My Approach to Assessment After Tricuspid Interventions: Tips and Tricks

Bruna Morhy Borges Leal Assunção,[1,2] Arthur Cortez Gonçalves,[1] Lucas Velloso Dutra,[1,3] Renata de Sá Cassar[1,4]

Hospital Sirio-Libanes,[1] São Paulo, SP – Brazil

Instituto do Câncer do Estado de São Paulo (ICESP),[2] São Paulo, SP – Brazil

Hospital Edmundo Vasconcelos,[3] São Paulo, SP – Brazil

Instituto do Coracão do Estado de São Paulo (Incor),[4] São Paulo, SP – Brazil

Abstract

Severe tricuspid regurgitation (TR) is associated with high morbidity and mortality. Given that surgical treatment of TR alone has been associated with high mortality, transcatheter interventions in the tricuspid valve (TV) have been used for its treatment, with relatively lower risk. There is a delay in intervention for TR, and this is probably related to a limited understanding of the anatomy of the TV and the right ventricle, in addition to an underestimation of the severity of TR. In this scenario, it is necessary to have comprehensive anatomical knowledge of the TV, the pathophysiology involved in the mechanism of regurgitation, and more accurate grading. The TV has anatomical, histological, and spatial peculiarities that make its assessment more complex when compared to the mitral valve, requiring knowledge and training in the various echocardiographic techniques that will often be used in combination for accurate assessment.

This review will describe the anatomy of the TV, the role of echocardiography in the diagnosis, grading, and pathophysiology involved in TR; the main transcatheter treatment options currently available for TR; and the assessment of outcomes after transcatheter intervention by means of multiple echocardiographic modalities.

Introduction

Tricuspid regurgitation (TR) is a frequent echocardiographic finding that is present in 80–90% of normal individuals. Mild or minimal TR has no impact on clinical outcomes. However, moderate or severe TR is associated with worse prognosis regardless of left ventricular dysfunction or pulmonary arterial hypertension.[1]

The cause of TR may be related to the valve apparatus (primary TR) or the heart structure (secondary or functional TR), the latter being responsible for up to 90% of cases.[2]

In advanced stages, the conventional approach through open heart surgery may be indicated. Replacement of the diseased valve is performed with mechanical or biological valve prostheses. The choice of device depends on availability and on the age of the patient. Another surgical option is valve repair, mostly with the implantation of an associated valve annulus to reduce the size of the native valve annulus. Surgical repair mortality ranges from 13.9 to 33%. On average, operative mortality of tricuspid valve (TV) surgery is 19% at 30 days.[2] Due to advanced age and concomitant pathologies, many individuals with severe TR are considered inoperable or at prohibitive surgical risk, and only 18% of them are actually referred for valve surgery.[3]

Successful development and outcomes of transcatheter aortic valve implantation, followed by transcatheter therapies for mitral valve disease, have opened up a plethora of opportunities for transcatheter treatment of TR, a valvular heart disease traditionally considered benign and often left untreated.[4]

Current transcatheter treatment options mimic surgical techniques and include European-approved solutions such as leaflet approximation, direct annuloplasty, and heterotopic vena cava implantation, as well as transcatheter TV replacement systems not yet commercially available, using orthotopic valve implant.[4] (Figure 1) Compared to mitral procedures, transcatheter tricuspid valve interventions (TTVI) present several additional technical and anatomic challenges, including difficult visualization of the VT apparatus, variable anatomy with thinner valve leaflets, and a large coaptation gap. An algorithm for TTVI device selection was recently proposed.[4] (Figure 2)

The TV anatomy

TV is the largest of the four heart valves, and its area varies between 7 and 9 cm². Due to its large size and low pressure differences between the right atrium (RA) and right ventricle (RV), peak transvalvular diastolic velocities are typically smaller than 1 m/s with mean gradients <2 mmHg.[5] TV has anterior, septal, and posterior cusps. The anterior cusp is usually the largest, 2.2 cm wide. The septal and posterior cusps are notably smaller and measure approximately 1.5 and 2.0 cm, respectively.[6] In addition, it is the most apically positioned valve and, similar to the mitral valve, it consists of four components: the annulus fibrosus, the three cusps, the papillary muscles and the chordae tendineae.[7] The anterior papillary muscle has chordae for the anterior and posterior cusps, and the medial papillary muscle for the posterior and septal cusps. The septal wall provides chordae for the anterior and septal cusps. In addition, there may be accessory chordae connections to the RV free wall and to the moderator band.[8] The normal tricuspid annulus (TA) is triangular and saddle shaped.[8] When functional dilation occurs, the TA becomes more circular and planar, dilating from the septum to the lateral wall (Figure 3E).[9]

