Doppler Echocardiographic Changes Found in Diastolic Dysfunction

Loren S. Kane, MD

Diastolic dysfunction may be associated with increased morbidity and mortality. In this article, an overview of the pathophysiology of diastolic dysfunction is discussed and the findings of Doppler echocardiography used to aid in its diagnosis are reviewed.

Congestive heart failure may be defined as an inability of the left ventricle to create adequate cardiac output either at rest or with exercise. It is now commonly believed that there are two separate pathophysiologic mechanisms that can lead to congestive heart failure, namely systolic and diastolic dysfunction. These two mechanisms exist on individual pathways that can overlap late in their respective courses.

Systolic dysfunction occurs when there is a decreased ejection fraction (usually less than 45%) and impaired left ventricular contractility. It is associated with coronary artery disease and previous myocardial infarctions with impaired wall motion, valvular heart disease, and idiopathic dilated cardiomyopathy. Patients classically will present with symptoms and signs of dyspnea, orthopnea, pulmonary rales, jugular venous distension, and peripheral edema. Studies may reveal cardiomegaly with pulmonary edema on chest radiography and a decreased ejection fraction with abnormal wall motion on echocardiography. Diastolic dysfunction occurs when there is impaired ventricular filling with normal ventricular contractility. The left ventricle cannot accommodate its usual blood volume at normal filling pressures due to hindered relaxation and increased stiffness and requires increasing filling pressures to maintain cardiac output. This is illustrated as an upward shift of the pressure volume loop (Figure 1). As resistance increases in the left ventricle, despite increased filling pressures, the filling is inadequate, causing the pressure-volume loop to shift to the left and the cardiac output to fall. It is associated with transient, acute myocardial ischemia, chronic long-standing systemic hypertension, and aging.

Patients with diastolic failure exhibit many of the signs and symptoms of systolic failure but may be differentiated clinically by the presence of an S4 upon cardiac auscultation (versus an S3 with systolic failure), a history of long-standing hypertension, and even possibly normal cardiac size on chest radiography. Overall, however, these differences can be subtle, and thus Doppler echocardiogra-
Figure 1. Comparison of normal cardiac pressure-volume loops with those of diastolic and systolic dysfunction. (Reproduced with permission from the editors of Braunwald E, Heart Disease: A Textbook of Cardiovascular Medicine.)

Figure 2. Normal transmitral Doppler signal during diastole. (Reproduced with permission from the editors of Geriatrics.)

Doppler signal can be extremely helpful, and sometimes necessary, in separating the two.

On echocardiography, Doppler signal across the mitral valve in a healthy heart reveals a large E wave (early filling flow velocity) that occurs as blood passively flows from the left atrium into the relaxed and compliant left ventricle early in diastole, followed by a small A wave (late filling flow velocity) that occurs when the left atrium actively contracts in late diastole. Normally, atrial contraction plays only a minor role in ventricular filling, as most of the volume is filled passively in early diastole and the E/A ratio is greater than one (E/A > 1) (Figure 2).

However, with increased stiffening of the left ventricle, decreased compliance, and abnormal relaxation, mitral flow velocities are altered. Initially, as passive flow during early diastole is impaired, a forceful and augmented atrial contraction results in an attempt to compensate. This causes an increase in the peak A wave velocity, which, when compared to a diminished E wave velocity, yields a reversal of the E-to-A ratio (E/A < 1) (Figure 3).

This is the earliest and mildest distortion of the ventricular-filling flow velocity pattern and is categorized as grade I. As ventricular compliance decreases, left atrial pressures rise to maintain ventricular filling, and there is a resultant increase in both the passive early filling and late atrial filling, with pseudo normalization of the E/A ratio (E/A > 1),
Figure 3. Doppler-based grading system for diastolic dysfunction. (Reproduced with permission from the editors of Geriatrics.)

categorized as grade II. This can be difficult to distinguish from a normal pattern but is reportedly characterized by a shortened deceleration time. Evaluation of abnormal blood flow back into the pulmonary vasculature (pulmonary venous A wave) can also be used to distinguish pseudo normalization from a normal filling pattern. Further progression of decreased compliance results in markedly increased atrial pressures and forceful early diastolic filling, with minimal benefit from a relatively weakened atrial contraction in late diastole, that produces a restrictive (first reversible, then finally irreversible) E-to-A ratio that is much greater than one (E/A $\gg 1$). These levels of dysfunction are categorized as grade III and grade IV, respectively, and herald the onset of overt congestive heart failure.

Reports suggest that 30–40% of all patients with signs and symptoms of congestive heart failure actually have diastolic, rather than systolic, dysfunction. This proportion may be higher in the elderly due to greater prevalence of diastolic dysfunction in older populations. Elderly patients may present with minor complaints secondary to relative inactivity, masking their dyspnea. Thus, Doppler echocardiography can be of great use in detecting diastolic dysfunction and identifying individuals that may have increased morbidity and mortality risk.

REFERENCES