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Research Article

Caval Aorta Index and Central Venous Pressure Correlation in Assessing Fluid Status! "Ultrasound Bridging the Gap"

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Accurate body fluid assessment and estimation of fluid status are essential in guiding fluid therapy in emergency setup. This prospective cross-sectional descriptive study conducted to ascertain the effectiveness of inferior vena cava and aorta (IVC/Aorta) index in assessing the fluid status by comparing it with the central venous pressure (CVP). Results showed the mean IVC/Aorta index in patients who had normal CVP range was 1.2 ± 0.12 SD, while in patients with low CVP, the mean index was 0.7 ± 0.09 SD, and, patients with high CVP, the mean index was 1.6 ± 0.05 SD. In conclusion, the sonographic IVC/Aorta index assessment seems to be a quick, simple, noninvasive, and reliable method to access the fluid status in a busy setup like an emergency room.

1. Introduction

Physicians need to understand, evaluate, and address the hemodynamics in every patient, especially for patients in the emergency room (ER) and intensive care units (ICU). Accurate body fluid assessment is always challenging, and estimation of fluid status is needed for guiding fluid therapy for such patients [1].

There are various techniques for assessing the fluid status such as clinical examination, central venous pressure (CVP) measurement, biochemical markers, bioimpedance, continuous blood volume measurement, or sonographic inferior vena cava (IVC) diameter assessment. However, all of these methods have some limitations when used in clinical practice [2–4].

Being able to determine and interpret the CVP for assessing the fluid status, though not accurate always, is one of the most commonly followed techniques at tamost hospitals, even till today in India. To measure CVP, a central venous access is essential; it's an invasive procedure, not easily done in an emergency setup, time consuming, and difficult to maintain sterile precautions and has its own risks and complications [5].

Sonographic evaluation of the IVC diameter and its usefulness in evaluating the volume status are studied and documented [6, 7]. Also, ultrasound [USG] imaging has several advantages; it is simple, noninvasive and can be used for repeated assessment. Ultrasound units are present in most ER to routinely perform the focused assessment sonography in trauma victims and emergency USG in critically ill patients [1].

Hence, if this study can establish that sonographic evaluation of the IVC can predict the volume status, then this tool can assist emergency physicians in rapid diagnosis and prompt resuscitation of patients, especially for those who present in hypovolemic shock. The aim is to study the effectiveness of inferior vena cava/aorta index (IVC/Ao) in assessing the fluid status by comparing it with the CVP.

2. Materials and Methodology

This is a prospective cross-sectional descriptive study conducted in the Department of Accident & Emergency medicine, Vinayaka Mission's Kirupananda Variyar Medical College & Hospitals, Salem over a time period from January 2010–July 2011 with ethical standards of the institution.