Keywords

Tricuspid valve; tricuspid regurgitation; transcatheter

Mailing Address: Bruna Morhy Borges Leal Assunção •
Rua Sabara, 315, apt 1003. Postal code: 01239-011. Higienópolis, São Paulo, SP - Brazil.
E-mail: brunaleal@gmail.com
Manuscript received November 30, 2022; revised manuscript December 1, 2022; accepted December 2, 2022.
Editor responsável pela revisão: Daniela do Carmo Rassi Frota

DOI: https://doi.org/10.36660/abcimg.20230006i

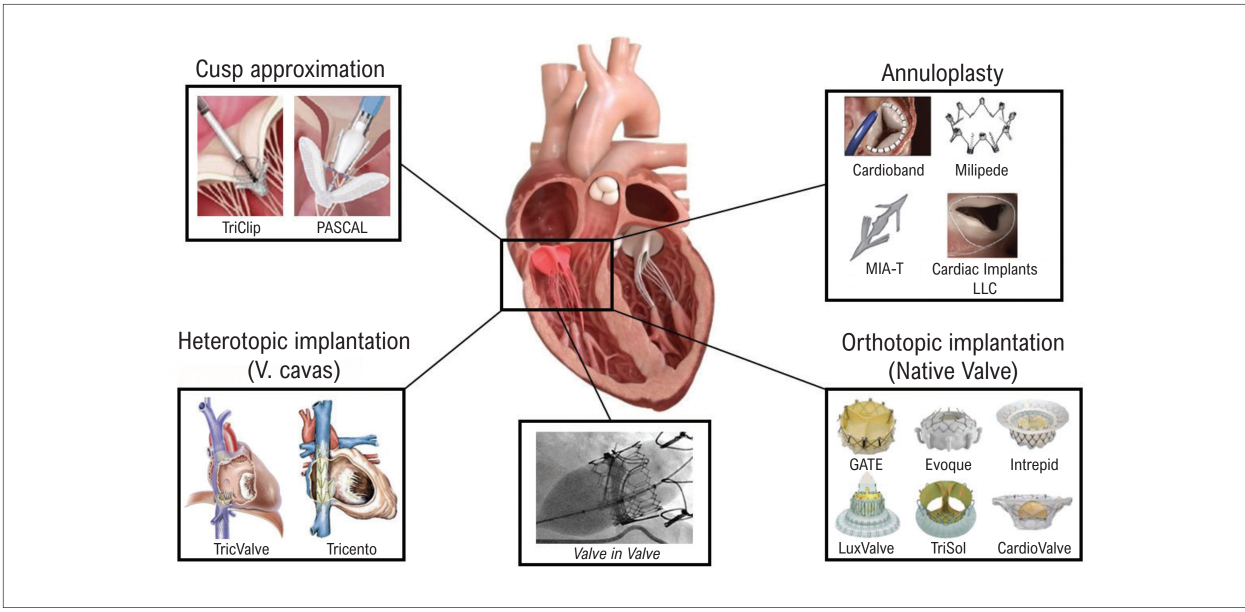


Figure 1 – *Current options for transcatheter TV intervention that are approved or under clinical evaluation. Adapted from Praz F, et al.[4]*

