Estimation of the PASP in RVOT Obstruction

As stated previously, in the absence of RVOT obstruction or pulmonary stenosis, the RVSP and the PASP are the same. However, in the presence of RVOT obstruction (including pulmonary stenosis), the RVSP will be greater than the PASP as flow always travels from a higher pressure to a lower pressure area. In this instance, the RVSP will be equal to the sum of the PASP and the pressure gradient across the pulmonary valve (Fig. 11.25):

Equation 11.34

$$RVSP = PASP + \Delta P_{RV\text{-}PA}$$

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

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

Equation 11.35

$$PASP = RVSP - \Delta P_{RV\text{-}PA}$$

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

As illustrated in Figure 11.25, 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 ($\Delta P_{RV\text{-}PA}$) 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.

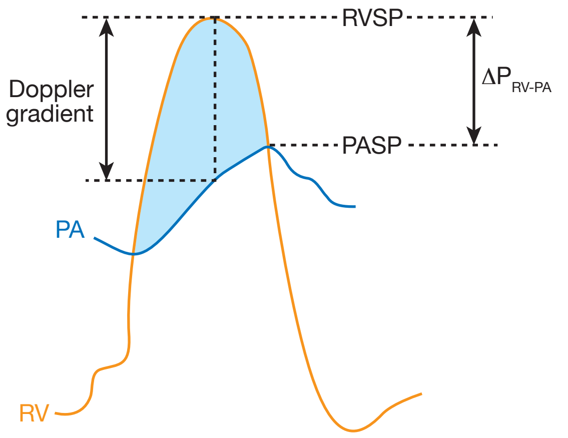


Figure 11.25 This schematic illustrates the right ventricular (RV) and pulmonary artery (PA) pressure traces in pulmonary stenosis. The pressure difference between the right ventricular systolic pressure (RVSP) and the pulmonary artery systolic pressure (PASP) is equivalent to the systolic pressure gradient between the RV and PA ($\Delta P_{RV\text{-}PA}$). Observe that the RVSP peaks before the PASP; for this reason, the pressure gradient between the RV and PA is also referred to as the 'peak-to-peak' pressure gradient.

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 pulmonary artery 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 [11.5]. Therefore, the PASP via Doppler can be estimated as (see Practical Example 11.4):

Equation 11.36

$$PASP = RVSP - mPG_{PV}$$

where PASP = pulmonary artery systolic pressure (mm Hg)
RVSP = right ventricular systolic pressure (mm Hg)
mPG_{PV} = 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. 11.26). 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 (see Practical Example 11.5):

Equation 11.37

$$PASP_C = RVSP - MIPG_{PV}$$

where $PASP_C$ = pulmonary artery systolic pressure in critical pulmonary stenosis (mm Hg)
RVSP = right ventricular systolic pressure (mm Hg)
$MIPG_{PV}$ = maximum instantaneous pressure gradient across the pulmonary valve (mm Hg)

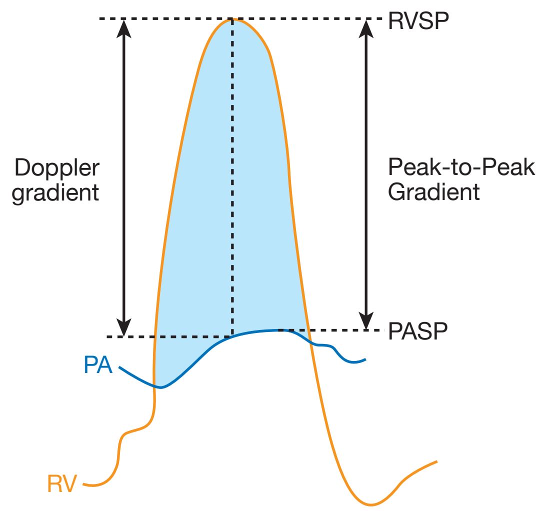
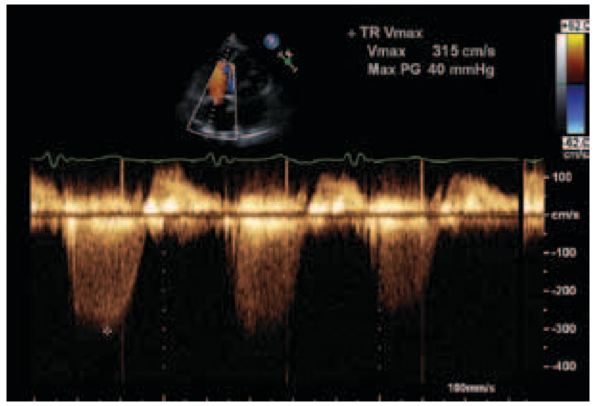


