Section: Emergency Medicine

Original Research Article

COMPARISON OF INTERNAL JUGULAR VEIN COLLAPSIBILITY INDEX AND FEMORAL VEIN COLLAPSIBILITY INDEX WITH INFERIOR VENA CAVA COLLAPSIBILITY INDEX IN TRAUMA PATIENTS PRESENTING WITH DIFFERENT GRADES OF SHOCK TO EMERGENCY DEPARTMENT – A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Shock is an acute circulatory failure resulting in inadequate tissue perfusion and organ dysfunction. Early assessment of intravascular volume status is critical in trauma patients; however, conventional clinical parameters are often unreliable. Point-of-care ultrasound (POCUS)-based indices such as inferior vena cava collapsibility index (IVC-CI) are widely used. Alternative venous indices like internal jugular vein collapsibility index (IJV-CI) and femoral vein collapsibility index (FV-CI) may offer practical advantages. The study aims to compare IJV-CI and FV-CI with IVC-CI in trauma patients presenting with varying grades of shock and to evaluate the time required for image acquisition. **Materials and Methods:** In this prospective observational study, trauma patients meeting inclusion criteria were enrolled after informed consent. Ultrasound measurements of internal jugular vein (IJV), femoral vein (FV), and inferior vena cava (IVC) were performed by a single trained sonographer. Collapsibility index (CI) was calculated using the formula: CI = [(Dmax − Dmin)/Dmax] × 100. Correlation between the indices and the average time taken for acquisition were analysed. **Result:** IJV-CI and FV-CI demonstrated strong correlation with IVC-CI (r = 0.95 & r = 0.94) and showed a consistent increase with worsening haemorrhagic shock. Both IJV-CI and FV-CI were obtained significantly faster than IVC-CI and were more feasible in challenging imaging conditions such as abdominal trauma and obesity. **Conclusion:** IJV-CI and FV-CI are reliable, rapid, and non-invasive surrogate for IVC-CI in trauma patients, particularly when IVC visualization is limited. Incorporating IJV-CI & FV-CI into emergency assessment may enhance early volume status evaluation and guide resuscitation.

INTRODUCTION

Accurate assessment of intravascular volume status is crucial in managing critically ill and trauma patients, as both hypovolemia and hypervolemia are associated with increased morbidity and mortality.[1,2] Traditional methods such as clinical examination and central venous pressure (CVP) monitoring are limited by poor reliability, invasiveness, and inability to predict fluid responsiveness.[3,4] Point-of-care ultrasound (POCUS) has emerged as a rapid, non-invasive alternative, with inferior vena cava collapsibility index (IVC-CI) widely used for volume assessment.[5,6] However, IVC visualization may be challenging in certain patients. Hence, alternative indices such as internal jugular vein and femoral vein collapsibility are being explored.[7,8]

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Emergency Medicine of a tertiary care centre equipped with facilities for trauma resuscitation, critical care, and point-of-care ultrasound (POCUS). The study was carried out over a period of 18 months.

This study was performed according to the Helsinki Declaration (http://www.wma.net/en/30publications/10policies/b3/) and approved by the Research Ethics Committee (REC) of the institution where the experiment was performed. A written informed consent was obtained from all subjects. Adult trauma patients (>18 years) presenting to the emergency department with features suggestive of shock were considered for inclusion. A total of 100 patients meeting predefined inclusion and exclusion criteria were enrolled after obtaining written informed consent.

Patients presenting with trauma and more than two of the following: systolic blood pressure <100 mmHg, heart rate >100/min or respiratory rate >20/min, pulse pressure <25 mmHg, altered mental status, urine output <30 mL/hour, or capillary refill time >2 seconds were included. Patients with known coronary artery disease, chronic kidney disease, or chronic obstructive pulmonary disease; those on mechanical ventilation with positive end-expiratory pressure >5 cm H_2O; patients with anatomical limitations to ultrasound assessment; those in cardiac arrest at presentation were excluded.

All patients were initially assessed and managed according to Advanced Trauma Life Support (ATLS) guidelines. Baseline demographic and clinical parameters, including vital signs, Glasgow Coma Scale, capillary refill time, and urine output, were recorded. Patients were categorized into haemorrhagic shock classes (I–IV) based on standard ATLS criteria.

