Inferior Vena Cava Diameter and Collapsibility Index: A Practical Non-Invasive Evaluation of Intravascular Fluid Volume in Critically-Ill Patients

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Background: *Assessment of intravascular volume status is an essential parameter for the diagnosis and management of critically-ill patients. Generally, central venous pressure (CVP), which is an invasive measure, has been recommended for this purpose. Since CVP has been associated with many complications, inferior vena cava diameter and collapsibility index (IVC-CI) were used in the present study to evaluate the intravascular volume status of critically-ill patients at Rajavithi Hospital.*
Objective: *To conduct a prospective, cross-sectional study to evaluate the IVC diameter as a guidance for estimating the volume status in critically-ill patients by bedside ultrasonography, focusing on correlations between CVP and IVC-CI and IVC diameter.*
Material and Method: *Critically-ill patients who had been placed with a functioning central venous catheter were prospectively enrolled. Evaluation of intravascular volume status was performed by bedside ultrasonography to measure the IVC diameters (IVCD), both end-inspiratory (iIVCD) and end-expiratory (eIVCD). The IVC collapsibility indices (IVC-CI) were calculated by an equation and then were compared with the CVP values.*
Results: *Of the 70 enrolled patients, with a mean age of 63.8 $\pm$ 1.9 years, 64.3% were intubated. The most common indication of ICU admission was sepsis with hemodynamic instability (80.0%). The volume status of patients was stratified by their CVP levels as hypovolemic 15.7%, euvolemic 32.9% and hypervolemic 51.4% which correspond with the IVC-CI of 45.69 $\pm$ 16.16%, 31.23 $\pm$ 16.77%, and 17.82 $\pm$ 12.36% respectively ($p < 0.001$). The highest significant correlation was found between the CVP and IVC-CI ($r = -0.612$, $p < 0.001$). In addition, there was a significant correlation between CVP and iIVCD ($r = 0.535$, $p < 0.001$); and between the CVP and mean IVCD ($r = 0.397$, $p = 0.001$).*
Conclusion: *The present study supported the correlation between CVP and IVC-CI. The authors conclude that the IVC-CI can provide a useful guide for noninvasive intravascular volume status assessment of critically-ill patients.*

Keywords: *Central venous pressure, Inferior vena cava diameter, Collapsibility index, Intravascular fluid volume, Ultrasonography*

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Accurate assessment of intravascular volume status in critically-ill patients is crucial for their diagnosis and management. Although clinical assessments are still obtained from changes of skin turgor, mucous membrane and jugular venous pulse, there are some limitations in using these clinical parameters, especially in obese or aging patients, that may lead to misinterpretation. Traditionally, it has been believed that central venous pressure (CVP) is a key physiologic estimate of preload, which in turn helps to define the intravascular fluid volume status and guide fluid management. It is a particularly important parameter to measure in critically-ill patients who may require fluid resuscitation. A European survey of intensivists/anesthesiologists reported that more than 90% used CVP to guide fluid management[1]. Moreover, a Canadian survey reported that 90% of intensivists used CVP to monitor fluid resuscitation in patients with

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septic shock[2]. However, CVP measurement requires invasive central venous catheter placement which is time-consuming and may be associated with a number of complications by the percutanous insertion method e.g. arterial puncture, hemothorax, pneumothorax, venous air embolism[3], or even damage to a major vein of the arm if the catheters are placed through a venesection of the basilic vein.

The size and shape of the inferior vena cava (IVC) is correlated to the CVP and circulating blood volume, and the IVC is a highly compliant vessel with no valve whose size varies easily with changes of intravascular pressure. As a result, normal respiratory cycle causes changes in intrathoracic pressure which in turn influence venous return from the IVC and also affect the variation of IVC diameter. Consequently, the IVC collapses with inspiration as the blood is pumped out of the IVC due to the negative pressure created by chest expansion. In healthy subjects breathing spontaneously, cyclic changes in thoracic pressure may result in collapse of the IVC diameter of approximately 50%[4]. Therefore, IVC diameter measurements can also assist in ongoing resuscitation by providing a means to measure CVP non-invasively. Clinician-performed bedside ultrasonographic evaluation of the IVC is a tool that could potentially provide an instant and non-invasive measure of volume status[5] which in turn could be rapidly deployed for initial assessment to guide subsequent therapy[6,7].

