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Original Article

Association of Inferior Vena Cava Diameter and Compressibility Index with Central Venous Pressure

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Abstract

Background: In critical patients, it's often challenging to assess intravascular volume status at bedside. Central venous pressure (CVP) is commonly used to measure it in Intensive care units (ICUs) through an invasive method and associated with complications of central venous catheters (CVC). Ultrasound is alternative non-invasive tool, without radiation risk and readily available in ICUs with comparable results.
Objective: To determine the correlation between inferior vena cava (IVC) diameter and IVC Compressibility Index (CI) assessed by ultrasound with CVP value for assessing intravascular volume status in critical patients.
Methods: Cross-sectional study conducted at ICU of Mayo Hospital Lahore for a period of 6 months from January 2023 to June 2023. A total of 97 patients fulfilling selection criteria were enrolled after written informed consent. Ultrasonographic measurement of IVC diameter obtained and IVC-CI calculated. Measurement of CVP was done according to standard protocol immediately after the diameter of IVC had been measured. All findings were noted down on proforma and subjected to statistical analysis.
Results The mean age of patients was 50±13.8 years, the mean IVC diameter was 1.9±0.56 cm, the mean CVP value was 13±3.48 cm H_2O and the mean IVC-CI was 48±12.36%. There was a statistically significant positive correlation between IVC diameter and CVP as was indicated by r =0.871, p <0.001 and between IVC-CI and CVP there was a statistically significant negative correlation as was indicated by r =-0.695, p <0.001.
Conclusion: The IVC diameter positively and significantly correlated with CVP value and IVC-CI negatively correlated with CVP and thus IVC measurements can be used as non-invasive method of assessing volume status in critical patients.
Key words: IVC compressibility, critical patient, IVC, CVP, POCUS.

Introduction

In critical patients, it is often difficult to evaluate the status of intra-vascular fluid volume at bedside.[1] It has been discovered that the clinical examination is unreliable, inaccurate, and imprecise in determining the intravascular volume status of critical patients.[2] Vital signs have been proven to be insufficient predictors of acute haemorrhage, hypovolumic shock and treatment responsiveness in critical patients.[3] The patients' vital parameters do not precisely indicate low fluid volume in early shock. In the initial phase of hemorrhagic shock, significant blood volume loss is possible despite absence of tachycardia and hypotension.[3] Relying merely on the clinical findings and vital parameters may lead to mis-representation and lose critical time during resuscitation.[4] As an adjunct to physical examination findings and evaluation done by laboratory investigation, the clinicians often utilize invasive monitoring of hemodynamic parameters in order to reach a final strategy for managing fluids.[5] One such hemodynamic parameter which is being used extensively is central venous pressure (CVP).[5]

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Authors Contribution

MN & AWG conceptualized the project. MN, SK & RA did the data collection. AWG, MY & AH did the literature search. MN, MY, RA & AH performed the statistical analysis. Drafting, revision & writing of manuscript were done by MY, RA, SK & RA. AWG also did the editing and proof reading.

In a survey, it was found that 90% of the staff working in ICU utilize CVP for monitoring of fluid resuscitation in patients who had septic shock.[6] Raised CVP has been found to be linked with states of volume overload, whereas low CVP is linked with states having volume depletion.[6] CVP can be a good representative of pressure in the right atrium, which further is an important determinant of filling of the right ventricle.[7] Hence, CVP is a good indicator of right ventricular preload.[3] However, CVP is associated with certain complications such as failure of catheter placement, puncture of arteries, mal-positioned catheter, pneumothorax, hematoma formation subcutaneously, hemothorax, cardiac arrest and infection related to catheter.[8]

In ICU, cost-effective and non-invasive modalities like ultrasound can help in approaching diagnosis and treating patients who are critical.[9] Ultrasound guided inferior vena cava (IVC)diameter measurement helps in the evaluation of intra-vascular volume status.[9] In a healthy individual, the changes that occur cyclically in thoracic pressure leads to collapse of IVC diameter approximately 50%.[10] IVC diameter has been seen to be helpful in assessing the treatment response in patients who have acute cardiac failure. It further assists in resuscitation by providing non-invasive CVP measurement.[10]