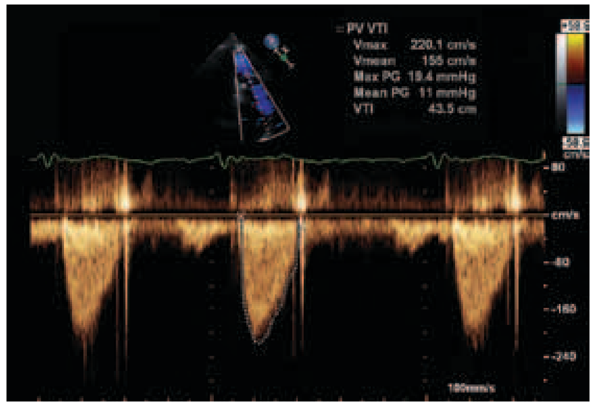
Figure 11.26 This schematic illustrates the right ventricular (RV) and pulmonary artery (PA) pressure traces in critical pulmonary stenosis. Observe that the Doppler-derived pressure gradient and the invasively-derived 'peak-to-peak' pressure gradient are very similar due to damping and 'flattening' of the PA pressure trace.

[11.5] Silvilairat S, Cabalka AK, Cetta F, Hagler DJ, O'Leary PW. Echocardiographic assessment of isolated pulmonary valve stenosis: which outpatient Doppler gradient has the most clinical validity? *J Am Soc Echocardiogr.* 2005 Nov;18(11):1137-42.

Practical Example 11.4

From the spectral Doppler signals below, calculate the pulmonary artery systolic pressure (PASP). Assume that RAP is 8 mm Hg.





These CW Doppler traces were acquired across the tricuspid regurgitant (TR) jet (*top*) and across the pulmonary valve (*bottom*).

Step 1: Calculate the RVSP
Using Equation 11.29:

$RVSP = 4\,V_{TR}^2 + RAP$
$= 4\,(3.15^2) + 8$
$= 39.69 + 8$
$= 48$ mm Hg

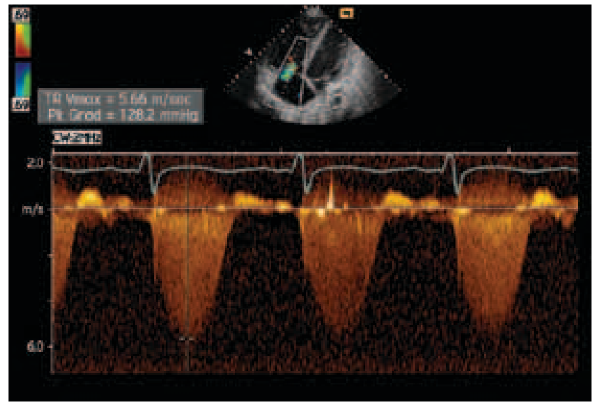
Step 2: Calculate the PASP
The signal across the pulmonary valve is V-shaped and peaks in early systole; therefore, the PASP is calculated using Equation 11.36:

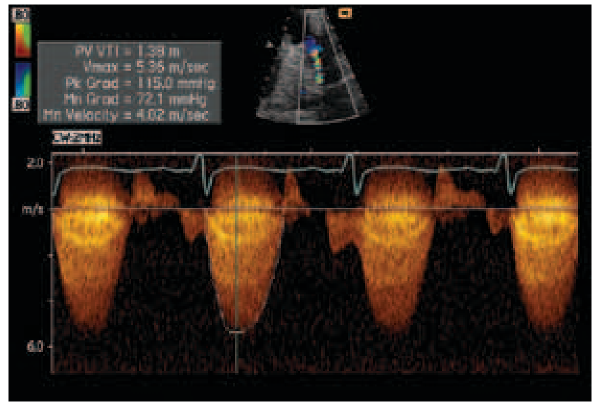
$PASP = RVSP - mPG_{PV}$
$= 48 - 11$
$= 37$ mm Hg

Note: For simplicity, traces have been measured once. In reality, TR velocities should be averaged over the respiratory cycle and pulmonary valve signals should be averaged over at least 2 consecutive cardiac cycles.

Practical Example 11.5

From the spectral Doppler signals below, calculate the pulmonary artery systolic pressure (PASP). Assume that RAP is 15 mm Hg.





These CW Doppler traces were acquired across the tricuspid regurgitant (TR) jet (*top*) and across the pulmonary valve (*bottom*).

Step 1: Calculate the RVSP
Using Equation 11.29:

$RVSP = 4\,V_{TR}^2 + RAP$
$= 4\,(5.66^2) + 15$
$= 128 + 15$
$= 143$ mm Hg

Step 2: Calculate the PASP
The signal across the pulmonary valve is rounded and peaks in mid systole; this is consistent with critical pulmonary stenosis. Therefore, the PASP is calculated using Equation 11.37:

$PASP_c = RVSP - MIPG_{PV}$
$= 143 - 115$
$= 28$ mm Hg

Note: For simplicity, traces have been measured once. In reality, TR velocities should be averaged over the respiratory cycle and pulmonary valve signals should be averaged over at least 2 consecutive cardiac cycles.