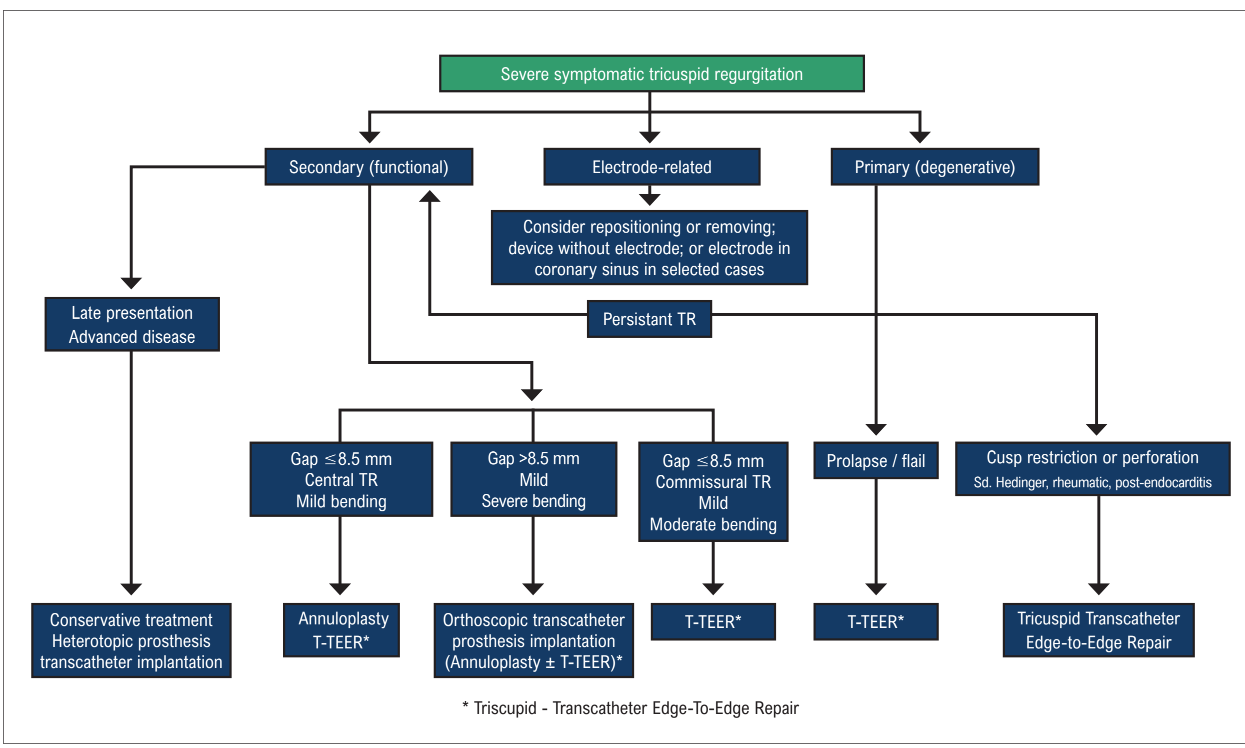


Figure 2 – *Algorithm for selecting the TTVI device. Adapted from Praz F, et al.[4] TR: tricuspid regurgitation.*

The role of echocardiogram

Echocardiography is routinely used in clinical practice to assess the severity of TR. This is done in an integrated way, using the color Doppler study by calculating the jet area, evaluating vena contracta width, calculating convergence flow, in addition to the size and direction of regurgitant jet.[10] On a two-dimensional transthoracic echocardiogram (2D TTE), the three cusps cannot be viewed simultaneously, requiring the acquisition of different echocardiographic windows. Through the longitudinal parasternal window via RV inlet, the anterior cusp will always be viewed in the proximal field, but in the distal field the septal cusp may be present (when the interventricular septum and/or the left ventricle are seen) or the posterior cusp (when the interventricular septum

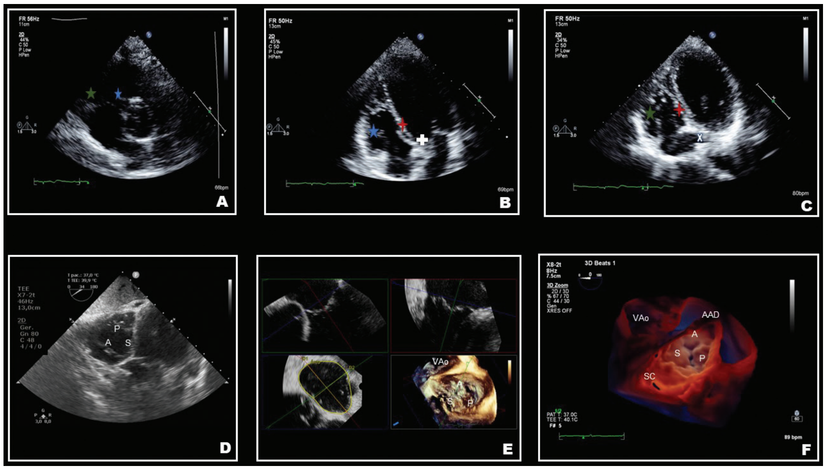
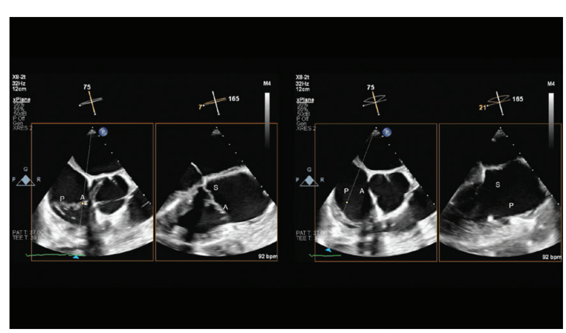


