Pulmonary Venous AR Velocity and Duration

When there is pseudonormalisation there is a moderate increase in the LAP as well as an elevation in the LVEDP. As described previously, an elevation of the LVEDP can be identified by: (1) an increase in the PV_e′ velocity and/or (2) shortening of the duration of the mitral A wave compared with PV_e′ duration. Therefore, a ‘normal’ transmitral inflow profile with an increased PV_e′ velocity (>35 cm/s) and/or an AR_e′-A_e ≥ 30 ms is suggestive of pseudonormalisation (Fig. 15.13). In addition, a decrease in the PV_e′ velocity and an increase in the PV_e′ velocity may also be seen when there is pseudonormalisation.

Decreased DTI e’/+ Delayed Onset to DTI e’

As previously stated, the e’ is inversely related to LV myocardial relaxation. As DTI e′ is pseudonormalisation.

As described previously, an elevation of the LVEDP can be identified by: (1) an increase in the PV_e′ velocity and (2) the onset of the QRS complex or peak R wave on the ECG to the transmitral E velocity (Fig. 15.15).

Important limitations of the T_e′ measurement include: (1) the inability of most ultrasound systems to simultaneously measure each time interval and, therefore, variation in the cycle length may significantly affect the accuracy of this measurement, and (2) time intervals are numerically quite small so any error in measurement may prove significant.

Increased E/e’ Ratio

As previously described, when the LAP is elevated, the transmitral E velocity is increased; however, the DTI e′ velocity, which is inversely related to myocardial relaxation, remains reduced (and delayed) across all stages of diastolic dysfunction. Therefore, a high transmitral E and a low e′ (or an increased E/e′ ratio) indicates an elevation of LAP. Hence, a ‘normal’ transmitral inflow profile in conjunction with an elevated E/e′ ratio is indicative of pseudonormalisation.

In particular, the E/e’ ratio has been found to correlate with various LVFPs (see “Echocardiographic Parameters for Identifying Elevated LVFP” below).

Slow Flow Propagation Velocity (< 45 cm/s)

The flow propagation velocity (Vp) is a measurement of the velocity at which flow propagates within the ventricle. In particular, the Vp is indirectly related to the time constant of relaxation (tau) such that the longer it takes for the ventricle to relax, the slower the Vp. Therefore, a ‘normal’ transmitral inflow profile in conjunction with a slower than normal Vp is indicative of pseudonormalisation.

The Vp is measured from the apical 4-chamber view. From this view colour Doppler imaging of transmitral inflow is performed with an M-mode cursor is placed along the central path of transmitral inflow. Via this technique, the intraventricular pressure gradients over time can be measured as blood flow propagates from the mitral annulus toward the LV apex (Fig. 15.16). The Vp is then measured as the slope of the early transmitral wavefront.

While several methods have been described for the specific measurement of the Vp, the simplest method involves measurement of the early diastolic slope along the aliased velocity from the level of the mitral annulus to a distance of at least 4 cm into the LV cavity (Fig. 15.17). To enhance the early diastolic slope, the colour Nyquist limit is lowered by either decreasing the colour velocity scale or by moving the colour baseline upwards in the direction of flow; this creates aliasing and enhances the demarcation of the Vp slope. The normal Vp is ≤ 50 cm/s; when there is prolongation of LV relaxation, the Vp is slowed (< 45 cm/s).

Increased PA Pressures

Elevated LAP is usually associated with some degree of pulmonary hypertension due to the backward transmission of the elevated LAP to the lungs. Hence, in the absence of pulmonary disease, an elevation in the pulmonary artery systolic pressure (PASP) suggests an elevation in the LAP. In particular, it has been noted that a PASP of 30 mm Hg or less indicates a normal PCWP while a PASP > 40 mm Hg is associated with elevated PCWP. To simplify this further, a TR velocity > 2.8 m/s is also suggestive of an elevated LAP (see Information Box below). Therefore, a ‘normal’ transmitral inflow profile and a TR velocity > 2.8 m/s (or an RVSP/ PASP > 40 mm Hg), in the absence of pulmonary disease, is suggestive of pseudonormalisation.

If a PASP of 40 mm Hg is consistent with an elevated PCWP/LAP then a TR velocity of > 2.8 m/s is also consistent with a PASP > 40 mm Hg and an elevated PCWP/LAP. This is based on the assumption that: (1) the RAP is 8 mm Hg and (2) the RVSP is equal to the PASP. As detailed in Chapter 11, the RVSP is calculated from the peak TR velocity and the RAP so if the RVSP = 40 mm Hg and the RAP = 8 mm Hg, then:

\[
\frac{RVSP}{PASP} = 4 \frac{V_{TR}}{V_{TR}} + RAP
\]

\[
4V_{TR} = RVSP \times PASP - RAP
\]

\[
V_{TR} = \frac{40 - 8}{4} = 8 \text{ m/s}
\]

\[
V_{TR} = 8 \text{ m/s}
\]

\[
\text{RVSP} = 22 \text{ mm Hg}
\]

\[
\text{PASP} = 50 \text{ mm Hg}
\]

\[
\text{TR velocity} = \frac{V_{TR}}{4} = 2.8 \text{ m/s}
\]