POCUS examinations were performed at the bedside using a portable ultrasound system (Mindray) with curvilinear and linear probes by trained clinicians.

- IVC-CI: Measured in the supine position using curvilinear transducer in subxiphoid paramedian long-axis view, 0.5–3 cm from the right atrium.
- IJV-CI: Assessed with a linear probe placed transversely in the mid-to-lower neck with slight head rotation to contralateral side.
- FV-CI: Measured 1–2 inches below the inguinal ligament in a short-axis view.

For all vessels, maximum (Dmax) and minimum (Dmin) diameters were recorded using M-mode during respiratory cycles. Collapsibility index (CI) was calculated as: CI = [(Dmax − Dmin) / Dmax] × 100. Time required for each measurement was recorded from probe placement to acquisition of an adequate M-mode image.

All clinical and ultrasound data were recorded using a standardized proforma and entered into Microsoft Excel for tabulation. Statistical analysis was performed using IBM SPSS version 27. Correlation between IVC-CI and IJV-CI/FV-CI was assessed using Pearson or Spearman correlation coefficients based on data distribution. Linear regression analysis was performed to evaluate relationships between variables. Paired samples t-test was used to compare mean time required for acquisition of indices. Agreement between methods was assessed using Bland–Altman analysis. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 100 adult trauma patients presenting with varying grades of shock were included in this prospective observational study. The mean age was 43.54 ± 13.38 years (range: 18–73 years), with the highest proportion of patients (26%) in the 50–60-year age group [Figure 1]. Males constituted 75% of the study population, while females accounted for 25% [Figure 2].

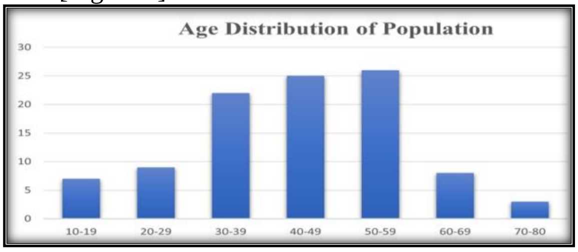

Figure 1: Age Distribution of Study Population. The bar chart depicts the number and percentage of participants across predefined age groups.

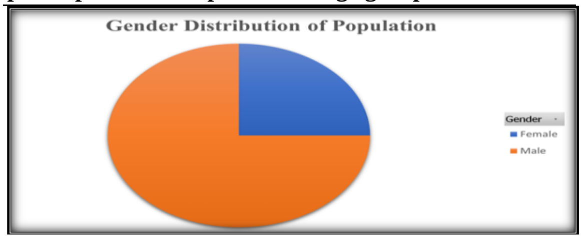

Figure 2: Gender Distribution of Population. The pie chart illustrates the proportion of male and female participants in the study cohort

The median Glasgow Coma Scale (GCS) score was 12 (IQR: 9–13), with values ranging from 4 to 15. The mean pulse rate was 115.12 ± 18.05 beats per minute (range: 70–159 bpm) [Table 1]. The median systolic blood pressure (SBP) was 93 mmHg (IQR: 80–110), and the median diastolic blood pressure (DBP) was 60 mmHg (IQR: 50–68), with ranges of 52–138 mmHg and 28–90 mmHg, respectively. The median pulse pressure was 35 mmHg (IQR: 24–44) [Figure 3].

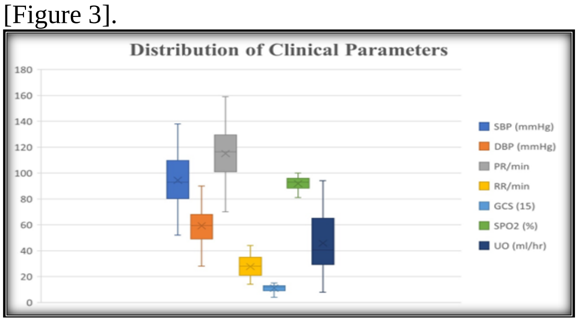

Figure 3: Box-and-whisker plots showing the distribution of physiological parameters including pulse rate (PR), peripheral oxygen saturation (SpO_2), urine output (UO) in mL/hr, respiratory rate (RR), systolic blood pressure (SBP), and diastolic blood pressure (DBP). For each variable, the central line within the box represents the median, the box denotes the interquartile range (IQR).

