Central venous pressure correlates with inferior vena cava collapsibility index in patients treated in intensive care unit

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ABSTRACT

Background: Intravascular volume status is an important parameter in monitoring the patients treated at intensive care unit (ICU), so accuracy and strict monitoring of fluid volume is one factor that influence patient’s health status. Amongst others, two ways to monitor body fluid volume status is central venous pressure (CVP) and collapsibility index of inferior vena cava (IVC) diameter. The purpose of this study is to determine the correlation between CVP with the IVC collapsibility index in patients treated in ICU Sanglah Hospital in Denpasar.

Method: Seventy patients treated at Sanglah Hospital ICU with already inserted CVC for appropriate indication, were measured for CVP, then followed by examination the diameter of IVC with ultrasound to measure the maximum and minimum collapsibility index. Spearman’s correlation coefficients was used to assess the correlation between CVP and collapsibility index of the IVC.

Results: In 70 patients, we found a very strong negative correlation between CVP and IVC’s collapsibility index (Spearman’s rho = -0.854; p <0.001).

Conclusion: This study found that there is a very strong negative correlation between CVP and collapsibility index of IVC. This finding indicates that the collapsibility index of the IVC may substitute CVP in determining the status of the intravascular volume.

Keywords: volume status, central venous pressure, inferior vena cava diameter, collapsibility index


INTRODUCTION

Fluid balance is a term used to describe the balance of the input and output of fluids in the body to allow metabolic processes to function correctly.¹ To make an accurate assessment of fluid balance, we need to understand the fluid compartments within the body and how fluid moves between these compartments.² Fluid circulates between compartments by diffusion. This is the random movement of particles from regions where they are highly concentrated to areas of low concentration. Movement continues until the concentration is equally distributed.² This is normally a passive process but it can be facilitated by a carrier molecule, usually a specific protein.³

There are many ways that can be done to estimate the intravascular volume, including measurement of central venous pressure (CVP) and collapsibility index of inferior vena cava diameter (IVC-CI) by using ultrasound. Central venous pressure is a key physiologic estimation of preload, which in turn helps define the intravascular fluid status. It is an important parameter to measure in critically ill and injured patients who may require fluid resuscitation. Unfortunately, CVP measurement requires invasive central venous catheters that can be difficult and time-consuming to insert and associated with complications. A non-invasive mean of inferring the CVP will provide clinicians an acceptable alternative.⁴ Determination of IVC diameters and its collapsibility index (CI) has been found correlated to intravascular volume status and clinical response to clinical interventions.⁵

The aim of this study was to determine if CVP correlates with collapsibility index of IVC.

MATERIAL AND METHODS

This study was conducted from September to October of 2016 at the intensive care unit (ICU) of Sanglah General Hospital at Bali Island, Indonesia. Seventy adult patients of both genders treated at ICU with aged ranged from 18 to 64 years, who were able to lie supine with normal body mass index, mechanically ventilated using Positive End-Expiratory Pressure (PEEP) 5 cm H₂O with already inserted CVC by proper indication, were measured for CVP. Then followed by ultrasound examination to measure the IVC diameters and its IVC-CI. Patients who refuse to join the study, on vasoconstrictor or vasodilator drugs, with cardiac dysfunction, increasing abdominal pressure and...
intrathoracic pressure are excluded from the study. The CVP is measured manually using manometer at midaxillary level with patient lying supine. Maximum and minimum IVC diameter measurements were obtained by M mode of ultrasound view under subxiphoid approach. Readings were conducted by a team of one intensivist and two residents who were trained using bedside ultrasonography. Data was simultaneously collected.

Data analyzed using SPSS version 18. Kolmogorov-Smirnov test was used to evaluate data distribution normality. Median and interquartile range (IQR) were calculated for data that is not normally distributed. Correlation between CVP and IVC-CI were evaluated using Spearman’s correlation test. A p-value of <0.05 was considered statistically significant.

