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Original Article

Correlation between Central Venous Pressure and Femoral Vein Diameter

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ABSTRACT

Objective: To determine the correlation between central venous pressure and femoral vein diameter.
Study Design: Cross sectional analytical study.
Place and Duration of Study: Surgical Intensive Care Unit, Combined Military Hospital (CMH), Rawalpindi Pakistan, from May to Sep, 2025.
Methodology: This study included 84 patients. Patients who were 18 years or older, on mechanical ventilation with central venous catheter passed in internal jugular or subclavian veins were included in study. Those with deep venous thrombosis, raised intraabdominal pressure were excluded. Central venous pressure (CVP) was measured with manual manometer technique and was recorded in 'centimetres of water' (cm H2O). Femoral vein diameter (FVD) was measured non-invasively with linear transducer below sapheno femoral junction and was recorded in 'centimetres' (cm). Both measurements were taken with patient in supine position and were recorded by two critical care medicine residents who were blinded to each other results.
Results: There was a moderate correlation between femoral vein diameter and central venous pressure (r=0.40, p<0.001). Regression result suggested that a 1cm increase in FVD was associated with a 5.32 cm increase in CVP and was significant at the 99%CI.
Conclusion: Considering a moderate correlation between central venous pressure and femoral vein diameter, FVD may be used as a marker for intravascular volume status however, further studies are needed.

Keywords: Central Venous Pressure, Femoral Vein, Ultrasound.

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INTRODUCTION

Fluid management has always been challenging in critically ill patients. Current guidelines for patients with septic shock advocate the administration of 30 ml/kg crystalloid bolus as part of initial resuscitation in hypotensive patients.[1] However, liberal fluid administration without simultaneous assessment of patient's fluid status leads to fluid overload that causes untoward effects like pulmonary edema and abdominal compartment syndrome.[2]

To overcome the problems associated with fluid balance, invasive techniques of hemodynamic monitoring were explored. Conventionally, pulmonary artery catheter was considered the gold standard; however due to its invasiveness, it was replaced by central venous catheterisation and central venous pressure (CVP) monitoring.[3] Apart from patients' fluid status, CVP is also affected by intra thoracic pressures, intra peritoneal pressure and valvular pathologies.[4] In addition, the insertion of central venous catheter for CVP monitoring has been associated with complications like infection, pneumothorax and venous thrombosis.[5] It is because of aforementioned reasons that the use of CVP to guide fluid resuscitation has declined.[5]

An alternative to CVP measurement is ultrasound of femoral vein. Beghum M *et al.*, conducted a study to find the correlation between CVP measured via catheter and femoral vein diameter (FVD) measured using ultrasound.[6] The study showed a significant correlation between CVP and FVD (r=0.407, p<0.001).[6] Another study conducted by Cho RJ *et al.*, found a moderate correlation between FVD and CVP (r=0.66, p<0.001).[7]

The purpose of this study was to establish whether diameter of femoral vein (measured non-invasively using ultrasound) correlates with central venous pressure (measured via central venous catheter). If a positive correlation can be established, then in future FVD can be used as an alternative to estimate patient's intravascular volume to guide fluid resuscitation, and complications 5 associated with insertion of CVC can be avoided.

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METHODOLOGY

This was an analytical cross-sectional study that was carried out in the surgical intensive care unit of Combined Military Hospital Rawalpindi, Pakistan from May, 2025 till September, 2025.

The sample size was calculated using "G*Power (version 3.1.9.7)" sample size calculator.[8] Assuming a minimum correlation (r) of 0.3 between femoral vein diameter and central venous pressure, a power of 0.8 and a type 1 error probability of 0.05, a minimum sample of 84 was required to assess the correlation between the continuous variables. Non probability convenient sampling technique was used.

Inclusion Criteria: Patients of either genders, males and females (above 18 years of age) who were mechanically ventilated and had central venous catheter placed in either internal jugular vein or subclavian vein were included.

Exclusion Criteria: Patients who had central venous catheter inserted in femoral vein or had deep venous thrombosis or had clinical signs of raised intra-abdominal pressure, were excluded.

After seeking permission from the hospital ethical committee (vide letter number 909, dated 13th July, 2025), the purpose of the study was explained to the attendant of the patient fulfilling the inclusion criteria and an informed written consent was obtained. Two critical care trainees with required competency independently measured central venous pressure and femoral vein diameter on the same patient simultaneously and were blinded to each other results. Both measurements were taken in supine position.

