The Prognostic Value of the Physical Examination in Patients With Chronic Heart Failure

The importance placed on the physical examination in the assessment of patients with cardiovascular disorders appears to be declining, perhaps in part due to a paucity of data showing its value in the modern era. To determine whether the physical examination provides important prognostic information in patients with chronic heart failure, the authors performed a post-hoc analysis of 2479 participants from the Studies of Left Ventricular Dysfunction (SOLVD) treatment trial. The presence of elevated jugular venous pressure and a third heart sound at baseline were each associated with subsequent heart failure hospitalization, the composite end point of death or heart failure hospitalization, and pump-failure death, independently of many other markers of disease severity. The subgroup of patients with at least one of these two physical examination findings was at increased risk for all-cause mortality. The authors believe that additional studies assessing the prognostic value of the physical examination should be conducted and, if favorable, likely would lead to a renewed interest in the physical examination. (CHF. 2003;9:170–175, 178)

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The central role of the physical examination in the assessment of cardiovascular disorders appears to be in jeopardy1,2 as manifested by concerning deficiencies in the proficiency of recent medical graduates in cardiac auscultation.3–5 Several events may have contributed to this phenomenon. Perhaps most important are the dramatic advances in technologies such as echocardiography that have attracted attention away from the physical examination,1,2,6,7 a trend that will undoubtedly accelerate as hand-held echocardiography8 makes its way to the bedside. Furthermore, as the number of physicians classically trained in the art of the cardiac physical examination during the pre-echocardiography era declines,7 there simply may not be enough teachers available to pass these skills on to subsequent generations of physicians.

A decline in the interest in the cardiovascular physical examination may also be related to a paucity of evidence that demonstrates its value when compared with more sophisticated diagnostic modalities. For example, studies that compare the physical examination with echocardiography,8,9 catheter-based hemodynamic assessments,10–12 or with novel bioassays such as B-type natriuretic peptide,13 often conclude that the information gleaned by a physical examination is inferior to that of the new technologies or invasive approaches. Because “evidence-based” medicine has become the gold standard of clinical practice, this paucity in data may contribute to an unwillingness of physicians-in-training to take the time to master the physical examination.

In this review, we will summarize some of the existing evidence demonstrating the importance of the physical examination in the evaluation of patients with chronic heart failure. First, we will review data regarding whether the physical examination can provide clues to the hemodynamic status of patients, specifically, whether the cardiac index is low and whether left ventricular (LV) filling pressures are elevated. Our intent here is to review those findings we believe most useful in the clinical assessment of patients. Next, we will review recent studies that address the prognostic value of the physical examination in patients with heart failure.
Physical Examination to Assess Hemodynamic Status

Low Cardiac Index. In clinical practice, a cardiac index <2.2 L/min/m² as measured by a right-sided heart catheter is often used as a threshold to determine whether the heart is pumping sufficient blood at rest. Such a finding may have direct clinical consequences by leading to the administration of parenteral inotropic and/or vasodilator pharmacologic agents in an effort to improve perfusion. Interest in determining the cardiac output of patients by noninvasive modalities is considerable in hopes of avoiding the potential complications associated with right-sided heart catheterization. A device that measures changes in impedance across the thorax to determine stroke volume and cardiac output is now commercially available, and its measures of cardiac output correlate with those obtained by invasive right-sided heart catheterization in patients with chronic heart failure.14

The physical examination is another potential noninvasive modality to determine the adequacy of the cardiac output. A depressed proportional pulse pressure (the difference between systolic and diastolic pressures divided by the systolic pressure) may reflect the presence of a low output state. In a cohort of 50 patients with chronic dilated LV failure (one third ischemic and two thirds of nonischemic etiology) with a mean LV ejection fraction (EF) of 18%, proportional pulse pressure correlated well with cardiac index (r=0.82).15 In this study, a proportional pulse pressure ≤25% was found to be 91% sensitive and 83% specific for a cardiac index ≤2.2 L/min/m².