The present study examined the effect of the respiratory cycle on the IVC diameter (IVCD); the correlation between CVP and the IVC diameter (IVCD); and also the IVC collapsibility index (IVC-CI), as measured by the bedside ultrasonographic technique, in critically-ill patients[8].

Material and Method

Patients

The present study was performed in the medical intensive care unit of Rajavithi Hospital, a supertertiary hospital of the Ministry of Public Health of Thailand. Critically-ill patients were prospectively enrolled between November 2009 and March 2011. To be included, the study patients were required to meet the following criteria: (1) critically-ill patients in the medical intensive care unit with age of $\geq$ 18 years old; (2) patients had a functioning central venous catheter that had already been placed for clinical indications for less than 24 hours. Patients were excluded when any of the following criteria were met: (1) patients had a central venous catheter inserted for more than 24 hours; (2) patients with signs of overt right heart failure or with moderate-to-severe tricuspid regurgitation; (3) patients with clinical signs of elevated intraabdominal pressure; (4) patients for whom the required ultrasound examination would not be appropriate e.g. when the supine position was medically contraindicated or not tolerated, including spontaneously-breathing patients with severe orthopnea or severely-elevated intracranial pressure.

Written informed consent was obtained from all patients' respective authorized representatives and the study protocol was reviewed and approved by the Ethical Committee of Rajavithi Hospital.

Methods

The present study was a prospective, cross-sectional study that utilized a one-time assessment of the IVC diameter to determine any correlation with CVP. All critically-ill patients in the medical intensive care unit who had already been fitted with a central venous catheter for CVP monitoring, according to their clinical indications, were assessed for eligibility. Their demographic and basic clinical data, including primary illness, ventilatory mode, amount of positive end-expiratory pressure administered, and hydration status were recorded. Immediately after the time of IVC diameter assessment, CVP measurements were also recorded concomitantly. All ultrasonographic examinations were performed in a blinded fashion with the patients in supine position by the same physician throughout the present study, using a portable ultrasonography unit (Aloka SSD-1200CV Ultrasound machine, 3.5M convex probe, Japan). Before the IVC diameter evaluation, the examiner was not informed of the hemodynamic and CVP data. The anteroposterior diameter of inferior vena cava (IVCD) was measured duplicately, using images frozen according to operator judgement, at end of inspiration (iIVCD) and end of expiration (eIVCD) in a subxiphoid location in the longitudinal axis 2 cm distal to the IVC-hepatic vein junction where the anterior and posterior wall of the IVC are easily visualized and lie parallel to each other[9] as shown in Fig. 1. Measurements in non-intubated patients were obtained during their normal spontaneous inspiration and expiration while trying to avoid Valsalva maneuvers. Ventilated patients were evaluated during normal ventilatory cycling. The mean IVCD was expressed as (iIVCD + eIVCD)/2[10]. The IVC collapsibility index (IVC-CI), which is a widely-used parameter in IVC assessment of intravascular volume, was determined as the percentage of the difference between eIVCD and iIVCD divided

by the eIVCD as expressed by the following equation: IVC-CI = [(eIVCD-iIVCD)/eIVCD] x 100[8,11]. The CVP was also measured in the supine position immediately after the IVC evaluation by using the manometer technique at the phlebostatic point[12] and was used as the reference parameter for stratifying each patient's intravascular volume status. The normal range of CVP measurement is 8-12 cmH_2O[13] and this was used for determining the euvolemic status.

