Original Article

Correlation between Inferior Vena Cava Diameter Assessed on Ultrasonography and Central Venous Pressure among Critically ILL Patients Admitted In Intensive Care Unit

Shabih Zehra, Atif Latif, Asiya Kazi, Syed Ijaz Hussain Zaidi

ABSTRACT

Objective: To assess the correlation between inferior vena cava(IVC) diameter and central venous pressure (CVP) in critical patients admitted in ICU.

Study Design and Setting: The cross-sectional pilot study was conducted at Radiology Department of PNS SHIFA Hospital.

Methodology: 18-80 years patients were included and patients with severe orthopnea, unable to lie in supine position, morbid obese, pneumothorax, mass in mediastinum, tricuspid regurgitation and intra-cerebral bleeds were excluded.

Results: The mean age of 50 patients was 41.44±16.73 years. Mean measurement of CVP was considered as 10.41±4.18 mm. Mean diameter of IVC was 12.65±2.22 mm. The study results showed weak negative correlation between the CVP and IVC (r= - 0.110, p=0.04). It was also predicted that patients with age =50 years showed weak negative correlation between the CVP and IVC (r=-0.290, p=0.034). Similarly, in patients with age >50 years there was strong negative correlation between CVP and IVC (r=-0.680, p=0.045). The study results also showed that in male patients there was weak negative correlation between the CVP and IVC i.e. (r=-0.045, p=0.048). However, in female patients there was moderate positive correlation (r=0.685, p=0.001).

Conclusion: Weak negative correlation was found between inferior vena cava diameter on ultrasonography and central venous pressure measurement among critically ill patients.

Keywords: central venous pressure, inferior vena cava.

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INTRODUCTION:

The hemodynamic status of intensive care patients that are critically ill is of vital importance for critical care physicians in order to achieve appropriate goals for their patient's fluid therapy[1]..A variety of techniques exist which are used for this purpose, most of them include physical examination, measurement of central venous pressure (CVP), biochemical markers, estimation of vascular width, pulmonary artery catheterization and ultra-sonographic inferior vena cava (IVC) diameter assessment.[2] The measurement of CVP is the most commonly employed technique through the help of preload estimation. Requisites in the measurement of CVP are insertion of a central venous catheter that can be time-consuming, expensive and could lead to complications.[3]

The use of ultrasonography in intensive care setups as a bed-side technique are due to easy availability but also being cheap, safe and more importantly non-invasive. Inferior vena cava visualization on ultrasound is a technique used for providing rapid and non-invasive means of gauging preload and is also needed for fluid resuscitation[4.]Researches have shown correlations between measurements of CVP and IVC. The rapid measurement of CVP through non-invasive means is critically important especially in intensive care setups[5.] Any change in volume status will be depicted through a change in diameter of IVC, whereby it can aid in differentiating between hypovolemic, cardiogenic and septic shock[6]

The precision in assessing volume status is vital for patients having critical illnesses like acute renal failure, congestive cardiac failure, septic shock and acute blood loss. For instance, a study demonstrated that CVP measurement as an early hemodynamic assessment modality led to substantial improvements in patient's outcomes with septic shock and severe sepsis[7]Jugular venous pulse (JVP) examination for estimating. CVP is usually done as a bed-side technique. CVP refers to mean vena caval or the right atrial pressure

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(RAP) that is equal to right ventricular and diastolic pressure. Detecting elevated JVP among left-sided heart failure patients is predicted with elevations in pulmonary capillary wedge pressure, without severe pulmonary disease, indicating poor prognosis [8]

Nevertheless, accurately measuring JVP is seldom difficult to obtain due to poor technique of the examiner [9]Measuring CVP through invasive methods either by internal jugular vein or subclavian vein catheterization have reported few complications like air embolism, pneumothorax, arterial puncture, catheter associated infection and injury of great vessels. Therefore, it is important to determine CVP through a reliable and non-invasive means.[10] Many researches have observed fair to excellent correlations between CVP and various IVC parameters.[11-13] The studies used diameter of IVC greater than 10 to 20 mm as a cutoff point for high CVP. Size and shape of IVC were not only correlated to CVP but also to circulating volume of blood. Since IVC is a highly compliant vessel having no valves therefore size variations are easily seen with changes in intra-vascular pressure. Consequently, even normal respiratory movements lead to change in intra thoracic pressure that in turn influence venous return from IVC and also affect the IVC diameter[14]. As a result, IVC collapses during inspiration as blood gets pumped out of IVC because of negative pressure created through chest expansion. In spontaneously breathing healthy subjects, cyclic changes in thoracic pressures might result in collapse of IVC diameter by around 50 %[15].Hence, measuring diameter of IVC could possibly also aid in ongoing resuscitation by providing a means for CVP measurement through non-invasive methods. Performance of bed-side ultrasonography for evaluating IVC by clinicians is a technique which potentially can provide instant and non-invasive measures of volume status which in turn can help in rapid initial assessment for guiding subsequent therapies. Multiple studies conducted outside the country but there is very little data in Pakistani population. Therefore, the objective of this study was to done to evaluate the correlation between IVC diameter and CVP measurement among critically ill patients admitted in intensive care unit in Pakistani population.

