Highlights of the physical examination in heart failure

Sandesh Dev

Division of Cardiology, Center for Heart Failure, Northwestern University Feinberg School of Medicine, Chicago, IL 60611, USA

Abstract Because decompensated heart failure (HF) patients present primarily with symptoms of congestion, the assessment of volume status is of paramount importance. Despite the addition of new technologies that can predict intracardiac filling pressures, the physical examination (PE) remains the most accessible and cost-effective tool available to clinicians. An elevated jugular venous pressure (JVP) is considered the most sensitive sign of volume overload, although the commonly used ‘method of Lewis’ has several limitations. A useful cutoff is that if the JVP is greater than 3 cm in vertical distance above the sternal angle, the central venous pressure is elevated. In addition to assessment of volume status, the PE in HF can reveal adverse prognostic signs, namely: elevated JVP, presence of third heart sound, elevated heart rate, low systolic BP, and low proportional pulse pressure (<25%). This article will review the evidence for the diagnostic and prognostic utility of common PE findings in HF. (J Geriatr Cardiol 2006;3:237-241.)

Key Words jugular venous pressure; central venous pressure; heart failure; physical examination; hepatojugular reflex; abdominal compression test; Method of Lewis; proportional pulse pressure

Introduction

Despite the increasing array of technical devices utilized in the management of heart failure (HF), the physical examination (PE) remains an essential tool for the HF clinician. Although current physicians-in-training appear to have limited cardiac auscultation skills,1 the importance of physical signs of HF may actually be increasing as a result of the rising number of HF hospitalizations due to the aging of the US population.2 In adults greater than 65 years of age, HF is the most common cause for hospitalization in the United States.3

The assessment of volume status is the key feature of the HF-directed examination since symptoms of congestion are the primary presenting complaints of HF patients seeking urgent care. Expert HF clinicians universally stress the importance of bedside estimation of jugular venous pressure,4 and national guidelines for chronic HF also recommend serial volume status assessment during patient encounters.5,6 Emerging guidelines for the management of acute decompensated HF will likely emphasize assessment of volume status since inadequate diuresis and weight loss have been implicated as factors contributing to the high rate of HF readmissions nationally.7 However, what is missing in existing HF guidelines is practical advice for clinicians on PE methods to determine volume status, such as estimation of jugular venous pressure (JVP) and the abdominal compression test. In this article, I hope to refresh the reader on simple techniques of examination (with a focus on volume status assessment), as well as highlight the prognostic impact of physical exam signs in HF. Please note, however, that the physical exam findings which I will describe have been studied primarily in patients with systolic HF.

Venous pressure

The JVP has been well-described since the late 1800s and the recognition of elevated JVP as a finding in HF since the 1930s (Table 1). The venous pressure can be estimated by PE or obtained directly by venous cannulation, but studies comparing these techniques have concluded that PE is unreliable and inaccurate. Actually, both of these methods are useful, but may not be directly comparable.7

Central venous pressure (CVP) refers to mean venous cava1 pressure or right atrial pressure. In perhaps the most comprehensive review of venous pressure, McGee stresses two concepts that are important in understanding of venous pressure: the physiological zero point and the external reference point.

Physiological zero point

The physiological zero point is defined as the location in the cardiovascular system where the CVP is tightly regulated and changes little during positional shifts such as sitting or standing. To obtain reproducible measurements that are independent of position, the ‘zero’ mark of the manom-
The external reference point is a landmark which is used to locate the level of the right atrium during the PE or right heart catheterization. Various reference points have been proposed over the years to help clinicians locate the level of the right atrium, but the evidence offered for these reference points is scant. In 1930, Sir Thomas Lewis observed that the top of the jugular veins of normal individuals always came within 1 to 2 cm of vertical distance from the sternal angle, whether the individual was supine, semiprivate, or upright. If the neck veins were higher than this, Lewis concluded that the patient had elevated venous pressure. A modification of this technique, called the ‘method of Lewis’ states that the CVP equals the vertical distance between a point 5 cm below the sternal angle and the top of the neck veins, though Lewis did not make such a claim. One of the limitations of these external reference points is that they identify sites that differ in the supine patient by several centimeters vertically (e.g., 5 cm below sternal angle versus midaxillary line). Thus, clinicians (using different reference points) who agree on the position of neck veins of a given patient will still arrive with different CVP measurements (Fig. 1).

