ORIGINAL ARTICLE

Is Femoral Vein Diameter a Reliable Marker of Central Venous Pressure?

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ABSTRACT

Objective: To determine the correlation of femoral vein diameter with central venous pressure.

Study Design: Cross-sectional analytical study.

Place and Duration of Study: The study was carried out at the Intensive Care Unit (ICU) of Combined Military Hospital (CMH), Peshawar, Pakistan from March 2021 to July 2021.

Materials and Methods: This study was done on patients aged ≥18 years who were admitted to the intensive care unit and had a central venous line passed. Patients with lower extremity deep vein thrombosis, conditions associated with raised intra-abdominal pressure like pregnancy or recent laparotomy and those unable to lie supine were excluded. Central venous pressure was measured by a manual manometer. Femoral vein diameter was also measured in horizontal and vertical dimensions at the bedside and the mean was calculated.

Results: There were 150 patients, including 109 (72.7%) males and 41 (27.3%) females, with a mean age of 36.53 ± 13.83 years. Mechanical ventilation was given to 17 (11.33%) patients. The mean central venous pressure and femoral vein diameter were 8.82 ±3.87 cm and 9.36 ± 3.14 cm, respectively. The overall regression was statistically significant (r=0.407, p<0.001). Femoral vein diameter significantly predicted central venous pressure (0.502, p<0.001).

Conclusion: Femoral vein diameter can be used as a bedside non-invasive method to determine central venous pressure.

Keywords: *Central Venous Catheterization, Central Venous Pressure, Critical Illness, Septic Shock.*

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Introduction

Fluid resuscitation in intensive care patients remains one of the most challenging tasks for physicians. As excessive intravenous fluid will lead to fluid overload, increased mortality and renal insult.[1] A meta-analysis by Chen et al. in 2020 concluded that raised central venous pressure was linked to increased mortality and acute kidney injury in intensive care patients.[2] Fluid resuscitation is one of the cornerstones of treatment for septic shock. Yet, two-thirds of the patients end up having fluid overload on the first day.[3] To encounter this issue, fluid status should be assessed through central venous pressure (CVP) monitoring. The gold standard is pulmonary artery catheterization but because of its invasiveness and requirement of a specialized setup, this method is not widely used.

Intensivists use CVP for fluid management in hemodynamically unstable patients.[4] This is frequently done with a central venous catheter (CVC) placed in an internal jugular vein or subclavian vein. CVC can also be used for administering certain drugs like chemotherapy agents, vasopressors, potassium replacement and total parental nutrition.[5] CVC insertion is an invasive procedure associated with serious mechanical, thromboembolic or infectious complications, both in the short and long term.[6] It has been estimated that these complications could occur in one out of every six patients getting a central venous line.[7]

Non-invasive methods like clinical examination of jugular venous pressure measurement show

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unreliable results of CVP estimation.[8] In recent years, many different novels and advanced non-invasive methods have been proposed for the estimation of central venous pressure, like near- infrared spectroscopy, and venous congestion meter.[9,10] These models need specialized training and a lot more research before they could be recommended for clinical use as a surrogate marker of central venous pressure.

The widely used, non-invasive and reliable method is the ultrasonographic use of the inferior vena cava collapsibility index. It has been shown to have a good correlation with CVP in many previous studies.[11] It is often difficult to visualise this blood vessel, especially in wounded, obese or pregnant patients. Amongst 40 mixed medical and surgical patients from two American intensive care units, Kent et al have shown a weak correlation between collapsibility indices of the femoral vein and inferior vena cava.[12] They suggested using femoral vein collapsibility as a second-line method in case of emergency. Considering the ease associated with scanning the femoral veins, we have focused on femoral vein diameter for the estimation of central venous pressure in critically ill patients in this study. The results would help identify a non-invasive marker that could provide an accurate assessment of fluid status and yet avoid potential complications associated with an invasive procedure.

Materials and Methods

This cross-sectional study analytical study was carried out in intensive care unit (ICU) of Combined Military Hospital Peshawar, Pakistan from March 2021 to July 2021. It was approved by the Ethical Review Committee of Combined Military Hospital Peshawar via serial no 05 dated 13th Nov 2020. The sample size calculation was done using an online calculator.[13] Assuming one predictor, a medium effect (effect size 0.39), power 0.8 and a 5% significance level, there was a requirement for a minimum of 54 cases to be included in this study. The study adopted a non-probability convenience sampling technique in sample selection. The following inclusion/exclusion criteria were used:

All adult patients admitted to the medical or surgical Intensive Care Unit who had central line catheters in situ for therapeutic purposes were included.

Those with deep vein thrombosis or any condition with raised intra-abdominal pressure like pregnancy or laparotomy were excluded. Patients who were unable to lie supine were also excluded from our study.

Informed consent was taken from the patients or the attendants in case of unconscious patients. Demographic parameters were noted. A central venous catheter (CVC) had already been passed for any condition like fluid resuscitation or drug administration, as decided by the intensivist. Two doctors well versed with the procedure were assigned roles to independently measure CVP and the femoral vein diameters on the same patient simultaneously. To avoid biased results, both were blinded to each other readings. Central venous pressure was measured manually using a manometer with the patient lying flat. For mechanically ventilated patients, one-third of positive end-expiratory pressure being applied at the time of CVP measurement was subtracted from this reading to give the adjusted CVP. Esaote MyLab™ Seven ultrasound machine was used to measure the right femoral vein diameter. Femoral blood vessels were identified in the upper thigh keeping the inguinal ligament as a landmark. The femoral vein lies medial to the femoral artery. It was also confirmed by the complete compressibility of the vein with the linear ultrasound probe. The probe was held against the skin using the least possible pressure. After excluding the deep vein thrombosis (DVT) femoral vein diameter was measured in both vertical and horizontal dimensions just proximal to where the superficial femoral vein joins the femoral vein. The mean of these two dimensions was considered as femoral vein diameter for the purpose of this study.

