IJV-CI and CVP (r = -0.117 for diameter and r = -0.109 for CSA at 30°), while stronger correlations were observed for IVC-CI (r = -0.452 for diameter and r = -0.503 for CSA) (15). These differences highlight the potential variability in collapsibility indices based on methodology, sample size, and clinical conditions. The main limitations of our study include its single-center design and relatively small sample size, which may restrict the generalizability of our findings. Additionally, collapsibility measurements could have been influenced by inter-individual anatomical differences, respiratory patterns, and technical aspects of ultrasound imaging. To validate and expand upon these results, larger multicenter studies with standardized imaging protocols are necessary.

CONCLUSION

The current research demonstrates that the internal jugular vein (IJV) collapsibility index is a superior clinical predictor for estimating central venous pressure (CVP) when compared to the inferior vena cava (IVC) collapsibility index. Given its stronger correlation and reduced susceptibility to confounding variables, IJV measurement should be prioritized in volume status assessment using point-of-care ultrasound (POCUS). Nonetheless, due to the inherent limitations of ultrasound-based CVP estimation, a comprehensive haemodynamic assessment remains essential in the management of critically ill patients.

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