Capillary refill time (CRT) was prolonged (>3 seconds) in 60% of patients, while 40% had CRT <3 seconds. The mean respiratory rate was 27.71 ± 7.54 cycles per minute (range: 14–44), and the mean oxygen saturation (SpO_2) on room air was 91.8 ± 5.01% (range: 81–100%). The mean urine output was 45.8 ± 22.01 mL/hour (range: 8–94 mL/hour). Based on ATLS classification, 40% of patients were in class III haemorrhagic shock, 30% in class II, 20% in class IV, and 10% in class I [Figure 4].

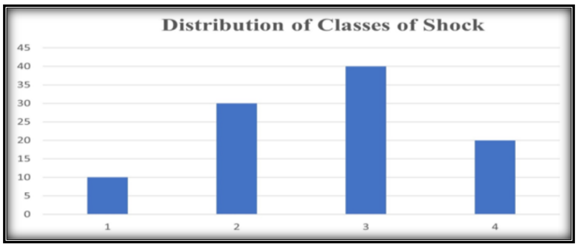

Figure 4: Distribution of Class of Shock. The bar chart illustrates the frequency and proportion of patients across the four classes of hemorrhagic shock.

The mean time required to obtain the inferior vena cava collapsibility index (IVC-CI) was 85.69 ± 24.74 seconds (range: 30–152 seconds). The mean time required to obtain the internal jugular vein collapsibility index (IJV-CI) was significantly shorter at 37.31 ± 10.64 seconds (range: 15–66 seconds). The mean time required to obtain the femoral vein collapsibility index (FV-CI) was 50.36 ± 15.74 seconds (range: 20–84 seconds). On comparative analysis using paired samples t-test, IJV-CI was obtained significantly faster than IVC-CI, with a mean difference of 48 seconds ($p < 0.001$). Similarly, FV-CI was acquired 35 seconds faster than IVC-CI, and this difference was also statistically significant ($p < 0.001$) [Figure 5, Table 2].

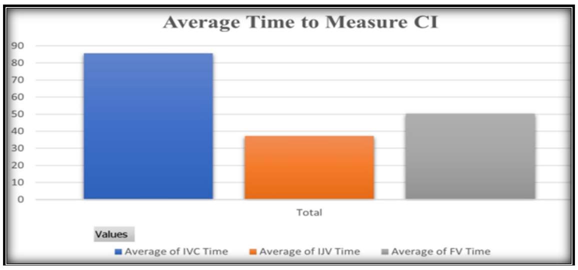

Figure 5: Mean Time Taken to Measure Indices (in Seconds). Time taken to measure ultrasound-derived indices. The bar chart illustrates the mean time required to obtain measurements of the inferior vena cava (IVC), internal jugular vein (IJV), and femoral vein (FV).

The mean IVC collapsibility index (IVC-CI) was 38.02% ± 15.02%. The mean internal jugular vein collapsibility index (IJV-CI) was slightly higher at 43.11% ± 17.65%, while the mean femoral vein collapsibility index (FV-CI) was lower at 34.62% ± 15.37%. These findings demonstrate variation in collapsibility indices across different venous sites [Figure 6]. All collapsibility indices show a progressive increase from lower to higher shock classes, peaking in class 4. This indicates the hemodynamic responses among the three indices with worsening shock severity [Figure 7].

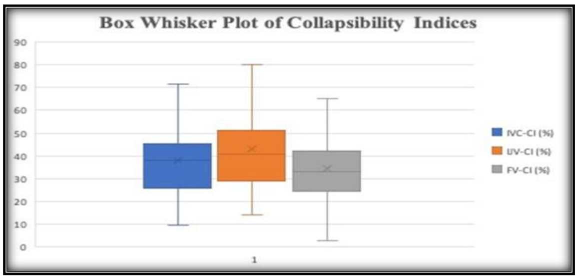

Figure 6: Box-and-whisker plot comparing three groups (IVC-CI, IV-CI, and FV-CI). The plot shows the distribution of values for each group, including median, quartiles, range, and outliers, highlighting differences in central tendency and variability among the groups.