**Changing relation between zero point and reference point**

The angle at which the patient is positioned will affect the vertical distance between the zero point and the reference point. Some of this variation may be due to the drop in the position of the heart in the upright position because of gravity. Furthermore, in different positions, the distance between the zero point and the reference point will change due to simple geometry. If the clinician uses the sternal angle as the reference point (Fig. 1, sternal angle reference point depicted at right, stippled bar), the venous pressure will appear to fall 2 to 3 cm in the 45-degree position, compared with the supine and upright position, simply because the vertical distance (between sternal angle and RA) is greatest at 45 degrees. These data emphasize that the clinician’s estimate of venous pressure depends greatly on the external reference point used during the examination.

**Postural regulation of venous pressure in sick patients**

Given multiple studies concluding that clinical estimates of CVP are inaccurate, one of the potential sources for discrepancy is that CVP is measured supine during catheterization, but PE requires whichever angle that allows for the best visualization of neck veins. Thus, postural regulation of venous pressure is important to appreciate.

The CVP drops significantly in patients with volume depletion or heart failure. In a study that used the phlebostatic axis (posterior RA) as a reference point in 110 subjects, the venous pressure did not change when normal adults and those with NYHA class I HF sat up, but venous pressure fell 8 cm H₂O when patients with class III or IV HF sat upright.

Perhaps the best method to estimate CVP, given the limitations described above, is to consider the CVP elevated when the vertical distance is greater than 3 cm above the sternal angle, regardless of the patient’s position. The only disadvantage of this technique is that it might underestimate the actual supine venous pressure, but would nonetheless...

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**Fig. 1. Impact of posture and external reference point on measured CVP**

A: T1-gated sagittal magnetic resonance image of a 43-year-old man, just to right of midline. White cross marks phlebostatic axis. B: Schematic drawings that illustrate changing vertical relations between heart and three external reference points as patient moves from supine (0 degree) to semiupright (45 degrees) to upright (90 degrees). Only anterior thoracic wall, mammary, intercostal spaces, and right atrium, adapted from magnetic resonance image, in A appear in drawings (across in posterior right atrium marks phlebostatic axis). Three reference points are (1) point 5 cm posterior to anterior body wall at fourth intercostal space (left, open bar), (2) phlebostatic axis (center, solid bar), and (3) 5 cm below sternal angle (“method of Lewis,” right, stippled bar). CVP at phlebostatic axis (12 cm H₂O) is assumed to remain constant in different positions, and right atrium is presumed to not drop from gravity in upright position. Height of vertical bar, labeled in centimeters of water above each bar, depicts measured CVP according to each external reference point.
Relation of CVP to PCW

Adjustments to diuretic therapy are frequently based on manifestations of right-sided filling pressures, but the relation of right-sided to left-sided pressures had not been previously described in HF. In a study of 1000 patients referred for heart transplantation evaluation who underwent pulmonary artery catheterization, RA pressure correlated with pulmonary capillary wedge pressure (PCW) (r=0.64) regardless of severity of tricuspid regurgitation (TR). Discordance was defined as RA ≥10mmHg despite PCW <22mmHg (6%) or RA <10mmHg despite PCW ≥22mmHg (15%). For detection of PCW ≥22mmHg, positive predictive value was 88% for RA ≥10mmHg. Thus, for the majority of patients with HF, estimation of JVP is a valuable tool to estimate left-sided filling pressures through simple bedside examination.

Prognostic implications of JVP

Like other prognostic markers such as maximal oxygen consumption and serum sodium level which have been associated with an increased mortality in HF, elevated JVP is a predictor of poor outcomes in both symptomatic and asymptomatic HF patients. In a retrospective analysis of the Studies of Left Ventricular Dysfunction (SOLVD) treatment trial (symptomatic HF patients, EF ≤35% randomized to enalapril or placebo), the presence of an elevated JVP was associated with increased risk of hospitalization for HF (RR 1.32, 95% CI 1.11 to 1.62; P<0.01), death or HF hospitalization (RR, 1.30; 95% CI 1.11 to 1.53; P<0.005), and death from pump failure (RR 1.32, 95% CI 1.07-1.75; P<0.05) compared to patients without elevated JVP (Fig. 2). Similarly, in the SOLVD prevention trial (asymptomatic HF patients with EF ≤35%), elevated JVP was associated with death or HF hospitalization (RR 1.47, 95% CI 0.98-2.18; P=0.06) and the development of HF (RR 1.51, 95% CI, 1.04-2.19; P=0.03). In both of these analyses, these effects persisted after adjustment for many other markers of HF severity, including left ventricular ejection fraction (LVEF), NYHA functional class, and serum sodium level. Why elevated JVP is associated with a poorer prognosis in HF is unknown, but may reflect higher left-sided filling pressures which have been associated with adverse outcomes.

