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SHORT REPORT

Is there an association between central venous pressure measurement and ultrasound assessment of the inferior vena cava?

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ABSTRACT

Introduction: Early assessment of volume status is paramount in critically ill patients. Central venous pressure (CVP) measurement and ultrasound assessment of the inferior vena cava (IVC) are both used for volume assessment in the emergency centre. Recent data is conflicting over whether there is a correlation between CVP and ultrasound assessment of the IVC.

Methods: This was a retrospective review of an audit previously performed in the Emergency Unit of Ngwelezane Hospital in Kwazulu-Natal. The audit involved measuring inferior vena cava collapsibility index (IVC-CI) within 5 min of CVP measurement. In this retrospective study, audit data were analysed to determine if an association exists.

Results: Twenty-four patients were included. The median age of participants was 36 (IQR 42) years (95% CI 33–56). The median time to ultrasound was 18.6 (52.5) h (95% CI 7.5–36.2). The mean CVP was 13.7 ± 7.7 cm H_2O and mean IVC-CI was 39.4 ± 17.8%. Based on a Pearson correlation test, there was a weak negative correlation between CVP and IVC-CI, which was not statistically significant ($r = -0.05$, $n = 24$, $p = 0.81$, 95% CI −0.5 to 0.4) for all participants. However, among females there was a moderate negative correlation between CVP and IVC-CI, which was not statistically significant ($r = -0.43$, $n = 7$, $p = 0.34$, 95% CI −0.9 to 0.5), while among males there was a weak positive correlation, which was not statistically significant ($r = 0.16$, $n = 17$, $p = 0.53$, 95% CI −0.3 to 0.6).

Discussion: There is no significant correlation between CVP and IVC-CI. Further validation research is required to support our preliminary findings of no significant correlation between CVP measurement and ultrasound assessment of the IVC. CVP and IVC ultrasound should be used as clinical adjuncts, and not as stand-alone measures of volume assessment.

African relevance

- Volume assessment is a critical step in the management of critically ill patients presenting to the emergency centre.
- CVP is used for volume assessment where other measures are not available.
- Use of ultrasound is increasing in African emergency centres.
- Other adjunctive methods of volume assessment are rarely available in African emergency centres.

Introduction

Early determination of a critically ill patient's hydration status i.e. fluid responsiveness, is pivotal in emergency centre (EC) management. Various methods of assessment have been described, but no single gold standard measure has been proven to exist [1]. Even though central venous pressure (CVP) has been proven to be unreliable, it is still used in ECs around the world [2].

Emergency physicians have difficulty with physical assessment of hydration status, compared to more objective measures [3]. Use of ultrasound in volume assessment is increasing. Volume status of critically ill patients is frequently assessed by ultrasound measurement of inferior vena cava (IVC) diameter and IVC collapsibility index (IVC-CI) [4]. IVC-CI provides a real time reflection of right atrial opening pressure and cardiac preload. As CVP theoretically provides the same information, demonstrating correlation, between IVC-CI and CVP, could provide a non-invasive, easily repeatable, adjunctive method of volume assessment.

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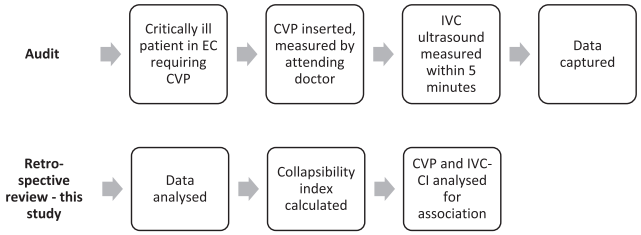

Fig. 1. Flow diagram of data collection process during audit and subsequent analysis.

Due to the lack of more advanced methods of volume assessment in the third world emergency centre, CVP, IVC-CI and IVC diameter are used for initial patient assessment and management. In this study, we determine if there is any correlation between CVP and IVC-CI, regardless of haemodynamic parameters or clinical diagnosis.

Methods

A comparative analysis was performed on data from a prospective, observational audit previously done in Ngwelezane Hospital emergency centre. During the audit, a convenience sample of critically ill adults, who required CVP catheter insertion in the emergency centre, was taken. Patients were included when an accredited ultrasonographer was available to perform an ultrasound within specific time frames (Fig. 1). Patients who were ventilated, pregnant, age younger than 16 years and those with inadequate ultrasound views, were excluded.

During the audit, accuracy of CVP measurement by the attending doctor was improved and standardised by supine position, a free flowing line, standardised manometers and use of the phlebostatic axis as the zero point. No intravascular fluid was administered between CVP and IVC measurements.

The level 1 accredited ultrasonographer was blinded to the CVP value, the patient's provisional diagnosis and clinical state. IVC measurements were made 1 cm distal to the confluence of the hepatic vein and inferior vena cava, using 2-dimensional mode and M-mode. With the patient supine, anteroposterior diameter measurements of the IVC were taken during inspiration and expiration. Adequacy of views were documented.