Statistical analysis

Sample size estimation based on correlation analysis[14] was used for determining the sample size in the present study, and the correlation as reported by Stawicki et al[8] was used as a reference value.

Continuous variables are expressed as mean values ± standard deviation. One-way ANOVA was utilized for comparison among the 3 groups of patients with different intravascular volume status and the Tukey method was used for multiple comparison. Pearson correlation coefficients(r) and their significance were calculated between two related variables. To assess the relationship between two variables and to predict one variable from another, regression models were used. Subgroup analysis was also performed for patients receiving mechanical ventilation and those with spontaneous breathing. P-values of less than or equal to 0.05 were considered to be statistically significant. Data were collected on Microsoft Excel 2007 spreadsheet software and imported into SPSS for Windows version 17 for statistical analysis.

Results

Patient characteristics

During a 16-month prospective cross-sectional study, 70 critically-ill patients in the medical intensive care unit, with a mean age of 63.8 ± 1.9 years (range 17 to 96 years) and 50% being male, met the enrollment criteria and agreed to participate in the present study. All of these patients had already been fitted with a central venous catheter for CVP monitoring according to their clinical indications. Their demographic characteristics are presented in Table 1. Most patients (80%) were admitted to the ICU because of sepsis with hemodynamic instability. The remaining primary diagnoses were cardiovascular (myocardial infarction, arrhythmia, dilated cardiomyopathy) 8.6%, gastrointestinal (ischemic bowel disease, gastrointestinal bleeding, acute abdomen) 5.7%, endocrinologic (hyperglycemia, insulinoma) 2.9%, stroke 1.4% and acute asthmatic attack 1.4%. Among the sepsis patients, pneumonia was the major leading cause (50%), and the remaining patients' sepsis was caused by unknown source (21.4%), urinary tract infection (7.1%), severe fungal infection (5.4%), cellulitis (5.4%) and other causes (10.7%). Forty-five (64.3%) patients were intubated for ventilatory support in various modes (Table 1). All of the intubated patients were ventilated with positive-end expiratory pressure (PEEP) in the amount of 4.04 ± 1.51 cmH_2O (range 3-9 cmH_2O).

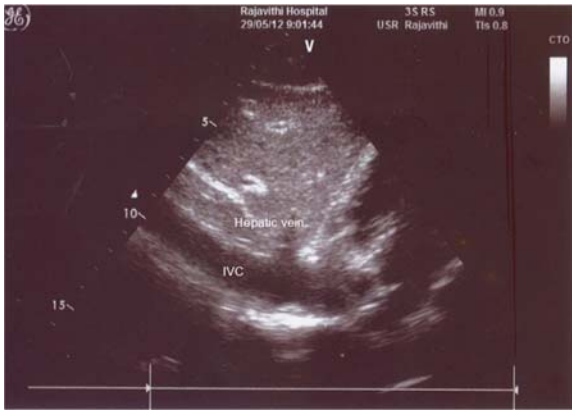

Fig. 1 Ultrasound image depicting the measure of the inferior vena cava (IVC) diameter in the longitudinal orientation

Table 1. Demographic data of the critically-ill patients

Parameters	Value
Total number of patients enrolled (n)	70
Male gender, n (%)	35 (50.00)
Age (y), mean ± SD	63.8 ± 1.9
Major disease, n (%)	
Sepsis	56 (80.0)
Cardiovascular (Myocardial infarction, Arrhythmia, DCM)	6 (8.6)
Gastrointestinal (Ischemic bowel disease, GI bleeding, acute abdomen)	4 (5.7)
Endocrine (Hyperglycemia, Insulinoma)	2 (2.9)
Stroke	1 (1.4)
Acute asthmatic attack	1 (1.4)
Intubated patients, n (%)	45 (64.30)
PEEP (cmH_2O) (n = 45), mean ± SD	4.04 ± 1.5
median (range)	13.00 (3-9)
Mechanical ventilator modes, n (%)	45 (64.30)
Control modes (volume or pressure control)	40 (88.90)*
Partial control modes (SIMV)	3 (6.70)*
Spontaneous modes (CPAP)	2 (4.40)*