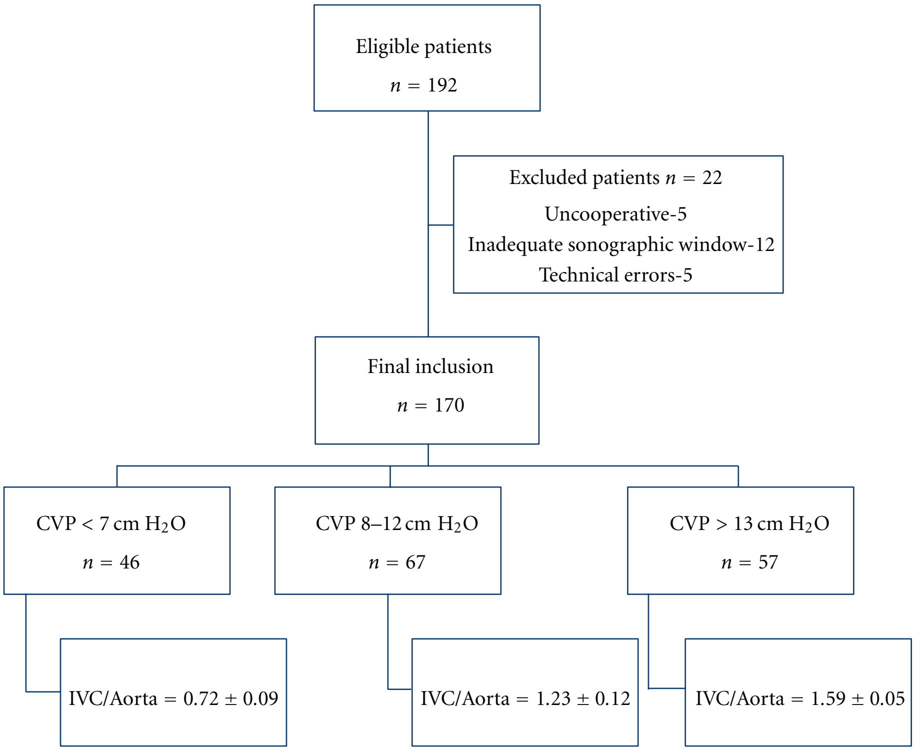

Figure 1: Flow diagram representing the study population.

Patients presenting to the ER and admitted to the ICU, aged above 18 years, nonintubated, having bilateral arm constant blood pressures and normal echocardiography study, and requiring central venous (internal jugular or subclavian vein) access are included in the study.

Patients with a body mass index (BMI) above 30 kg/m^2, II/III trimester pregnancy and patients with clinical or radiological evidence of mediastinal mass, pneumo/hemothorax, portal hypertension, and suspected or diagnosed raised intra abdominal pressures are excluded from the study.

An oral consent was obtained. While the patient lies supine, the CVP was noted using a standard manometer at random time by an emergency physician (EP1), and simultaneous sonographic assessment of the IVC and aorta diameters was conducted by the second emergency physician [EP2]. The EP1 and EP2 were constant for obtaining the required values throughout the study. The obtained values were blinded from each other and recorded in a data sheet.

To measure the IVC diameter, a curvilinear probe of 3.5 MHz of the Scizon-Minre USG machine was placed in the subxiphoid region to visualize the confluence of the hepatic veins draining the IVC. The maximum internal anterior posterior [AP] diameter of the IVC just caudal to the confluence of the hepatic veins in the longitudinal plane is measured on the M mode.

The transverse aortic section in the supxiphoid region is noted lying left lateral to the IVC, and the maximum internal AP diameter of the aorta is measured in the longitudinal plane on the M mode.

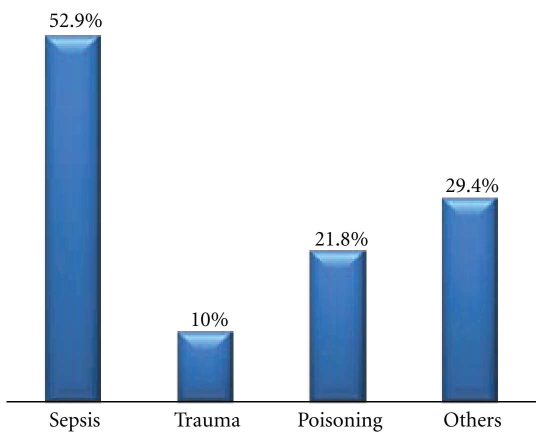

Figure 2: Percentage distribution of diagnosis.

The IVC/Ao is derived by taking the ratio of the two respective diameters measured. The statistical analysis was used to calculate the mean, standard deviations, and correlation coefficient between the measured CVP and the corresponding IVC/Ao using the Pearson's formula.

3. Results

This study consists of 170 patients (Figure 1) of an average age 40 ± 11 years with a male female ratio of 3.2 : 1. Sepsis was the prevailing diagnosis (Figure 2); 84% cases had

Table 1: CVP values and its corresponding IVC diameter measurements.

CVP	Range of max IVC measurements (cm)	Mean max IVC diameter (cm)	Standard deviation
<7 cm H_2O	0.9–2.23	1.41	0.28
8–12 cm H_2O	1.8–2.9	2.34	0.29
>13 cm H_2O	2.36–3.3	2.92	0.21

Table 2: CVP values and its corresponding aorta measurements.