Various international studies have been conducted which have established correlation between the volume status assessed by measuring IVC diameter using ultrasound and that measured by placing a CVP catheter. A local study showed a simple bedside sonography of inferior vena cava diameter correlates well with extremes of CVP values and can be helpful in assessing intravascular fluid status in ICU patients.[11] However, there is paucity of local data. Therefore, this research aims to see the inter-relation of inferior vena cava caliberas well as IVC compressibility index measured using ultrasound with CV pressure for measurement of fluid balance status in critical patients. It will help developing a non-invasive technique that can suggest the fluid balance incritical patients. This shall prevent hassel of utilizing invasive methods for measurements of hemodynamic parameters i.e. CVP and reducing complications associated with these procedures in ICU setup. This will help reducing overall morbidity in critical patients.

Methods

This cross-sectional study was conducted for a period of 6 months at the Critical Care Unit of Mayo Hospital, Lahore. A sample size of 97 patients was determined, maintaining 95% confidence interval, 5% margin of error and expected correlation coefficient (r) between IVC caliber/diameter and CV hemodynamic pressure as r=0.281.[9] Non-probability consecutive sampling was done. An aggregate of 97 patients ranging 18 to 80 years of age, of either gender, who were critical with a working patent central venous line in situ for less than 24 hours were selected for the study. Patients who had a CVP catheter inserted for more than 24 hours, with signs of moderate to severe regurgitation of tricuspid valve, with overt failure of the right side of heart, with increased pressure in the abdomen, patients in whom ultrasonographic evaluation was not possible e.g. when there was a contraindication for positioning the patients in the supine position including patients who were breathing spontaneously and had severe orthopnea or had severely high intracranial pressure were excluded from the study.

Inferior vena cava diameter (in cm) was assessed by ultrasound and was calculated. It was categorized as small diameter = <1.2 cm, normal diameter = 1.2 to 1.7 cm, dilated diameter = >1.7–2.5 cm and markedly dilated when it was >2.6 cm. Inferior vena cava compressibility index (IVC-CI) was also calculated and documented on proforma.

Right ventricular preload was frequently estimated using central venous pressure, which also revealed mean right atrial pressure. In order to categorize each patient's intravascular volume status, the CVP was measured in the supine position at the phlebostatic point with manometer technique. Euvolemia was determined using the typical range of CVP measurement, 8–12 cmH_2O; hypovolemia was labeled if CVP was 8mmHg, and hypervolemia was labeled if CVP was >12 mmHg. Critical life threatening illness was considered as a state of serious health with vital organ malfunction, a high risk of possible death if care was not provided timely and the potential for reversibility. Patients who had a critical illness were labeled as critical.[11]

Demographic biodata, history and clinical examination was performed in all patients and findings were entered on a pre-designed proforma. Ventilation strategy, end expiratory positive pressure (PEEP) and active on going disease was entered on a pre-designed Performa. Ultrasound machine was used to measure the caliber of IVC by an examiner who was blinded to the CVP value of patients. The IVC measurements were performed by Consultant Pulmonologists & Critical Care Specialists, having qualifications of FCPS Pulmonology & FCPS Critical Care Medicine with an experience of more than 5 years. The standard site of measurement is 2-3 cm distally located to the meeting point of IVC-RA. Measurement of IVC diameter was measured both in longitudinal as well as transverse planes. As soon as the IVC transverse plane was obtained, the ultrasonographic image was frozen when expiration ended and measurements were made. For each variable, two measurements were taken and the calculation of value which is an average of two was done. Measurement of CVP was done according to standard protocol immediately after the diameter of IVC had been measured. Catheters for measuring CVP were placed in either the subclavian or the internal jugular vein. Three measurements of CVP were obtained consecutively and average value was determined and the findings were subjected to statistical analysis after assessing the volume status of all participants as per operational definition. All the data wasentered on pre-designed proforma and analyzed with SPSS version 24.0. Numeric variables including age, duration of mechanical ventilation, heart rate, IVC diameter, CVP were described as mean value and SD. Qualitative data including gender and volume status of the patients was presented as frequency and percentage. Correlation between IVC diameter and CVP and IVC-CI and CVP was determined by Pearson's correlation and a *p*-value ≤0.05 treated statistically significant.

