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The Comparison of the Caval Index with the Invasive Method for Estimating Low CVP in ICU-Admitted Patients, Kerman, Iran

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ABSTRACT

Introduction: *The measurement of the CVP is an important way of estimating the preload volume and the intravascular fluid volume for critically ill patients who require emergency attention to their hemodynamic status, this measurement is very important. Recent researches have shown that in severe sepsis and septic shock, CVP <8 mmHg, urgent fluid resuscitation should be considered. Therefore, this study aimed to investigate the ultrasonography examination of the inferior vena cava as well caval index in order to estimate low CVP.* ***Method:*** *This prospective study was performed on 70 patients admitted in ICU of Shahid Bahonar hospital of Kerman who were all reported to utilize central venous catheter. The IVC diameter was measured in 2 cm to 3 cm distance to the right atrium, in subxiphoid area and sagittal views at the end of inspiration and expiration phases. The CVP was measured by a pressure monometer and an indwelling central vein catheter. Caval index, indicating the relative decrease in IVC diameter from inhalation to exhalation, was measured via utilizing CVP monitoring.* ***Results:*** *The results show that there is a positive relationship between the inspiratory phase IVC diameter and the CVP and also between the expiratory phase IVC diameter and the CVP so that increase in the CVP causes increase in inspiratory and expiratory IVC diameters. Also, the caval index >50% has a sensitivity of 94% and the specificity of 97% in the prediction of the low CVP (<8 mmHg).* ***Discussion:*** *It seems that the portable IVC sonography of the emergency patients is non-invasive and a fast way to estimate the CVP and hemodynamic condition of the patient.*

Keywords: IVC, ultrasound, CVP, caval index

INTRODUCTION

The central venous pressure (CVP) is the mean pressure in the superior vena cava, reflecting right ventricular end diastolic pressure.

The measurement of the CVP is particularly important way of estimating the preload volume and the intravascular fluid volume for critically ill patients who require emergency attention to their hemodynamic status, this measurement is very important [1].

Recent researches have shown that in severe sepsis and septic shock, in the CVP <8 mmHg, urgent fluid resuscitation should be considered [2-4]. Unfortunately, the measurement of the CVP requires invasive procedures (such as the insertion of CV catheter) which are associated with a great risk of infectious and thrombotic complications [5], they are also time consuming and expensive. Researchers are always looking for fast and non-invasive methods to estimate the CVP, especially in emergency patients. Recently, studies have shown a positive relationship between the Inferior vena cava (IVC) diameter and the CVP [6,7].

Some studies also have shown that the IVC diameter changes during a respiratory cycle that can reflect the CVP

changes [7-9]. The IVC diameter changes during a respiratory cycle (the respiratory pressure required to decrease the IVC diameter to greater than or equal to 85% of the difference between its maximal and minimal values) was similar or equal to the mean right atrial pressure. The minimal to maximal IVC diameter ratio was inversely related to the mean right atrial pressure [10,11].

The caval index is used to evaluate the changes in the IVC diameter during the respiratory cycle [6,7,12,13]. The caval index (CI) is written in percentage. Various studies have shown the capability of the IVC sonography in the evaluation of the CVP, for example, in a study [7], it was shown that an IVC collapsibility index <40% was highly predictive of the right atrial pressure >10 mmHg.

In another study on 83 ICU-admitted patients, an inverse relation was shown between the CI and the CVP [10]. FICU. In another study on 70 patients, a positive relationship was found between the IVC diameter (measured by TEE and during cardiac surgery) and the CVP [14].

It seems that the portable IVC sonography of the emergency patients is non-invasive and a fast way to estimate the CVP and hemodynamic condition of the patient.

METHODS

This is an observational study. The 70 patients who were registered were the ICU-admitted patients in Bahonar Hospital, all of them had the CV line.

The exclusion criteria were:

1. Patients with chronic diseases (heart failure, arrhythmia, COPD).
2. Patients with increased abdominal pressure (ascites, pregnancy).
3. Patients with PEEP >10.
4. Patients who were unable to undergo sonography for any reason such as obesity.

