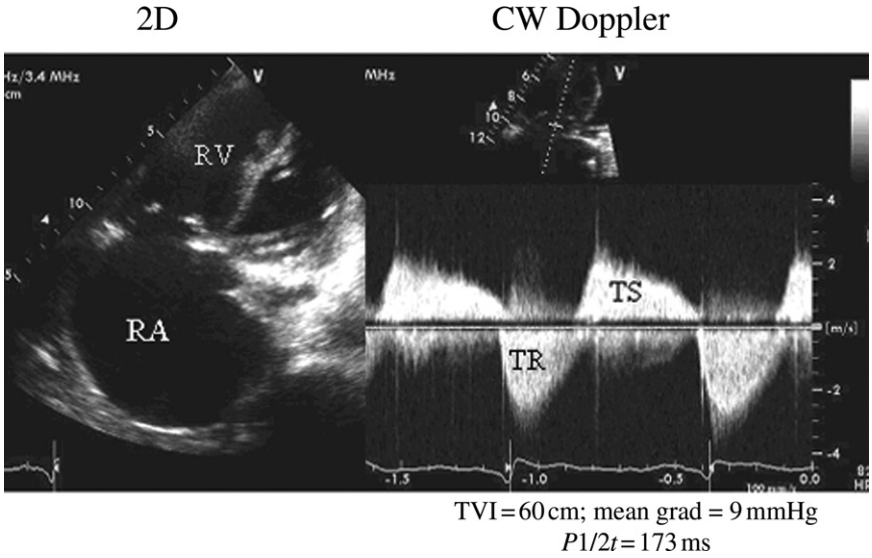

Figure 11 The left panel illustrates a 2D echocardiographic image of a stenotic tricuspid valve obtained in a modified apical four-chamber view during diastole. Note the thickening and diastolic doming of the valve, and the marked enlargement of the right atrium (RA). The right panel shows a CW Doppler recording through the tricuspid valve. Note the elevated peak diastolic velocity of 2 m/s and the systolic tricuspid regurgitation (TR) recording. The diastolic time–velocity integral (TVI), mean gradient (Grad), and pressure half-time ($T_{1/2}$) values are listed.

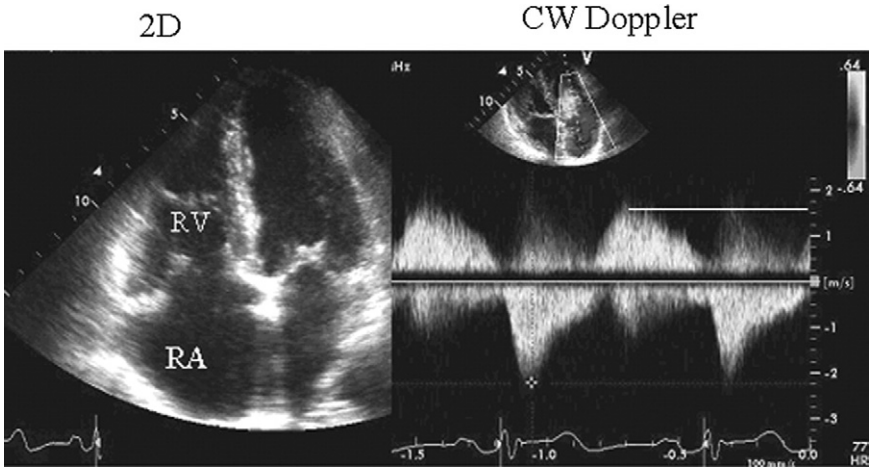

Figure 12 The left panel illustrates a 2D echocardiographic image of a tricuspid valve in a patient with carcinoid syndrome, obtained in an apical four-chamber view during systole. Note the thickening and opened appearance of the valve. The right panel shows a continuous-wave Doppler recording through the tricuspid valve. Note an elevated peak diastolic velocity of 1.6 m/s and the systolic TR recording.

The hallmark of a stenotic valve is an increase in transvalvular velocity recorded by CWD (Figures 11 and 12). Peak inflow velocity through a normal tricuspid valve rarely exceeds 0.7 m/s. Tricuspid inflow is normally accentuated during inspiration; consequently, with TS, it is common to record peak velocities >1.0m/s that may approach 2 m/s during inspiration. As a general rule, the mean pressure gradient derived using the $4v^2$ equation is lower in tricuspid than in MS, usually ranging between 2 and 10 mmHg, and averaging around 5 mmHg. Higher gradients may be seen with combined stenosis and regurgitation.[91–93]

The primary consequence of TS is elevation of right atrial pressure and development of right-sided congestion.Because of the frequent presence of TR, the transvalvular gradient is clinically more relevant for assessment of severity and decision-making than the actual stenotic valve area. In addition, because anatomical valve orifice area is difficult to measure (not withstanding future developments in 3D), and TR is so frequently present, the typical CWD methods for valve

Table 10 Findings indicative of haemodynamically significant tricuspid stenosis

Specific findings	
Mean pressure gradient	≥5 mmHg
Inflow time–velocity integral	>60 cm
$T_{1/2}$	≥190 ms
Valve area by continuity equation[a]	≤1 cm^{2a}
Supportive findings	
Enlarged right atrium ≥moderate	
Dilated inferior vena cava	

[a]Stroke volume derived from left or right ventricular outflow. In the presence of more than mild TR, the derived valve area will be underestimated. Nevertheless, a value ≤1 cm^2 implies a significant haemodynamic burden imposed by the combined lesion.

area determination are not very accurate. The pressure half-time method ($T_{1/2}$) has been applied in a manner analogous to MS. Some authors have used the same constant of 220, while others have proposed a constant of 190 with valve area determined as: $190/T_{1/2}$.[93] Although validation studies with TS are less than those with MS, valve area by the $T_{1/2}$ method may be less accurate than in MS. This is probably due to differences in atrioventricular compliance between the right and left side, and the influence of right ventricular relaxation, respiration, and TR on the pressure half-time. However, as a general rule, a longer $T_{1/2}$ implies a greater TS severity with values >190 frequently associated with significant (or critical) stenosis.

In theory, the continuity equation should provide a robust method for determining the effective valve area as SV divided by the tricuspid inflow VTI as recorded with CWD.[94] The main limitation of the method is obtaining an accurate measurement of the inflow volume passing through the tricuspid valve. In the absence of significant TR, one can use the SV obtained from either the left or right ventricular outflow; a valve area of ≤1 cm^2 is considered indicative of severe TS. However, as severity of TR increases, valve area is progressively underestimated by this method. Nevertheless, a value ≤1 cm^2, although it is not accounting for the additional regurgitant volume, may still be indicative of a significant hemodynamic burden induced by the combined lesion.

C. How to Grade Tricuspid Stenosis

From a clinical standpoint, the importance of an accurate assessment of TS is to be able to recognize patients with haemodynamically significant stenosis in whom a surgical- or catheter-based procedure may be necessary to relieve symptoms of right-sided failure. In the presence of anatomic evidence by 2D echo of TS, the findings listed in Table 10 are consistent with significant stenosis with or without regurgitation.