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REVIEW ARTICLE

Echocardiographic Evaluation of Tricuspid Prosthetic Valves: An Update

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Abstract This review focuses on the diagnostic value of novel echocardiographic techniques and the clinical application of recently described algorithms to assess tricuspid prosthetic valve function.

1. Introduction

Accurate prosthetic valve assessment is of great importance for clinical decisions. Current guidelines recommend noninvasive evaluation in patients with tricuspid prosthetic valves (TPV) with Doppler echocardiography.[1] Normal Doppler derived indices such as transprosthetic peak velocity, mean transprosthetic pressure gradient and pressure half time (PHT) have been reported, although not validated. Studies using large series of early postoperative data have proposed additional parameters and clinically helpful algorithms to evaluate both bioprosthetic and mechanical valves in the tricuspid position.[2,3] The addition of newer techniques such as three-dimensional echocardiography may also add value to traditional tricuspid prosthetic valve evaluation. The purpose of this review is to focus on these new proposed indices to better describe the nature of pathologic TPV dysfunction.

2. Echocardiographic Evaluation of Tricuspid Prosthetic Valve Function

2.1. 2D Echocardiography

Comprehensive evaluation either with transthoracic echocardiography (TTE) or transesophageal echocardiography

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(TEE) has been traditionally used to assess TPV function and structure. Standard transthoracic (RV inflow, four chamber, RV inflow-outflow and subcostal views) and transesophageal views (mid-esophageal (ME) 4 chamber, the ME inflow-outflow, the ME-modified bicaval TV and the transgastric (TG) RV inflow-outflow view)[4] can visualize the appropriate seating of the TPV in the annulus, diagnose TPV degeneration due to leaflet calcification and thickening and possibly identify causes of obstruction (thrombus, pannus, vegetation) or regurgitation (vegetation, dehiscence). Transthoracic imaging can provide excellent quality images because the tricuspid valve is an anterior structure. 2D echocardiography may also provide additional information about RV and RA size and function, which results in an integrated approach to evaluate the presence and severity of TPV dysfunction.

2.2. Color Doppler Imaging

Color Doppler shows the blood flow pattern across the prostheses. In bioprosthetic TPVs the diastolic flow jet is smooth and wide, with no apparent aliasing. In mechanical TPVs, the antegrade color Doppler jet direction and pattern may differ among variable valve types (ball cage, bileaflet valves). Color Doppler is also the preferred method for assessing TPV transprosthetic and periprosthetic regurgitation. Mild regurgitant washing jets are apparent in normally functioning mechanical TPVs, while mild regurgitant transprosthetic jets might be rarely seen in normally functioning bioprosthetic TPVs early post-surgery. Acoustic shadowing from the valve's metallic elements may interfere with color Doppler interrogation, and views with minimal shadowing are preferred with TTE (the RV inflow and the subcostal views). Multiplane TEE may offer additional views, avoiding acoustic shadowing, especially in cases when significant transprosthetic or periprosthetic regurgitation is suspected.

2.3. Spectral Doppler Echocardiography

Doppler echocardiography is currently recommended for TPV evaluation early post implantation.[1] The transprosthetic velocity can be noninvasively estimated with continuous wave (CW) Doppler and pressure gradient (peak and mean) can be estimated by applying the simplified Bernoulli equation. Adequate Doppler alignment with flow appears to be superior with traditional TTE views, whereas valve interrogation with CW by the TEE approach might be challenging in some cases. Current guidelines[1] report normal transprosthetic gradient and pressure half time values; however, additional Doppler derived parameters such as the effective orifice area (EOA) and time velocity integral (TVI) ratio have been recently described in larger population studies[2,3] to provide a comprehensive evaluation of TPV function.

Respiratory transprosthetic velocities may vary during the respiratory cycle; therefore, Doppler measurements from at least five cycles have been proposed to be averaged in current guidelines whether the patient is in sinus rhythm or atrial fibrillation. In cases of significant Doppler velocity variation, more cycles might be averaged.[1]

2.4. Mean Gradient

Current guidelines state that normally functioning tricuspid prostheses have a mean gradient $<$6mmHg.[1] Recently, Blawet et al. have shown that a transvalvular mean gradient $<$9mmHg identifies normally functioning bioprosthetic tricuspid valves.[2] They included a variety of different types of valves and sizes (Carpentier-Edwards Duraflex, Medtronic Mosaic, St. Jude Medical Biocor, Carpentier-Edwards Perimount and Medtronic Hancock II). In another study evaluating mechanical tricuspid bileaflet valves, a mean gradient $<$6 mmHg reflected normally functioning valves.[3] However, it should be noted that the mean gradient may be altered significantly in high flow states (anemia, hyperthyroidism, sepsis), where the valves are still functioning normally despite higher reported gradients.[1] Other conditions such as constrictive pericarditis or elevated right ventricular diastolic pressures can also affect transprosthetic gradients. Although high right atrial pressure or a noncompliant right atrium can affect the contour of the continuous wave Doppler in cases of tricuspid regurgitation reflecting the relation of pressures across the prosthesis, their contribution to the transvalvular diastolic mean gradient assessment remains unclear.

2.5. Pressure Half-Time

Pressure half time (PHT) is the time it takes for the transprosthetic peak gradient measured by Doppler to decline to half of its initial value. Current guidelines recommend that a PHT$<$230 msec indicates the absence of significant valve stenosis.[1] It should be noted, that rounded spectral Doppler contours are not uncommon and PHT cannot be reliably evaluated in these cases. The normal value of 200-238 msec has been proposed as an upper limit for bioprosthetic TVPs.[5,6] Blawet et al recently showed that normally operating bioprostheses in the tricuspid position have a PHT $<$200 msec.[2] Different values have been published for the normal mechanical tricuspid prostheses. In a recent study, a PHT$<$130 msec was associated with normal function in bileaflet mechanical tricuspid prostheses (St. Jude Medical Standard, CarboMedics Standard).[3] This is consistent with previously published reports, where the mean PHT ranged between 102-120 msec for St Jude bileaflet mechanical valves (St. Jude Medical Standard).[7,8] In a past study in which older prostheses types were used, Conolly et al. demonstrated that mean PHT for normal ball caged valves was 144 ± 46 msec.[5]

2.6. TVI Ratio for Tricuspid Prosthetic Valves

Similar to mitral mechanical prosthetic valves, a ratio of (TVI_{TPV}) to the left ventricle outflow tract TVI (TVI_{LVOT}) has been investigated as a useful index of tricuspid prosthetic valve function. Blauwet et al. demonstrated that a peak tricuspid E velocity $<$2.1 m/sec, $TVI_{TPV}/TVI_{LVOT}<3.3$ and PHT$<$200msec were predictive of normal TPV function in tricuspid valve bioprostheses.[2] The same group has also proposed the use of the TVI ratio for the evaluation of mechanical tricuspid valve prostheses. A peak tricuspid E

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