RESULTS

A total 70 patients were enrolled for this study. The characteristics of eligible subjects are presented in Table 1. The median (IQR) age of the patients was 50 (23) years, 46 (65.7%) were male, and the rest (34.3%) were female. Most frequent diagnosis was traumatic brain injury post trepanation (52.9%).

CVP ranged from 6-18 cmH₂O with median (IQR) of 11 (4) cmH₂O. Maximum IVC diameter ranged from 1.50-2.50 mm with median (IQR) of 1.67 (0.38) mm. Collapsibility index ranged from 4.32-69.28% with median (IQR) of 29.60 (36.16)%. Correlation coefficient (r) between CVP and IVC-CI was -0.854 (p<0.001) as displayed in Table 2. Scatter plot between CVP and IVC-CI is shown in Figure 1.

DISCUSSION

Assessing intravascular volume is very important for the improvement of patients during hospital care. A number of ways in measuring fluid status, such as measuring CVP and IVC-CI, each has its own advantages and disadvantages. The fact is there is no single way of measurement that is considered ideal.7

One limitation in assessing intravascular volume by CVP is that it is not a true reflection of preload. Some limitations of using CVP are that it’s invasive, expensive, time consuming, and requires considerable expertise. Nagdev et al reported 50% collapse of the IVC diameter during respiratory cycle as being strongly associated with low CVP.8 Others factors may influence the diameter of IVC. Mookadam et al found that when in supine position, patients have larger IVC diameter in both systolic and diastolic phases compared to when they are in lateral position (17.2+4.1 vs. 10.9+4.4 mm, p<0.001; 16.2+4.5 vs. 9.9+4.4 mm, p<0.001).9 Kathuria et al found that IVC diameter by bedside USG increase with age sample aged 0-22 years old (r = 0.79, p<0.001).10 Patil et al found a strong correlation was observed between IVC diameter and height (r = 0.623, p < 0.001), weight (r = 0.886, p < 0.001) and BMI (r = 0.710, p < 0.001) of the individuals.11 Thanakitcharu et al found there was a significant correlation between CVP and end-inspiration IVC diameter (r = 0.535, p<0.001) and between the CVP and mean IVC diameter (r = 0.397, p = 0.001).12 Khalil et al found correlation between CVP and maximum IVC diameter was moderately significant (r = 0.53, p<0.001).13 There are differences in the results between previous studies and the present study.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n</th>
<th>Age (years old), median (IQR)</th>
<th>Gender</th>
<th>MAP (mmHg), median (IQR)</th>
<th>Pulse (bpm), mean ± SD</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male [n (%)]</td>
<td>Female [n (%)]</td>
<td>89 (13)</td>
<td>94.70 ± 11.47</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>50 (23)</td>
<td>46 (65,7%)</td>
<td>24 (34,3%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>95% CI</th>
<th>Median (IQR)</th>
<th>r</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVP</td>
<td>1.72-1.84</td>
<td>11 (4)</td>
<td>-0.854</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IVC-CI</td>
<td>30.87-40.59</td>
<td>29,60 (36.16)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1 Scatter plot display for correlation between CVP and IVC-CI values (r = -0.854, p<0.001)
where we found weak correlation between CVP and maximum IVC diameter ($r = 0.267; p < 0.05$).

Another assessment method of intravascular volume is by IVC-CI using bedside ultrasonography. Advantages of using this technique are that it’s accurate measurement of internal structures including the IVC, safe, non-invasive, portable, faster assessment than inserting CVC in measuring fluid status. In the present study we found that CVP strongly correlated with IVC-CI ($r = -0.854; p < 0.001$), this indicated that an increase in CVP is followed a decrease in CVI-CI. Thanakitcharu et al found significant correlation between the CVP and IVC-CI ($r = -0.612, p < 0.001$) in critically–ill patients.

CONCLUSION

Central venous pressure (CVP) value is highly correlated with inferior vena cava diameter and collapsibility index (IVC-CI). Ultrasonography measured IVC-CI is considered safer that CVP, which has a number of complication, in assessing intravascular volume in emergency department and intensive care unit settings. This examination method should be followed by periodic evaluation of clinical examinations.

REFERENCES


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