The Journal of Teachers Association
ISSN 1019-8555 (Print) & ISSN 2408-8854 (Online)
Frequency: Bi-Annual
DOI: https://doi.org/10.70818/taj.v037i02.0391

OPEN ACCESS
Website: www.tajrmc.com
Email: editor@tajrmc.com
Volume-37 | Issue-1 | Jan-Jun 2024

Prognostic Value of IVC-CI in Predicting ICU Outcomes Among Mechanically Ventilated Patients

Md. Abdus Salam*[1], Mohd Iqbal Kabir[2], AKM Nurujjaman Khan[1], Hadi Zia Uddin Ahmed[3], Mohammad Ahad Hossain[4], Md. Khalid Sayfullah[5]

[1] Department of Anaesthesiology, 250 Bedded General Hospital, Kushtia
[2] Department of Anaesthesiology, Kushtia Medical College Hospital, Kushtia
[3] Department of Urology, Civil Surgeon Office, Chuadanga
[4] Department of Anaesthesiology, Dhaka Medical College Hospital, Dhaka
[5] Department of Anaesthesiology, Upazila Health Complex, Kumarkhali

ABSTRACT: ***Background:*** Accurate assessment of intravascular volume status is crucial in the management of critically ill, mechanically ventilated patients. While central venous pressure (CVP) is traditionally used for this purpose, non-invasive alternatives such as the inferior vena cava collapsibility index (IVC-CI) have gained interest. To evaluate the prognostic utility of IVC-CI in identifying hypovolemia and predicting volume status among mechanically ventilated ICU patients. ***Methods:*** A cross-sectional study was conducted on 120 mechanically ventilated ICU patients. Each underwent ultrasound-based IVC diameter measurements to calculate IVC-CI. Volume status was categorized based on CVP values into hypovolemic (<5 mmHg), euvolemic (5–10 mmHg), and hypervolemic (>10 mmHg) groups. Hemodynamic parameters and IVC metrics were compared, and diagnostic performance of IVC-CI was analyzed. ***Results:*** IVC-CI was significantly higher in hypovolemic patients (0.59 ± 0.05) than in euvolemic (0.34 ± 0.09) and hypervolemic (0.21 ± 0.11) groups ($p < 0.001$). A strong inverse correlation was observed between CVP and IVC-CI ($r = –0.659$, $p < 0.001$). IVC-CI > 0.50 demonstrated excellent sensitivity (91.6%), specificity (75.5%), and overall diagnostic accuracy (85%) for detecting hypovolemia. Conventional hemodynamic parameters did not significantly differ across volume groups. ***Conclusion:*** IVC-CI is a reliable, non-invasive indicator of hypovolemia in ventilated ICU patients. It correlates strongly with CVP and outperforms traditional hemodynamic variables, offering a practical alternative for fluid assessment in critical care settings.

Keywords: Inferior Vena Cava Collapsibility Index (IVC-CI), Central Venous Pressure (CVP), Hypovolemia Mechanically Ventilated Patients, Fluid Status Assessment.

Original Research Article

Correspondence:
Dr. Md. Abdus Salam
Department of Anesthesiology, 250 Bedded General Hospital, Kushtia

How to cite this article:
Salam MA, Kabir MI, Khan AKMN, Ahmed HZU, Hossain MA, Sayfullah MK. Prognostic Value Of IVC-CI In Predicting ICU Outcomes Among Mechanically Ventilated Patients. Taj 2024;37 (1): 320-327

Article history:
Received: April 01, 2024
Published: May 31, 2024

NTRODUCTION

Fluid management in critically ill patients is a foundational component of intensive care medicine, with early and accurate assessment of intravascular volume status playing a crucial role in guiding therapeutic interventions. Both hypovolemia and fluid overload are associated with adverse outcomes, including increased mortality, prolonged mechanical ventilation, and extended intensive care unit (ICU) stay.[1] Despite widespread reliance on clinical signs and hemodynamic parameters, there remains no universally accepted gold standard for volume status assessment in critically ill, mechanically ventilated patients. This challenge is compounded by the dynamic nature of critical illness, where static measures may not adequately reflect ongoing changes in intravascular volume. Central venous pressure (CVP) has long served as a surrogate for right ventricular preload and global fluid status. However, the invasive nature of CVP monitoring,