For our, retrospective study, we used a two sided test to calculate a sample size to determine a conservative correlation coefficient (rho) of 0.5, using a 5% significance level ($\alpha = 0.05$) and 80% statistical power ($\beta = 0.2$). A minimum sample size of 10 was determined. However, all 24 audit participants were included in an attempt to improve clinical significance. The IVC-CI (Inferior Vena Cava Collapsibility Index) was calculated, from the audit data, as follows: IVC-CI = [(IVC diameter in expiration − ICV diameter in inspiration)/(IVC diameter in expiration)] * 100.

CVP and IVC-CI data were analysed for association. The Statistical Package for Social Sciences version 24 (SPSS) was employed for data analysis. Using Shapiro-Wilk's test for normality, CVP and IVC-CI had p-values of 0.28 and 0.82 respectively, meaning both variables were normally distributed. These were expressed as mean ± standard deviation and compared using Student's *t*-test. Non-normally distributed variables were expressed using medians (interquartile range [IQR]). Descriptive statistics and correlations between IVC-CI and CVP were undertaken. CVP and IVC-CI were evaluated using Pearson's correlation test. The level of significance was set at $p < 0.05$.

Ethics approval was obtained from the Biomedical Research Ethics Committee of the University of KwaZulu-Natal BE 323/15.

Table 1
Participant CVP and IVC-CI values. CVP, Central Venous Pressure; IVC-CI, Inferior Vena Cava Collapsibility Index.

	n	Mean	Standard Deviation
All participants			
CVP (cm H_20)	24	13.7	7.7
IVC-CI (%)	24	39.4	17.8
Males			
CVP (cm H_2O)	17	13.5	7.9
IVC-CI (%)	17	42.5	15.4
Females			
CVP (cm H_20)	7	14.3	7.8
IVC-CI (%)	7	31.7	21.9

Results

A total of 24 patients were included in this study. Of these, 70.8% (n = 17) were male and 29.2% (n = 7) were female. The median age was 36 (IQR 42) years (95% CI 33–56). Median time to ultrasound was 18.6 (52.5) h (95% CI 7.5–36.2). Participant CVP and IVC-CI values are presented in Table 1. The mean CVP was 13.7 ± 7.7 cm H_2O. The mean IVC-CI was 39.4 ± 17.8%. Male mean IVC-CI (42.5 ± 15.4%) was higher than female mean IVC-CI (31.7 ± 21.9%), but this difference was not statistically significant using the Student's *t*-test, p = 0.26. Female mean CVP 14.3 ± 7.8 cm H_2O, was slightly higher than male mean CVP 13.5 ± 7.9 cm H_2O, but this was not statistically significant, p = 0.82.

There was a weak negative correlation between CVP and IVC-CI, which was not statistically significant (r = −0.05, n = 24, p = 0.81, 95% CI −0.5 to 0.4), for all participants. Scatter plot of correlation between CVP and IVC-CI is illustrated in Fig. 2. Among females there was a moderate negative correlation between CVP and IVC-CI, which was not statistically significant (r = −0.43, n = 7, p = 0.34, 95% CI −0.9 to 0.5), while among males there was a weak positive correlation, which was not statistically significant (r = 0.16, n = 17, p = 0.53, 95% CI −0.3 to 0.6).

Discussion

Assessment of volume status in critically ill patients is an essential but challenging step. There is currently no gold standard. All techniques, static or dynamic, have limitations. CVP continues to be used for volume assessment. Provided principles of physiology and of measurement are borne in mind, CVP can provide a useful guide to assessment of cardiac preload, volume status, and the cause of a change in cardiac output and blood pressure [5]. Specific lower and higher CVP values have been shown to have positive and negative predictive value, respectively, for fluid responsiveness [6]. CVP has been used as a surrogate for preload and changes in CVP have been used to predict volume responsiveness, but this has been challenged by a large body of evidence. Recent international guidelines have recommended that the use of CVP alone to guide fluid resuscitation can no longer be justified [2]. According to these guidelines, volume status and tissue perfusion may be assessed by focussed examination, or a combination of two of CVP, central venous oxygen saturation, cardiovascular ultrasound and other dynamic measures like passive leg raise or fluid challenge. CVP catheter insertion is invasive and time-consuming.

A useful and simple method of assessing intravascular volume is by IVC diameter and collapsibility [7]. The collapsibility index is associated with volume status. It was found to be significantly higher in patients with volume loss [8]. Ultrasound measurement of IVC diameter has been shown to be consistently low in hypovolaemic patients [9]. Ultrasound could provide a safe, rapid, non-invasive and easily repeatable assessment of volume status in the emergency centre. It may be used as an alternative adjunctive measure of volume status. Due to