

Estimation of Central Venous Pressure by Ultrasound of the Internal Jugular Vein

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This article describes a simple, new technique using ultrasound (US) to estimate central venous pressure (CVP). The sonographic patterns of the internal jugular vein (IJV) with a low, normal, and elevated CVP are also described. Although bedside visual inspection of the height of the jugular veins as an estimate of CVP has been an integral part of the physical examination, its major limitation has been that the jugular veins are not always observable. In obese patients, a layer of fat often obscures the jugular pulsations. US has proven to be a powerful tool to noninvasively visualize neck veins in the emergency department. Bedside US of the IJV, performed by emergency physicians, provides immediate, important information that cannot be obtained without invasive catheters. (*Am J Emerg Med* 2000;18:432-434. Copyright © 2000 by W.B. Saunders Company)

Almost 7 decades have passed since Sir Thomas Lewis described a technique for estimating the central venous pressure (CVP) by measuring the height of the column of blood in the jugular veins.¹ Since then, evaluation of the neck veins for distention has been an integral part of the physical examination. One major limitation of this technique is that the jugular veins are not always visible, even to the trained observer.² Ultrasound (US) has proven to be a powerful tool to noninvasively visualize neck veins in the emergency department (ED).^{3,4} The use of real-time US in the ED to determine elevated jugular venous pressure in a patient without obvious neck vein distention has recently been described.⁵ It is an extremely simple method that emergency physicians could quickly master. This article will describe how to use US to measure CVP as well as the sonographic patterns of the internal jugular vein (IJV) with low, normal, and elevated central venous pressures.

MEASUREMENT OF CENTRAL VENOUS PRESSURE

For centuries, clinicians have noted the relationship of the jugular pulse to cardiac activity. It was not until the

beginning of the 20th century that direct measurement of the right atrial pressure was accomplished.⁶ A noninvasive bedside approach to assess the CVP was clearly needed. It was proposed that the CVP could be estimated by using the jugular veins as manometer tubes to the right atrium.¹ Two points on the patient are required to determine the height of the column of blood in the jugular veins. The first point is the position of the right atrium or "zero reference point." Because this site cannot be directly located on the thorax, the angle of Louis is commonly substituted. This landmark, which is at the junction of the manubrium and body of the sternum, usually lies 5 cm directly above the right atrium regardless of the angle at which that the patient is reclining.⁷ The second point corresponds to the top of the column of blood in the jugular vein and is obtained by visualizing its point of collapse. The vein at this point will show oscillations related to the cardiac cycle, manifesting clinically as jugular pulsations. Above this point, the vein is collapsed; below this point, the vein is distended and nonpulsatile. This is the point which can be located using real-time US. The vertical distance between the top of the jugular pulse and the angle of Louis is measured; 5 cm is added to equal the CVP in centimeters of H₂O.

Which vein should be measured, the IJV or the external jugular vein (EJV)? The EJV is certainly easier to visualize, but because of its tortuous course, competent valves and small size it may not accurately transmit the pressure from the right atrium. When CVP estimates from both the IJV and EJV were compared with actual measured pressures in ICU patients, the IJV was more accurate but was visible only 20% of the time.⁸ The right IJV is preferred; it is a large vessel with a straight line to the superior vena cava.⁹

Obese patients represent a significant challenge as a thick layer of fat attenuates the jugular pulsations. Another difficult situation occurs when the CVP is greater than 25 cm of water and the top of the column of blood is located above the angle of the mandible.¹⁰ The venous pulsations may not be visible, even in a sitting position. Fortunately, these situations pose no difficulty for real-time US.

ULTRASOUND OF NECK VEINS

The IJV is easily visualized by real-time US in the supine patient.^{3,4,11} Because of the superficial location of the IJV, it is best viewed with a high-frequency linear transducer (7 to 9 MHz). The IJV is located just under the sternocleidomastoid muscle and anteriolateral to the common carotid artery

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(CCA). In the transverse plane, the IJV appears as an anechoic (black) oval structure on both sides the neck (Figure 1). The CCA is also anechoic but it is rounder than the adjacent IJV, has “sharper” pulsations in real-time and is not compressible. An increase in the size of the IJV, but not the CCA, can be obtained by placing the patient in the head-down position or by having the patient perform the Valsalva maneuver¹² (Figure 2). The EJV is usually not visualized sonographically because of its small size and marked compressibility.