Figure 3 – *A) Parasternal short axis window (TTE). The leaflet adjacent to the free wall is posterior (green star) and the opposite leaflet adjacent to the aorta is anterior (blue star). B) Apical four-chamber window (TTE). The septal leaflet of the TV is adjacent to the septum (red star), while the opposite leaflet is anterior (blue star), once the aorta is displayed (white cross). C) Apical four-chamber window (TTE). The septal leaflet of the TV is adjacent to the septum (red star), while the opposite leaflet is posterior (green star), once the coronary sinus is displayed ("white X"). D) Transgastric short-axis view (TEE), which is the only two-dimensional view that generally provides simultaneous imaging of all three VT cusps. E) Evaluation of the measurements of the TA through multiplanar reconstruction (3D TEE). F) 3D TEE photorealistic rendering with transparency — atrial view of the TV and its relationships. (P: posterior cusp; S: septal cusp; A: anterior cusp); AoV: aortic valve; CS: coronary sinus; RAA: right atrial appendage)*

is not seen).[5] In the short-axis parasternal window, the cusp adjacent to the aorta is the septal (when the left ventricular outflow tract is seen) or anterior cusp (Figure 3A), and the cusp adjacent to the free wall is usually the posterior cusp (Figure 3A).[5] In the apical four-chamber window, the septal cusp will always be adjacent to the septum and the opposite cusp will be the anterior one when the transducer is angled anteriorly, and the aorta is seen (Figure 3B). However, if the transducer is angled posteriorly, displaying the coronary sinus, the opposite cusp will be the posterior one (Figure 3C).[5] The transesophageal echocardiogram (TEE) includes additional images, many of which are intended to improve TV image. Given the position of the heart in relation to the esophagus and stomach, the mid-esophagus, distal esophagus, transgastric, and deep transgastric views can bring the probe closer to the TV for two-dimensional (2D) and three-dimensional (3D) images.[11]

Multiple echocardiographic windows are needed to assess TV starting from the mid-esophageal plane. Four-chamber window displays the septal cusp and anterior cusp; Biplanar imaging can help clarify which cusp is displayed because the anterior cusp is normally seen adjacent to the aorta (Video 1). In the distal esophageal plane at the level of the coronary sinus, the posterior and anterior cusps are typically displayed. Advancing the TEE probe into the stomach and rotating approximately 20°–60° produces the transgastric short-axis view, which is the only two-dimensional view that generally provides simultaneous imaging of all three TV cusps (Figure 3D). Using the biplanar image, all cusp coaptation points can be seen. Advancing the TEE probe along with the right anterior flexion and returning the angle to 0°–20° produces a deep transgastric plane of the TV.[11]

Three-dimensional echocardiography significantly improved the accuracy of imaging and identification of cusps and associated anatomical components of the TV complex, eliminating the need for mental reconstruction of multiple 2D planes. Lang et al. suggested standardization of 3D acquisition of the VT, with the interatrial septum positioned inferiorly (at six o'clock), so that the anterior cusp is on the right, the posterior cusp on the left and the septal cusp on the distal field.[12] Due to the more anterior position of the right heart chambers, 3D TV images on TTE can be equal to or sometimes better than the 3D images on TEE. As in TTE, 3D TV images on TEE must have the interatrial septum positioned inferiorly as standard. Thus, the anterior cusp is on the left, the posterior cusp on the right and the septal cusp in the distal field (Figure 3F).