To perform ultrasound of femoral vein, Siemens ultrasound machine with linear transducer was used. 'Vascular' preset was chosen. The transducer was initially placed horizontally below and parallel to the inguinal ligament crease. The femoral artery was identified as pulsatile structure with femoral vein lying medial to it. To confirm that the vessel indeed was vein, compression technique was used. The transducer was then moved caudally and the site where the great saphenous vein drains into common femoral vein (anterior and medially) was identified (Figure-1A). The transducer was then moved slightly caudal and the site where the great saphenous vein could no longer be visualised was chosen as the point for measuring the diameter of the femoral vein in antero posterior direction (Figure-1B). FVD was recorded in centimetres (cm).

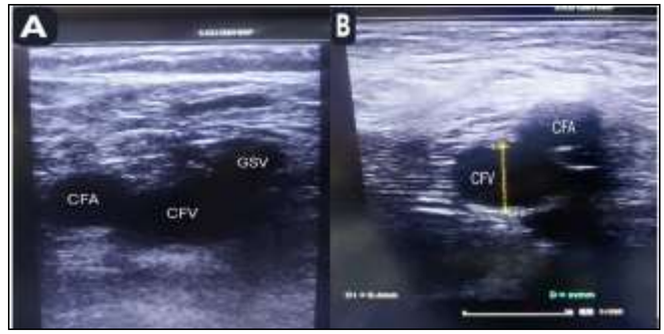

Figure-1: Ultrasound image of right femoral vein obtained by sliding probe in a caudal direction from inguinal ligament. (A) Transverse view of common femoral vein (CFV), common femoral artery (CFA) and great saphenous vein (GSV). (B) CFV identified at the site where GSV cannot be visualized; femoral vein diameter measured in ante posterior direction (as indicated by yellow dotted line)

To measure central venous pressure, manual manometer technique was used. The water manometer was connected to central venous catheter via a three-way stopcock. The zero point of manometer was aligned with patient's fourth inter costal space in the mid axillary line and CVP was recorded in 'centimetres of water (cm of H2O)' as the vertical height of manometer above the zero point.

Data collected was entered and analysed in STATA version 18. Frequency and percentages were calculated for qualitative variables whereas mean and standard deviation were measured for quantitative variables. Qualitative variables included gender and primary diagnosis. Quantitative variables include age, body mass index (BMI), mean arterial pressure, ventilator parameters, central venous pressure and femoral vein diameter. Correlation coefficient was calculated between central venous pressure (CVP) and femoral in diameter (FVD), the *p*-value of ≤0.05 was considered as significant.

RESULTS

The following results were calculated based on a sample size of 84 patients out of which 61(72.60%) were males and 23(27.40%) were females. Moreover, 27(32.14%) patients were of septic shock, 23(27.40%) of traumatic brain injury, 11(13.09%) post cardiac arrest, 12(14.28%) of seizures, and 11(13.09%) were diagnosed cases of pulmonary embolism. Demographic and clinical features are illustrated in Table. Figure-2 shows that there was a moderate correlation between FVD and CVP (r-value=0.40, *p*<0.001). Regression results also suggest that a 1 cm increase in FVD is associated with a 5.32 cm increase in CVP and was significant at the 99%CI. This association holds even when including demographic controls such as age, sex, and BMI ($\beta 1=4.87$, $p<0.01$), as illustrated in Figure-3. The mean central venous pressure and femoral vein diameter were 8.44±4.42 cm and 1.06±0.33 cm, respectively.

Table: Demographic Details and Ventilator Parameters (n=84)

Ventilator Parameters	Mean±SD
Age (years)	47.13±17.09
Body Mass Index (kg/m2)	24.14±4.600
Intensive Care Unit Characteristics	
Mean Arterial Pressure (mmHg)	71.69±13.83
Tidal (ml/IBW)	6.795±0.913
Fraction of Inspired Oxygen (FiO2)	0.657±0.267
Positive End Expiratory Pressure PEEP (cmH2O)	5.595±1.651