ULTRASOUND OF NECK VEINS WITH NORMAL CVP

As the patient with a normal CVP (0 to 10 cm of H₂O) assumes a semiupright position, the pressure in the jugular vein falls. At some point in the neck, the extravascular tissue pressure is greater than the local venous pressure and the vessel collapses. In the longitudinal plane, the shape of the IJV in this transitional zone resembles a wine bottle with a wide inferior base tapering to a narrow superior neck (Figure 3). It is in this tapering portion of the IJV that the vein walls will appear to flutter in real-time. This is the site of the jugular venous pulse. The most superior point of this tapering portion is the location of vein collapse and is the sonographic equivalent of the top of the column of blood in the jugular vein. Occasionally, this point has been referred to as a “meniscus.”² It is an inaccurate analogy, because a true meniscus does not exhibit this tapering shape. In the sitting position, the patient with a normal CVP will have an IJV that is almost completely collapsed. In the transverse plane it will either be nonvisualized or appear as a small crescent or slit (Figure 4). The IJV will transiently distend with forced expiration or Valsalva but will promptly collapse with normal respiration. In the semiupright position with a normal CVP, the top of the column of blood will be inferior to the clavicles and the IJV will be collapsed in the middle of the neck. The reclining angle must be lowered until the IJV becomes distended. The vein should be visualized by scanning the neck in the transverse plane. The probe is then moved in a superior direction on the neck to locate the point

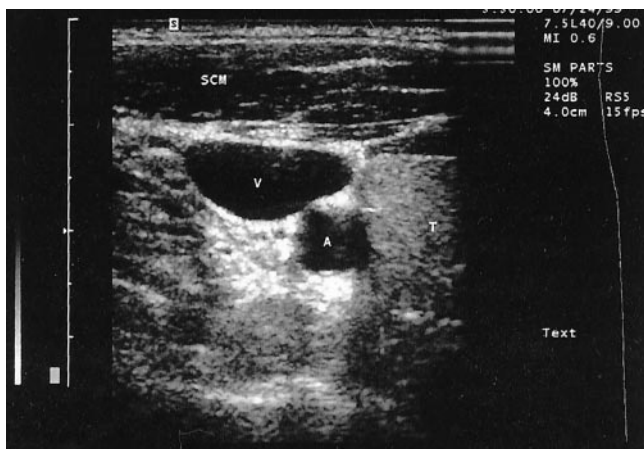


FIGURE 1. Transverse view of the right side of the neck in the supine position showing the internal jugular vein (V), the common carotid artery (A), the overlying sternocleidomastoid muscle (SCM), and the more medial thyroid gland (T).

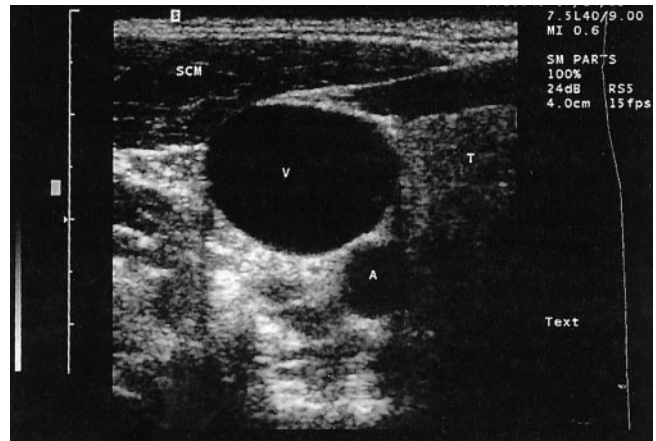


FIGURE 2. Transverse view of the right side of the neck showing the enlargement of the internal jugular vein (V) with the Valsalva maneuver.

of vein collapse. The point under the transducer on the neck is marked. The vertical distance in cm between this point and the angle of Louis is measured; 5 cm is added to obtain the estimated CVP.

ULTRASOUND OF NECK VEINS WITH ELEVATED CVP

If the CVP is elevated above 10 cm of H₂O, the IJV becomes distended, even in the semiupright position. Scanning the midneck in the transverse plane, the IJV will assume an oval or round appearance. With the patient in a semiupright position it will appear as large or larger than the adjacent CCA (Figure 1). Occasionally, a patient with an extremely elevated CVP (above 20 cm of H₂O) must be scanned in the standing position to locate the point of vein collapse between the clavicle and the angle of the mandible. Again, the vertical distance between the point of collapse and the angle of Louis is measured; 5 cm is added to obtain the estimated CVP.