Results

A total of 97 patients were registered in study. The patients' mean age was 50±13.8 years, the mean heart rate of the patients was 98±6.7 beats per minute, the mean duration of mechanical ventilation was 11.5±5.44 hours, the mean IVC diameter was 1.9±0.56 cm, the mean CVP value was 13±3.48 cm H_2O and the mean IVC-CI was 48±12.36% (Table-1). There were 52 males and 45 females.

Table 1: Mean of quantitative variables. (N=97)

Variables	*Mean±SD*
Age (in years)	50±13.8
Heart rate (in beats per minute)	98±6.7
Duration of mechanical ventilation (in hours)	11.5±5.44
IVC diameter (in cm)	1.9±0.56
CVP (in cm H2O)	13±3.48
IVC-CI (in %)	48±12.36

In terms of diameter of IVC, small diameter was present in 11 (11.4%), normal IVC diameter was seen in 29 (29.9%), dilated diameter was seen in 43 (44.3%) and markedly dilated diameter was seen in 14 (14.4%) (Table-2). In terms of volume status of the patients, euvolemic status was seen in 29 (29.9%) patients, 11 (11.3%) patients had hypovolemia and 57 (58.8%) were hypervolemic. In terms of diagnosis of the patients, shock was the primary diagnosis in 4 (4.1%), sepsis was diagnosed in 29 (29.9%), acute renal failure was diagnosed in 31 (32%), 15 (15.5%) had chronic liver disease, 10 (10.3%) had diabetic ketoacidosis and 8 (8.2%) had pulmonary embolism (Table-2).

Table 2: Frequency of qualitative variables. (n=97)

Variables		*n (%)*
Diameter of IVC	Small	11 (11.4)
	Normal	29 (29.9)
	Dilated	43 (44.3)
	Markedly dilated	14 (14.4)
Volume status	Euvolemia	29 (29.9)
	Hypovolemia	11 (11.3)
	Hypervolemia	57 (58.8)
Diagnosis of the patients	Shock	4 (4.1)
	Sepsis	29 (29.9)
	Acute renal failure	31 (32.0)
	Chronic liver disease	15 (15.5)
	Diabetic ketoacidosis	10 (10.3)
	Pulmonary embolism	8 (8.2)

In terms of correlation, it was revealed that there was a statistically significant positive correlation between IVC diameter and CVP as was indicated by r =0.871, *p* =0.000 and between IVC-CI and CVP there was a statistically significant negative correlation as was indicated by r =-0.695, *p* =0.000 (Table-3).

Table 3: Correlation between IVC diameter and IVC-CI with CVP.

Variables	*Mean±SD*	*r value*	*p value*
IVC diameter CVP	1.9±0.56 13±3.48	0.871	0.000
IVC-CI CVP	48±12.36 13±3.48	-0.645	0.000

Discussion

CVP should be monitored in patients who are admitted to the emergency room in cases of failure of circulation or shock, the requirement for massive infusions or transfusions, situations involving a high risk of bleeding & requiring careful fluid resuscitation, such as in patients with cardiac issues.[12] Pressure of the right atrium or filling pressure of the right ventricle is indicated by the value of CVP.[13] CVP is a basic indication of right heart performance and intravascular fluid state. Changes in CVP and variations in the filling pressure of the left ventricle are associated in healthy persons.[13] A number of variables, including cardiac function, volume of blood, tone of the vessels, increased intrabdominal or intrathoracic pressure and vasopressor medication, affect the value of CVP.[14] An intrusive technique, like inserting a central venous catheter, is necessary for this measurement. An intrusive treatment like inserting a central venous catheter carries 15% risk of both initial and delayed complications.[14] Additionally, there are also drawbacks including extended hospital stays, rising medical expenses, and lowered quality of life.[15] This calls for the employment of an accurate non-invasive hemodynamic monitoring technique.[11]