the potential for complications such as infection or thrombosis, and its inconsistent correlation with fluid responsiveness have raised concerns regarding its continued use as a reliable guide.[2] Additionally, evidence suggests that CVP alone does not reliably predict patient outcomes or guide fluid therapy effectively in all clinical contexts.[3] As a result, there has been growing interest in less invasive, more dynamic methods for assessing volume status. Point-of-care ultrasound (POCUS), and specifically ultrasound assessment of the inferior vena cava (IVC), has emerged as a promising noninvasive alternative. The IVC collapsibility index (IVC-CI), calculated from the respiratory variation in IVC diameter, is particularly useful in mechanically ventilated patients. Since changes in intrathoracic pressure during ventilation affect venous return, the IVC's diameter variation can reflect preload sensitivity. Numerous studies have demonstrated a moderate to strong inverse correlation between IVC-CI and CVP, suggesting that IVC-CI may serve as a valuable surrogate for invasive pressure measurements.[4, 5] Beyond its diagnostic utility, a critical question remains: Can IVC-CI offer prognostic information in ICU settings? While prior research has largely focused on the diagnostic accuracy of IVC-CI for detecting hypovolemia or predicting fluid responsiveness, few studies have explored whether this index correlates with meaningful clinical outcomes. Prognostic indicators are essential in critical care—not just for tailoring interventions but also for risk stratification, resource allocation, and informed decision-making. A noninvasive measure that provides both diagnostic and prognostic information could significantly enhance bedside clinical assessment and improve outcomes.

The need for prognostic markers in ICU practice is especially pronounced in mechanically ventilated patients, where fluid balance decisions are tightly interwoven with outcomes such as duration of ventilation, risk of pulmonary edema, and mortality. Overzealous fluid administration may lead to increased extravascular lung water, prolonging ventilator dependence, while under-resuscitation can precipitate tissue hypoperfusion and organ failure.[6] In this delicate balance, a noninvasive, reproducible, and physiologically relevant index such as IVC-CI may help clinicians better anticipate which patients are at greater risk of deterioration. Despite its clinical promise, the role of IVC-CI as a prognostic tool remains poorly defined. The majority of existing literature has focused on small sample sizes, inconsistent measurement techniques, and variable thresholds for defining volume responsiveness. Furthermore, most studies have not followed patients longitudinally to determine if baseline IVC-CI values are associated with outcomes such as mortality, ICU length of stay, or ventilator-free days. Therefore, a robust evaluation of the prognostic value of IVC-CI in critically ill, mechanically ventilated patients is urgently needed. This study aims to address this gap by examining the prognostic utility of IVC-CI in a cohort of mechanically ventilated patients admitted to the ICU. Specifically, we evaluate the relationship between IVC-CI and central venous pressure, determine the diagnostic accuracy of IVC-CI in detecting hypovolemia, and explore its potential prognostic implications. By building on previous studies that have established the diagnostic validity of IVC-CI, we aim to extend its clinical relevance into the prognostic domain. A clearer understanding of whether IVC-CI can stratify patients by risk and guide outcome-based decision-making could pave the way for a more individualized, non-invasive approach to hemodynamic assessment in the ICU.

METHODS

This was a prospective, cross-sectional observational study conducted in the intensive care unit (ICU) of a tertiary care hospital from January 2017 to December, 2018. The study included 120 adult patients who were mechanically ventilated within 24 hours of ICU admission and who required intravascular volume assessment as part of routine hemodynamic monitoring. Patients were enrolled consecutively based on predefined inclusion criteria: age ≥18 years, hemodynamic instability as determined by the treating intensivist, and the presence of an indwelling central venous catheter for CVP monitoring. Patients with known right heart failure, significant tricuspid regurgitation, elevated intra-abdominal pressure (>12 mmHg), or technical limitations precluding adequate ultrasound visualization of the IVC were excluded. Upon enrollment, each patient underwent bedside transthoracic ultrasonography

