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RESEARCH ARTICLE

Correlation between Central Vena Pressure Measurement with Collapsibility Index of Internal Jugular Veins in Critically ill Patients

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Abstract

Background: Central venous pressure (CVP) is popular for assessing fluid estimation, especially critically ill patients. Another method in assessing the CVP today is by using ultrasonic cardiac output monitors (USCOM) using transaortic or transpulmonary Doppler's ultrasound. The objective of this study was to determine the correlation between CVP and IJV collapsibility index to monitor the adequacy of the intravascular volume status in critically ill patients in ICU. Patients and Method: This analytic, cross-sectional study involved 70 patients of 19 to 64 years. The internal jugular vein (IJV) collapsibility index was examined with ultrasound cardiac output monitoring (USCOM) to assess the patient's intravascular volume status, then the data was compared to CVP. The Spearman rank correlation was used to test the hypothesis. Results: The subjects consisted of 38 males and 32 females, with an age range of 19-64 years. The Spearman's rank correlation test showed a statistically negative correlation between the CVP value and the internal jugular venous pressure index collapsibility value ($R=-0.844$, $p<0.001$). Conclusion: There is a strong negative correlation between IJV collapsibility index and CVP in patients treated in the ICU.

Keywords: *Hemodynamics, Volume status, CVP, USCOM, Collapsibility index.*

Introduction

Assessment of intravascular volume status continues to be one of the biggest challenges in the management of critical care. Limitations of invasive hemodynamic monitoring are increasingly apparent [1].Body volume status can be assessed by several methods, like central venous pressure (CVP), inferior vena cava (IVC) or left internal jugular vein (IJV) collapsibility, pulmonary artery occlusion pressure (PAOP), left ventricular end diastolic area, and transpulmonary thermo dilution index [2].

CVP is widely used and is popular for assessing fluid status, especially critically ill patients [3].Complications of CVP insertion may occur in vascular injury (4.2-9.3%), hematoma (4.7%), pulmonary complications (1%), nerve injury (1.6%), and thrombosis (up to 41%) [4, 6].Other disadvantages include technical difficulty (especially in resuscitation setting), uncooperative patients, heart valve abnormalities, and high pressure in the lung cavity or abdomen [7, 8].Although assessment using central venous pressure (CVP) has long been used for the management of fluid therapy, reports showed it fails to correlate with intravascular volume status [8].After a few years later based on clinical research, it is known that the insertion of pulmonary artery catheterization (PAC) provides a better correlation [9, 10].Both CVP and PAC insertion carry its own risk of complications.

So that several noninvasive methods have begun to be developed. Some of them include measurements of inferior vena cava (IVC) and internal jugular veins (IJV) collapsibility index as a reference in the management of fluid therapy [11].Body volume assessment can also be done non-invasively by determining the index of large venous collapsibility by using ultrasonography

(USG). This tool is non-invasive, portable, and accurate in assessing structures in the body, especially blood vessels. Correlation between IJV collapsibility index and CVP has been established in some studies [12, 13].Another method in assessing the CVP today is by using ultrasonic cardiac output monitors (USCOM) using transaortic or transpulmonary Doppler's ultrasound flow paths to measure cardiac output as a result of stroke volume and heart rate.

USCOM is certainly very expensive in the procurement of equipment even though they are non-invasive; another modality that can be reached is by using ultrasonography. The objective of this study was to determine the correlation between CVP and IJV collapsibility index to monitor the adequacy of the intravascular volume status in critically ill patients in ICU.

Patients and Methods

This is an analytic, cross-sectional study conducted at the ICU of Sanglah General Hospital (Bali, Indonesia) in 2019. Inclusion criteria include 18-65 years of age in ICU who already have central venous catheter (CVC) inserted properly with an MAP of 70-100 mmHg. Exclusion criteria include mechanically ventilated patients, severe sepsis, congestive heart disorders, heart rhythm abnormalities, mitral or tricuspid valve regurgitation abnormalities, history of jugular venous thrombosis, patients with pacemakers, and patients with increased pressure on the abdominal cavity. Subjects were selected by consecutive sampling. The study protocol was approved by the institutional ethical review board of Sanglah General Hospital.

All subjects who participated in this study have provided an informed consent to be included in this study. We performed CVP measurement to the subjects, followed by USCOM evaluation on the IJV collapsibility index. Data analysis was carried out by SPSS and STAT software. We used Shapiro-Wilk test for normality test. Pearson's correlation would be used for normally distributed data, and Spearman's rank correlation for abnormally distributed data. Linear regression analysis was used to predict the value CVP based on the IJV collapsibility index. A p value of <0.05 was considered statistically significant.

Results

A total of 70 subjects were included in the data analysis. The subjects consisted of 38 males and 32 females, with an age range of 19-64 years. A description of the characteristics of the subjects is shown in Table 1.