CVP	Range of max aorta measurements (cm)	Mean max aorta diameter (cm)	Standard deviation
<7 cm H_2O	1.68–2.4	1.88	0.14
8–12 cm H_2O	1.64–2.3	1.86	0.14
>13 cm H_2O	1.64–2.04	1.87	0.10

Table 3: CVP values and its corresponding IVC/aorta indices.

CVP	Range of IVC/aorta index	Mean IVC/aorta index	Standard deviation
<7 cm H_2O	0.56–0.88	0.72	0.09
8–12 cm H_2O	1.03–1.42	1.23	0.12
>13 cm H_2O	1.51–1.66	1.59	0.05

a central line access for CVP-guided fluid therapy, infusion of vasoactive agent in 58%, hypertonic solution 38%, parenteral nutrition 9%, and others 6%. The right internal jugular vein access was most preferred (66.5%) (Figure 3). The CVP measurements were taken on an average, on the third day ($\pm$1.5) of central venous access placement.

The mean maximum IVC diameter and aorta diameter readings on patients with CVP less than 7 cm of water [cm H_2O] were 1.4 $\pm$ 0.3 cm and 1.88 $\pm$ 0.14 cm, CVP between 8 to 12 cm H_2O were 2.3 $\pm$ 0.3 cm and 1.86 $\pm$ 0.14 cm, and CVP more than 13 cm H_2O were 2.9 $\pm$ 0.2 cm, and 1.87 $\pm$ 0.10 cm respectively (Tables 1 and 2).

The mean IVC/Aorta index of patients with CVP of less than 7 cm H_2O was 0.7 $\pm$ 0.09, CVP between 8 to 12 cm H_2O was 1.2 $\pm$ 0.12 and CVP more than 13 cm H_2O was 1.6 $\pm$ 0.05 (Table 3). Average time taken to assess and calculate the IVC/Ao was 8 $\pm$ 1.5 minutes.

The scattered diagram of the various mean IVC/Ao against its corresponding CVP values (Figure 4) depicts a sigmoid curve, with an initial rapid rise and a gradual plateau as CVP rises above normal. A positive correlation exists between the CVP measurement and the IVC/Ao, as calculated using the Pearson formula; the correlation coefficient is 0.9696.

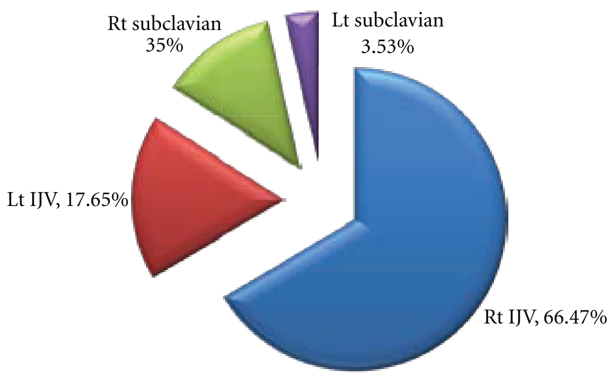

Figure 3: Percentage distribution of central line access.

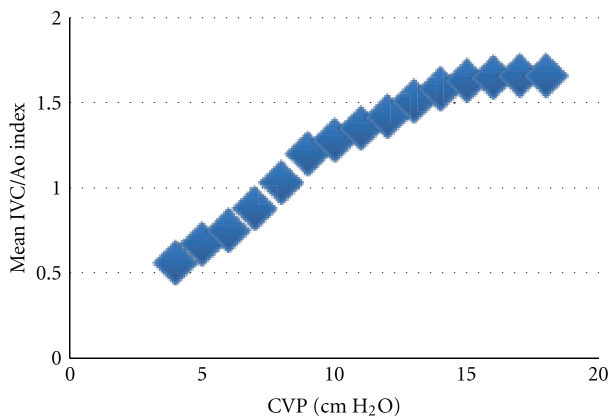

Figure 4: Scattered diagram of various mean IVC/Aorta index against its corresponding CVP values.

