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Investigating the Anteroposterior Diameter of the Inferior Vena Cava as a Measure of the Adequacy of Fluid Therapy in Patients

Abstract

Introduction: Investigating and adjusting the volume of intravascular fluids in many patients is significant for diagnosis, management, and evaluation of response to treatment. Measuring central venous pressure (CVP) is the preferred method of physicians to estimate or adequacy of fluid therapy in most cases. However, based on the studies, there is an interest in measuring the diameter of the inferior vena cava (IVC) using ultrasound as a non-invasive and fast method. However, there are several confounding factors and technical reasons to fear the accuracy of IVC measurements. It requires more studies in different groups. Thus, the present study investigates the anteroposterior diameter of the IVC after fluid therapy as a measure of the adequacy of fluid therapy and compares it with CVP.

Methods: This cross-sectional descriptive study was conducted at the Kausar Teaching Center of Kurdistan in 2022. The studied population included patients who need fluid therapy and were referred to the hospital. They were included in the study by a census method between the beginning of September and the end of October 2021 (two months). The inclusion criteria were patients with falls, burns, trauma, and accidents. The exclusion criteria also included other groups of patients and non-satisfaction of the patients. A radiology specialist and the sonography device, model ESAOTE MYLAB SIGMA, were used to measure the anteroposterior diameter of the IVC. Additionally, CVP was determined by central venous catheter. The demographic information was recorded in a checklist. Data were analyzed using SPSS16 software and Pearson correlation coefficient, and linear regression ($P<0.05$).

Results: Twenty-two patients were included in the study. The mean age of the patients was 37.88 ± 20.98. Most of them (54.5%) were male. The clients were burn patients (41%). The mean anteroposterior diameter of IVC was 13.80 ± 1.93 mm during inhalation and 13.32 ± 2.01 mm during exhalation. The mean CVP was 11.13 ± 1.62 cm of water. There was a significant and positive correlation between the anteroposterior diameter of IVC and CVP during inhalation ($r=0.59$, $P=0.004$). The correlation was positive and significant during exhalation ($r=0.56$, $P=0.006$). The results of linear regression analysis also revealed that for each unit of increase in IVC diameter, CVP increases by 0.495 units during inhalation. For each unit of increase in IVC diameter, CVP increases by 0.457 units during exhalation, which was significant.

Conclusion: Based on the results of the present study and similar studies, measuring the anteroposterior diameter of the IVC during inhalation and exhalation using ultrasound can be used as an indicator of the adequacy of fluid therapy. It is a non-invasive and quick method for patients suffering from burns and falls, trauma, and accident.

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Introduction

It is very significant and often difficult to investigate and adjust the volume of intravascular fluids in various emergency and non-emergency patients for diagnosis, management, and evaluation of response to treatment. Measurement of central venous pressure (CVP) is currently an accurate and common method to estimate the body's need for fluids. In this method, central venous pressure is measured by placing a catheter in the superior vena cava through the internal jugular or subclavian vein. However, this method is invasive. In addition to its specific limitations, it can cause complications such as vessel rupture, venous thrombosis, pneumothorax, hemothorax, etc. (1).

According to many experts, there is an association between the dynamics of the dimensions of the inferior vena cava and the hemodynamic status (2). Thus, several studies have been conducted to measure the diameter of the inferior vena cava (IVC) using ultrasound as a non-invasive and fast method for hemodynamic monitoring. These studies have investigated different groups of patients, including patients hospitalized in special units, shock patients, dialysis patients, etc. Most of them have revealed the effectiveness and superiority of this method over other methods. However, this relationship is not well known based on the studies (3, 4). For example, Hasanin et al. examined the internal diameter of the IVC, the collapse, and the dimensions of the internal jugular vein to predict the adequacy of fluid therapy in patients with septic shock. In the mentioned study, an ultrasound examination was performed before fluid therapy. The minimum and maximum internal diameters of the IVC were the best parameters in diagnosing the adequacy of fluid therapy (5).