The largest low-pressure vein in the venous system is the inferior vena cava. In certain ways, the vein's enlargement reflects variations in venous pressure[16]. Additionally, the increase in intravascular volume is reflected in this alteration.[17] Because of this, measuring the IVC diameter may be a useful diagnostic technique in determining if someone has hyper- or hypovolemia.[18] The IVC's movements and size are affected by breathing and total body fluid.[19] During inspiration, intrapleural pressure decreases,while increasing the venous return to the right heart and the intraluminal pressure decreases.[20]

The current study results revealed that CVP was positively correlated with IVC diameter and negatively correlated with IVC-CI and both correlations were statistically significant. A study was conducted by Agmy *et al.* in which the volume status of patients was assessed by measurement of IVC diameter by utilizing transthoracic ultrasonography and it was seen that IVC index and CVP negatively correlated as was shown by r =−0.89 and this correlation reached statistical significance i.e. p value <0.001.[6] Another study similarly reported that IVC-CI and CVP values were negatively and significantly correlated i.e. r =–0.540, p =0.0001.[7] Chardoli *et al.* revealed that in patients who had hypotension, there was a significant positive correlation between IVC diameter and CVP values before and after treating such patients with saline i.e. r =0.941, p <0.0001 and r =0.95, p < 0.0001, respectively.[8] Hanafe *et al.* also revealed that the diameter of IVC correlated positively with CVP value (r =0.281, p =0.048).[9] These findings are consistent with our study findings.

Thus, instead of invasive monitoring of volume status of critical patients, non-invasive methods can be utilized for making accurate assessments of volume status in such patients without increasing the risk of further complications.

The current study had certain limitations. There is an issue of applicability of the results due to single centered small sample size study. Secondly, patients who presented in emergency situations were not assessed thus the estimate of volume status in those patients could not be commented on. Lastly, the effect of mechanical ventilation of measurement of IVC diameter and CVP was not assessed.

Conclusion

The current study concluded that IVC diameter positively and significantly correlated with CVP value and IVC-CI negatively correlated with CVP. Because there is a substantial association between IVC diameters measured by bedside ultrasonography at the end of the expiratory and inspiratory phases and observed CVP values at the same phases, IVC diameter measures can be utilized to estimate intravascular volume status in critical patients. It is also concluded that IVC measurements may serve as a supportive non-invasive tool, but further large-scale studies are required before replacing invasive CVP monitoring. This study will be advantageous in terms of ICU experiences and also suitable for guiding treatment by physicians in emergency department, because of its capacity to offer non-invasive intravascular volume status of patients. Regular use of this approach is possible with extensive and in-depth exams.

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Availability of Data: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval: The Institutional Review Board of King Edward Medical University, Lahore approved the study via letter no. 896/RC/KEMU dated 31/10/2022.

Conflict of Interest: None declared.

References

1. Shalaby MI, Roshdy HM, Elmahdy WM, El Mezayen AE. Correlation between central venous pressure and the diameter of inferior vena cava by using ultrasonography for the assessment of the fluid status in intensive care unit patients. Egypt J Hosp Med 2018; 72(10): 5375-84.
2. Szymczyk T, Sauzet O, Paluszkiewicz LJ, Costard-Jäckle A, Potratz M, Rudolph V, et al. Non-invasive assessment of central venous pressure in heart