Data were analyzed with IBM Social Package for Social Sciences (SPSS) version 23. Quantitative variables were described as mean ± standard deviation. Linear regression analysis was done to determine if femoral vein diameter could predict central venous pressure. A p-value < 0.05 was taken as statistically significant.

Results

There were 150 patients in this study, including 109 (72.7%) males and 41 (27.3%) females. Their mean age was 36.53 ± 13.83 years. Specialty wise breakdown of these patients is shown in Table 1.

Table 1: Frequencies of indoor patients in the intensive care unit

Sr No	Specialty	Frequency
1.	Surgery	70 (46.67%)
2.	Medicine	54 (36.00%)
3.	Orthopedics	15 (10.00%)
4.	Gynecology	11 (7.33%)

Mechanical ventilation was done in 17 (11.33%) patients. The mean CVP was 8.82 ±3.87 cm, whereas the mean femoral vein diameter was 9.36 ± 3.13 cm. The relationship between CVP and femoral vein diameter is shown in Figure 1. The overall regression model was statistically significant (r=0.407, p<0.001). The following equation could be used to determine CVP from femoral vein diameter:

CVP= 4.12+ (0.50 X femoral vein diameter)

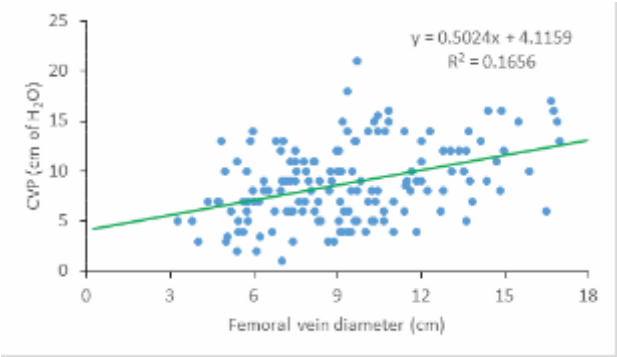

Fig 1: Linear regression between femoral vein diameter and CVP

Discussion

Our study showed a significant correlation between invasive CVP measurement and a non-invasive assessment of femoral vein diameter using ultrasonography.

Fluid resuscitation is an increasingly important factor in the management of critically ill patients and non-invasive techniques have been proposed as a fundamental tool for the evaluation of fluid status nowadays. This provides an immediate initial fluid evaluation in patients with shock exclusively in distributive and hypovolemic. A passive leg raising test can be performed and studies have shown its effectiveness in assessing response of cardiac output to fluid resuscitation.[14] It has its own inherent limitations, as there is a need for a couple of staff members and is impossible in wounded or amputated patients and those having deep venous thrombosis. Ultrasound evaluation of the inferior vena cava collapsibility index is yet another non-invasive and inexpensive method. Inferior vena cava pressure varies with respiration and position, so its use is more pronounced in mechanically ventilated patients.[15] A systemic review of 17 studies on a total of 533 patients by Long et al showed a limited role of inferior vena cava collapsibility index in predicting response to fluid challenge amongst spontaneously breathing patients.[16]

To overcome these hurdles, we selected a more peripherally and superficially placed large vessel that can be easily assessed by ultrasound and is also not affected by respiration or mechanical ventilation. It does not require any specialized training. We measured both vertical and horizontal dimensions of the femoral vein so as to eliminate any possible effect of transducer pressure on the vessel wall. A single doctor measured femoral vein diameters for all patients to avoid interobserver variability. Our study showed that mean femoral vein diameter could be used as an alternative bedside method for assessing CVP in critically ill patients. These results are supported by a cohort study done on 108 patients at Shifa International Hospital Islamabad by Malik et al.[17] There was a strong correlation between sonographic femoral vein diameter and CVP measurement. Our study further supported the conclusions made by these authors. They had suggested that small sample size could lead to the overfitting of a regression model. We enrolled a greater number of patients, to ensure that this study is adequately powered. The degree of correlation between CVP and femoral vein diameter, though statistically significant, was weaker than that observed in the study quoted. A similar study carried out by Cho et al. on 97 mechanically ventilated patients in Minnesota demonstrated a moderate correlation between femoral vein diameter and CVP measurement (r= 0.66).[18] Another recent study done on 130 Chinese patients by Ma et al. showed that the ratio of the femoral vein and femoral artery diameters had a strong correlation with central venous pressure.[19]

This is a single-center study focusing on critically ill patients only. Thus, caution needs to be exercised when generalizing the results to patients from other setups or with different disease severity. This is

important considering the variations in clinical presentations of patients at different healthcare setups. We did not account for age, gender, the height of body mass index of the patients while analyzing the data, and factors that could directly affect the femoral vein diameter.[20] Not all of these patients were on ventilatory support during data collection. For patients on mechanical ventilation, we adjusted the CVP for the positive end expiratory pressure. Still, given the small number of patients on mechanical ventilation, we are not sure if the results, especially the regression equation, would be impacted any further by mechanical ventilation.

Conclusion

There is a moderate correlation between the invasive central venous pressure measure and a non-invasive ultrasound-based femoral vein diameter so we can reliably use the latter as an alternative method for the assessment of fluid status in critically ill patients.

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