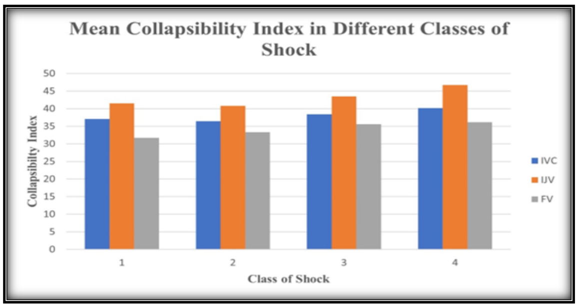

Figure 7: Comparison of mean IVC-CI, IJV-CI, and FV-CI values across four class of Shock, showing trends in collapsibility indices.

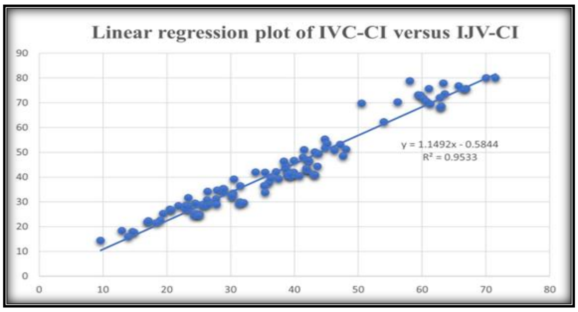

Figure 8: Scatter plot showing a positive correlation between IVC-CI and IJV-CI, with a strong linear relationship (y = 1.1492x – 0.5844)

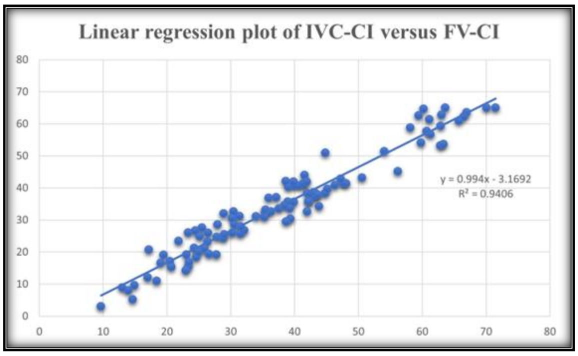

Figure 9: Scatter plot showing a positive correlation between IVC-CI and FV-CI, demonstrating a strong linear relationship (y = 0.994x – 3.1692)

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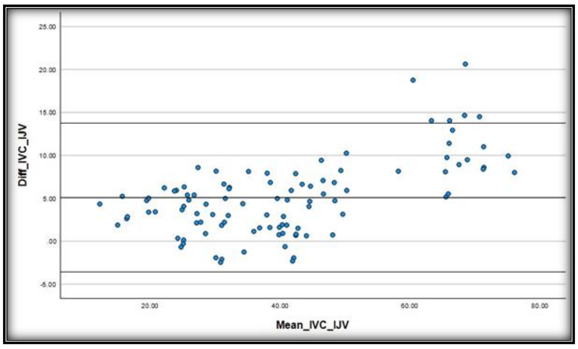

Figure 10: Bland–Altman plot showing agreement between IVC-CI and IJV-CI, with most values clustered around the mean difference and acceptable limits of agreement.

Pearson's correlation analysis demonstrated a positive correlation between IVC-CI and IJV-CI, with a correlation coefficient (r) of 0.95, indicating a strong positive strength of association. The correlation between IVC-CI and FV-CI was also strong positive, with a correlation coefficient (r) of 0.94. Linear regression analysis further illustrated these relationships [Figure 8, Figure 9].

Bland–Altman analysis revealed a mean measurement bias of 5% and a median bias of 5%, indicating a slight overestimation of collapsibility by IJV-CI relative to IVC-CI. Subgroup analysis showed that when IJV-CI values were <30%, there was a mean bias of 2.8%, suggesting overestimation relative to IVC-CI. Proportional bias was observed at lower ranges (<30%). For IJV-CI values between 30–60%, the bias was approximately 3.1%, and for values >60%, the bias increased to approximately 11.1%, indicating progressive overestimation at higher collapsibility values [Figure 10].