Video 1 – *Biplanar image through the middle esophageal plane (TEE). Commissural TV view (inlet and outlet of the RV), using a simultaneous orthogonal view for better identification of the cusps. (P: posterior cusp; S: septal cusp; A: anterior cusp)*
Link: http://abcimaging.org/supplementary-material/2023/3601/convite-Bruna-Leal-video_01.mp4

Post-procedure assessment

One of the main objectives of evaluating the success of percutaneous tricuspid procedure is evaluating residual TR. Similar to pre-procedure quantification, post-procedure assessment should attempt to quantify the severity of TR as much as possible. TR grading is well described both in the guidelines of the American Society of Echocardiography and in the European Cardiovascular Imaging Association.[13,14] In both documents, significant TR is defined as vena contracta diameter ≥0.7 cm; PISA radius >0.9 cm (when aliasing speed=28 cm/s); ERO≥40 mm^2; regurgitant volume ≥45 ml; inferior vena cava diameter >25 mm; RA area >18 cm^2, triangular shape of TR on continuous Doppler flow, in addition to reverse flow in hepatic veins. Measurement of 3D vena contracta area (VCA) has a good correlation with the regurgitant orifice area. A cut off >0.36 cm^2 for 3D VCA values has been shown to present 89% sensitivity and 84% specificity in predicting severe TR.[15] However, since patients undergoing TTVI often have an anatomical regurgitant area several times larger than an effective regurgitant orifice area (EROA) of 0.40 cm^2, an extended classification to include "massive" and "torrential" TR (both associated with harmful results) has been recently proposed (Table 1). To date, the complete elimination of TR after a percutaneous procedure is not achievable with currently available technology. However, most patients show significant improvement in functional class with reduction of at least two degrees of TR severity (e.g., from torrential to severe TR).[16]

While it is important to assess residual TR, equally important is the assessment of RV size and systolic function.[13] Including TA plane systolic excursion (TAPSE), RV fractional area change (FAC), tissue Doppler-derived lateral TA systolic wave velocity, RV myocardial performance index (MPI), myocardial strain indices, such as the global longitudinal strain or longitudinal strain of the 2D RV free wall, in addition to RV ejection fraction by the three-dimensional method. TAPSE values <17 mm, FAC <35%, S' <9.5 cm/s, RV free wall longitudinal strain <20% (absolute values), RV MPI by pulsed Doppler <0.43 s and 3D RV ejection fraction <45% are considered abnormal RV systolic function values[13] (Figure 4).

Significant TA dilation is defined by a diastolic diameter of ≥40 mm or >21 mm/m^2 by the apical four-chamber TTE window and is indicative of severe TR by the latest American Heart Association/American College of Cardiology guidelines.[19] Besides, TV thetering distance measurements (>0.76 cm) and TV thetering area (>1.63 cm^2) are predictors of TR recurrence after surgery.[20,21]

The TriClip system (Abbott Vascular, Abbott Park, Illinois) is an adaptation of the Abbott Vascular MitraClip system for the TV. The main objective of the tricuspid transcatheter edge-to-edge repair system is to restore coaptation between leaflets and reduce the regurgitant orifice area.[22] Quantification of TR severity can be challenging because TR jets are often deflected in multiple directions. Furthermore, it is important to inform the number of clips released, commissures/cusps captured and whether there is a single leaflet captured by the device. A mean transvalvular gradient <3 mmHg is acceptable after clip release.[2]

The FORMA Spacer System is a device that aims to fill the coaptation gap resulting from annulus and TV leaflet dilation. It consists of two pieces: a foam polymer balloon spacer placed in the regurgitant orifice, creating a surface for cusp coaptation and an anchorage system attached to the apex of the RV. After the FORMA procedure, it is difficult to quantify TR due to non-circular jets that appear around the device.[22] It is important to describe the percentage of device length in RV and RA.

RV inlet and outlet images are the main echocardiographic windows on TTE to assess device position (TriClip and FORMA). Short-axis parasternal and short-axis subcoastal windows are also helpful.[5] On TEE, the distal esophagus plane is typically the best for assessing regurgitant jet, leaflet capture by the clip, and tricuspid transvalvular gradients.[22] Transgastric planes are also useful for evaluating clip position, and Doppler scan in the deep transgastric planes.[5] The PISA method is generally not suitable for evaluating multiple regurgitant jets. A semiquantitative approach based on color Doppler and multiple echocardiographic windows might be required in such patients. The vena contracta area measured by 3D can also be useful in this context to assess the severity of residual TR after the procedure.[22]

There are two TTVI devices available in Brazil: TricValve and the Valve-in-Valve Tricuspid. TricValve (P&F Products & Features

Table 1 – Extended classification for grading TR. Adapted from Hahn et al.[17,18]

Parameters	Mild	Moderate	Moderate/ Severe	Severe	Massive	Torrential
Vena contracta width	< 3 mm	3–6.9 mm	6–6.9 mm	7–13 mm	14–20 mm	≥21 mm
EROA	20 mm^2	20–29 mm^2	30–39 mm^2	40–59 mm^2	60–79 mm^2	≥80 mm^2
Regurgitant volume	< 15 mL	15–29 mL	30–44 mL	40–59 mL	60–74 mL	≥75 mL
3D ECHO Regurgitant Fraction (MRI)*	< 25% (30%)*	< 25–44% (30–49%)*		< 45% (50%)*		
3D vena contracta				75–94 mm^2	95–114 mm^2	>115 mm^2

EROA: effective regurgitant orifice area; MRI: magnetic resonance imaging.