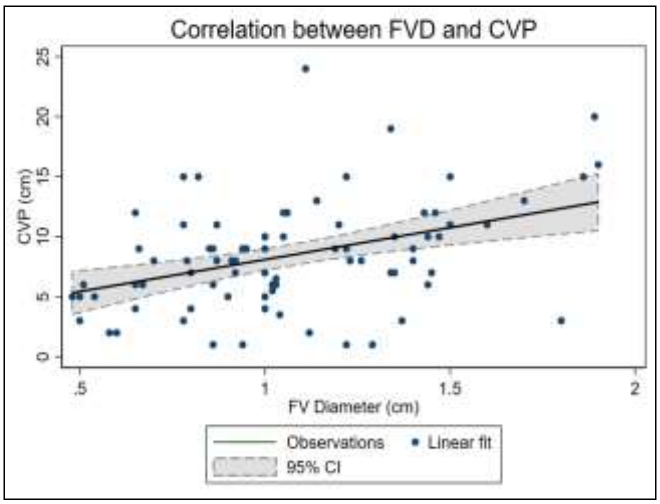

Figure-2: Linear regression relationship of Femoral Vein Diameter (FVD) residuals versus Central Venous Pressure (CVP) residuals, without Controls (n=84)

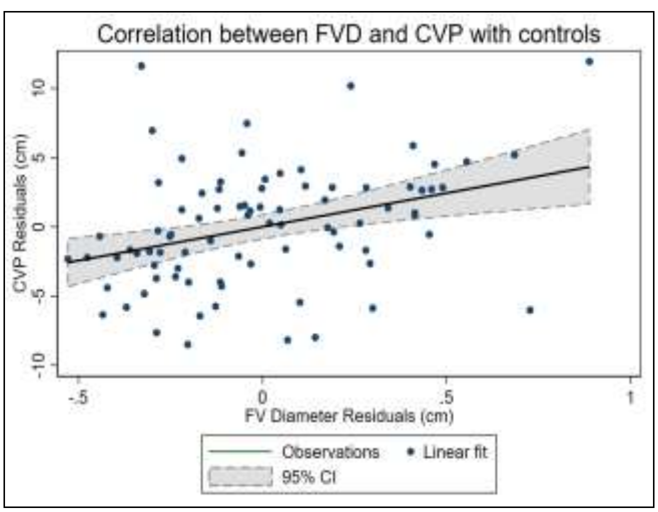

Figure-3: Linear regression relationship of Femoral Vein Diameter (FVD) residuals versus Central Venous Pressure (CVP) residuals, with Controls (n=84)

DISCUSSION

In critical care settings, assessment of intravascular volume is challenging and several studies have stressed the importance of adverse outcomes associated with over aggressive resuscitation in terms of 'fluid accumulation syndrome'.[9] There are several studies that have proved association between aggressive fluid resuscitation and increase in overall mortality, both in adults and paediatric age group likewise.[10,11] One such example is the detrimental effects of hypervolemia observed in cases of Covid 19 infection complicated by Acute Respiratory Distress Syndrome (ARDS).[12]

Central venous catheterization involves cannulation of internal jugular, subclavian or femoral veins. The lumen of catheter is connected through saline fluid column to a transducer that is placed at the level of right atrium and the waveform is displayed on a monitoring device.[3] Conversely, it can also be measured manually using water manometer.[4] The normal CVP ranges from 8-12 and it is an estimate of right atrial pressure.[3] Low CVP indicates hypovolemia whereas high CVP indicates fluid overload.

Lately, the use of ultrasound to measure the diameter of inferior vena cava (IVC) as indicator of intravascular volume status has been advocated as a non-invasive technique.[13] The diameter is measured typically 2 centimetres from the junction of IVC with the right atrium.[14] Both static diameter as well as the variations in diameter of IVC that occur with phases of respiration have been used. In spontaneously breathing patients, the collapsibility index is calculated whereas in patients who are on mechanical ventilation distensibility index is used.[13,14] However, volume status is not the only factor that affects IVC diameter. It is affected by changes in intra thoracic pressure, changes in intra-abdominal pressure, arrhythmias like atrial fibrillation and abnormalities in right heart function. Because of the aforementioned confounding factors, and the expertise required to visualize IVC, the reliability of use of IVC ultrasound as a measure of intravascular volume status has now been questioned in several studies.[13,14]