A qualitative assessment of the temperature in the distal extremities is another physical examination finding often used to evaluate the adequacy of perfusion. In a study of 100 patients,16 the temperature measured by thermistors placed on the digital pad of the first toe did correlate with cardiac output (r=0.71) and severity of shock. However, to our knowledge there are no data that correlate the standard bedside evaluation of perfusion (a qualitative assessment of the temperature of the leg such as warm, lukewarm, or cold) with invasive measures of the cardiac output in a series of patients with chronic heart failure. There are scant data regarding the utility of other physical examination findings that may reflect a low cardiac output17 such as alterations of the peripheral pulse (low amplitude or mechanical alternans) and changes in mental status.

Elevated LV Filling Pressures. Many of the symptoms of patients with chronic heart failure that lead to presentation to the emergency department18 or hospitalization are the result of elevations of LV filling pressures. Compared with detection of a low cardiac output, there are more physical examination findings available to assess filling pressures including pulmonary rales, peripheral edema, elevation in the jugular venous pressure (JVP), presence of abdominojugular reflux, and an abnormal systolic arterial pressure response during the Valsalva maneuver.17 Some of these signs reflect elevations in right-sided heart filling pressures, but are useful in estimating LV filling pressures likely due to the high concordance (80%) of right- and left-sided filling pressures in patients with chronic heart failure.19

The utility of these various physical examination findings in detecting elevated LV filling pressures is not uniformly favorable. Pulmonary rales were audible in only 19% and peripheral edema was present in only 23% of 43 patients with pulmonary capillary wedge pressure (PCWP) ≥22 mm Hg.15 Other studies20,21 have confirmed the low sensitivity of pulmonary rales for detecting an elevated PCWP.

The presence of elevated JVP, either at rest or following abdominal pressure (abdominojugular reflux), appears to be a more useful sign for detecting elevated LV filling pressures. In a study22 that included 65 patients who did not all have chronic heart failure, an abdominojugular reflux had a sensitivity of 93% and specificity of 86%, a positive likelihood ratio of 6.7, and a negative likelihood ratio of 0.08 for the detection of PCWP ≥16 mm Hg. In a study20 of 52 patients referred for heart transplant evaluation, the presence of an elevated JVP or abdominojugular reflux had a sensitivity of 81% and a specificity of 80% for a PCWP ≥18 mm Hg. In this study, the probability of a PCWP ≥18 mm Hg was 0.86 when either of these two variables was present. Other studies of patients with chronic heart failure have also found elevated JVP to be a better predictor than peripheral edema or pulmonary rales for detecting elevated left-sided filling pressures.15 The utility of elevated JVP is perhaps unexpected given the difficulties in accurately estimating the JVP by physical examination compared with invasive measures of right atrial pressure.9-12,23 Nevertheless, in a recent series of letters offering “clinical pearls” regarding the physical examination in heart failure, several experienced heart failure specialists commented that interpretation of the JVP was an extremely important, if not vital, tool used in their practices, suggesting that this physical examination finding remains clinically useful despite the above-stated limitations.

The systolic blood pressure (SBP) response to the Valsalva maneuver is another physical examination finding that may be useful in assessing the volume
status of patients with heart failure. The normal SBP response during the four phases of the Valsalva maneuver has three components easily detectable at the bedside. With onset of strain during the Valsalva maneuver, there is an initial transient increase in SBP above its baseline level (component 1) secondary to the acute increase in intrathoracic pressure. Subsequently, during the ongoing strain, the SBP decreases below its initial baseline level (component 2), in large part due to a fall in venous return that results from the increase in thoracic pressure. When the strain is released, SBP abruptly declines further, although in our experience this response is not easily detectable or clinically useful. However, in healthy individuals, the SBP will then again increase above the initial baseline level (component 3), a response that has been termed the “overshoot.” Thus, there is a detectable triphasic, sinusoidal response of the SBP elicited by the Valsalva maneuver in healthy individuals: first SBP increases above baseline, then it decreases below the baseline, and then it again increases above the initial baseline during the overshoot.

