Tricuspid Valve and Pulmonic Valve

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TEE evaluation of the **tricuspid valve (TV)** focuses on the same standard views described for evaluating the right ventricle (RV). From the standard **mid-esophageal 4-chamber view**, slight rightward (clockwise) rotation of the probe will move the TV to the center of the scan plan, then advancing and withdrawing the transducer allows imaging of the entire TV. In the 4-chamber view, the TV annulus is noted to be located in a slightly more apical position than the mitral valve. This normal apical displacement of the TV is not present in patients with endocardial cushion defects and primum atrial septal defects, and is exaggerated in patients with Ebstein’s Anomaly of the TV. The latter condition should be suspected when the separation between the mitral and tricuspid annular planes exceeds 11 mm, which causes a portion of the morphological right ventricle to become atrialized.

The **mid-esophageal RV inflow-outflow view** provides an additional, nearly orthogonal, view of the TV. In this scan plane, the TV lies in a plane that is more nearly perpendicular to the TEE transducer. Consequently, quantitative measurement of tricuspid flow velocities with continuous wave Doppler will provide more accurate results.

The trans-gastric views used to evaluate the RV also provide useful windows for imaging the TV. Rightward (clockwise) rotation of the TEE transducer from the **trans-gastric mid short axis view** provides a good view of the TV in short axis, allowing identification of its septal, anterior, and posterior leaflets. The commissures separating the cusps of the TV are not as deep as those separating the two leaflets of the mitral valve. These commissures never reach the TV annulus; hence the TV cusps are incompletely separated from one another. The **trans-gastric right ventricular inflow view** provides the best image of the chordae tendinae and RV papillary muscles supporting the TV.
Tricuspid regurgitation (TR) is the most common right-sided valvular lesion in adults. Nearly 70% of normal individuals have trace to mild TR. Significant TR is most commonly caused by tricuspid annular dilatation associated with pulmonary hypertension or right ventricular dysfunction. Other primary causes include endocarditis, carcinoid heart disease, Ebstein’s Anomaly, and rheumatic heart disease. In patients with functional TR related to pulmonary hypertension and annular dilatation, surgical decision making is complicated by a number of factors. In many cases, significant degrees of TR will resolve or improve markedly following surgical correction of associated mitral valve disease. Therefore, mild TR should not be addressed surgically, whereas moderate TR is treated often with a suture annuloplasty, while severe TR may require insertion of a ring annuloplasty. Unless the tricuspid leaflets are involved in the disease process, valvular replacement is rarely needed.

Quantification of tricuspid regurgitation severity relies on many of the same techniques used for grading severity of left-sided valvular regurgitation, but the quantitative reference standards are less well established for this lesion. Furthermore, most tricuspid valve repairs or replacements are performed in patients who are undergoing other valvular procedures, usually mitral valve surgery. Severity of regurgitation is usually assessed with color flow Doppler, with severe regurgitation represented by a large color flow disturbance.
that fills more than half of the right atrium. When the regurgitant jet is directed at the atrial septum, it must be distinguished from normal caval inflow or an atrial septal defect. Pulsed-wave Doppler assessment of caval flow or hepatic vein flow may reveal abnormal reversed (retrograde) flow in systole, which reflects severe TR.

For more detailed assessment of TR severity, a number of echocardiographic and Doppler parameters should be utilized. These include an assessment of valvular morphology; size of right atrium, ventricle, and vena cava; area of the color flow TR jet; width of the vena contracta; dimension of the proximal isovelocity surface area (PISA) radius; continuous wave Doppler spectral envelope characteristics; and pulsed wave Doppler pattern in the hepatic veins.