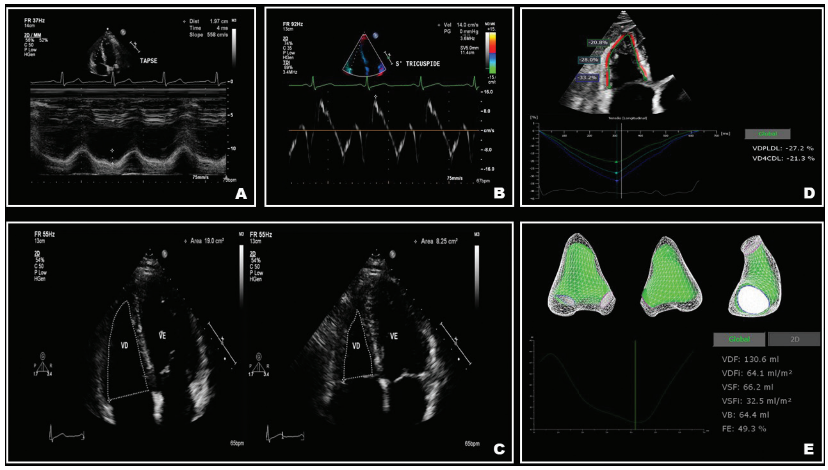
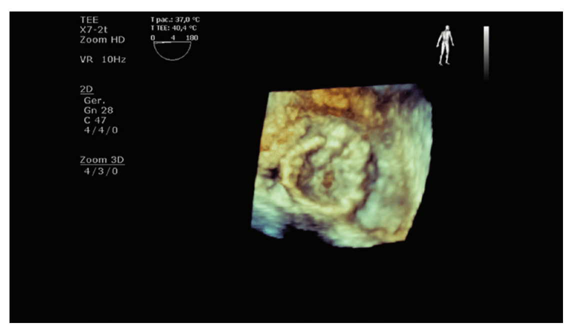


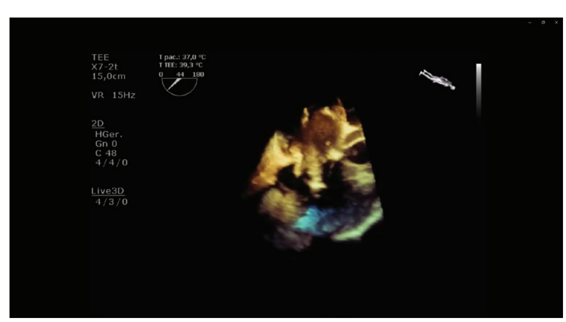
Figure 4 – *Quantitative parameters for assessing RV function (TTE): A) TA plane systolic excursion (TAPSE); B) RV fractional area change (FAC); C) lateral TA systolic wave velocity derived from tissue Doppler; D) 2D RV free wall longitudinal strain; E) and assessment of RV volumes and three-dimensional RV ejection fraction.*

Vertriebs GmbH, Vienna, Austria, in cooperation with Braile Biomedica, São José do Rio Preto, Brazil) consists of two self-expanding heterotopic bioprosthetic valves implanted in the superior and inferior vena cava and anchored in the cavo-atrial inflow. Transcatheter implantation of Valve-in-Valve Tricuspid through expandable balloon prosthesis consists of percutaneously treating dysfunction of TV bioprosthesis (Video 3). A recent pilot study carried out at Instituto do Coração do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, from June 2015 to August 2022, evaluated 12 patients, most of them with congenital heart disease (66% Tetralogy of Fallot or Ebstein anomaly), who underwent percutaneous implantation of Valve-in-Valve in the tricuspid position due to symptomatic bioprosthesis dysfunction (50% NYHA functional class III-IV heart failure). The main mechanism of prosthetic dysfunction was failure (66%) and double prosthetic dysfunction (75%). Two expandable balloon prostheses were used: Inovare (Braile) in 10 patients and Sapien 3 (Edwards) in two patients. Mean length of stay was 12±5.4 days, with 67% of patients discharged in NYHA functional class I. There were no in-hospital or 29-month follow-up deaths; the predominant antithrombotic regimen was vitamin K antagonist in 10 (83%) and late bioprosthesis thrombosis occurred in one (8.3%) patient (Video 2), due to Covid-19 infection. One-year echocardiographic control showed a mean tricuspid gradient of 7.7±2.4 mmHg and one case with moderate paravalvular leak. This pilot retrospective registry demonstrated safety, efficacy and significant improvement in symptoms in the medium term.[23]