Compared with healthy individuals, patients with heart failure and elevated left-sided filling pressures have a distinctly different SBP response during the Valsalva maneuver. Because the fall in SBP during the strain phase (component 2) is largely due to a decrease of LV filling, in patients with elevated left-sided filling pressures, SBP remains elevated throughout the strain phase as LV filling remains adequate. Furthermore, release of the strain is not followed by an overshoot of the blood pressure. The blood pressure response in patients with elevated left-sided filling pressures has thus been termed a “square wave” response—an increase in SBP that persists throughout the strain phase and then returns to baseline levels when the strain is released. These changes in the blood pressure response to the Valsalva maneuver have been shown to be useful for detection of elevated left-sided filling pressures. The SBP response to the Valsalva maneuver has also been shown to correlate with neurohormonal levels (A-type natriuretic peptide and B-type natriuretic peptide [BNP]), exercise tolerance and other clinical parameters indicating severity of heart failure in a study of 45 patients with stable heart failure (mean LVEF, 28%). In this study, the mean BNP level was 282±289 pg/mL in patients with an abnormal blood pressure response to the straining phase of the Valsalva maneuver compared with a mean BNP level of 81±85 pg/mL in patients with a normal blood pressure response. From a clinical perspective, we have found this maneuver to be easily performed unless atrial fibrillation is present, in which case variable cycle lengths can affect the SBP and complicate the interpretation.

### Prognostic Value of Physical Examination Findings

In addition to characterization of the hemodynamic status, the physical examination may also provide important prognostic information in patients with heart failure. A low “congestion score” based on the absence of elevated JVP and peripheral edema in addition to three other clinical factors (orthopnea, weight gain, and new increase in baseline diuretics) was found to be associated with a favorable outcome despite prior New York Heart Association (NYHA) class IV symptoms of heart failure. Another classification system characterizes heart failure patients into four hemodynamic profiles, based on whether LV filling pressures are elevated or not and whether the cardiac output is adequate or not, as assessed by the history and physical examination (i.e., volume overloaded with either adequate or insufficient perfusion; euvolesmic with either adequate or insufficient perfusion). In a recent preliminary report this classification has been shown to offer independent prognostic information. However, there was no association of these hemodynamic profiles with survival in a retrospective analysis of the Flolan International Randomized Survival Trial. The basis for the discrepancy between these results is not clear, but in the latter study, the hemodynamic profiles were based on invasive catheter-based measurements rather than assessment by history and physical examination. Further studies are needed to clarify the prognostic utility of this proposed classification system.

### Elevated JVP and a Third Heart Sound

Two cardinal physical examination findings of patients with heart failure are elevations of JVP and a third heart sound (also called an S₃ gallop). Until recently, there have been limited data regarding the independent prognostic value of these findings in patients with heart failure. In one study of 269 patients with advanced heart failure, the association of elevated JVP and event-free survival had only marginal significance on univariate analysis. Other studies have shown that right atrial pressure measured by catheterization was associated with an adverse prognosis. However, given the discrepancy between catheter measurements and estimates of right atrial pressure by physical examination (see above), it was not clear to what extent the prognostic value of measured right atrial pressure would be applicable to estimated JVP.
Several observational studies have demonstrated an association of an S3 gallop with adverse outcomes in patients with heart failure. In a multivariate Cox regression model where the actuarial survival of patients awaiting heart transplant was 59% at 2 years, the presence of a third heart sound was comparable to NYHA functional class IV in its association with survival. However, in another study of patients referred for cardiac transplantation evaluation, the presence of an S3 gallop did not enhance the discriminatory capacity of a multivariable proportional hazard model for the composite end point of United Network for Organ Sharing (UNOS) 1 transplant or death without transplant.

The Independent Prognostic Value of Elevated JVP or S3. We recently tested the hypothesis that elevated JVP and the presence of a third heart sound could independently predict adverse outcomes in patients with heart failure by completing a post-hoc analysis of the Studies in Left Ventricular Dysfunction (SOLVD) treatment trial. The SOLVD treatment trial was designed to test the efficacy of angiotensin-converting enzyme (ACE) inhibition by randomly assigning patients with symptomatic heart failure and an LVEF of ≤0.35 to receive enalapril or placebo. Of the 2569 SOLVD treatment trial participants, 2479 with complete data were included in this post-hoc analysis. At enrollment, baseline demographic and clinical data had been ascertained, including the presence or absence of elevated JVP and an S3 gallop. Participants were followed for an average of 32±15 months. Deaths were subclassified as death from pump failure or death from arrhythmia. Details regarding the rationale, design, and primary outcome of the SOLVD treatment trial are reported elsewhere.

