How Much Tricuspid Insufficiency and Should the Valve be Repaired?

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Tricuspid Valve Anatomy
The tricuspid valve consists of three asymmetric leaflets (Fig 1) that are supported by multiple chordae tendinae and three papillary muscles. The commissures between each of the leaflets are less well defined than those of the mitral valve. The annulus of the tricuspid valve is partially fibrous and partially muscular, which allows annular contraction during systole. The normal tricuspid annulus is saddle shaped with the highest points located in an anteroposterior orientation and the lowest points in a mediolateral orientation. The membranous septum and the bundle of His are near the commissure between the anterior and septal leaflets. The plane of the TV annulus is slightly apical (6 to 10 mm) relative to the plane of the mitral valve—this is recognized echocardiographically by the TV septal leaflet’s more apical attachment to the ventricular septum than the anterior mitral leaflet’s. Greater apical displacement of the septal leaflet is seen in Ebstein’s anomaly; absence of apical displacement indicates an AV canal defect.

![Figure 1. Tricuspid Valve](image)

TEE Exam of the Tricuspid Valve:
There are four standard SCA/ASE views and 2 modified views that facilitate assessment of the tricuspid valve apparatus and the degree of tricuspid insufficiency.

View 1: ME Four Chamber View
The assessment of the TV usually begins with the mid-esophageal 4-chamber view (Fig 2). The septal leaflet is seen medially. The leaflet on the lateral aspect of the sector scan is either the anterior or posterior leaflet, depending on the probe position. If the probe is anteflexed (and part of the aortic valve is seen), it will be the anterior leaflet. If the probe is retroflexed (and part of the coronary sinus is visible), it will be the posterior leaflet. Leaflet mobility and thickness should be assessed. Usually the subvalvular apparatus is hypoechoic in this view—if it is easy to see it may indicate fibrosis and thickening. Note the position of the TV relative to the mitral valve in this view. This is a good view to assess the TR jet area and TR vena contracta width. TV annulus and the degree of TV leaflet tethering should be measured here. The size and function of the RV and RA should also be evaluated.

View 2: ME RV Inflow-Outflow View:
The second view is obtained by positioning the TV in the center of the scan plane and advancing the omniplane to approximately 40-70 degrees. The TV and the PV should be visible simultaneously (Fig 3). This view provides a view of the septal or anterior leaflet medially and the posterior leaflet laterally. It usually provides good alignment for PW and CW Doppler assessment. This view should not be used to measure the TR vena contracta.¹
View 3: Modified ME LAX View:
The third view is achieved by rotating the omniplane another 90 degrees to 130-170 degrees (Fig 4). The anterior leaflet is seen at the bottom of the sector scan. This view is frequently a good view to assess the leaflets and the vena contracta.

Six Tricuspid Valve Views

View 4: TG Basal SAX View:
The fourth view is obtained with the probe in the transgastric position. After finding the TG basal SAX view (Fig 5), rotate the probe rightward to identify the TV (Fig 8). The probe may need slight insertion to obtain the SAX TV view—rotation of the omniplane 20-50 degrees may provide the best view of the three TV leaflets. The commissures will not be as well defined as those of the mitral valve. The anterior, septal, and posterior leaflets are defined in figure 8.

View 5: TG RV Inflow View:
With the TV SAX essentially in the center of the sector scan, rotate the omniplane 90 degrees (usually to 110-130 degrees) to obtain the TG RV inflow view (Fig 6). This view provides excellent visualization of the leaflets and the subvalvular apparatus. Typically, the anterior and posterior leaflets will be seen in this view. Rotation of the probe to the left (counterclockwise) will provide a view of the septal leaflet and its supporting apparatus.

View 6: Modified Deep TG View:
The last view is a modification of the Deep TG view. A slight adjustment in probe position (anterior flexion to view more a more posterior aspect of the heart and rightward probe rotation) is required. This
often provides the best alignment of the Doppler beam with TV inflow or regurgitation (Fig 7). It is particularly helpful when there is a prosthesis in the aortic position.

**Estimation of Tricuspid Regurgitation Severity**

The assessment of TR always begins with the 2-D exam of the TV apparatus—including the leaflets, the chordae, the annulus, the RV and the RA. Jet area should be measured with a Nyquist limit of 50-60 cm/s and appropriate color gain settings. The three transesophageal views should all be examined to assess jet area.

Measurement of the vena contracta (VC)—the narrowest width of the regurgitant jet that is immediately downstream to the flow convergence area—provides a more hemodynamically independent estimate of the TR severity. By TTE, this method has been shown to correlate well with the effective orifice area. A VC greater than 6.5 mm (7 mm was adopted by the ASE/ACC) indicates severe TR. Again, it is important to use the Nyquist limit of 50-60 cm/s. To obtain this measurement, one has to find an image plane in which the proximal flow acceleration and the distal jet expansion are clearly visible (Fig. 9). Then use maximal zoom to best measure the VC. The four chamber view and the modified LAX view work best for this measurement.

![Figure 9. Measurement of the VC](image)

Assessment of the hepatic vein flow profile can be helpful in differentiating the various degrees of TR just as the assessment of pulmonary vein flow can assist in the assessment of MR. To find a hepatic vein, obtain the bicaval view and follow the IVC into the liver by inserting the probe slightly and rotating it to the right. The PWD sample volume is placed 1-2 cm into the orifice of a central hepatic vein. The normal hepatic vein PWD profile is characterized by antegrade systolic flow (S), transient flow reversal as the TV annulus recoils at the end of systole (v), antegrade flow in diastole (D), and flow reversal during the atrial contraction (a) (Fig 10).