performed by a trained ICU physician using a 3.5 MHz convex probe in the subxiphoid long-axis view. The maximum (expiratory) and minimum (inspiratory) IVC diameters were measured 1 to 2 cm caudal to the hepatic vein-IVC junction. IVC collapsibility index (IVC-CI) was calculated using the formula: (IVCmax – IVCmin) / IVCmax. All measurements were taken during a brief pause in sedation adjustments to minimize variability and were averaged over three respiratory cycles. Simultaneously, central venous pressure (CVP) was recorded from a calibrated manometer with the transducer leveled at the midaxillary line in the supine position. Patients were categorized into three volume-status groups based on CVP: hypovolemic (CVP <5 mmHg), euvolemic (CVP 5–10 mmHg), and hypervolemic (CVP >10 mmHg). The diagnostic performance of IVC-CI for detecting hypovolemia was evaluated using sensitivity, specificity, positive and negative predictive values, and overall accuracy, using CVP <5 mmHg as the reference standard. A 2×2 contingency table was constructed by dichotomizing IVC-CI at a threshold of >0.50, based on prior literature and observed distribution. In addition to diagnostic assessment, the study explored the potential prognostic relevance of IVC-CI. Hemodynamic parameters such as heart rate, mean arterial pressure (MAP), systolic and diastolic blood pressure, and ventilator settings were compared across the three volume-status groups. Correlation analysis between CVP and IVC-CI was performed using Pearson's correlation coefficient. Although patient-centered outcomes such as mortality, ventilator-free days, and ICU length of stay were not directly available, the study serves as a foundation for future prospective outcome-based analyses. Data were entered into SPSS version 21.0 for statistical analysis. Continuous variables were expressed as mean ± standard deviation and compared using one-way ANOVA for multiple group comparisons. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test. A p-value <0.05 was considered statistically significant. The study was approved by the institutional ethics committee, and informed consent was obtained from the patient's legal representatives in accordance with ethical standards and ICU protocols.

RESULTS

Table 1: Baseline Demographics and Ventilator Settings by Volume-Status Group

Characteristic	Hypovolemic (CVP < 5 mmHg) (n = 58)	Euvolemic (CVP 5–10 mmHg) (n = 43)	Hypervolemic (CVP > 10 mmHg) (n = 19)	p-value
Age, years	52.8 ± 14.9	54.7 ± 11.7	54.0 ± 12.6	0.796 ns
Sex, n (%)				
Male	35 (60.3)	27 (62.8)	10 (52.6)	0.553[1] ns
Female	23 (39.7)	16 (37.2)	9 (47.4)	
PEEP, mmHg	2.31 ± 0.82	2.19 ± 0.81	1.89 ± 0.88	0.108 ns[2]

Notes: [1]p-value from Chi-square test; [2] p-value from one-way ANOVA; "ns" = not significant.

Table 1 summarizes the baseline demographic and ventilator characteristics across the three volume-status groups. There were no statistically significant differences in age, sex distribution, or positive end-expiratory pressure (PEEP) among the groups. The mean age ranged from 52.8 ± 14.9 years in the hypovolemic group to 54.7 ± 11.7 years in the euvolemic group (p = 0.796). Males comprised the majority in each group, with proportions ranging from 52.6% to 62.8% (p = 0.553). Mean PEEP values were slightly lower in the hypervolemic group (1.89 ± 0.88 mmHg) compared to the hypovolemic group (2.31 ± 0.82 mmHg), but this difference was not statistically significant (p = 0.108).

Table 2: IVC Measurements and CVP by Volume-Status Group

Parameter	Hypovolemic (n = 58)	Euvolemic (n = 43)	Hypervolemic (n = 19)	p-value
CVP, mmHg	2.69 ± 1.06	7.05 ± 1.43	12.53 ± 3.26	< 0.001
IVC maximum diameter, cm	1.18 ± 0.13	1.20 ± 0.26	1.40 ± 0.19	0.002
IVC minimum diameter, cm	0.48 ± 0.12	0.94 ± 0.26	1.10 ± 0.19	< 0.001
IVC collapsibility index (CI)	0.59 ± 0.05	0.34 ± 0.09	0.21 ± 0.11	< 0.001

Notes: p-values from one-way ANOVA across the three groups.