A comparison of baseline characteristics of patients with and without elevated JVP or an S3 showed that participants with these physical findings had more advanced heart failure. Participants with elevated JVP (n=280) at enrollment were more likely to be characterized as NYHA functional class III or IV (63%) than those participants without elevated JVP (29%). Likewise, subjects with an S3 (n=597) were more likely to be characterized as NYHA class III or IV (46%) than those participants without an S3 (28%). Other markers of disease severity, including lower LVEF and increased heart rate, were also more likely to be present in patients with elevated JVP or a third heart sound than in participants without these physical examination findings. Given these disparities in baseline characteristics, it is not surprising that patients with elevated JVP and those with a third heart sound were each at significantly higher risk on univariate analysis than participants without these physical examination findings for adverse outcomes, including all-cause mortality (elevated JVP: relative risk [RR], 1.52; 95% confidence interval [CI], 1.27–1.82; p<0.001; presence of S3: RR, 1.35; 95% CI, 1.17–1.55; p<0.001) and subsequent heart failure hospitalization (elevated JVP: RR, 1.78; 95% CI, 1.47–2.17; p<0.001; presence of S3: RR, 1.70; 95% CI, 1.46–1.97; p<0.001).

What is the significance of the findings from the univariate analysis? One could argue that these physical examination findings would have clinical utility even if they merely are markers for other adverse prognostic variables since they can be rapidly acquired (often before echocardiography) and easily repeated. Furthermore, the magnitude of the point estimates of the relative risk associated with the presence of these findings for adverse outcomes is large, suggesting they would enhance risk-stratification of patients. Alternatively, one could argue that the SOLVD investigators may have been unintentionally biased to record the presence of these physical examination findings in patients they assessed as having more advanced disease based on other components of their clinical assessment. If true, the prognostic value attributed to these physical examination findings would likely be equally assignable to the physician’s overall assessment of the severity of the patient’s condition. To address this latter possibility, we performed a multivariate analysis to determine whether the presence of these physical examination findings had prognostic value independent of other known markers of disease severity.

The multivariate model (Table) included age, LVEF, NYHA class, treatment assignment (enalapril vs. placebo), gender, ischemic or nonischemic etiology, black race, electrocardiographic atrial fibrillation, serum sodium, serum creatinine, history of diabetes, history of hypertension, and use of β blockers, digoxin, or diuretics. The presence of elevated JVP was associated with a statistically significant increase in the relative risk of hospitalization for heart failure (RR, 1.32; 95% CI, 1.08–1.62; p<0.01), death or hospitalization for heart failure (RR, 1.30; 95% CI, 1.11–1.53; p<0.005), and pump failure death (RR, 1.37; 95% CI, 1.07–1.75; p<0.05). Likewise, the presence of a third heart sound was associated with a statistically significant increase in the relative risk of hospitalization for heart failure (RR, 1.42; 95% CI, 1.21–1.66; p<0.001), death or hospitalization for heart failure (RR, 1.22; 95% CI, 1.08–1.38; p<0.005), and pump failure death (RR, 1.40; 95% CI, 1.14–1.71; p<0.005). In patients with an elevated JVP, S3, or both (n=706), there was also a statistically
significant increase in the relative risk of all-cause mortality (RR, 1.17; 95% CI, 1.02–1.35; \( p < 0.05 \)) compared with participants without these physical examination findings.

Two subgroup analyses were performed. When patients were stratified according to NYHA functional class assignment (NYHA I–II or NYHA III–IV), the relative risk associated with the presence of elevated JVP and with the presence of a third heart sound for heart failure hospitalization, death or heart failure hospitalization, and pump-failure death remained greater than one in both subgroups. Similarly, when patients were stratified by treatment assignment (those randomized to placebo and those randomized to enalapril), the relative risk associated with the presence of elevated JVP and with the presence of a third heart sound again remained greater than one for the end points of heart failure hospitalization, death or heart failure hospitalization, and pump-failure death in both subgroups.

These data demonstrate that the presence of elevated JVP or an S3 is associated with adverse outcomes, independent of many other known markers of heart failure severity. Although there were baseline disparities in other measures of disease severity between patients with and without elevated JVP and between patients with or without an S3, these potential confounders were adjusted for in multivariate analysis. Because characterization of NYHA functional class would likely be influenced by a physician’s overall estimate of heart failure severity, and because NYHA class was included in the multivariate models, such potential physician bias is likely accounted for in our analysis. The stratified multivariate analysis in which the relative risks associated with the presence of elevated JVP or an S3 remained greater than one in both the subgroup of patients classified as NYHA I–II and the subgroup classified as NYHA III–IV also suggests that these physical examination findings offer prognostic value independent of an overall assessment of illness severity.