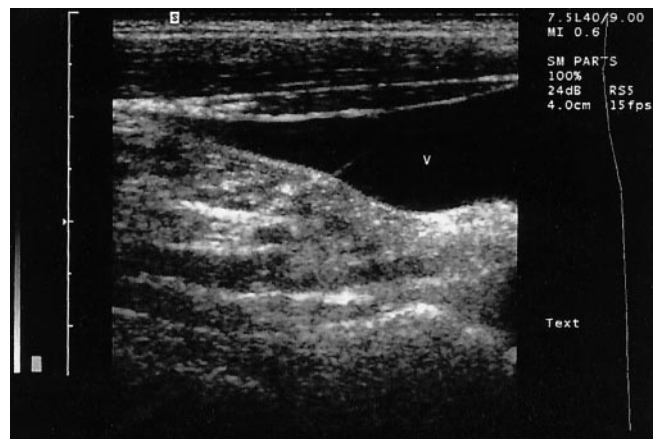


FIGURE 3. Longitudinal view of the neck showing the tapering portion of the internal jugular vein (V). This is where jugular pulsations are present in real-time.

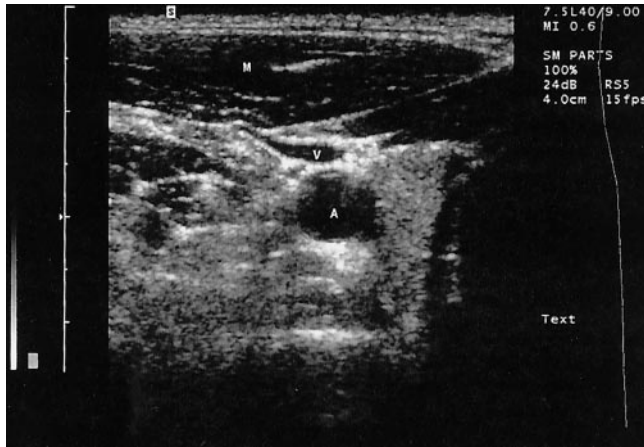


FIGURE 4. Transverse view of the right neck showing a collapsed internal jugular vein (V).

ULTRASOUND OF NECK VEINS WITH LOW CVP

If the CVP is very low (less than 0 cm of H₂O) the vein will appear almost collapsed, even in the supine position. The sonographic appearance will be similar to the patient with a normal CVP in the upright position (Figure 4).

TECHNICAL POINTS

Several caveats are important when scanning the IJV. Veins are low-pressure vessels and when located superficially are easily compressed. Gentle pressure with the transducer is all that is necessary; too much pressure will collapse the vein and mislead the clinician. Because the examination is performed in real-time, any operator-induced collapse should be obvious. If a high frequency transducer is not available, a lower frequency probe (5 MHz) may be substituted, but image resolution will be poorer. Image depth must be decreased manually to optimally visualize superficial structures. The vessels should be scanned with the head in a neutral position, as the IJV tends to collapse with extension of the neck.¹² The point of collapse may fluctuate up and down slightly with normal respiration, as pressure in the central veins is affected by intrathoracic pressure. There is usually a fall of the point of collapse of several cm on normal inspiration.^{7,13} Mark the point in the neck at end-expiration; this is the same phase of respiration that the CVP is measured with a central catheter and pressure transducer.¹⁴ Position the patient so the point of vein collapse is located in the middle third of the neck. The IJV, even with a normal CVP, may be distended at the base of the neck. This is because the vessel is “splinted” open by the negative intrathoracic pressure as it enters the chest cavity. This is also where thin, mobile valves in the IJV are often located.

The thyroid gland is located medial to the vessels low in the neck. Cysts and nodules are common and are usually clinically insignificant. Always start by scanning the right IJV but confirm findings by examining the contralateral vein. If the patient has had previous neck surgery, IJV cannulation, or irradiation, the vein may not distend normally with elevated pressure.

ROLE OF JUGULAR VENOUS ULTRASOUND

Ultrasound of the internal jugular vein is probably the easiest examination for the novice sonographer to master. However, not every patient needs an ultrasound examination of his or her jugular vein. As clinicians, it is important to perform an adequate visual inspection of the jugular pulse.¹⁵ Nonetheless, there are situations with some patients where the physical examination does not furnish the information needed. Bedside sonography performed by emergency physicians provides immediate, important information that would otherwise require the use of invasive catheters.

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