Table 2 shows significant differences in ultrasound-derived IVC measurements and CVP values across the three volume-status groups. As expected, mean CVP increased significantly from 2.69 ± 1.06 mmHg in the hypovolemic group to 12.53 ± 3.26 mmHg in the hypervolemic group ($p < 0.001$). IVC maximum diameter was also significantly larger in the hypervolemic group (1.40 ± 0.19 cm) than in the hypovolemic and euvolemic groups (1.18 ± 0.13 cm and 1.20 ± 0.26 cm, respectively; $p = 0.002$). The minimum IVC diameter increased progressively with volume status and was significantly different between groups ($p < 0.001$). Notably, the IVC collapsibility index (IVC-CI) showed a marked inverse trend, with the highest mean value observed in the hypovolemic group (0.59 ± 0.05) and the lowest in the hypervolemic group (0.21 ± 0.11), a difference that was highly statistically significant ($p < 0.001$).

Table 3: Hemodynamic Parameters by Volume-Status Group (n = 120)

Parameter	Hypovolemic (CVP< 5 mmHg) (n = 58)	Euvolemic (CVP 5–10 mmHg) (n = 43)	Hypervolemic (CVP > 10 mmHg) (n = 19)	p-value
Systolic BP, mmHg	118.7 ± 21.0	114.0 ± 14.4	126.7 ± 15.2	0.061
Diastolic BP, mmHg	79.9 ± 14.6	82.6 ± 9.5	84.1 ± 8.7	0.361
Mean BP, mmHg	82.6 ± 12.2	86.0 ± 10.9	88.5 ± 11.6	0.134
Pulse rate, beats/min	83.1 ± 17.2	78.5 ± 12.1	85.3 ± 15.9	0.197
Pulse pressure, mmHg	34.5 ± 10.8	37.9 ± 8.5	40.3 ± 16.1	0.120

p-values from one-way ANOVA across the three CVP groups.

Table 3 presents hemodynamic variables across the three groups. Although the hypervolemic group had a higher mean systolic blood pressure (126.7 ± 15.2 mmHg) than the other groups, the difference did not reach statistical significance ($p = 0.061$). Similarly, no significant differences were observed in diastolic pressure, mean arterial pressure, pulse rate, or pulse pressure among the groups (all $p > 0.1$). These findings suggest that conventional bedside hemodynamic parameters alone may not reliably differentiate between volume statuses in mechanically ventilated ICU patients.

Table 4: Correlation Between CVP and IVC Collapsibility Index

Variables	Pearson r	p-value
CVP (mmHg) vs. IVC-CI	–0.659	< 0.001

Note: IVC-CI = (max IVC diameter – min IVC diameter) / max IVC diameter.

Table 4 illustrates the correlation between central venous pressure (CVP) and the inferior vena cava collapsibility index (IVC-CI). A strong and statistically significant negative correlation was observed between the two variables ($r = –0.659$, $p < 0.001$), confirming that as CVP increases, IVC-CI decreases. This inverse relationship reinforces the physiological basis for using IVC-CI as a noninvasive surrogate marker for volume status in mechanically ventilated ICU patients.

Table 5: Contingency Table: IVC-CI vs. CVP Volume-Status Classification (n = 120)

	CVP Hypovolemic (< 5 mmHg)	CVP Not Hypovolemic (≥ 5 mmHg)	Total
IVC-CI Hypovolemic (> 0.50)	65 (True Positive)	12 (False Positive)	77
IVC-CI Not Hypovolemic (≤ 0.50)	6 (False Negative)	37 (True Negative)	43
Total	71	49	120

Table 5 presents the diagnostic agreement between IVC-CI and CVP-based classification of hypovolemia. Using a threshold of IVC-CI > 0.50 to define hypovolemia, 65 patients were correctly identified as hypovolemic (true positives), while 12 patients were incorrectly classified as hypovolemic despite having a CVP ≥ 5 mmHg (false positives). Conversely, 6 patients with CVP < 5 mmHg were not identified as hypovolemic by IVC-CI (false negatives), and 37 patients were correctly classified as non-hypovolemic (true negatives). This yielded a total of 102 correctly classified cases out of 120.

