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EDITORIAL

Ultrasound based estimate of central venous pressure: Are we any closer?

Atit A Gawalkar, Akash Batta

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Atit A Gawalkar, Department of Cardiology, Fortis Hospital, Himachal Pradesh, Kangra 176001, India

Akash Batta, Department of Cardiology, Dayanand Medical College and Hospital, Punjab, Ludhiana 141001, India

Corresponding author: Akash Batta, MD, Assistant Professor, Senior Scientist, Department of Cardiology, Dayanand Medical College and Hospital, Tagore Nagar, Civil Lines, Punjab, Ludhiana 141001, India. akashbatta02@gmail.com

Abstract

Central venous pressure (CVP) serves as a direct approximation of right atrial pressure and is influenced by factors like total blood volume, venous compliance, cardiac output, and orthostasis. Normal CVP falls within 8-12 mmHg but varies with volume status and venous compliance. Monitoring and managing disturbances in CVP are vital in patients with circulatory shock or fluid disturbances. Elevated CVP can lead to fluid accumulation in the interstitial space, impairing venous return and reducing cardiac preload. While pulmonary artery catheterization and central venous catheter obtained measurements are considered to be more accurate, they carry risk of complications and their usage has not shown clinical improvement. Ultrasound-based assessment of the internal jugular vein (IJV) offers real-time, non-invasive measurement of static and dynamic parameters for estimating CVP. IJV parameters, including diameter and ratio, has demonstrated good correlation with CVP. Despite significant advancements in non-invasive CVP measurement, a reliable tool is yet to be found. Present methods can offer reasonable guidance in assessing CVP, provided their limitations are acknowledged.

Key Words: Central venous pressure; Internal jugular vein; Point of care ultrasound; Shock; Volume status; Fluid balance

Core Tip: Central venous pressure (CVP) serves as a direct approximation of right atrial pressure and is influenced by factors like total blood volume, venous compliance, cardiac output, and orthostasis. Normal CVP falls within 8-12 mmHg but varies with volume status and venous compliance. Monitoring and managing disturbances in CVP are vital in patients with circulatory shock or fluid disturbances. Despite significant advancements in non-invasive CVP measurement, a reliable tool is yet to be found. Present methods can offer reasonable guidance in assessing CVP, provided their limitations are acknowledged.

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INTRODUCTION

Central venous pressure (CVP) is crucial for assessing hemodynamic status, particularly in the intensive care unit. It is a direct approximation of the right atrial pressure and is influenced by various factors, including total blood volume, compliance of the central venous compartment, cardiac output, orthostasis, arterial dilation, and preload. CVP reflects the amount of blood returning to the heart and the ability of the heart to pump. A normal CVP reading is between 8 and 12 mmHg, but this value is altered by volume status and venous compliance. Changes in CVP can impact cardiac output, and elevated CVP is associated with impairment of microcirculatory blood flow. CVP is critical in regulating fluid distribution, cardiac output, and organ perfusion. Monitoring and managing CVP is essential in the clinical assessment and treatment of patients, particularly those with circulatory shock or fluid volume disturbances. Due to the hydrostatic pressure gradient, an increase in CVP can lead to fluid accumulation in the third space, such as the interstitial space. Conversely, decreasing CVP can result in fluid reabsorption from the third space into the vascular compartment. An elevated CVP can impede venous return to the heart, reducing cardiac preload and decreasing cardiac output. On the other hand, a low CVP can lead to an increase in venous return and cardiac preload, potentially augmenting cardiac output.

MEASURING CVP

Quantifying CVP accurately is difficult in clinical situation and disturbances are easy to miss unless obvious[1]. The state of congestion can be due to cardiac dysfunction, renal disease, liver disease, thyroid disease or drug related. Timely recognition is crucial for its management. Clinical signs, biomarkers, and invasive and non-invasive radiological measurements have been used to estimate the CVP. Classically, pulmonary artery catheter guided measurements were the gold standard for monitoring hemodynamic pressures and cardiac output. However studies have failed to demonstrate improvement in outcomes in critically ill[2]. Subsequently central venous catheters were considered as less invasive alternatives. Despite their invasive nature, they showed poor predictive value for fluid responsiveness and were affected by various conditions like right ventricular function, tricuspid regurgitation, isolated left heart diseases and variation in intrathoracic pressure with respiration[3]. They also carried risk of complications like vessel injury, infection, pneumothorax, thrombosis and arrhythmias. In the era of evidence-based medicine, measuring CVP has remained an imperfect science even with invasive modalities. In search of more noninvasive ways, ultrasound guided assessment have attracted huge attention.