* percentage of all patients with ventilatory support

Measurement of IVC diameters

Regarding the obtained CVP measurements, patients were stratified into 3 groups: 11 patients (15.7%) were hypovolemic (CVP < 8 cmH_2O); 23 patients (32.9%) were euvolemic (CVP 8-12 cmH_2O); and 36 patients (51.4 %) were hypervolemic (CVP > 12 cmH_2O). Among the 3 groups, with respect to their intravascular volume status (Table 2), the systolic and diastolic blood pressure, mean blood pressure, pulse blood pressure, hemoglobin and hematocrit levels, blood urea nitrogen and serum creatinine, serum electrolytes, and serum albumin levels, were not significantly different. In Table 3, the CVP in the 3 groups (hypovolemic, euvolemic, hypervolemic) were 5.32 ± 1.49, 10.67 ± 1.29, 16.86 ±

Table 2. Comparison of basic laboratory data of patients in the 3 groups of intravascular volume status

Parameters	Hypovolemia* n = 11 (15.71%)	Euvolemia** n = 23 (32.86%)	Hypervolemia*** n = 36 (51.43%)	p-value
Hemoglobin (g %)	10.60 ± 3.17	9.51 ± 1.89	9.91 ± 2.27	0.445
Hematocrit (%)	32.32 ± 9.08	28.87 ± 6.01	30.04 ± 6.56	0.393
WBC count (x 10^3 /cu.mm.)	24.0 ± 36.6	18.0 ± 20.8	17.90 ± 19.4	0.485
BUN (mg/dl)	50.64 ± 35.03	37.04 ± 26.23	57.83 ± 38.67	0.086
Cr (mg/dl)	2.70 ± 2.33	1.74 ± 2.10	3.11 ± 3.10	0.171
Sodium (mEq/L)	125.70 ± 42.1	137.30 ± 5.1	135.10 ± 24.0	0.413
Potassium (mEq/L)	4.13 ± 0.86	3.83 ± 1.34	3.93 ± 1.03	0.764
Bicarbonate (mEq/L)	18.82 ± 5.29	20.57 ± 8.55	19.75 ± 7.18	0.806
Albumin (g/dl)	2.60 ± 0.8	2.50 ± 0.6	2.70 ± 0.7	0.658
Globulin (g/dl)	3.60 ± 1.2	2.80 ± 0.8	3.0 ± 0.9	0.075
AST (U/L)	207.60 ± 368.9	119.80 ± 259.6	515.60 ± 1,708.5	0.505
ALT (U/L)	156.80 ± 393.2	73.50 ± 161.3	237.70 ± 650.7	0.520

*Hypovolemia: CVP < 8 cmH_2O, **Euvolemia: CVP 8-12 cmH_2O, ***Hypervolemia: CVP > 12 cmH_2O

Table 3. Comparison of blood pressure, CVP and IVCD, IVC-CI of patients in the 3 groups of intravascular volume status