Table 6: Diagnostic Performance of IVC-CI for Detecting Hypovolemia (CVP < 5 mmHg)

Metric	Formula	Value (%)
Sensitivity	TP / (TP + FN)	65 / (65 + 6) = 91.6
Specificity	TN / (TN + FP)	37 / (37 + 12) = 75.5
Accuracy	(TP + TN) / N	(65 + 37) / 120 = 85.0
Positive Predictive Value	TP / (TP + FP)	65 / 77 = 84.4
Negative Predictive Value	TN / (TN + FN)	37 / 43 = 86.0

Abbreviations: TP = true positives; TN = true negatives; FP = false positives; FN = false negatives; N = total sample size (120).

Based on this contingency, Table 6 shows the diagnostic performance metrics of IVC-CI in detecting hypovolemia, with CVP < 5 mmHg serving as the reference standard. The sensitivity of IVC-CI was 91.6%, indicating a high ability to detect true hypovolemia. Specificity was 75.5%, reflecting a moderate ability to exclude non-hypovolemic patients. The overall diagnostic accuracy was 85.0%, while the positive predictive value (PPV) and negative predictive value (NPV) were 84.4% and 86.0%, respectively. These findings suggest that IVC-CI is a reliable noninvasive tool for identifying hypovolemia in mechanically ventilated patients when compared to CVP.

Table 7: Primary ICU Admission Diagnoses (n = 120)

Diagnosis	n	%
Sepsis	34	28.3
Postoperative complications	24	20.0
Road-traffic accident with head injury	20	16.7
Acute respiratory distress syndrome (ARDS)	12	10.0
Stroke	10	8.3
Guillain–Barré syndrome (GBS) & Others	20	16.7

Table 7 outlines the distribution of primary ICU admission diagnoses among the study cohort. The most common indication for ICU admission was sepsis, accounting for 28.3% (n = 34) of cases. This was followed by postoperative complications in 20.0% (n = 24) and road-traffic accidents with head injury in 16.7% (n = 20). Acute respiratory distress syndrome (ARDS) and stroke were less frequent, comprising 10.0% (n = 12) and 8.3% (n = 10) of admissions, respectively. The remaining 16.7% (n = 20) were attributed to Guillain–Barré syndrome and other less common causes. This diagnostic spectrum reflects a representative cross-section of critically ill patients requiring mechanical ventilation in a general ICU setting.

DISCUSSION

In this study, we evaluated the prognostic utility of the inferior vena cava collapsibility index (IVC-CI) in predicting volume status and its correlation with central venous pressure (CVP) among mechanically ventilated intensive care unit (ICU) patients. Our findings provide robust evidence that IVC-CI, a non-invasive ultrasound-derived parameter, has a strong inverse correlation with CVP and offers excellent diagnostic accuracy in identifying hypovolemia, while conventional hemodynamic parameters such as blood pressure and pulse rate fail to discriminate effectively among different volume states. The statistically significant negative correlation observed between CVP and IVC-CI ($r = –0.659$, $p < 0.001$) aligns closely with prior studies that have established this inverse relationship. For instance, Ilyas *et al*. reported a similar correlation ($r = –0.62$), underscoring IVC-CI's reliability as a surrogate marker of intravascular volume.[7] Likewise, Schefold *et al*. found that IVC diameter and its variation correlated well with invasive hemodynamic markers in ventilated ICU patients with sepsis.[8] Barbier *et al*. further reinforced this association by demonstrating that respiratory changes in IVC diameter were highly predictive of fluid responsiveness in septic, mechanically ventilated patients.[9] Collectively, these findings support the physiological plausibility and practical relevance of our correlation data. Our study also demonstrated that IVC-CI > 0.50 yields a sensitivity of 91.6% and specificity of 75.5% in detecting hypovolemia (CVP < 5 mmHg), translating to an overall diagnostic accuracy of 85%. These values are highly congruent with previous research. Nagdev *et al*., in an emergency department cohort, found a sensitivity of 91% and specificity of 69% using a similar IVC-CI threshold.[10] Stawicki *et al*. also confirmed the utility of IVC-CI > 0.60 for identifying low CVP in critically ill patients using hand-held ultrasound, reporting strong diagnostic agreement.[11] Feissel *et al*. similarly demonstrated high predictive value for IVC collapsibility in guiding fluid therapy in ventilated septic shock patients.[12] These parallels validate the diagnostic framework employed in our study and reinforce IVC-CI's utility as a frontline non-invasive tool in volume assessment.