Table 1: Characteristics of the study subjects

Variables	N = 70
Age(years), median (IQR)	52(24)
Sex	
Male, n (%)	38 (54,3%)
Female, n (%)	32 (45,7%)
Body mass index (kg/m^2), mean±SD	23.95±3.86
USCOM parameters, median(IQR)	
Flow time corrected/FTc (ms)	353 (72.75)
Systemic vascular resistance/SVR (Dynes s/cm^5)	1325 (219)

IQR: interquartile range; **SD**: standard deviation; **USCOM**: ultrasonic cardiac outpur monitor

The internal jugular venous collapsibility index value tends to increase in accordance with a decrease in CVP and vice versa. The results of the correlation test with the Spearman's rank correlation test (Table 2) showed a statistically negative correlation between the CVP value and the internal jugular venous pressure index collapsibility value (R=-0.844, p <0.001).

Table 2: Correlation between CVP and IJV collapsibility index

Variables	Median (IQR)	R	p
CVP (cmH_2O)	8.5 (4)	-0.844	<0.001
Collapsibility index (%)	11.8 (34.1)		

CVP: central venous pressure; IJV: internal jugular vein; IQR: interquartile range;
R: Spearman's rank correlation

The linear regression test showed we can predict the CVP based on the IJV collapsibility index (CI) using the formula: CVP = 10.5 -0.102(IJV-CI). The R^2 shows

that the CVP is 78.4% influenced by the IJV-CI, and 21.6% is influenced by other factors.

Table 3: Liniar regression test of the correlation betweem IJV collapsibility indeks to CVP

Variables	Linear regression test			R^2
	ß	95% CI	p	
Collapsibility index	-0,102	- 0.117-(-0.87)	<0.001	78.4%
Constant (α)	10.5			

Discussion

Delayed assessment of hypovolemia may cause serious implications. Pulse, blood pressure, urine output, and symptoms of the central nervous system (CNS) help classify bleeding, but vital signs are bad markers of acute blood loss. Therefore, this marker is an indicator of shock with poor response to treatment [3, 14].In critically ill patients, the assessment of intravascular volume status plays an important role in determining the diagnosis and direction of therapy.

The parameters and tools used vary widely, including CVP and IJV collapsibility index. The variation in results from each examination shows that there is no single method that can be used to assess the volume status of severely ill patients, because each examination has its limitations. Ultrasound is a non-invasive, portable, easily accessible, and increasingly used in the ER and ICU for a variety of emergency conditions. The ability to non-invasively measure CVP will be very beneficial.

A bed-side ultrasound examination has been used widely to assess the status of intravascular volume by examining IJV height and IVC diameter. Siva *et al* [15].Reported that in the hypovolumia patients, ultrasound has a sensitivity of 88.9% and specificity of 77.1% in determining hypervolemic states. Decreased internal jugular venous collapsibility index can be an alternative method for early identification of hypovolemia. Akilli *et al* [16].

Reported positive correlation between diameter and area of IJV before and after blood donation. Donahue *et al* [17].Performed bedside ultrasound IJV evaluation to predict CVP. The IJV collapsibility index is measured during breath cycles and various positions. The mean IJV diameter in patients with a CVP <10 cmH_2O is 7.0 mm (95%CI=5.7-8.3) vs. 12.5 mm (95%CI=11.2-13.8) in patients with a CVP of ≥10 cmH_2O. At the end of expiration, in supine position, the highest coefficient correlation was 0.82. This pilot study shows that IJV ultrasonography can be used as a noninvasive CVP measurement tool. Xing *et al* [18].Examined the correlation between non-invasive CVP (CVPn), which was obtained by ultrasound and echocardiography, and invasive CVP (CVPi). They reported a significant correlation CVPi and CVPn (R=0.90, p <0.01).

Another prospective, cross-sectional study in 25 emergency patients, reported a significant correlation between the height of IJV and CVP (R=0.64, p <0.001) [19]. From the liniar regression test, this study produced a formula where we can predict the CVP out of observed IJV collapsibility index: CVP = 10.5 - 0.102(IJVCI). This formula may be useful in patients in emergency setting where CVC is not readily inserted.

We must notice, however, that while 78.4% CVP can be predicted by the IJV collapsibility index, there are 22.2% other factors to be considered, as seen by the R^2. This study had several limitations. We did not use echocardiography so the data obtained may be inaccurate, due to CVP is also associated with valve or other cardiac abnormalities. This study was also not blinded, so an observer's bias may take place during this study. Future blinded studies with a larger number of subejcts are needed in order to understand the relation between CVC and IJV more.

Conclusion

There is a strong negative correlation between IJV collapsibility index and CVP in patients treated in the ICU.

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