It is unclear why the presence of elevated JVP and an S3 are associated with an increased risk for subsequent progression of heart failure. Given the retrospective nature of the study, the possibility of a false association due to residual confounding cannot be excluded. However, we believe there is a biologically plausible explanation for the association of these physical findings with adverse outcomes. Specifically, elevated JVP and an S3 are associated with elevated LV filling pressures, and elevated LV filling pressures have been associated with adverse prognosis in multiple studies. The association of elevated BNP levels and a restrictive filling pattern on echocardiography with adverse outcomes in patients with chronic heart failure, undoubtedly based, in part, on similar pathophysiologic events as those that lead to the presence of elevated JVP or an S3, enhances the plausibility of the associations reported in our study.

### Conclusion

The physical examination has long been a cornerstone of the assessment of patients with cardiovascular disorders, but its role is being threatened by technologic advances. Many previous studies have assessed the role of the physical examination in chronic heart failure, and these studies have generally shown that the physical examination findings are associated with adverse outcomes. However, these studies have not been able to fully control for potential confounders, and the role of the physical examination in the assessment of patients with chronic heart failure has been questioned.

### Table

Multivariate Analysis Assessing Risk Associated With Elevated Jugular Venous Pressure (JVP) and a Third Heart Sound (S3) in Patients With Heart Failure

<table>
<thead>
<tr>
<th>END POINT</th>
<th>ELEVATED JVP* RR (95% CI)</th>
<th>S3* RR (95% CI)</th>
<th>ELEVATED JVP, S3, OR BOTH* RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>1.15 (0.95–1.38)</td>
<td>1.15 (0.99–1.33)</td>
<td>1.17 (1.02–1.35) ( p &lt; 0.05 )</td>
</tr>
<tr>
<td>Chronic heart failure hospitalization</td>
<td>1.32 (1.08–1.62) ( p &lt; 0.001 )</td>
<td>1.42 (1.21–1.66) ( p &lt; 0.001 )</td>
<td>1.43 (1.23–1.66) ( p &lt; 0.001 )</td>
</tr>
<tr>
<td>Death or chronic heart failure hospitalization</td>
<td>1.30 (1.11–1.53) ( p &lt; 0.005 )</td>
<td>1.22 (1.08–1.38) ( p &lt; 0.005 )</td>
<td>1.28 (1.14–1.45) ( p &lt; 0.001 )</td>
</tr>
<tr>
<td>Pump-failure death</td>
<td>1.37 (1.07–1.75) ( p &lt; 0.05 )</td>
<td>1.40 (1.14–1.71) ( p &lt; 0.005 )</td>
<td>1.47 (1.21–1.79) ( p &lt; 0.001 )</td>
</tr>
</tbody>
</table>

*Data represent relative risks (RR) (95% confidence intervals [CIs]) and associated \( p \) values are for the comparison to participants without the respective physical examination finding(s). Each model also included age, ejection fraction, New York Heart Association class, assigned treatment (enalapril or placebo), gender, ischemic etiology for left ventricular systolic dysfunction, African American ethnicity, atrial fibrillation, serum sodium, serum creatinine, history of diabetes mellitus or hypertension, baseline use of \( \beta \) blockers, digoxin, or diuretics. Adapted with permission from *N Engl J Med.* 2001;345:574–581. Copyright 2001. Massachusetts Medical Society.
addressed whether the physical examination is a reliable tool to determine the adequacy of cardiac output and the presence of elevated left-sided filling pressures in patients with heart failure. In the present era of evidence-based medicine, we believe that it is equally important to determine whether physical examination findings offer independent prognostic value in patients with heart failure. Such data are now available for two common physical examination findings: elevated JVP and a third heart sound. We hope that future research will assess the prognostic value of other physical examination findings in patients with heart failure, as well as address the value of the physical examination in other cardiovascular disorders, for in our opinion, renewal of interest in the art of the physical examination would be greatly facilitated by such studies.

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Rame (continued from page 175)