A retrospective study by Mon evaluated the effectiveness of the diameter and inferior vena cava collapse index as a clinical index for the adequacy of fluid therapy in patients with emergency low blood pressure. In these patients, the diameter and collapse index of the inferior vena cava at the time of admission and during fluid therapy were examined by ultrasound and compared with the control group. The results

revealed that the diameter and collapse index of the inferior vena cava can be considered a tool for the adequacy of fluid therapy in patients with emergency low blood pressure (6). Both of the mentioned studies were conducted on patients hospitalized in intensive care units. Millington has emphasized that the use of ultrasound for resuscitation purposes is progressing rapidly. However, there are several confounding factors and technical reasons to fear the accuracy of IVC measurements. Further studies are needed for different groups (7). Despite several studies, based on examination of the present study researchers and their experiences, CVP measurement is still a significant criterion for fluid therapy. Moreover, most of the available studies have examined and compared these two indices, i.e. the anteroposterior diameter of IVC and CVP at the time of admission of patients and the length of their treatment. Thus, given what was stated above, the present study takes a different look at this issue and examines and compares the anteroposterior diameter of IVC with CVP to determine whether the examination of the anteroposterior diameter of the IVC can be used as a criterion for the adequacy of fluid therapy?

Methods

This cross-sectional descriptive study was conducted in …Teaching Center of Kurdistan in 2022. The studied population included patients who need fluid therapy and were referred to the hospital. The inclusion criteria were patients with falls, burns, trauma, and accidents. The exclusion criteria also included other groups of patients and non-satisfaction of the patients. These patients were included in the study between the beginning of September and the end of October 2022 (two months) using the census method. A radiology specialist and the sonography device, model ESAOTE MYLAB SIGMA, were used to measure the anteroposterior diameter of the IVC. After fluid therapy, the anteroposterior diameter of the inferior vena cava was recorded during inhalation and exhalation in the supine position. Additionally, the central venous pressure (CVP) was determined by the central venous catheter during inhalation and exhalation. The demographic information of the patients, including gender and age, was recorded in a checklist. Data were analyzed using SPSS16 software and Pearson's correlation coefficient, and linear regression ($P<0.05$).

Results

Twenty-two patients were finally included in the study after applying the inclusion and exclusion criteria. The mean age of the patients was 37.88 ± 20.98. Most of them (54.5%) were male and 41% of the clients were burn patients. Table 1 presents the demographic characteristics of the patients.

Table 1) Demographic characteristics of the studied sample

Characteristic	**N**	**%**
Gender	Female	10	45.5
	Male	12	54.5
Reason of referral	Falls	5	23
	Burns	9	41
	Accident and trauma	8	36

The mean anteroposterior diameter of the inferior vena cava in the studied sample was 13.80 ± 1.93 mm during inhalation and 13.32 ± 2.01 mm during exhalation. The mean central venous pressure was 11.13 ± 1.62 cm of water. Table 2 shows the mean anteroposterior diameter of the inferior vena cava during inhalation and exhalation and the mean central venous pressure after fluid therapy based on the reason for referral and gender (Table 2).

Table 2- Mean CVP and anteroposterior diameter of the IVC in inhalation and exhalation based on gender and reason for referral

Characteristic		Mean anteroposterior diameter of the IVC during inhalation	Mean anteroposterior diameter of the IVC during expiration	CVP
Gender	Male	14.21±1.75	13.73±1.88	11.75±1.53
	Female	13.31±2.11	12.84±2.15	10.40±1.48
Reason of referral	Falls	13.46±2.05	12.94±2.02	11.00±1.22
	Accident and trauma	14.63±1.92	14.25±2.06	11.75±1.30
	and burns	13.25±1.84	12.72±1.86	10.66±2.01

Investigating the Pearson correlation coefficient revealed a significant positive correlation between the anteroposterior diameter of the inferior vena cava and CVP during inspiration ($r=0.59$, $P=0.004$). Additionally, this correlation was positive and significant during exhalation ($r=0.56$, $P=0.006$). It means that the central venous pressure also increases with an increase in the anteroposterior diameter of the inferior vena cava during inhalation and exhalation. Analysis of variance confirmed the validity of regression analysis in predicting central venous pressure. The results of linear regression analysis revealed that

the central venous pressure increases by 0.495 during inhalation and 0.457 during exhalation for each unit of increase in IVC diameter. This relationship was significant (Tables 3 and 4).