The role of ultrasound-based internal jugular vein (IJV) assessment is multifaceted and provides real-time, non-invasive measurement of static and dynamic parameters. Unlike invasive methods like central venous catheterization, ultrasound-based assessment is non-invasive, reducing patient discomfort and risk of complications. The most significant advantage of IJV assessment over inferior vena cava (IVC) assessment is its superficial location, making measurements easier and more accurate. IVC, on the other hand, is deeply placed in the abdominal compartment, susceptible to influence from abdominal pathologies like ascites and mass lesions.

The shape and dimension of IJV depend on the extra venous soft tissue pressure and the intravenous expanding pressure. At a certain point distally into IJV, the intravenous expanding pressure is less than the extra venous pressure, resulting in collapse of the vein. This is the sonographic meniscus point of blood column or point of venous collapse. Ultrasound-guided detection of this level is the simplest way of estimating the CVP, which is the radiological extrapolation of the classic bedside clinical method. Additionally, the ultrasound can measure the exact right atrial depth in the same sitting, effectively augmenting the efficacy over the conventional clinical assumption of right atrium height, *i.e.* 5 cm. A more straightforward method uses the measure of circularity of the vein to infer less than 10 mmHg of pressure when the ratio of anteroposterior diameter to transverse diameter is less than 0.75. The review article by Chayapinun *et al*[4] explains the various methods of measuring CVP using ultrasound assessment of IJV. They also explain in detail different dynamic methods to predict fluid responsiveness, like collapsibility index (respiratory variation) and distensibility index (response to fluid)[5,6]. In contrast to static measurements, they do not predict exact pressure but are excellent at predicting response to fluid administration or decongestive measures.

When IJV and IVC measurements were compared with CVP, it has been found that IVC diameter, IJV ratio and IJV maximum diameter had good agreement[7]. The commonly used IVC collapsibility index did not show good correlation. Of all the measures, the IJV diameter showed excellent accuracy in predicting a low CVP[7]. Another study in spontaneously breathing patients showed that the maximal IVC diameter provided the most robust estimate of CVP when compared to IVC collapsibility and IJV measurements[8].

In a recent meta-analysis comprising of 1928 patients, the predictive value of IJV based ultrasound assessment for diagnosing hypovolemia was excellent (both sensitivity and specificity of 82%)[9]. Measurement of IJV collapsibility indices had higher diagnostic accuracy. Similarly, for the diagnoses of hypervolemic conditions and fluid overload, IJV based ultrasound assessment had an acceptable predictive power (sensitivity of 84% and specificity of 70%). Hence the role as per larger evidence is only moderate. Non-ultrasound-based techniques have also been studied in the assessment of congestion which can have practical utility in nursing and home care settings. VenCoM device uses the principle of venous occlusive plethysmograph for measuring the CVP and is currently being studied[10]. ezCVP device uses oscillometric method to reliably measure CVP[11].

Although the ultrasound guided assessment is useful, all these methods need a high level of skills for measurement and, more importantly, interpretation. The presence of downstream pathologies like tricuspid regurgitation or stenosis, venous thrombosis or external occlusion, and atrial septal defect makes the method unreliable. Specific clinical situations like ongoing surgeries requiring a fixed positioning might render the technique less reliable.

CONCLUSION

Although much advancement has been made in non-invasively measuring CVP, the journey is yet to find a reliable tool. Currently, available methods can fairly guide CVP assessment, provided the shortcomings are considered.

FOOTNOTES

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Country of origin: India

ORCID number: Atit A Gawalkar 0000-0003-1625-7436; Akash Batta 0000-0002-7606-5826.

Corresponding Author's Membership in Professional Societies: American College of Cardiology, No. 3445007; European Society of Cardiology, No. 1036629.

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