The end point was a composite of death or hospitalization for heart failure. In Panel A, the 280 patients with elevated jugular venous pressure were significantly more likely than the 199 patients without elevated jugular venous pressure to reach the composite end point (P<0.001 by the log-rank test). In Panel B, the 597 patients with a third heart sound were significantly more likely than the 1882 patients without a third heart sound to reach the composite end point (P<0.001 by the log-rank test).

Abdominojugular compression test (hepatojugular reflux)

Technique

There are two varying definitions of a positive abdominojugular compression test (AJT) response: (1) increase in JVP >3 cm that is sustained longer than 15 seconds or (2) an abrupt fall in JVP ≤4 cm after release of 10 seconds of abdominal compression. The patient should be positioned so that the JVP can be seen. Slow, steady abdominal pressure of 20-30 mmHg should be applied to the center of the abdomen. Midabdominal (rather than left upper quadrant) pressure may be preferable, as this may avoid a Valsalva maneuver in response to pain from pressure.

Table 1. Tips on estimation of JVP

- First examine the JVP with the patient sitting upright as elevated neck veins can be easily missed.
- If pulsations of JVP are absent, patient may be lying too supine. Increase the angle at which the patient is reclined until you observe the venous pulsations. Don’t forget to observe the angle of the jaw as a possible location.
- To distinguish the JVP from carotid pulsation, use broad side of hand to firmly compress the neck. The biphasic (in sinus rhythm) JVP, since it is compressible, will no longer pulsate, unlike the carotid, which is non-compressible and monophasic.
- If you are unsure about the highest point of the JVP, abdominal compression will alter the height of the JVP, thus allowing you to confirm or refute your impression.
- In addition to the internal jugular vein, nonpulsatile external jugular can also be used to estimate the mean JVP (but a and v waves are absent).
- Some clinicians prefer to always assess the JVP with the patient sitting upright in order to minimize the effects of posture on the estimation of CVP (though there is no validation of this technique vis-à-vis others).
on the liver. The Valsalva maneuver, by increasing positive intrathoracic pressure, will negate the venous inflow to the right heart by abdominal pressure. It is important that patients do not experience pain or hold their breath during this test.

Pathophysiology

The AJT test was initially described as a method for diagnosing tricuspid regurgitation. The mechanism of positive results of the AJT is unknown. It is thought that abdominal pressure increases venous return to the RA and right ventricle (RV), with a subsequent rise in CVP. In patients with normal cardiac function, this effect is transient, as the right heart compensates with augmented right ventricular output (Starling effect). Sustained central venous distension is indicative of failure of the RV to accommodate to increased venous return. Any condition that limits RV output can lead to a positive AJT including the following: (1) increased afterload — pulmonary hypertension or left ventricular failure (2) RV systolic failure — RV cardiomyopathy or infarction (3) RV diastolic dysfunction — constrictive pericarditis, and (4) increased preload — tricuspid regurgitation.

Test characteristics

Ewy found that a positive AJT was highly predictive of elevated PCW pressure. In a heterogenous group of cardiac patients (not chronic HF patients), 43 of 44 patients with a negative sign had PCW ≤ 15. However, 18 of 21 patients with a positive response had a PCW of ≥ 15 mmHg. Patients with positive AJT had higher RA pressures, suggesting that AJT may be a marker of both elevated right- and left-sided filling pressures. In another study of 52 systolic HF patients undergoing heart transplantation (HT) evaluation, a positive AJT added to the sensitivity of predicting elevated PCW beyond that of JVP alone. A positive AJT was present in 33 of 52 patients (63%), including all 22 patients with elevated JVP and 11 without elevated JVP at rest. Compared with the presence or absence of elevated JVP at rest alone, the presence of either of these signs for a PCW > 18 mmHg increased from 57% to 81%, though the specificity fell from 93% to 80%.