Parameters	Hypovolemia* n = 11 (15.71%)	Euvolemia** n = 23 (32.86%)	Hypervolemia*** n = 36 (51.43%)	p-value
Systolic BP (mmHg)	118.7 ± 20.0 (105.3-132.2)	113.3 ± 21.5 (104.0-122.6)	109.7 ± 18.7 (103.4-116.0)	0.403
Diastolic BP (mmHg)	72.9 ± 14.6 (63.1-82.7)	65.7 ± 16.5 (58.6-72.9)	68.6 ± 15.74 (63.3-73.9)	0.465
Mean BP (mmHg)	88.2 ± 16.1 (77.4-99.0)	81.6 ± 17.3 (74.1-89.1)	82.3 ± 16.2 (76.8-87.8)	0.522
Pulse BP (mmHg)	45.8 ± 8.4 (40.2-51.5)	47.5 ± 12.6 (42.1-53.0)	41.1 ± 8.9 (38.1-44.1)	0.056
CVP (cmH_2O)	5.32 ± 1.49[a] (4.3-6.3)	10.67 ± 1.29[b] (10.1-11.2)	16.89 ± 2.99[c] (15.9-17.9)	< 0.001
iIVC (cm)	0.83 ± 0.32[a] (0.62-1.05)	1.18 ± 0.53[ab] (0.95-1.41)	1.42 ± 0.40[b] (1.28-1.56)	0.001
eIVC (cm)	1.52 ± 0.42 (1.24-1.80)	1.66 ± 0.51 (1.44-1.88)	1.71 ± 0.43 (1.57-1.86)	0.491
meanIVC (cm)	1.219 ± 0.37[a] (0.96-1.45)	1.44 ± 0.51[ab] (1.22-1.66)	1.59 ± 0.41[b] (1.45-1.73)	0.045
IVC-CI (%)	45.69 ± 16.15[a] (34.84-56.53)	31.23 ± 16.77[b] (23.98-38.48)	17.82 ± 12.36[c] (13.63-22.00)	< 0.001

*Hypovolemia: CVP < 8 cmH_2O, **Euvolemia: CVP 8-12 cmH_2O, ***Hypervolemia: CVP > 12 cmH_2O

[a,b,c] different character mean significant different between groups in the multiple comparison

Values in the parentheses depicted the 95% confidence interval for mean

2.99 cmH_2O respectively, and these values were significanty different ($p < 0.001$). The IVC diameter at end-inspiration (iIVCD) values were highest in hypervolemic patients (1.42 $\pm$ 0.40 cm), followed by the euvolemic patients (1.18 $\pm$ 0.53 cm) and lowest in the hypovolemic patients (0.83 $\pm$ 0.32 cm), and these values were significantly different ($p = 0.001$). The mean IVC diameter (mIVCD) values were also highest in the hypervolemic patients (1.59 $\pm$ 0.41 cm), followed by the euvolemic patients (1.44 $\pm$ 0.51 cm), and lowest in the hypovolemic patients (1.22 $\pm$ 0.37 cm); these results were statistically significant in a lesser degree ($p = 0.045$). Although the IVC diameter values at end-expiration (eIVCD) were also highest in the hypervolemic patients (1.71 $\pm$ 0.43 cm), they were not significantly different among the 3 groups ($p = 0.491$). On the other hand, the IVC-CI values were highest in the hypovolemic patients (45.69 $\pm$ 16.15 %), followed by the euvolemic patients (31.23 $\pm$ 16.77 %), and lowest in the hypervolemic patients (17.82 $\pm$ 12.36 %), and these values were significantly different ($p < 0.001$).

Correlation of CVP and IVC diameters

The correlation values obtained between the CVP values and the IVC diameters were all statistically significant in the following order; IVC-CI ($r = -0.612$. $p < 0.001$), iIVCD ($r = 0.535$, $p < 0.001$), mean IVCD ($r = 0.397$, $p = 0.001$) and eIVCD ($r = 0.241$, $p = 0.044$). A linear regression model for the correlation between CVP and IVC-CI is shown in Fig. 2.

Subgroup analysis between patients receiving mechanical ventilation with PEEP support and those with spontaneous breathing also demonstrated statistically significant correlation inversely between CVP and IVC-CI in patients with spontaneous breathing ($r = -0.682$, $p < 0.001$) and those with PEEP support ($r = -0.561$, $p < 0.001$).