METHODOLOGY:

This cross-sectional pilot study using non-probability convenient sampling technique was carried out at the department of Radiology, PNS Shifa Hospital, Karachi for duration of 6 months from January 2018 to Jun 2018. After ethical approval from the Institutional Review Board (IRB) of the hospital, non-intubated adult patients of either gender, between the ages from 18 to 80 years, that were admitted in the intensive care unit of the hospital, and those who were able to breathe spontaneously and lie in supine position; already had CVP catheter (subclavian or internal jugular vein) in place were included in the study. Patients below 18 years of age or above 87 years, with severe orthopnea and unable to lie in supine position, morbid obese, with pneumothorax, mass in mediastinum, tricuspid regurgitation and intra-cerebral bleeds were excluded from the study. Fifty patients were included in the study after taking informed consent from the patient's attendants. Patients were requested to lie in supine position and ultrasound machine was used to obtain ultrasonic images of IVC diameter. A portable ultrasound machine with 17 mm curved probe and cardiac transducer for IVC imaging 3.5MHz, 21 mm phase array was used. Sub-xiphoid approach was used for IVC visualization. Maximum IVC diameter (antero-posterior diameter) was measured during end expiration 2cm confluence of hepatic veins in longitudinal plane. All readings were observed (reported by two intensive care clinicians with the help of trained nursing assistant. Similarly, CVP measurement was done using catheter in place and measured by two intensive care clinicians and an assistant nurse with the help of manometer at mid-axillary level and patients in supine position. Three readings were obtained and their mean reported.

Data analysis was done using SPSS version 20.0. Correlation between CVP and IVC diameter was determined on the basis of gender and with IVC diameter of <50 mm and >50 mm using Pearson correlation coefficient keeping a P-value =0.05 as significant level.

RESULTS:

Among the total of 50 patients enrolled in the study, the mean age of the patients was 41.44±16.73 years with minimum and maximum ages of 22 and 67 years respectively. Total 34(68%) patients were male and 16(32%) patients were females. Male to female ratio of the patients was approximately 2:1. Out of these 50 patients, the patients with diagnosis of sepsis, severe hypertension, uncontrolled diabetes, hysterectomy, IUD and hysterectomy, MVA, and pulmonary embolism were 3(6%) for each category. The patients of drowning were 9(18%), the patients with ectopic pregnancy, IHD were 4(8%) respectively and the patients with LSCS and RTA were 6(12%) respectively for each. The mean CVP of the patients reported in the study was 10.41±4.18 mm with minimum and maximum values of 3 and 16 mm respectively.The mean value of the diameter of IVC of the patients in the study was 12.65±2.22 mm with minimum and maximum values of 10 and 18 mm respectively. (Table: I)

The study results showed weak negative correlation between the CVP and IVC (r= - 0.110, p=0.04). It was also predicted that in patients with age =50 years there was weak negative correlation between the CVP and IVC (r=-0.290, p=0.034). Similarly, in patients with age >50 years there was moderate negative correlation between the CVP and IVC (r=-0.680, p=0.045). The study results also showed that in male patients there was weak negative correlation between the CVP and IVC i.e. (r=-0.045, p=0.048). However, in female patients there was moderate positive correlation (r=0.685, p=0.001). (Table: II)

DISCUSSION:

CVP monitoring has been observed to be a mainstay for estimation of intra-vascular fluid status and cardiac pre-load in critically-ill patients. It has been criticized that the use of CVP measurement for estimating fluid responsiveness arguing that CVP as an absolute value or in terms of changes in response to fluid, do not correlate with ventricular volume or volume responsiveness.[16-17]

