Shortened P½t (or DS) for Significant Semilunar Valve Regurgitation

As stated, the Doppler velocity spectrum reflects the pressure gradient between two chambers or vessels. In AR, the Doppler velocity spectrum reflects the pressure gradient between the aorta and left ventricle (LV) during diastole. In the case of PR, the Doppler velocity spectrum represents the pressure gradient between the pulmonary artery and right ventricle (RV) during diastole. The rapidity with which the pressures between the aorta or pulmonary artery and their respective ventricles approach one another can be used to determine the severity of regurgitation. In AR, the maximum Doppler velocity of the regurgitant signal occurs following aortic valve closure when the pressure difference between the aorta and LV is greatest. The velocities of the Doppler regurgitant signal then decrease over the diastolic period as the pressure difference between the aorta and LV decreases due to (1) the fall in the aortic diastolic pressure which occurs due to a combination of forward run-off to the periphery as well as regurgitation back into the LV, and (2) the rise in the LV diastolic pressure which occurs due to a combination of normal transmitial inflow and the aortic regurgitant volume into the LV. With mild AR, the early diastolic pressure gradient is high and this pressure gradient then gradually declines over the diastolic period due to a gradual decline in the aortic diastolic pressure and only a small increase in the LV end-diastolic pressure (LVEDP) (Fig. 13.9, left). As a result, the decline in the AR deceleration slope over diastole is gradual.

In the presence of acute, severe AR, two important pressure changes occur: (1) the aortic diastolic pressure falls rapidly, and (2) the LVEDP increases markedly. This results in rapid decline or decay of the pressure gradient over the diastolic period (Fig. 13.9, right). As a result, the decline in the AR deceleration slope over diastole falls rapidly. This same concept can also be applied to the assessment of PR. That is, when there is mild PR there is a gradual decline in the PR deceleration slope over diastole; when there is severe PR in association with significant increase in the RV end-diastolic pressure (RVEDP), there is a rapid decline of the PR deceleration slope over the diastolic period. The rate of decline of the AR velocity spectrum can be measured using either the DS or, more commonly, the P½t (Fig. 13.10). The DS is derived from the peak velocity and the deceleration time (DT) and can be expressed as:

Equation 13.1

\[ DS = \frac{V_{peak}}{V_{1/2}} = \frac{V_{peak}}{\Delta P} \]

where \( DS \) = deceleration slope (m/s²)
\( V_{peak} \) = peak velocity (m/s)
\( V_{1/2} \) = velocity corresponding to one-half the peak pressure (m/s)
\( \Delta P \) = pressure gradient (mmHg)

Measurement of the P½t is analogous to that used in the Doppler assessment of mitral stenosis. Recall that the P½t is defined as the time required for the pressure to decay to half its original value (see Chapter 12). In Doppler, velocity rather than pressure is displayed on the Doppler spectrum. Since velocity and pressure are related, the P½t can be measured from the velocity spectrum as:

Equation 13.2

\[ P_{1/2} = \frac{V_{1/2}}{V_{peak}} \]

where \( V_{1/2} \) = velocity corresponding to one-half the peak pressure (m/s)
\( V_{peak} \) = peak velocity (m/s)

The P½t is also related to the DT such that the P½t is equal to 29% of the DT.

Equation 13.3

\[ P_{1/2} = 0.29 \times DT \]

where \( P_{1/2} \) = pressure half-time (ms)
\( DT \) = deceleration time (ms)

Limitations of the contour of the regurgitant Doppler signal as an indicator of significant regurgitation relate to other factors that also affect the contour of the signal. Importantly, the contour of the regurgitant Doppler signal only reflects the pressure gradient between two chambers. Therefore, other factors that affect the pressures within these chambers besides the regurgitant volume, such as chamber compliance, may also affect the contour of the regurgitant signal. For example, shortening of the P½t in the absence of significant AR may be seen in patients who have a “stiff”, noncompliant LV with an associated increase in the LVEDP. Furthermore, aortic diastolic pressure decay is not only related to the severity of AR but also to the systemic vascular resistance (afterload). Therefore, an increase in the systemic vascular resistance may result in an increase in the rate of decline of the P½t without any change in regurgitant orifice size. This can also occur in PR where an increase in the pulmonary vascular resistance may result in an increase in the rate of decline of the P½t without any change in regurgitant orifice size. Another limitation of using the contour as an indirect sign of regurgitation severity is based on poor or inadequate Doppler alignment with regurgitant jets. For example, poor alignment of the ultrasound beam with the direction of the regurgitant jet and/or eccentric jets may underestimate or overestimate the P½t of the regurgitant jet.