Bland–Altman analysis between IVC-CI and FV-CI demonstrated a mean bias of -3% and a median bias of -4%, indicating that FV-CI generally underestimated collapsibility compared to IVC-CI. Subgroup analysis revealed the greatest underestimation observed in the <20% subgroup (mean bias -5.87%). This bias decreased in the 20–40% subgroup (-3.13%) and further reduced in the >40% subgroup (-2.44%), indicating improved agreement at higher FV-CI values [Figure 11]. Proportional bias was observed at mid ranges (20-40%).

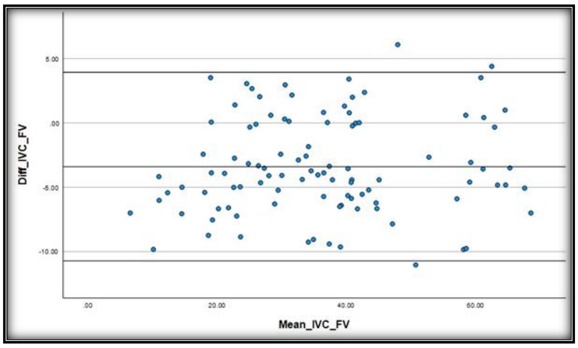

Figure 11: Bland–Altman plot showing agreement between IVC-CI and FV-CI, with most observations lying within the limits of agreement and minimal bias.

Table 1: Baseline clinical and physiological characteristics of the study population at presentation. Data are presented as median, standard deviation (SD), minimum, maximum, range, and interquartile range (IQR). Variables include demographic details, neurological status (GCS), hemodynamic parameters, oxygenation, urine output, and respiratory rate at emergency department admission.

	Mean	Median	Std. Deviation	Range	Minimum	Maximum	IQR
SBP	94.4	93.0	18.7	86.0	52.0	138.0	29.5
DBP	59.3	59.5	13.3	62.0	28.0	90.0	19.0
PR	115.1	116.5	18.1	89.0	70.0	159.0	28.5
RR	27.7	28.0	7.5	30.0	14.0	44.0	14.0
GCS	11.1	12.0	2.6	11.0	4.0	15.0	4.0
SPO2	91.9	93.0	5.0	19.0	81.0	100.0	7.8
UO	45.8	40.5	22.0	86.0	8.0	94.0	35.8
Age	43.5	44.0	13.4	55.0	18.0	73.0	19.0

Table 2: Comparison of time required for acquisition of venous collapsibility indices. Data are presented as minimum, maximum, mean, and standard deviation (SD) of acquisition time (seconds). Paired sample t test demonstrates significantly shorter acquisition times for IJV-CI and FV-CI compared to IVC-CI (p < 0.001). Abbreviations: IVC-CI - Inferior Vena Cava Collapsibility Index; IJV-CI - Internal Jugular Vein Collapsibility Index; FV-CI-Femoral Vein Collapsibility Index; SD – Standard Deviation

Time taken to acquire	Minimum (Sec)	Maximum (Sec)	Mean (Sec)	SD	p Value (Paired Sample t-test)
IVC-CI	30	152	85.69	24.74	<0.001
IJV-CI	15	66	37.31	10.64	
IVC-CI	30	152	85.69	24.74	<0.001
FV-CI	20	84	50.36	15.74	

DISCUSSION

Accurate assessment of intravascular volume status remains a cornerstone in the management of trauma patients presenting with shock. In this study, we evaluated the utility of internal jugular vein collapsibility index (IJV-CI) and femoral vein collapsibility index (FV-CI) as alternatives to inferior vena cava collapsibility index (IVC-CI), with additional emphasis on feasibility and acquisition time.

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The mean IVC-CI observed in our study (38.02%) is consistent with prior literature demonstrating that IVC collapsibility reflects intravascular volume status and correlates with central venous pressure (CVP).[9] However, increasing evidence suggests that although IVC-CI correlates with CVP, its ability to reliably predict fluid responsiveness remains variable, especially in heterogeneous critically ill populations.[10]

Our study demonstrated a strong positive correlation between IJV-CI and IVC-CI (r = 0.95). This finding aligns with previous studies showing significant correlations between IJV collapsibility and CVP, supporting its role as a non-invasive surrogate for volume assessment.[11] Notably, studies have shown that IJV-CI measured at 30° head elevation exhibits strong correlation with CVP and may serve as a first-line bedside tool. The strong correlation observed in our study suggests that IJV-CI can be reliably used in emergency settings, particularly when IVC visualization is limited.[12]