The presence of potential short- and long-term complications, such as device detachment, degeneration, annulus or leaflet rupture, endocarditis, pericardial effusion or cardiac tamponade, prosthetic thrombosis and perivalvular regurgitation in cases of tricuspid valve-in-valve), in addition to impairment of right coronary artery should be investigated and detected by TTE. In case of doubtful findings, 2D/3D TEE should be requested.[22]



Video 2 – *3D TEE Tricuspid endoprosthesis (Valve-in-Valve) with restricted leaflet mobility.*
Link: http://abcimaging.org/supplementary-material/2023/3601/convite-Bruna-Leal-video_02.mp4



Video 3 – *Tricuspid Valve-in-Valve image (Edwards 3 prosthesis number 29): endoprosthesis placement on three-dimensional TEE image.*
Link: http://abcimaging.org/supplementary-material/2023/3601/convite-Bruna-Leal-video_03.mp4

Conclusion

Interest in TV has increased in a scenario of evidence that TR impacts morbidity and mortality of individuals. The complex anatomy and function of TV implies an evaluation using multiple windows and echocardiographic modalities (2D/3D TTE and 2D/3D TEE). After percutaneous TV intervention, residual TR, annulus size, RV function and size should be evaluated. The main complications include significant TR (single leaflet captured by the device), prosthesis thrombosis, endocarditis, pericardial effusion, and impairment of right coronary artery. Ideally, TTE should be performed at one, six and twelve months, and annually after the procedure.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Author Contributions