Vital Signs

Despite the large number of factors that have been associated with a poor HF prognosis such as brain natriuretic peptide, serum creatinine, and ischemic etiology, the vital signs still impart independent prognostic information. For example, the Heart Failure Survival Score (HFSS) is a validated prognostic score which utilizes seven weighted variables to predict risk of death or transplant for end-stage HF patients. Two of the seven variables are simply from vital signs: mean blood pressure (BP) and resting heart rate (HR). That is, the higher the resting HR or lower the mean BP, the greater association with increased risk of death without transplant, UNOS status 1 (urgent) transplant, or left ventricle (LV) assist device implantation. Similarly, the Seattle Heart Failure Model, which was validated in nearly 10,000 HF patients, also incorporates systolic BP in the 24 variables used to calculate a prognostic score. In fact, the systolic BP is the second most predictive variable in the model (after daily diuretic dose).

Not only are the vital signs cost-effective (actually cost little to obtain) and impart prognostic information, but they can be used to estimate hemodynamics, specifically, the cardiac index. Calculated from the systolic and diastolic BP, a proportional pulse pressure [(SBP-DBP)/SBP] less than 25% had a 91% sensitivity and 83% specificity for a cardiac index (CI) < 2.2 L/min/m². This simple calculation can be very useful when initially risk stratifying patients presenting for evaluation of HF before one has had begun to order any diagnostic tests. This is particularly helpful when evaluating a patient for cardiac transplantation because a CI < 2.2 L/min/m² is typically associated with end-stage HF and often inotrope dependence.

Third heart sound

Technique

The third heart sound, or S3, is a low-frequency event best heard in a quiet room when the bell of the stethoscope is lightly placed over the left or right ventricular impulse to obtain a skin seal. Patients with HF may have a S3 sound due to low ventricular compliance, increased filling pressures, or increased early diastolic filling rates.

Test characteristics

In a study of 52 HF patients evaluated for HT, the presence of a third heart sound was heard in 25 (68%) of 37 patients with a PCW ≥ 18 mmHg (sensitivity 68%) and 4 (27%) of 15 patients with a PCW < 18 (specificity 73%).

Prognostic value

In a multivariate analysis of the SOLVD treatment trial, the presence of the S3 had similar prognostic value as elevated JVP. A S3 was associated with hospitalization for HF (RR 1.42, 95% CI 1.21-1.66) and death from pump failure (RR 1.40, 95% CI 1.14-1.71) (Fig. 2).

Pulmonary crackles

Crackles are an extremely insensitive but very specific sign in chronic HF. In a study of 52 HF patients evaluated for HT, crackles were noted in only 9 (24%) of 37 patients with PCW ≥ 18 mmHg, and in none of 15 patients with PCW < 18 mmHg (P < 0.05). Thus, the presence of crackles had a low sensitivity of 24% but a specificity of 100% for PCW < 18 mmHg.
because of the central importance of serial volume status assessment in the HF patient. One must be aware that there are several anatomic and postural limitations to JVP assessment in the HF patient; one must be aware that there is no clinical 'gold standard' technique of assessment, a JVP greater than 3 cm in vertical distance above the sternal angle is abnormally elevated, regardless of the patient position. Elevation of JVP not only carries an adverse prognostic significance in systolic HF, but also identifies patients with elevation in left-sided filling pressures in greater than 80% of cases. Adding the AJT to the PE will further increase the sensitivity of identifying patients with elevated left-sided filling pressures compared to JVP assessment alone. Further, in an era of online risk calculators, we should not forget that the vital signs themselves can help to identify high-risk patients when the proportional pulse pressure and SBP are low, or the HR is elevated. In short, despite the new electronic tools that are emerging to detect volume overload in the HF patient, the busy clinician will appreciate the simplicity, speed, and prognostication that PE still affords.

Summary

The diligent clinician who learns to identify an elevated JVP will be rewarded at every patient encounter because of the central importance of serial volume status assessment in the HF patient. One must be aware that there are several anatomic and postural limitations to JVP assessment. But while there is no clinical 'gold standard' technique of assessment, a JVP greater than 3 cm in vertical distance above the sternal angle is abnormally elevated, regardless of the patient position. Elevation of JVP not only carries an adverse prognostic significance in systolic HF, but also identifies patients with elevation in left-sided filling pressures in greater than 80% of cases. Adding the AJT to the PE will further increase the sensitivity of identifying patients with elevated left-sided filling pressures compared to JVP assessment alone. Further, in an era of online risk calculators, we should not forget that the vital signs themselves can help to identify high-risk patients when the proportional pulse pressure and SBP are low, or the HR is elevated. In short, despite the new electronic tools that are emerging to detect volume overload in the HF patient, the busy clinician will appreciate the simplicity, speed, and prognostication that PE still affords.