### Evaluation of Tricuspid Regurgitation Severity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mild</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV Morphology</td>
<td>Normal</td>
<td>Abnormal, prolapse, mal-coaptation</td>
</tr>
<tr>
<td>RA/RV/IVC Size</td>
<td>Normal</td>
<td>Dilated</td>
</tr>
<tr>
<td>Color Flow Jet Area in RA</td>
<td>&lt; 5 cm²</td>
<td>&gt; 10 cm²</td>
</tr>
<tr>
<td>Vena Contracta Width</td>
<td>Undefined</td>
<td>&gt; 0.7 cm</td>
</tr>
<tr>
<td>PISA Radius</td>
<td>&lt; 0.6 cm</td>
<td>&gt; 0.9 cm</td>
</tr>
<tr>
<td>CWD TR Jet</td>
<td>Soft, parabolic</td>
<td>Dense, triangular, early peak</td>
</tr>
<tr>
<td>PWD Hepatic Vein Flow</td>
<td>Systolic dominance</td>
<td>Systolic flow reversal</td>
</tr>
</tbody>
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The jet of TR may also be interrogated with continuous wave Doppler to measure the peak velocity of the regurgitant jet. Using the simplified Bernoulli equation, the systolic transvalvular pressure gradient may be calculated as $\Delta P = 4V^2$. Finally, right ventricular systolic pressure is calculated by adding this pressure gradient to an estimate of right atrial pressure. In the absence of obstruction to RV outflow, this calculated RV systolic pressure provides a good estimate of pulmonary artery systolic pressure. Since the vast majority of patients with elevated pulmonary artery pressure have some degree of TR even in the absence of clinical signs, this measurement has wide application. However, when making this calculation, considerable care must be taken to align the ultrasound beam with the regurgitant jet to avoid underestimation of these pressures. It should also be noted that the TR jet peak velocity is unrelated to the severity of TR.

Tricuspid stenosis is diagnosed by the structural abnormalities of the leaflets and quantified by continuous wave Doppler examination of trans-tricuspid flow. Since the tricuspid is the largest of the four cardiac valves, flow velocities are the lowest across this valve, typically <0.7 m/sec. Although normal prosthetic valves in the tricuspid position
may demonstrate peak velocities nearly twice as high as normal, velocities >1.5 m/sec suggest significant tricuspid stenosis.

The valve least well imaged using TEE is the **pulmonic valve (PV)**. Like the aortic valve, the PV is a trileaflet, semilunar valve, but its leaflets are thinner than the aortic valve leaflets and its more anterior location places it at a greater distance from the ultrasound transducer located in the esophagus. Because of these unique anatomic features, complete ultrasound evaluation of the PV often requires transthoracic echocardiography (TTE) in addition to TEE. In fact, comprehensive evaluation of the right heart is best accomplished when TTE and TEE are combined. Not only are the anteriorly located right heart structures more accessible to TTE imaging, but also TTE provides a greater number of acoustic windows and greater ability to angulate the ultrasound probe. Unlike the constraints of TEE probe manipulation within the esophagus, TTE more readily provides optimal probe alignment parallel to the flow of interest, thereby avoiding underestimation of flow velocity measurements with pulsed-wave or continuous wave Doppler.

The most reliable scan plane for imaging the PV is the **mid-esophageal right ventricular inflow-outflow view**. In this imaging plane, the aortic valve provides a useful anatomic guide. The PV can be identified in its normal location adjacent to the commissure separating the right and left coronary cusps of the aortic valve. Since the PV is oriented at roughly a right angle to the aortic valve, it is typically seen in its long axis when the aortic valve is seen in short axis. This anatomic relation is demonstrated in the RV inflow-outflow view. Further slight withdrawal of the TEE probe reveals the **mid-esophageal aortic valve short axis view** where the PV may be seen again in long axis adjacent to the aortic valve. Further gradual probe withdrawal will usually show the main pulmonary artery above the PV and the pulmonary artery bifurcation into left and right branches. With the probe at this position high in the esophagus, transducer rotation to 90° reveals the **upper esophageal aortic arch short axis view**. In many patients, the main pulmonary artery, PV, and distal RV outflow tract can be seen beneath the aortic arch. This may be a particularly useful view for detecting pulmonic regurgitation or quantifying pulmonic stenosis with continuous wave Doppler, owing to the advantageous alignment with the predominant flow vector.

Pulmonic regurgitation (PR) is usually an incidental finding of little clinical importance. Minor degrees of PR are present in 40-80% of patients, and significant PR is almost always associated with structural abnormalities of the PV or right heart. While Doppler color flow mapping is the primary method for evaluating severity of PR, other techniques may also be helpful.
Pulmonic stenosis is usually congenital in origin and may be evaluated with continuous wave Doppler. Carcinoid heart disease is one of the few causes of pulmonic stenosis in the adult. It causes thickening and fibrosis of both the pulmonic and tricuspid valves. While the valvular involvement may produce stenosis or regurgitation, the more common pattern is severe tricuspid regurgitation with varying degrees of pulmonic stenosis. Unlike the changes seen in rheumatic heart disease, the valvular distortion in patients with carcinoid does not cause leaflet doming.

**Suggested Reading: Tricuspid & Pulmonic Valves**