Conception and design of the research: Assunção BMBL; writing of the manuscript: Assunção BMBL, Gonçalvez AC, Cassar RS; critical revision of the manuscript for intellectual content: Assunção BMBL, Gonçalvez AC, Cassar RS.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Nath J, Foster E, Heidenreich PA. Impact of Tricuspid Regurgitation on Long-Term Survival. J Am Coll Cardiol. 2004;43(3):405-9. doi: 10.1016/j.jacc.2003.09.036.
2. Izumi C. Isolated Functional Tricuspid Regurgitation: When Should We Go to Surgical Treatment? J Cardiol. 2020;75(4):339-43. doi: 10.1016/j.jjcc.2019.11.001.
3. Otto CM, Nishimura RA, Bonow RO, Carabello BA, Erwin JP, Gentile F, et al. 2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. J Am Coll Cardiol. 2021;77(4):e25-e197. doi: 10.1016/j.jacc.2020.11.018.
4. Praz F, Muraru D, Kreidel F, Lurz P, Hahn RT, Delgado V, et al. Transcatheter Treatment for Tricuspid Valve Disease. EuroIntervention. 2021;17(10):791-808. doi: 10.4244/EIJ-D-21-00695.
5. Hahn RT. State-of-the-Art Review of Echocardiographic Imaging in the Evaluation and Treatment of Functional Tricuspid Regurgitation. Circ Cardiovasc Imaging. 2016;9(12):e005332. doi: 10.1161/CIRCIMAGING.116.005332.
6. Silver MD, Lam JH, Ranganathan N, Wigle ED. Morphology of the Human Tricuspid Valve. Circulation. 1971;43(3):333-48. doi: 10.1161/01.cir.43.3.333.
7. Antunes MJ, Barlow JB. Management of Tricuspid Valve Regurgitation. Heart. 2007;93(2):271-6. doi: 10.1136/hrt.2006.095281.
8. Rogers JH, Bolling SF. The Tricuspid Valve: Current Perspective and Evolving Management of Tricuspid Regurgitation. Circulation. 2009;119(20):2718-25. doi: 10.1161/CIRCULATIONAHA.108.842773.
9. Mahmood F, Kim H, Chaudary B, Bergman R, Matyal R, Gerstle J, et al. Tricuspid Annular Geometry: A Three-Dimensional Transesophageal Echocardiographic Study. J Cardiothorac Vasc Anesth. 2013;27(4):639-46. doi: 10.1053/j.jvca.2012.12.014.
10. Zoghbi WA, Adams D, Bonow RO, Enriquez-Sarano M, Foster E, Grayburn PA, et al. Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation: A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance. J Am Soc Echocardiogr. 2017;30(4):303-71. doi: 10.1016/j.echo.2017.01.007.
11. Hahn RT, Abraham T, Adams MS, Bruce CJ, Glas KE, Lang RM, et al. Guidelines for Performing a Comprehensive Transesophageal Echocardiographic Examination: Recommendations from the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr. 2013;26(9):921-64. doi: 10.1016/j.echo.2013.07.009.
12. Lang RM, Badano LP, Tsang W, Adams DH, Agricola E, Buck T, et al. EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography. J Am Soc Echocardiogr. 2012;25(1):3-46. doi: 10.1016/j.echo.2011.11.010.
13. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: an Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr. 2015;28(1):1-39.e14. doi: 10.1016/j.echo.2014.10.003.
14. Lancellotti P, Moura L, Pierard LA, Agricola E, Popescu BA, Tribouilloy C, et al. European Association of Echocardiography Recommendations for the Assessment of Valvular Regurgitation. Part 2: Mitral and Tricuspid Regurgitation (Native Valve Disease). Eur J Echocardiogr. 2010;11(4):307-32. doi: 10.1093/ejechocard/jeq031.
15. Chen TE, Kwon SH, Enriquez-Sarano M, Wong BF, Mankad SV. Three-Dimensional Color Doppler Echocardiographic Quantification of Tricuspid Regurgitation Orifice Area: Comparison with Conventional Two-Dimensional Measures. J Am Soc Echocardiogr. 2013;26(10):1143-52. doi: 10.1016/j.echo.2013.07.020.
16. Hahn RT, Thomas JD, Khalique OK, Cavalcante JL, Praz F, Zoghbi WA. Imaging Assessment of Tricuspid Regurgitation Severity. JACC Cardiovasc Imaging. 2019;12(3):469-90. doi: 10.1016/j.jcmg.2018.07.033.
17. Hahn RT, Zamorano JL. The Need for a New Tricuspid Regurgitation Grading Scheme. Eur Heart J Cardiovasc Imaging. 2017;18(12):1342-1343. doi: 10.1093/ehjci/jex139.
18. Hahn RT, Badano LP, Bartko PE, Muraru D, Maisano F, Zamorano JL, et al. Tricuspid Regurgitation: Recent Advances in Understanding Pathophysiology, Severity Grading and Outcome. Eur Heart J Cardiovasc Imaging. 2022;23(7):913-29. doi: 10.1093/ehjci/jeac009.
19. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP, Fleisher LA, et al. 2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients with Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation. 2017;135(25):e1159-e1195. doi: 10.1161/CIR.0000000000000503.

20. Fukuda S, Song JM, Gillinov AM, McCarthy PM, Daimon M, Kongsaerepong V, et al. Tricuspid Valve Tethering Predicts Residual Tricuspid Regurgitation After Tricuspid Annuloplasty. Circulation. 2005;111(8):975-9. doi: 10.1161/01.CIR.0000156449.49998.51.

21. Raja SG, Dreyfus GD. Basis for Intervention on Functional Tricuspid Regurgitation. Semin Thorac Cardiovasc Surg. 2010;22(1):79-83. doi: 10.1053/j.semtcvs.2010.05.005.

22. Agricola E, Asmarats L, Maisano F, Cavalcante JL, Liu S, Milla F, et al. Imaging for Tricuspid Valve Repair and Replacement. JACC Cardiovasc Imaging. 2021;14(1):61-111. doi: 10.1016/j.jcmg.2020.01.031.

23. The Editorial Team (on behalf of the World Heart Federation). Abstract from the World Congress of Cardiology/Brazilian Congress of Cardiology 2022 [Internet]. Rio de Janeiro: World Heart Federation; 2022 [cited 2022 Dec 22]. Available from: https://world-heart-federation.org/world-congress-of-cardiology/rio-2022/

This is an open-access article distributed under the terms of the Creative Commons Attribution License