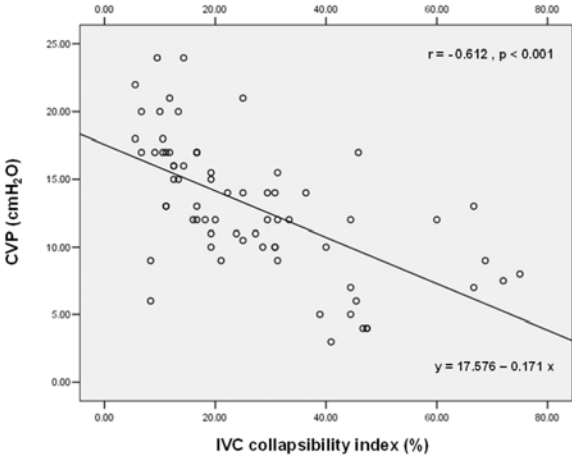

Fig. 2 Correlation of CVP (cmH_2O) and IVC-CI (%) in 70 critically-ill patients ($r = -0.612$, $p < 0.001$)

Discussion

Determination of body fluid volume status in critically-ill patients is important both for diagnosis and management. CVP monitoring is a mainstay of estimating intravascular fluid status and cardiac preload in critically-ill and injured patients[15]. There has been recent criticism of using CVP to estimate fluid responsiveness, arguing that CVP, whether as an absolute value or in terms of changes in response to fluid, does not correlate with ventricular volume or volume-responsiveness[16,17]. Nevertheless, guidelines for the hemodynamic management of critically-ill patients continue to promote the inclusion of filling pressures in treatment algorithms[18,19]. For example, a randomized trial comparing different fluid management strategies in patients with acute lung injury also included filling pressure in the algorithms[20], and the algorithm of the early goal-directed therapy for the treatment of sepsis included CVP[21]. Indeed, filling pressure measurements are not completely useless. The chance that a patient's fluid status is on the ascending limb of the Frank-Starling curve is much higher with low filling pressures than with high filling pressures. Therefore, CVP measurement is still a useful tool for guiding hemodynamic therapy and remains the standard of care in shock management[17,22]. However, CVP monitoring requires placement of a central venous catheter, which is often difficult in an urgent situation.

Bedside ultrasonography is nowadays a popularly-used technique that is available in most intensive care units. In addition, it is a safe, non-invasive, and portable tool. Accurate measurement of internal structures, and also large blood vessels including the IVC, are readily achieved with ultrasound[23]. It is known that the IVC diameter exhibits a variation with the respiratory cycle. Several authors measure both the inspiratory and expiratory diameters of the IVC and use them to calculate a so-called caval or collapsibility index[24]. Nagdev et al reported a 50% collapse of the IVC diameter during a respiratory cycle as being strongly associated with a low CVP[25]. Conversely, an IVC distensibility index [(maximal diameter at inflation-minimal diameter at expiration)/ maximal diameter] above 18% can predict fluid responsiveness[26]. Initially, IVC diameter evaluation has been used by nephrologists in hemodialysis patients for

determining their intravascular volume status and obtaining a more accurate dry weight adjustment. Subsequently, this technique has been performed by anesthesiologists, intensivists and cardiologists for determining body fluid volume status in critically-ill patients.

In the present study, which was a prospective cross-sectional study of 70 patients in the medical intensive care unit, most patients (80%) were admitted to the ICU because of sepsis with hemodynamic instability. The largest proportion of patients (51.4%) were in hypervolemic state and only a small number of patients (15.7%) were in hypovolemic state. Among different respiratory phases of IVC diameter and the IVC collapsibility index, the authors found that there was a significant correlation between CVP and IVC-CI, iIVCD, and mean IVCD, but not eIVCD. Only the IVC-CI and iIVCD were, respectively, best inversely correlated or correlated with the CVP. This understanding of the change in IVC diameter and collapsibility index will provide a good clinical adjustment in fluid therapy in critically-ill patients. As a consequence, fluid challenge should be avoided in patients with an increase in IVC diameter.