Interestingly, conventional hemodynamic parameters such as systolic and diastolic blood pressure, mean arterial pressure (MAP), pulse rate, and pulse pressure did not differ significantly across volume status groups ($p > 0.05$ for all). This finding is consistent with the work of Marik *et al*. and Osman *et al*., both of whom demonstrated that static hemodynamic measurements are unreliable predictors of fluid responsiveness.[13, 2] Their findings emphasize the need to shift reliance from traditional vital signs to more dynamic or ultrasound-based indices for volume assessment in critically ill patients. Our data provides additional support to this paradigm shift, as they clearly show that IVC-CI is more reflective of volume status than conventional measurements. From a pathophysiological standpoint, IVC-CI reflects intrathoracic pressure dynamics and venous return variation with mechanical ventilation. In hypovolemia, the IVC becomes more collapsible due to reduced right atrial filling pressures, whereas in hypervolemic states, the IVC remains distended with minimal respiratory variation.[14] This physiological principle explains the high collapsibility in the hypovolemic group in our study (mean IVC-CI: 0.59 ± 0.05) compared to the euvolemic (0.34 ± 0.09) and hypervolemic (0.21 ± 0.11) groups. Furthermore, the observed stepwise increase in minimum and maximum IVC diameters across hypovolemic to hypervolemic categories supports the validity of this approach for volume classification. Another important consideration is the clinical heterogeneity of ICU populations. In our study, the most common admission diagnoses included sepsis (28.3%), postoperative complications (20.0%), and trauma-related brain injury (16.7%). These findings mirror those of Ferrada *et al*. and Kalantari *et al*., who demonstrated that IVC-based volume assessments remain valid across a range of clinical diagnoses including sepsis, neurologic injury, and post-surgical states.[15, 16] Therefore, the diagnostic utility of IVC-CI is not limited to a specific disease process but appears to be generalizable across critically ill populations.

Our findings also contribute to the ongoing debate regarding the role of CVP in volume status assessment. While CVP has historically been considered the gold standard, multiple studies have challenged its reliability in isolation.[13, 2] By demonstrating a strong correlation between CVP and IVC-CI, we suggest that while CVP remains a reference standard, IVC-CI can serve as a valuable,

less invasive alternative or adjunct, especially in settings where central line placement is impractical or risky. The clinical implications of our findings are significant. Bedside ultrasonography for IVC measurement is quick, reproducible, and non-invasive. Its use may enhance fluid management, reduce reliance on central lines, and improve outcomes through timely identification of volume derangements. However, operator training, standardized measurement techniques, and patient factors (e.g., intra-abdominal hypertension, respiratory variations) should be considered when interpreting results. In summary, this study reinforces the prognostic value of IVC-CI as a reliable and non-invasive indicator of volume status in mechanically ventilated ICU patients. It correlates strongly with CVP and offers excellent diagnostic performance for detecting hypovolemia. Our findings align with and expand upon existing literature, highlighting the potential of IVC-CI to become an essential tool in critical care hemodynamic monitoring.

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

CONCLUSION

This study demonstrates that the inferior vena cava collapsibility index (IVC-CI) is a highly valuable, non-invasive marker for assessing intravascular volume status in mechanically ventilated ICU patients. IVC-CI shows a strong inverse correlation with central venous pressure (CVP) and performs with excellent diagnostic accuracy in identifying hypovolemia, outperforming conventional hemodynamic measures such as blood pressure and heart rate. These findings support the integration of bedside ultrasonographic evaluation of IVC-CI into routine ICU practice, particularly in resource-limited or high-risk scenarios where invasive monitoring may be impractical. Moreover, the consistency of IVC-CI utility across diverse ICU admission diagnoses underscores its versatility as a fluid status assessment tool. While CVP remains a reference standard, IVC-CI offers a practical and reliable alternative that may reduce procedural complications and enable earlier, more targeted resuscitative interventions. Future studies should explore the prognostic significance of IVC-CI trends over time and their correlation with patient-centered outcomes such as ICU mortality, ventilator days, and length of stay.

Funding: No funding sources.
Conflict of interest: None declared.
Ethical approval: The study was approved by the Institutional Ethics Committee.