All the sonographies were performed by portable 2D Medison sonography device, in supine position. The IVC diameter was measured in 2 cm to 3 cm distance to the Rt. Atrium, in subxiphoid area and sagittal views at the end of inspiration and expiration phases.

The CI which reflexes the change in the IVC diameter is calculated as below:

CI = [(IVC end-expiratory diameter-IVC end-inspiratory diameter)/IVC end-expiratory diameter] × 100

The CVP was measured by a pressure monometer and an indwelling central vein catheter (CVC). The patients' data, the end inspiratory and the end expiratory IVC diameters, the CI and the CVP were collected in a checklist.

The data were analysed using SPSS16 for descriptive analysis and Pearson correlation analysis. A receiver operating characteristic (ROC) curve was plotted to determine the threshold value of CI which provided the prediction of CVP <8 mmHg. The optimal cut-off values were obtained with the greatest sum of sensitivity and specificity using the Youden index.

RESULTS

In this study, the recruited statistics population were 70 patients (28.6% female and 71.4% male). The descriptive statistics are listed (Table 1).

Table 1 Descriptive statistics

Variables	Minimum	Maximum	Mean ± SD
Age	10	49	30.78 ± 8.01
IVC diameter (inspiratory phase)	4	13	9.95 ± 2.95
IVC diameter (expiratory phase)	11	18	16.15 ± 1.91
Caval Index	27	63	39.42 ± 12.87
CVP (invasive method)	3	12	9.16 ± 2.8

The results show that there is a positive relationship between the inspiratory phase IVC diameter and the CVP and also between the expiratory phase IVC diameter and the CVP so that increase in the CVP causes increase in inspiratory and expiratory IVC diameters (Table 2).

Table 2 relation between inspiratory and expiratory IVC diameter and the CVP

Variable	P-Value*	r
IVC diameter (inspiratory phase)	<0.001	0.991
IVC diameter (expiratory phase)	<0.001	0.979

* based on Pearson correlation analysis

Also, the caval index >50% has a sensitivity of 94% and the specificity of 97% in the prediction of the low CVP <8 mmHg.

DISCUSSION AND CONCLUSION

In this study, the relationship between the IVC diameter and its changes during the respiratory phase (obtained by sonography) and the CVP (obtained invasively) was evaluated.

This study shows that the CI >50% indicates a CVP <8 mmHg. In a similar study [10], 83 ICU-admitted patients were evaluated. The CVP and the CI were measured. The patients were divided into 3 groups based on the CI (>60%, 20% to 60%, <20%). The results showed that the increased CI was associated with a significant decrease in the CVP (p=0.23).

Recent researches have shown that CVP monitoring is an important way in evaluation and prevention of death in patients with severe sepsis and septic shock.

In a study [15], it was concluded that the CVP threshold where the fluid replacement therapy increases the cardiac output is less than 10 mmHg. Many studies have been conducted in this area and they all confirm that portable sonography of the IVC is a fast and non-invasive method for detecting the low CVP. For example, in a study [9], the CI ≥20% indicates a normal CVP. Another study [16] suggests that a change in the IVC diameter during respiration is an accurate predictor of the good response to fluid replacement therapy in sepsis. In several other studies, the IVC diameter which was estimated by transesophageal echocardiography was compared with the CVP and the results were similar to this study [17,18].

In a study [14], the patients were divided into 2 groups based on their baseline CVP:

First group: (CVP ≤11 mmHg)

Second group: (CVP >11 mmHg)

In the 1st group, the IVC diameter showed a strong correlation with the CVP. The IVC diameter was estimated by transesophageal echocardiography. Our study also shows that the CI >50% indicates the CVP <8 mmHg (Sensitivity 94%, specificity 97%).

In this study, the mechanical ventilated patients were excluded because of the possibility of positive pressure respiration effect on the CVP. Since a significant number of patients are under the mechanical ventilation in the ICU, it is suggested that further studies on these patients be conducted.

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