![Figure 10. Normal hepatic flow](image)  
![Figure 11. Systolic flow reversal](image)

A normal flow profile usually indicates the absence of significant TR. Blunted systolic flow is consistent with moderate TR. Systolic flow reversal is a specific indicator of severe TR (Fig 11). The absence of systolic flow reversal does not rule out severe TR, however. Severe TR may exist without systolic flow reversal in the chronic state due to right atrial enlargement.
Assessment of the TR jet with CWD can be helpful. The more severe the TR, the greater the intensity the TR jet will be. If the TR jet intensity approximates the antegrade flow intensity, the TR is severe. In addition, the greater the TR, the faster the TR jet velocity will decelerate (because the RA-RV pressure gradient falls more rapidly). Thus a bright and rapidly decaying TR jet is an indicator of severe TR; a flatter and less intense jet is associated with trace to mild TR.

Using the above data the anesthesiologist can use the ASE/ACC Recommendations for Assessment of TR severity to objectively grade the TR.

| Table 8 Echocardiographic and Doppler parameters used in grading tricuspid regurgitation severity |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Parameter                                      | Mild                                             | Moderate                                         | Severe                                          |
| Tricuspid valve                                | Usually normal                                   | Normal or abnormal                               | Abnormal/Flail leaflet/Poor coaptation           |
| RV/RA/TVC size                                 | Normal*                                          | Normal or dilated                                | Usually dilated**                               |
| Jet area-central jets (cm²)                   | < 5                                              | 5-10                                             | > 10                                            |
| VC width (cm)                                  | Not defined                                      | Not defined, but < 0.7                           | > 0.7                                           |
| PISA radius (cm)                               | ≤ 0.5                                            | 0.6-0.9                                         | > 0.9                                           |
| Jet density and contour-CW                     | Soft and parabolic                               | Dense, variable contour                          | Dense, triangular with early peaking            |
| Hepatic vein flow†                             | Systolic dominance                               | Systolic blunting                                | Systolic reversal                               |

CW, Continuous wave Doppler; TVC, inferior vena cava; RA, right atrium; RV, right ventricle; VC, vena contracta width.

* Unless there are other reasons for RA or RV dilation. Normal 2D measurements from the apical 4-chamber view: RV end-diastolic area ≤ 4.3 cm², RV end-systolic area ≤ 3.8 cm², RA end-diastolic area ≤ 4.6 cm² and ≤ 4.9 cm² respectively, maximal RA volume ≤ 33 ml/m² (J8,9).

** Exception: acute TR.

† At a Nyquist limit of 50-60 cm/s. Not valid in eccentric jets. Jet area is not recommended as the sole parameter of TR severity due to its dependence on hemodynamic and technical factors.

Typically the grade of TR after the induction of anesthesia is lower than that found in the preoperative exam. There are two important measurements that you should make that are not so dependent on hemodynamics. Both have been shown to predict the need for TV intervention in the setting of functional TR (i.e., TR not due to intrinsic leaflet disease).

Annular dilation (>34 mm in a TTE 4 chamber view at end systole) has been shown to be an independent predictor of severe TR in patients with functional TR. The annulus is frequently measured in the four chamber view, but Maslow et al showed that the TG RVIO view correlated best with surgical measurement.

Tethering height (TH) measured in the TTE four chamber view has been shown to be a very strong predictor of the likelihood of residual TR after left-sided lesion repair or TV repair.

**Should the Tricuspid Valve be repaired?**

When intrinsic leaflet pathology is not the cause of significant TR, the surgeon must decide what to do with the TV while typically operating on some left-sided valve lesion. The surgeon can leave the TV alone hoping that repairing the left-sided lesion will lead to a resolution of the TR. This was a common decision in the past. However, research has revealed that “functional TR” often does not resolve after the left-sided lesion repair. Rather, it often progresses and the TR becomes a significant burden for the patient. And not surprisingly, a redo operation to address the TR is associated with a very high mortality. Thus surgeons are now becoming more aggressive at treating functional TR with either a DeVega annuloplasty or a ring prosthesis. Several large centers use annular dimension and tethering height to determine whether or not the TV needs intervention.

But TV repair is not a panacea either—just as it has not been for functional MR. Plenty of patients who get some type of annuloplasty develop significant TR in the subsequent 5 years. Because a reoperation is so risky, many persist in a suboptimal physiologic state. Data showing that a preoperative tethering height
predicted moderate to severe TR after surgery with a sensitivity and specificity of 82% and 84%, respectively may compel more surgeons to consider a tricuspid replacement, especially in older patients. Historically, TV replacement has been thought to be associated with a very high risk and that a repair should be done if at all possible. A recent study however found no difference in outcome between TV repair and replacement.

In summary, we as cardiac anesthesiologists need to be aware of as much of the data as possible so that we can help the surgeons decide what is best for the patient. We have to be careful not to conclude that because the patient’s intraoperative TR is only mild, it therefore does not need intervention. The tricuspid valve is just beginning to be understood. Its function is dependent on the leaflets, the chordae, the RV and RA and even the LV as the interventricular septum is the attachment site for the TV’s septal papillary muscle. A dilated annulus or distorted papillary muscles do not necessarily recover when a left-sided lesion is repaired. The TV disease can be progressive and when it becomes problematic the surgical treatment is high-risk. We therefore owe it to the patients to assess not only the TR severity but also the other markers of TV disease progression (annular diameter, tethering height, RV dilation etc). We also must be certain to review the preoperative data and the patient’s symptoms carefully. Then we will be able to provide excellent intraoperative advice to the surgeon.

We should also be careful not to look at mild residual TR lightly. If after a TV repair for example, there is mild TR, we need to at least to encourage the surgeon to consider making it better. The good news is that the TV can be addressed without additional cardiac ischemic time.

References