Conventional Diastology: What Measurements Matter?

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Why is diastolic function important?

Heart failure is now the most common primary diagnosis of all hospitalized patients in the United States. Despite improvements in cardiovascular therapy, mortality and morbidity of heart failure still incurs high medical costs making early diagnosis paramount. The important distinguishing feature of diastolic heart failure is that it has a better long-term prognosis, with about half the mortality rate of systolic heart failure, and a distinctly different treatment rationale. Its recognition in cardiac surgical patients is therefore of paramount importance to intraoperative echocardiographers. The simple estimation of ejection fraction therefore is insufficient when assessing global myocardial function.

In contrast to diastolic heart failure, diastolic dysfunction is more prevalent and is principally an echocardiographic diagnosis without symptoms of heart failure. Moreover, diastolic dysfunction is associated with long-term adverse outcomes in the surgical population.

Conventional Measurements

Recognizing the importance of evaluation of diastolic function and variability in published data, the American Society of Echocardiography proposed specific guidelines for the echocardiographic assessment of diastolic function. Diastolic function can be graded as normal, impaired relaxation (grade 1), pseudonormal (grade 2) or restrictive (grade 3). Although most of the proposed parameters were based on transthoracic echocardiography, many may be applied using transesophageal echocardiography (TEE).

The conventional understanding of diastolic dysfunction is based on the relationship between the diastolic pressure-volume
relationship between the left ventricle (LV) and the left atrium (LA). The rationale is that diastolic filling patterns of the LV will accurately reflect its diastolic properties.

Transmitral Flow

The principal technique for assessment of LV filling uses transmitral flow (TMF) patterns with pulsed wave Doppler (figure 1). There are two waveforms in diastole that are important to consider: the early or ‘E’ wave, and the late, or ‘A’ wave. Measurements include the ratio of the two waves (E/A ratio), the deceleration time of the E wave, and the duration of the A wave. This is a simple method and provides a great deal of information on the diastolic properties of the left ventricle. However, it is also subject to several caveats, which makes its interpretation fairly cumbersome. Therefore, information from TMF patterns must be integrated with other maneuvers or parameters that are relatively flow-independent, such as tissue velocity imaging (TVI).

Tissue Velocity Imaging

It seems logical that direct measurement of tissue velocity is likely to provide more accurate information on tissue properties than TMF patterns. While conventional Doppler techniques focus on high velocity, low amplitude signals of blood flow, TVI measures low velocity, high amplitude signals from myocardial tissue. It is therefore able to quantify myocardial velocity through time and provide information on systolic and diastolic tissue deformation. When measured at the lateral mitral annulus, these recordings are accurate, more reproducible and have higher temporal resolution than comparable modalities. There are three distinct signals from the lateral mitral annulus during the cardiac cycle – a systolic signal below the baseline directed away from the probe and two diastolic signals, corresponding to early filling (E’) and atrial contraction (A’) (figure 2). Both diastolic signals are seen above the baseline, directed towards the probe, consistent with myocardial tissue motion in this phase.

In the early stages of diastolic dysfunction, the peak E’ wave velocity decreases, while peak A’ velocity shows a mild increase. With increase in left atrial pressures and progression of diastolic dysfunction to more restrictive physiology, the peak A’ velocity decreases. However, the decrease in E’ is more marked in these later stages of diastolic dysfunction. The decrease in peak E’ velocity can be used as a reasonable marker of both, elevated left atrial pressure and left ventricular end diastolic pressure (LVEDP). Studies have shown that a peak E’ of less than 8 cm/s is consistent with diastolic dysfunction. When considered along with transmitral early filling (or the E wave), the peak E’ velocity can add
diagnostic information, especially with normal ejection fraction. An E/E’ ratio of >15 suggests elevated LVEDP, while a ratio of <8 is specific for normal diastolic function.

Other Parameters

The ASE suggests several other parameters for a complete assessment of diastolic function, such as flow propagation velocity, pulmonary vein flow patterns and LA volume. A flow propagation velocity of less than 45 cm/s has been shown to be predictive of adverse outcome. A pulmonary ‘A reversal wave’ that is 35 msec longer than the transmitral A wave is also associated with high LV end-diastolic pressures typical of restrictive cardiomyopathy where the LA is unable to propel blood into an already full and non-compliant LV at the end of diastole. Left atrial volume is difficult to assess with TEE since part of the LA is usually obscured due to the close proximity of the TEE probe to the LA itself. Therefore, these parameters are not always available, measureable or aligned to enable grading of diastolic dysfunction. The dynamic intraoperative environment does not lend itself to a comprehensive measurement of diastolic function. Recognizing this limitation of the clinical setting, the ASE recommended the adoption of a simpler algorithm for grading diastolic dysfunction. However, no simple algorithm was proposed.

Measurements that matter

A practical approach should be based on obtaining parameters that are easily available, and algorithms that are simple to follow and interpret. However, any algorithm, regardless of simplicity, is irrelevant if it cannot grade diastolic dysfunction that accurately predicts worse outcome. In other words, do these measurements matter?

We recently assessed a simplified algorithm (figure 3) based on the ASE guidelines, and developed a simple method that is able to categorize most patients, and has relevance to outcome. This approach may be easily adopted, even in a busy clinical practice setting. Most ultrasound machines come equipped with technology that allows tissue Doppler assessment of the lateral mitral annular velocities using TVI. Early transmitral flow is also a ‘one-button’ measurement. Moreover, the E wave can be measured even when at higher heart rates that preclude assessment of deceleration time or the A wave. An E’ velocity less than 10 cm/s can be used as the first ‘screening’ measurement to determine whether diastolic function is abnormal. The algorithm then requires the assessment of the transmitral E wave to determine the grade of diastolic dysfunction.

Figure 3: Simplified algorithm for the assessment of diastolic dysfunction. This approach only involves the measurement of peak early diastolic tissue velocity (E’) using tissue Doppler, and early transmitral flow velocity (E).
Other important considerations for a practical approach include setting the ventilator to the apneic mode, if possible, and using an average of multiple measurements in case of variable rhythms such as atrial fibrillation.

**Summary**

The prognostic significance of diastolic dysfunction in the population we care for cannot be understated. We therefore, should make every effort to assess diastolic function in these patients. Since we perform a thorough echocardiographic assessment during cardiac surgery, determination of diastolic dysfunction should be logically included.

The assessment of diastolic function is important and need not be cumbersome or impractical. A simplified approach will allow assessment of severity of diastolic function in nearly all cases and allow tailoring of management, even in a busy clinical practice setting. Therefore, among all the parameters available for the assessment of diastolic function, perhaps the measurements that matter most are the ones simplest to acquire – the transmitral E velocity and the lateral mitral annulus tissue velocity.

**References**