failure: a systematic prospective comparison of echocardiography and Swan-Ganz catheter. Int J Cardiovasc Imag 2020; 36(10): 1821-9.
3. Babaie S, Behzad A, Mohammadpour M, Reisi M. A comparison between the bedside sonographic measurements of the inferior vena cava indices and the central venous pressure while assessing the decreased intravascular volume in children. Adv Biomed Res 2018; 7: 97-103.
4. Zhang Q, Wang X, Su L, Zhang H, Chai W, Chao Y, et al. Relationship between inferior vena cava diameter ratio and central venous pressure. J Clin Ultrasound 2018; 46(7): 450-4.
5. Mohammed MA, Hagag MG, Mousa WA, Toulan MT. Correlation of inferior vena cava diameter and collapsibility index with central venous pressure in shocked patients. Menoufia Med J 2020; 33(4): 1304-8.
6. Agmy G, Wafy S, Adam M. The relationship between inferior vena cava diameter measured by bedside ultrasonography and central venous pressure value. Egypt J Chest Dis Tuberc 2020; 69(2): 415-20.
7. Jassim HM, Naushad VA, Khatib MY, Chandra P, Abuhmaira MM, Koya SH, et al. IJV collapsibility index vs IVC collapsibility index by point of care ultrasound for estimation of CVP: a comparative study with direct estimation of CVP. Open Access Emerg Med 2019; 2019(11): 65-75.
8. Chardoli M, Ahmadi M, Shafe O, Bakhshandeh H. Inferior vena cava diameter as a guide in hypotensive patients for appropriate saline therapy: An observational study. Int J Crit Illn Inj Sci 2018; 8(3): 160-4.
9. Hanafe MG, Rashidi M, Mohamadian Y. Estimation of central venous pressure by measuring IVC collapsibility index by sonography. Electron J Gen Med 2018; 15(4): 1-7.
10. Huguet R, Fard D, d'Humieres T, Brault-Meslin O, Faivre L, Nahory L, et al. Three-dimensional inferior vena cava for assessing central venous pressure in patients with cardiogenic shock. J Am Soc Echocardiogr 2018; 31(9): 1034-43.
11. Khalil A, Khan A, Hayat A. Correlation of inferior vena cava (IVC) diameter and central venous pressure (CVP) for fluid monitoring in ICU. Pak Armed Forces Med J 2015; 65(2): 235-8.
12. Vaish H, Kumar V, Anand R, Chhapola V, Kanwal SK. The correlation between inferior vena cava diameter measured by ultrasonography and central venous pressure. Ind J Pediatr 2017; 84(10): 757-62.
13. Prekker ME, Scott NL, Hart D, Sprenkle MD, Leatherman JW. Point-of-care ultrasound to estimate central venous pressure: a comparison of three techniques. Crit Care Med 2013; 41(3): 833-41.
14. Zhang X, Luan H, Zhu P, Feng J, Cui J, Zhao Z. Does ultrasonographic measurement of the inferior vena cava diameter correlate with central venous pressure in the assessment of intravascular volume in patients undergoing gastrointestinal surgery? J Surg Res 2014; 191(2): 339-43.
15. Mugloo MM, Malik S, Akhtar R. Echocardiographic inferior vena cava measurement as an alternative to central venous pressure measurement in neonates. Ind J Pediatr 2017; 84(10): 751-6.
16. Chattopadhyay A, Lodha R. Can Inferior Vena Cava Measurement be an Alternative to Central Venous Pressure Measurement? Ind J Pediatr 2017; 84(10): 733-4.
17. Dalimunthe LR, Adriansyah R, Trisnawati Y. Correlation Between Central Venous Pressure and Inferior Vena Cava Distensibility Index for Assessment of Volume Status In critical Children. Int J Res Pub 2022; 97(1): 1-9.
18. Zidan D, Baess A. Comparison between femoral vein diameter and inferior vena cava diameter by ultrasound in estimation of central venous pressure in mechanically ventilated patients. Res Opin Anaesth Intens Care 2020; 7(1): 100-3.
19. Premkumar M, Rangegowda D, Kajal K, Khumukcham JS. Noninvasive estimation of intravascular volume status in cirrhosis by dynamic size and collapsibility indices of the inferior vena cava using bedside echocardiography. J Gastroenterol Hepatol Open 2019; 3(4): 322-8.
20. Ibrahim AE, Ahmed FM, Ahmed FI, Farid DM. Central Venous Pressure versus Internal Jugular Vein or Inferior Vena Cava Collapsibility Indices to Predict Fluid Status in critical Patients. Egypt J Hosp Med 2022; 89(1): 4416-22.