There has always been keen interest in investigating use of inferior vena cava (IVC) ultrasound as an alternative to measurement of central venous pressure to assess the patient's volume status and overall in critical care, the use of inferior vena cava (IVC) diameter as an indicator of fluid status has been more extensively studied as compared to femoral vein diameter.[15,16] However , the advantage of using femoral vein diameter as compared to inferior vena cava diameter include its ease of visualisation due to superficial location of femoral vein, and also the fact that FVD is not affected by intra thoracic pressures when compared to IVC diameter.[6,7] This study was conducted to establish degree of correlation between femoral vein diameter calculated using simple ultrasound and central venous pressure measured using central venous catheter inserted in internal jugular veins. Overall it found a moderate correlation between FVD and CVP (r=0.40, p<0.0001). Results of my study are comparable with study conducted by Beghum et al in which relationship between FVD and CVP was investigated in both spontaneously breathing and mechanically ventilated patients and according to that study there was moderate correlation between the two parameters (r=0.407, p<0.001).[6] This study also proposed an equation to calculate CVP from FVD: CVP= 2.77+ (5.32 X femoral vein diameter).[6] Cho *et al.,* conducted a similar study which showed that there was a moderate correlation between FVD and CVP (r=0.66, p=0.001).[7] According to results of that study, CVP of 10 mm Hg was best predicted by femoral vein diameter of less than 0.8 cm. Low CVP was indicated by FVD of less than 0.7 cm whereas high CVP was indicated by FVD of 1.2 cm.[7]

Another study carried out in Shifa International Hospital concluded that CVP is highly correlated to femoral vein diameter and suggested the following equation: CVP (cmH2O) = -0.039+10.718* FVD.[17]

In another study carried out in intensive care unit in China, ultrasound was used to measure femoral vein diameter (FVD) and femoral artery diameter (FAD) in patients who had either central venous catheter or swan ganz catheter inserted for invasive hemodynamic monitoring.[18] The FVD/FAD ratio was recorded along with measurements of central venous pressure (CVP) and mean pulmonary artery pressure (mPAP). The FVD/FAD ratio was strongly correlated with CVP (r=0.87, p<0.001) and mPAP (r=0.73, p<0.001).[18] This study concluded that FVD/FAD ratio could be used as a non-invasive parameter of volume assessment. Yet another study carried out in the intensive care department in Egypt found out that CVP correlation with FVD was 0.59 and with IVC diameter (during inspiration) was 0.41.[19]

Although the aforementioned studies support the results of my study, it has certain limitations. Firstly, the study enrolled only those patients who were mechanically ventilated and so it cannot ascertain whether the correlation holds true in spontaneously breathing awake patients as well or not. Secondly, the manometer technique was used to measure CVP and although it is one of the established techniques, there is always the possibility of inter observer variability with this method when compared to the electronic transducer method of CVP measurement. Thirdly, the sample might be said to be biased as there were different number of cases of either gender, or different number of cases of each primary diagnosis. Finally as the measurements were taken only in supine position and in patients without intra-abdominal hypertension, this study cannot reliably suggest that the correlation will be similar in different body positions and in patients with raised intra-abdominal pressure.

CONCLUSION

There is moderate correlation between central venous pressure measured invasively with central venous catheter and femoral vein diameter measured non-invasively with ultrasound. However further studies are needed to establish FVD as a reliable indicator of intravascular volume status.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

FTS & AMKB: Data acquisition, data analysis, critical review, approval of the final version to be published.

SK: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Evans L, Rhodes A, Alhazzani W, Antonelli M, Coopersmith CM, French C, et al. Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021. Intensive Care Med 2021; 49(11): 1063-143. https://doi.org/10.1097/CCM.0000000000005337
2. De Backer D, Aissaoui N, Cecconi M, Chew MS, Denault A, Hajjar L, et al. How can assessing hemodynamics help to assess volume status? Intensive Care Med 2022; 48(10): 1482-1494. https://doi.org/10.1007/s00134-022-06808-9
3. Gawalkar AA, Batta A. Ultrasound based estimate of central venous pressure: are we any closer? World J Cardiol 2024; 16(6): 310-313. https://doi.org/10.4330/wjc.v16.i6.310
4. Hill B, Smith C. Central venous pressure monitoring in critical care settings. Br J Nurs 2021; 30(4): 230-236. https://doi.org/10.12968/bjon.2021.30.4.230