Factors that may affect the IVC diameters include patients with elevated pulmonary artery pressures, tricuspid or pulmonic valve disease, overt right ventricular dysfunction and any condition with increased intraabdominal pressures, e.g. patients with morbid obesity or with moderate to massive amount of ascites[8]. Beside these, another problematic issue, which may have impact on the CVP and IVC-CI, is the interpretation in ventilated patients. During ventilation with PEEP support, it is believed to affect the CVP by increasing the intrathoracic pressure, decreasing venous return and increasing venous stasis, which in turn decrease cardiac output. Therefore, an increase in PEEP level would cause an increase in the iIVCD and eIVCD but decrease the IVC-CI[27]. In fact, PEEP is not transmitted directly to the venous system. In a lung with normal compliance, no more than 25% of the PEEP is transmitted to the central veins. But higher PEEP levels might affect the change in IVC diameter to some extent. Interestingly, Manaligod et al found that there was no significant increase in CVP when using physiologic PEEP (3-5 cmH_2O)[28]. In the present study, although all the intubated patients received ventilatory support with PEEP, the mean PEEP level was only 4.07 $\pm$ 1.52 cmH_2O which was still in the range of physiologic PEEP. For this reason, in the present study, the PEEP support may not affect the change in IVC diameter that much and a good correlation between CVP and IVCD was still able to be obtained. Nevertheless, the inverse correlation between the CVP and IVC-CI in non-ventilated patients ($r = -0.682$, $p < 0.001$) was slightly better than those with PEEP support ($r = -0.561$, $p < 0.001$). The authors propose that during the IVC diameter evaluation, one should temporarily decrease the PEEP level down to the physiologic PEEP level in order to get more reliable information. Interestingly, the present study was able to demonstrate a better correlation between the CVP and IVC-CI when comparing it with the other study ($r = -0.315$, $p = 0.023$)[8].

There are a number of important limitations in the present study: the internal validity was limited by the selection bias from the inclusion and exclusion criteria; the number of enrolled subjects was slightly below the total enrollment goal of 76; the CVP measurement techniques varied among nurses; and the external validity was further limited by single site only in the medical ICU. In the future, investigations at other intensive care units with a greater number of patients and also a strict technique for the CVP and IVC diameter measurements are necessary to confirm the present study findings.

Conclusion

Accurate assessment of body fluid status in critically-ill patients is essential for their diagnosis and management. Despite some criticisms on its interpretation, CVP is commonly used, and guidelines for the hemodynamic management of critically-ill patients continue to promote the inclusion of CVP in treatment algorithms. Nevertheless, measurement of CVP requires the insertion of invasive central venous catheters which is time-consuming and may be associated with a number of complications. In the present study, the authors proposed a non-invasive means of determining CVP by a simple bedside, subxiphoid-view, ultrasonographic measurement of IVC diameter and the collapsibility index which give a good correlation with CVP. The authors advocate wider use of IVC sonography in addition to invasive monitoring in intensive care units. Hopefully, IVC sonography might provide a valuable tool and more practical alternative approach for guidance of fluid and vasopressor therapy, not only for critically-ill patients in the intensive care unit but may also be useful in the emergency department.

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Potential conflicts of interest

None.

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การประเมินสภาวะน้ำในร่างกายผู้ป่วยวิกฤตในเวชปฏิบัติด้วยการตรวจวัด inferior vena cava diameter และ collapsibility index