Table 3- Regression coefficients of inferior vena cava with central venous pressure during inhalation

Model	B	Standard error	T	P. Value
Constant	4.30	2.11	2.03	0.05
Anteroposterior diameter of IVC during inhalation	0.495	0.15	3.26	0.004

Table 4- Regression coefficients of inferior vena cava with central venous pressure during exhalation

Model	**B**	**Standard error**	**T**	**P. Value**
Constant	5.04	2.11	2.51	0.02
Anteroposterior diameter of IVC during exhalation	0.457	0.149	3.06	0.006

Discussion

The present study investigated the anteroposterior diameter of the IVC after fluid therapy in patients with burns, falls, traumas, and accidents. The results revealed that the mean anteroposterior diameter of the inferior vena cava in the examined sample was 13.80±1.93 mm during inhalation and 13.32±2.01 mm during exhalation. The mean central venous pressure was 11.13 ± 1.62 cm of water. A significant positive correlation was found between the anteroposterior diameter of the inferior vena cava and CVP during inhalation and exhalation. The review of studies indicated that most of them are focused on a specific group of patients such as patients hospitalized in special care units, and dialysis patients at the time of their admission and during treatment. Moreover, reviewing various studies showed that the results of some of them are consistent with the results of the present study. For example, in a study by Nafisi Moghadam et al., the mean IVC diameter was 7.71±3.56 mm during inhalation and 11.97±3.38 mm during exhalation. They reported a significant linear relationship between CVP and IVC diameter during exhalation. However, this linear relationship was not significant during inspiration. In contrast to the results of the present study, a significant linear relationship was found between CVP and IVC diameter during inspiration (4).

Derakhshanfar et al. conducted a study on 114 patients with indications for central venous catheterization. Their results showed that portable sonographic measurement of caval index ≥ 50% is strongly associated with CVP > 8 and caval index ≤ 28% is associated with CVP < 12. Based on this study, sonography of the inferior vena cava is a suitable, non-invasive, and fast diagnostic tool for determining central venous pressure (2). Additionally, a review of the literature revealed that several published studies consider the caval index and IVC collapse more suitable for indicating central venous pressure. For example, a study by Nagi et al. revealed that the examination of IVC collapse can be a good and sensitive predictor for the adequacy of fluid therapy (8). In a study by Yildizdas & Aslan, measuring the IVC collapse index by ultrasound was suggested as a non-invasive, fast, and radiation-free method for patients. Based on the researchers, this measurement method is valuable for evaluating the volume of child patients in critical times for special care units (9).

However, some studies have questioned the value of these indices compared to other indices. For example, in a study by Saritas et al., IVC indices including expansion, collapse, and delta were examined to estimate the required volume of three groups of patients based on the CVP index. Ultrasound was used to determine the above indices in this study. The results revealed that the expansion index has a more accurate role in predicting the required volume of patients compared to collapse and delta (10). Metiocaptin and Elincaptin also stated that IVC ultrasound may be limited by factors affecting IVC diameter or collapse, clinical interpretation, or optimal visualization and it should be interpreted in the overall context of the clinical status (11). The results of a systematic review by Filho et al. revealed that the assessment of intravascular volume and fluid responsiveness through IVC ultrasound indices is applicable and safe for diagnosing and monitoring hemodynamic instability. However, it is necessary to conduct studies about the standardization of values, due to the divergence in the cut-off points used for each index (12).

Conclusion:

Based on the results of this study and similar studies, measuring the anteroposterior diameter of the IVC during inhalation and exhalation using ultrasound can be used as an index for the adequacy of fluid therapy and as a non-invasive and fast method in patients with burns, falls, trauma, and accident.

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