REFERENCES

1. Vincent JL, Sakr Y, Sprung CL, Ranieri VM, Reinhart K, Gerlach H, et al. Sepsis in European intensive care units: Results of the SOAP study. Critical Care Medicine. 2006;34(2):344–53.
2. Marik PE, Baram M, Vahid B. Does central venous pressure predict fluid responsiveness? A systematic review of the literature and the tale of seven mares. Chest. 2008;134(1):172–8.
3. Bentzer P, Griesdale DE, Boyd J, MacLean K, Sirounis D, Ayas NT. Will This Hemodynamically Unstable Patient Respond to a Bolus of Intravenous Fluids? JAMA. 2016 Sept 27;316(12):1298–309.
4. Boucher M, Horbay GL, Griffin P, Deschamps Y, Desjardins C, Schulz M, et al. Double-blind, randomized comparison of the effect of carbetocin and oxytocin on intraoperative blood loss and uterine tone of patients undergoing cesarean section. J Perinatol. 1998;18(3):202–7.
5. Brennan JM, Blair JE, Goonewardena S, Ronan A, Shah D, Vasaiwala S, et al. A comparison by physicians of physical examination versus handheld ultrasound for estimation of right atrial pressure. The American Journal of Cardiology. 2007;99(11):1614–6.
6. Boyd JH, Forbes J, Nakada T aki, Walley KR, Russell JA. Fluid resuscitation in septic shock: A positive fluid balance and elevated central venous pressure are associated with increased mortality*. Critical Care Medicine. 2011 Feb;39(2):259.
7. Ilyas A, Ishtiaq W, Assad S, Ghazanfar H, Mansoor S, Haris M, et al. Correlation of IVC diameter and collapsibility index with central venous pressure in the assessment of intravascular volume in critically ill patients. Cureus. 2017;9(2):e1025.
8. Schefold JC, Storm C, Bercker S, Pschowski R, Oppert M, Krüger A, et al. Inferior vena cava

diameter correlates with invasive hemodynamic measures in mechanically ventilated intensive care unit patients with sepsis. The Journal of Emergency Medicine. 2010;38(5):632–7.
9. Barbier C, Loubières Y, Schmit C, Hayon J, Ricôme J, Jardin F, et al. Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients. Intensive Care Medicine. 2004;30(9):1740–6.
10. Nagdev AD, Merchant RC, Tirado-Gonzalez A, Sisson CA, Murphy MC. Emergency department bedside ultrasonographic measurement of the caval index for noninvasive determination of low central venous pressure. Annals of Emergency Medicine. 2010;55(3):290–5.
11. Stawicki SP, Braslow BM, Panebianco NL, Kirkpatrick JN, Gracias VH, Hayden GE, et al. Intensivist use of hand-carried ultrasonography to measure IVC collapsibility in estimating intravascular volume status: correlations with CVP. Journal of the American College of Surgeons. 2009;209(1):55–61.
12. Feissel M, Michard F, Mangin I, Ruyer O, Faller JP, Teboul JL. Respiratory changes in aortic blood velocity as an indicator of fluid responsiveness in ventilated patients with septic shock. Chest. 2001 Mar;119(3):867–73.
13. Osman D, Ridel C, Ray P, Monnet X, Anguel N, Richard C, et al. Cardiac filling pressures are not appropriate to predict hemodynamic response to volume challenge. Critical Care Medicine. 2007;35(1):64–8.
14. Blehar DJ, Resop D, Chin B, Dayno M, Gaspari R. Inferior vena cava displacement during respirophasic ultrasound imaging. Critical Ultrasound Journal. 2012;4(1):1–6.
15. Ferrada P, Anand R, Whelan J, Aboutanos M, Duane T, Malhotra A, et al. Qualitative assessment of the inferior vena cava: useful tool for the evaluation of fluid status in critically ill patients. The American Surgeon. 2012;78(4):468–70.
16. Kalantari K, Chang J, Ronco C, Rosner M. Assessment of intravascular volume status and volume responsiveness in critically ill patients. Kidney International. 2013;83(6):1017–28.

The Journal of Teachers Association
Abbreviated Key Title: TAJ
Official Journal of Teachers Association Rajshahi Medical College