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ภูมิหลัง: การประเมินสภาวะน้ำในร่างกายผู้ป่วยวิกฤตทางอายุรกรรมอย่างถูกต้องมีความจำเป็นทั้งต่อการวินิจฉัยและการรักษา ในเวชปฏิบัติทั่วไปมักอาศัยการวัดความดันในหลอดเลือดดำใหญ่ส่วนกลาง (central venous pressure, CVP) เป็นแนวทางในการประเมินสภาวะของน้ำในร่างกาย แต่เนื่องจากเป็นวิธีที่ invasive และอาจเกิดภาวะแทรกซ้อนได้ การศึกษานี้จึงต้องการวัดเส้นผ่าศูนย์กลางของหลอดเลือดดำ inferior vena cava (IVC) และ collapsibility index ของหลอดเลือดดำ IVC (IVC-CI) เพื่อนำมาใช้ในการประเมินสภาวะของน้ำในร่างกายผู้ป่วยวิกฤตทางอายุรกรรมในโรงพยาบาลราชวิถี

วัตถุประสงค์: เพื่อศึกษาแบบไปข้างหน้าถึงการวัดเส้นผ่าศูนย์กลางของหลอดเลือดดำ IVC ด้วยเครื่องอัลตราซาวนด์เพื่อนำมาเป็นแนวทางในการประเมินสภาวะน้ำในร่างกายผู้ป่วยวิกฤต และหาความสัมพันธ์ระหว่าง CVP, IVC-CI และเส้นผ่าศูนย์กลางของ IVC

วัสดุและวิธีการ: เป็นการศึกษาแบบไปข้างหน้าในผู้ป่วยวิกฤตทางอายุรกรรมในโรงพยาบาลราชวิถี โดยใช้เครื่องอัลตราซาวนด์วัดเส้นผ่านศูนย์กลางของหลอดเลือดดำใหญ่ inferior vena cava (IVC diameter, IVCD) ขณะหายใจเข้าสุด (IVC diameter at end-inspiration, iIVCD) และหายใจออกสุด (IVC diameter at end- expiration, eIVCD) แล้วนำมาคำนวณหา IVC-CI ตามสูตร และนำค่าต่างๆ ที่ได้มาเปรียบเทียบกับ CVP ที่วัดในเวลาใกล้เคียงกัน

ผลการศึกษา: ผู้ป่วยวิกฤตในการศึกษานี้มีทั้งหมด 70 คน อายุเฉลี่ย 63.8 $\pm$ 1.9 ปี เป็นผู้ป่วยที่ต้องใส่ท่อช่วยหายใจ 45 คน (64.3 %) โดยผู้ป่วยส่วนใหญ่ (80 %) มีสาเหตุมาจากการติดเชื้อรุนแรงที่มีระบบไหลเวียนไม่คงที่ จากการประเมินด้วย CVP พบว่าผู้ป่วยมีสภาวะของน้ำในร่างกายแบ่งออกเป็น 3 กลุ่ม คือ hypovolemic 15.7 %, euvolemic 32.9 %, และ hypervolemic 51.4 % ซึ่งมีค่า IVC-CI เท่ากับ 45.69 $\pm$ 16.16 %, 31.23 $\pm$ 16.77 %, และ 17.82 $\pm$ 12.36 % ตามลำดับ ($p < 0.001$) พบว่ามีความสัมพันธ์อย่างผกผันสูงสุดและอย่างมีนัยสำคัญทางสถิติระหว่างการวัด CVP กับ IVC-CI ($r = -0.612$, $p < 0.001$) นอกจากนี้ยังพบว่ามีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติระหว่างการวัด CVP กับ iIVCD ($r = 0.535$, $p < 0.001$) และระหว่างการวัด CVP กับ meanIVCD ($r = 0.397$, $p = 0.001$) อีกด้วย

สรุป: การศึกษานี้สนับสนุนความสัมพันธ์ระหว่างการวัด CVP กับ IVC-CI เพื่อประเมินสภาวะน้ำในร่างกายผู้ป่วยวิกฤต ผู้วิจัยมีความเห็นว่าสมควรนำ IVC-CI ที่ได้จากการวัดด้วยเครื่องอัลตราซาวนด์ มาใช้เป็นเครื่องมือในการประเมินสภาวะน้ำในร่างกายของผู้ป่วยวิกฤตได้