4. Discussion

The body fluid status assessment in the diagnostic and therapeutic management of acute and chronic disorders has a significant role in their recovery. There are different methods of evaluating the body fluid status but none are optimal and have some limitations. In an ER, the ideal method should be easy to perform, quick, precise, and repetitive.

In 1979, Natori et al. [8] proved good correlation between the changes in IVC diameter and right atrial blood pressure. Studies are conducted on the usefulness of sonographic IVC diameter assessment in monitoring body fluid status in patients undergoing hemodialysis [6, 9, 10], patients with nephritic syndrome [11], or those hospitalized in ICU.

The IVC is a high capacitance vessel that can distend and collapse. Thus, in volume depletion, it is easily collapsible and has a smaller diameter. With fluid replacement, the collapsibility reduces and the diameter increases. In fluid overload, the vein elasticity reaches threshold further which is minimally distensible and cannot collapse, thus maintains a relative constant diameter. The IVC size varies greatly between individuals and it does not correlate well with BMI or body surface area (BSA) [12]. Also, there is a lack of clear IVC diameter reference values for pediatric and adult population.

Cheriex et al. [13] proposed the optimal values of IVC diameter ranging between 8 and 11.5 mm per square meter of BSA on the basis of measurements from the examined group of adult hemodialysis patients. According to Chang et al. [14], there is a significant reduction of complications if the body dry weight of hemodialysis patients was determined and monitored with the sonographic method to evaluate the fluid status.

The IVC collapses with decreased intrathoracic pressure during inspiration and expands with increased intrathoracic pressure during expiration. The degree of collapsibility during the respiratory cycle predicts the fluid status of the individual patient [15]. But, accurate measurements of the varying diameter are often difficult.

The correlation of IVC diameter, body height, and BSA has already been proven. With critically ill or emergency patients, accessing BSA is difficult and time consuming. The usefulness of this method would significantly increase if IVC diameter was compared with a parameter independent of body fluid status correlating with body growth and BSA.

The aorta is a noncollapsible structure and maintains a relatively constant diameter irrespective to the fluid status. The aortic diameter correlates with BSA, age, and sex of the patient [16, 17]. Kosiak et al. research study states that IVC/Ao is more specific in assessment of body fluid status [18].

Thus measuring the IVC/Ao irrespective to the respiratory cycle has made the study simpler and patient specific, and does not necessitate looking at reference values for each age group. This study states that the mean IVC/Ao in patients euvolemic is 1.2 ± 0.12 SD, hypovolemic is 0.7 ± 0.09 SD, and volume overloaded is 1.6 ± 0.05 SD, respectively.

The utility of IVC/Ao in trauma patients by Son et al. Inje University, Korea [19], quoted that non trauma patients had a mean IVC/Aorta index of 1.26 ± 0.17 SD and trauma patients had a mean index of 0.80 ± 0.33 SD. Sonographic IVC/Ao for fluid status in young individuals from the American Journal of Emergency Medicine [18] concluded that for the healthy young population, the IVC/Ao reference value is 1.2 ± 0.17 SD.

The IVC/Ao seems to play a very important role in diagnosing fluid status in emergency patients. The simplicity of the examination technique with quite constant measurement points can eliminate the examiner dependence. The IVC/Ao index assessment may be used in every situation where body fluid status affects further treatment and prognosis.

Limitations are as follows.

(1) Measurements of the vessel in the transverse plane was not included.

(2) Maximum AP diameter could not be assured as it could not be strictly median measurement.

(3) Two or more physicians were not utilised for sonographic measurements on the same patient at the same time which may have determined a level of agreement on the values obtained.

5. Conclusion

Sonographic IVC/Aorta index assessment seems to be a quick, simple, noninvasive, and reliable method to access the fluid status in a busy setup like an emergency room.

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