5. Tolson OW. Should central venous pressure be used to guide critical care management? Br J Hosp Med 2022; 83(10): 1-3. https://doi.org/10.12968/hmed.2022.0167
6. Begum M, Arshad AR, Hussain A, Khalid A. Is femoral vein diameter a reliable marker of central venous pressure? Life Sci 2023; 4(2): 4. https://doi.org/10.37185/LnS.1.1.272
7. Cho RJ, Williams DR, Leatherman JW. Measurement of femoral vein diameter by ultrasound to estimate central venous pressure. Ann Am Thorac Soc 2016; 13(1): 81-85. https://doi.org/10.1513/AnnalsATS.201506-337BC
8. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007; 39(2): 175-191. https://doi.org/10.3758/BF03193146
9. Pfortmueller CA, Dabrowski W, Wise R, van Regenmortel N, Malbrain ML. Fluid accumulation syndrome in sepsis and septic shock: pathophysiology, relevance and treatment—a comprehensive review. Ann Intensive Care 2024; 14(1): 115. https://doi.org/10.1186/s13613-024-01336-9
10. Fernández-Sarmiento J, Sierra-Zuñiga MF, González MP, Lucena N, Lanziotti VS, Agudelo S. Association between fluid overload and mortality in children with sepsis: a systematic review and meta-analysis. BMJ Paediatr Open 2023; 7(1): e002094. https://doi.org/10.1136/bmjpo-2023-002094
11. Ding X, Chen B. Effect of aggressive intravenous fluid resuscitation versus nonaggressive fluid resuscitation in the treatment of acute pancreatitis: a systematic review and meta-analysis. Pancreas 2023; 52(2): e89-e100. https://doi.org/10.1097/MPA.0000000000002230
12. Rodríguez-Moguel N, Osuna-Padilla IA, Piekarska KB, Negrete-García MF, Hernández-Muñoz A, Contreras-Marín JA, et al. Fluid status assessment in critically ill patients with COVID-19: a retrospective cohort study. J Clin Med 2024; 13(2): 540. https://doi.org/10.3390/jcm13020540
13. Coutinho AL, Barbosa RH, Lopes MR, Tenório AP. Inferior vena cava ultrasound for assessing volume status and fluid responsiveness in critically ill patients: a systematic review. Arq Bras Cardiol: Imagem cardiovasc. 2021; 34(3): 193. https://doi.org/10.47593/2675-312X/20213403eabc193
14. Di Nicolò P, Tavazzi G, Nannoni L, Corradi F. Inferior vena cava ultrasonography for volume status evaluation: an intriguing promise never fulfilled. J Clin Med 2023; 12(6): 2217. https://doi.org/10.3390/jcm12062217
15. Singh DR, Thapa AS, Limbu Y, Pandey S, Shrestha S. Correlation of inferior vena cava diameter and IVC collapsibility index with central venous pressure (CVP) in critically ill surgical patients. J Soc Surg Nepal 2021; 24(1): 19-22. https://doi.org/10.3126/jssn.v24i1.41005
16. Hakim DD, Meilyana F, Peryoga SU, Arniawati I, Wijaya EA, Martiano MR. Usefulness of non-invasive parameters (inferior vena cava diameter, inferior vena cava collapsibility, inferior vena cava-aortic ratio) for hemodynamic monitoring in critically ill children: a systematic review. Med Dev Evid Res 2024: 123-133. https://doi.org/10.2147/MDER.S454849
17. Malik A, Akhtar A, Saadat S, Mansoor S. Predicting central venous pressure by measuring femoral venous diameter using ultrasonography. Cureus 2016; 8(11): e893. https://doi.org/10.7759/cureus.893
18. Ma Z, Gai J, Sun Y, Bai Y, Cai H, Wu L, Sun L, et al. Measuring the ratio of femoral vein diameter to femoral artery diameter by ultrasound to estimate volume status. BMC Cardiovasc Disord 2021; 21(1): 506. https://doi.org/10.1186/s12872-021-02309-7
19. Zidan D, Baess A. Comparison between femoral vein diameter and inferior vena cava diameter by ultrasound in estimation of central venous pressure in mechanically ventilated patients. Res Opin Anesth Intensive Care 2020; 7(1): 100-103. https://doi.org/10.4103/roaic.roaic_1_19

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