An important practical advantage observed in our study was the significantly reduced time required to obtain IJV-CI compared to IVC-CI (mean difference 58 seconds, $p < 0.001$). This finding has significant clinical implications, particularly in time-sensitive scenarios such as the "golden hour" of trauma resuscitation. Rapid acquisition of hemodynamic parameters is critical in guiding early fluid resuscitation, and superficial veins such as the IJV offer a clear advantage due to ease of accessibility and minimal interference from abdominal factors.[13]

In contrast, the strong positive correlation observed between FV-CI and IVC-CI (r = 0.94) in our study suggests that femoral vein collapsibility may serve as a reliable surrogate for IVC-derived assessment of volume status. Our findings therefore strengthen the growing evidence supporting the use of peripheral venous indices, particularly in situations where IVC assessment may not be feasible.[14] Bland–Altman analysis demonstrated only a small mean bias of −3% between FV-CI and IVC-CI, indicating relatively close agreement despite a tendency for FV-CI to underestimate collapsibility. The presence of proportional bias in the mid-range values (20–40%) indicates that caution may still be required when interpreting intermediate FV-CI measurements. Overall, these findings suggest that FV-CI may represent a practical and clinically useful alternative to IVC-CI for bedside hemodynamic assessment.[15]

The Bland–Altman analysis in our study provides additional insights into the agreement between modalities. IJV-CI showed overall bias (5%), although proportional bias was observed at higher collapsibility values, indicating potential overestimation in severe hypovolemia. This trend has been reported in previous ultrasound-based studies, where venous collapsibility indices may behave differently at extreme volume states due to altered venous compliance and intrathoracic pressure dynamics.[9]

The clinical relevance of these findings lies in the limitations of IVC assessment, which are well documented. Factors such as obesity, abdominal trauma, bowel gas, and surgical dressings can significantly impair IVC visualization and reduce measurement reliability.[16] Additionally, respiratory mechanics, particularly in mechanically ventilated patients, can alter IVC dynamics and complicate interpretation. These limitations highlight the need for alternative, easily accessible venous parameters.[17]

POCUS-based assessment of venous collapsibility has gained increasing acceptance due to its non-invasive nature and ability to provide real-time hemodynamic information. Studies have demonstrated that ultrasound-based indices improve diagnostic accuracy and facilitate early differentiation of shock types in emergency and critical care settings. Furthermore, integration of multiple ultrasound parameters rather than reliance on a single index is increasingly advocated to improve clinical decision-making.[18]

Our study adds to the existing literature by providing trauma-specific data stratified by haemorrhagic shock class, an area that remains underexplored. The observed trend of increasing collapsibility indices with worsening shock severity supports their role not only in detecting hypovolemia but also in grading its severity [Figure 7]. This has important implications for guiding resuscitation strategies and monitoring response to therapy.

This study highlights the practical utility of IJV-CI and FV-CI as a rapid, bedside, and non-invasive tool for assessing volume status in trauma patients. Its ease of acquisition and strong correlation with IVC-CI make it particularly valuable in emergency settings where time and accessibility are critical. Incorporating IJV-CI / FV-CI into routine POCUS protocols may enhance early decision-making and improve resuscitation efficiency.

The study has certain limitations. The sample size was relatively small and derived from a single centre, which may limit generalizability. Additionally, CVP was not used as a gold standard comparator, and fluid responsiveness was not directly assessed. Operator dependency and potential measurement variability inherent to ultrasound-based techniques should also be considered.

CONCLUSION

Overall, IJV-CI & FV-CI emerge as feasible, non-invasive, and time-efficient alternatives to IVC-CI for volume assessment in trauma patients, especially when IVC visualization is not possible. Incorporation of IJV-CI into point-of-care ultrasound protocols may enhance early clinical decision-making and resuscitation strategies. Further large-scale, multicentre studies are needed to validate the use of IJV-CI and FV-CI as a surrogate for IVC-CI and to establish standardized cut-off values. Future research should also explore its role in predicting fluid responsiveness and outcomes in trauma patients.

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