Nonetheless, the guidelines for hemodynamic management of critical patients continue to promote inclusion of filling pressure among treatment regimens.Wiryanaet al., reported a statistically significant correlations between CVP and IVC diameter[18]. In another study by Wiwatworapan et al, a positive correlation was reported between IVC diameter and CVP (r = 0.75, p <0.001) [19] Similarly Ilyas et al reported in 100 patients a positive correlation between CVP and maximum IVC diameter (r = 0.371, p <0.005) and minimum IVC diameter (r = 0.57, p <0.005) [20] The findings of the above studies are contradictory to our observation. Nonetheless, one of the study reported a strong negative correlation of CVP measurement and IVC diameter (r = -0.721, p <0.001). However, the study was performed on only 30 patients and all the patients were diagnosed cases of shock [21]. Whereas in our study,the correlation is weak negative.

Table I: Demographic representation of patients admitted in intensive care unit

Variable		Mean ± SD/ n (%)
Age (Years)		41.44±16.73
Central Venous Pressure (mm)		10.41±4.18
Inferior Vena Cava Diameter (mm)		12.65±2.22
Gender	**Male**	34(68.0%)
	Female	16(32.0%)
Diagnosis	**Sepsis**	3(6.0%)
	Drowning	9(18.0%)
	Ectopic Pregnancy	4(8.0%)
	Severe Hypertension	3(6.0%)
	Uncontrolled Diabetes	3(6.0%)
	Hysterectomy	3(6.0%)
	IHD	4(8.0)
	IUD, Hysterectomy	3(6.0%)
	LSCS	6(12.0%)
	MVA Done	3(6.0%)
	Pulmonary Embolism	3(6.0%)
	RTA	6(12.0%)

Table II: Correlation of CVP and IVC diameter

Variable		CVP	
		r	p-value
IVC		- 0.110	0.04
IVC	**<50 years**	-0.290	0.034
	>50 Years	-0.680	0.045
IVC	**Male**	-0.045	0.048
	Female	0.685	0.01

Factors reported to affect the diameter of IVC include elevated pressures in pulmonary artery, pulmonic or tricuspid valve disease, dysfunction of right ventricle and any other condition having an increased intra-abdominal pressure, like morbid obesity or moderate to massive ascetic fluid. Other than these issues, interpretation of ventilated patients is also a problem, but since in our study only non-ventilated patients were included, this limitation was out of question [22] In a study by Garg et al, a negative correlation (r= -0.41) was reported while in a study by Airapetian et al, a strong positive correlation (r= 0.81) was recorded, thereby confirming the fact that paucity of data persists [23] In another study by Attainsee et al, moderate correlation was reported, however only hypovolemic patients were included in the study[24-25] Ciozda et al reported that in around 21 studies seeking to evaluate the correlation of CVP and IVC diameter, found a moderate to considerable correlation between them and concluded that IVC diameter measurement could be considered as a reliable method to calculate intravascular volume as a substitute for measuring CVP among adults[26]

Sridhar et al reported in a study that IVC diameter and CVP were significantly correlated (P <0.001) to each other and their correlation was used for evaluating intravascular volume in adults. Naghipour et al also reported similar results in their study. In another study done by Naghipour et al on American patients, no such significant correlations were observed between IVC diameter and CVP. However the study was done on pediatric ICU (PCIU) patients.

Thanakitcharu P et al in another study reported positive correlation between CVP and IVC diameter. Arthur et al in a study on 95 patients mechanically ventilated under general anesthesia, found a significant relationship in-between CVP and IVC diameter. Another study by Khalil et al on 115 adult patients reported a moderately significant correlation (r=0.53 p <0.001) in-between CVP and maximum as well as minimum IVC diameter. The findings of the above studies are contradictory to our results.

Our study had potential limiting points. Firstly ventilator support patients were not included in the study; moreover most patients had CVP in place for about 24 hours. The study might not be immune from selection and observer bias. Larger sample size and aiming to focus on evaluating patient's recovery from illness should also be measured and their values correlated.

However, the differences of gender ratio and small sample size in our study might have been a limiting factor due to which differences of correlation are reported in the studies.

CONCLUSION:

A negative correlation was found between inferior vena cava diameter on ultrasonography and central venous pressure measurement among critically ill patients admitted to the Intensive care unit. Further multi-centered large scale studies are needed to establish a precise correlation between central venous pressure and inferior vena cava diameter.

Author Contribution:
Shabih Zehra: Selection of topic, indtroduction and methodology
Atif Latif: Abstract writing and literature review
Asiya Kazi: Writing and discussion
Syed Ijaz Hussain Zaidi: Data analysis

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