Estimation of Severity

The severity of PS is assessed using the peak velocity and maximum pressure gradient across the pulmonary valve via CW Doppler (see Fig. 9.42). The criteria for defining the various grades of PS based on these values are listed in Table 9.6. While the application of the continuity and PISA principles for the calculation of the pulmonary valve area (PVA) is theoretically feasible, these methods have not been validated for PS. In addition, the significance of the PVA for determining the various grades of severity of PS has not been described; therefore, calculation of the PVA is not useful in the assessment of PS severity.

The most common error in the estimation of pressure gradients relates to suboptimal alignment of the ultrasound beam with the PS jet. Another caveat is the presence of increased velocities and pressure gradients, secondary to increased flow across the pulmonary valve in the absence of PS. For example, increased velocities across the pulmonary valve may be encountered when there is an atrial septal defect, a ventricular septal defect or significant pulmonary regurgitation. In these cases, the transpulmonary velocities are increased secondary to an increased stroke volume across the valve; therefore, careful interrogation of the pulmonary valve leaflets and motion is required to determine if coexistent PS is also present.

Measurement of the Pulmonary Annulus

The procedure of choice for patients with severe or symptomatic congenital PS is balloon pulmonary valvuloplasty. In order to determine the optimal balloon size for successful dilatation of the valve, the size of the pulmonary annulus needs to be measured prior to the procedure. Measurement of the pulmonary annulus is best achieved from a zoomed parasternal long or short axis view of the RVOT (Fig. 9.50, top). Colour flow Doppler imaging may also be useful in delineating the lateral border of the RVOT (Fig. 9.50, bottom).

Estimation of Pulmonary Artery Systolic Pressure

In the absence of PS or RVOT obstruction, it is assumed that the RVSP is the same as the pulmonary artery systolic pressure (PASP). However, when there is RVOT obstruction or PS, the RVSP will be greater than the PASP as flow always travels from a higher pressure to a lower pressure area. In particular, the RVSP will be equal to the sum of the PASP and the pressure gradient across the pulmonary valve (Fig. 9.51):

Equation 9.5

\[ RVSP = PASP + \Delta P_{RVPA} \]

where

- \( RVSP \) = right ventricular systolic pressure (mm Hg)
- \( PASP \) = pulmonary artery systolic pressure (mm Hg)
- \( \Delta P_{RVPA} \) = systolic pressure gradient between the RV and PA (mm Hg)

Therefore, by rearranging the above equation, the PASP can be derived:

Equation 9.6

\[ PASP = RVSP - \Delta P_{RVPA} \]

where

- \( PASP \) = pulmonary artery systolic pressure (mm Hg)
- \( RVSP \) = right ventricular systolic pressure (mm Hg)
- \( \Delta P_{RVPA} \) = systolic pressure gradient between the RV and PA (mm Hg)

Table 9.6 Recommendations for Classification of Pulmonary Stenosis Severity

<table>
<thead>
<tr>
<th>Grade</th>
<th>Mild PS</th>
<th>Moderate PS</th>
<th>Severe PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity (m/s)</td>
<td>&lt; 3</td>
<td>3 - 4</td>
<td>&gt; 4</td>
</tr>
<tr>
<td>Maximum gradient (mm Hg)</td>
<td>36 - 64</td>
<td>&gt; 64</td>
<td></td>
</tr>
</tbody>
</table>


As illustrated in Figure 9.51, the RVSP and the PASP do not peak at the same point in time and for this reason, the systolic pressure gradient between the RV and PA (\( \Delta P_{RVPA} \)) is referred to as the peak-to-peak pressure gradient. Therefore, the PASP is equal to the difference between the RVSP and the peak-to-peak pressure gradient across the pulmonary valve. Importantly, the peak-to-peak pressure gradient is different to the Doppler-derived pressure gradient which measures the maximum instantaneous pressure gradient between the RV and the PA at the same instant in the cardiac cycle. So in order to estimate the PASP via Doppler, the Doppler gradient that best correlates with the peak-to-peak pressure gradient is required; in most instances, this has been shown to be the mean pressure gradient. Therefore, the PASP via Doppler can be estimated as:

Equation 9.7

\[ PASP = RVSP - \text{mPG}_v \]

where

- \( PASP \) = pulmonary artery systolic pressure (mm Hg)
- \( RVSP \) = right ventricular systolic pressure (mm Hg)
- \( \text{mPG}_v \) = mean pressure gradient across the pulmonary valve (mm Hg)

However, in patients with very severe or critical PS, the Doppler maximum instantaneous pressure gradient and the peak-to-peak pressure gradient correlate extremely well. This is because in critical PS the pulmonary pressure waveform becomes quite ‘flat’, therefore the maximum instantaneous Doppler gradient and the peak-to-peak pressure gradient are very similar (Fig. 9.52). Therefore, in patients with critical PS, the PASP is estimated as the difference between the RVSP and the maximum instantaneous Doppler gradient across the valve:

Equation 9.8

\[ PASP = RVSP - \text{mPG}_{iv} \]

where

- \( PASP \) = pulmonary artery systolic pressure in critical pulmonary stenosis (mm Hg)
- \( RVSP \) = right ventricular systolic pressure (mm Hg)
- \( \text{mPG}_{iv} \) = maximum instantaneous pressure gradient across the pulmonary valve (mm Hg)

Critical PS can be identified based on the shape of the Doppler profile (Fig. 9.53). In critical PS, the Doppler profile across the pulmonary valve appears rounded with the peak velocity occurring in mid systole.