Right heart remodelling after bicaval TricValve implantation in patients with severe tricuspid regurgitation

Ignacio J. Amat-Santos^{1,2*}, MD, PhD; Rodrigo Estévez-Loureiro³, MD, PhD;

Angel Sánchez-Recalde⁴, MD, PhD; Ignacio Cruz-González^{1,5}, MD, PhD; Isaac Pascual^{1,6}, MD, PhD;

Julia Mascherbauer⁷, MD, PhD; Omar Abdul-Jawad Altisent^{1,8}, MD, PhD; Luis Nombela-Franco⁹, MD, PhD;

Manuel Pan¹⁰, MD, PhD; Ramiro Trillo^{1,11}, MD, PhD; Raul Moreno¹², MD, PhD; Georg Delle Karth¹³, MD, PhD;

Sara Blasco-Turrión², MD; Juan Pablo Sánchez-Luna², MD; Ana Revilla-Orodoea^{1,2}, MD, PhD;

Alfredo Redondo², MD; Jose Luis Zamorano^{1,4}, MD, PhD; Rishi Puri¹⁴, MBBS, PhD;
 Andrés Íñiguez-Romo³ MD, PhD: Alberto San Román^{1,2} MD, PhD

Andrés Íñiguez-Romo³, MD, PhD; Alberto San Román^{1,2}, MD, PhD
 14

1 2

3 4

5 6 7

8

9

10 11

15

16

17

23

24 25

50 51 52

53

1. Centro de Investigación Biomédica en Red, Enfermedades Cardiovasculares (CIBERCV), Madrid, Spain; 2. Hospital Clínico Universitario de Valladolid, Valladolid, Spain; 3. Hospital Alvaro Cunqueiro, Complejo Hospitalario Universitario de Vigo, Vigo,

Spain; 4. Hospital Universitario Ramon y Cajal, Madrid, Spain; 5. IBSAL, Hospital Clinico Universitario de Salamanca,

18 Salamanca, Spain; 6. Hospital Universitario Central de Asturias, Oviedo, Spain; 7. Department of Cardiology, University

19 Hospital Sankt Poelten, Karl Landsteiner University of Health Sciences, Krems, Austria; 8. Hospital Universitario Germans

Trias i Pujol, Barcelona, Spain; 9. Hospital Clinico Universitario San Carlos, Madrid, Spain; 10. Hospital Universitario Reina Sofia, Córdoba, Spain; 11. Hospital Clinico Universitario de Santiago de Compostela, Santiago, Spain; 12. IdiPAZ, Hospital

Sofia, Córdoba, Spain; 11. Hospital Clínico Universitario de Santiago de Compostela, Santiago, Spain; 12. IdiPAZ, Hospital
 Universitario La Paz, Madrid, Spain; 13. Hospital Floridsdorf, Vienna, Austria; 14. Cleveland Clinic, Cleveland, OH, USA

This paper also includes supplementary data published online at: https://eurointervention.pcronline.com/doi/10.4244/EIJ-D-23-00077

26 Severe tricuspid regurgitation (TR) is associated with significant 27 mortality¹; heterotopic caval valve implantation (CAVI) is an 28 emerging transcatheter solution for patients not deemed candi-29 dates for alternative therapies, yet the structural impact upon right 30 heart dimensions is unknown². TRICUS STUDY Euro is a non-31 randomised, single-arm, multicentre, prospective trial that recently 32 demonstrated a high procedural success rate and significant 33 improvements in both quality of life and functional parameters at 34 6 months with the TricValve (P&F Products and Features) trans-35 catheter bicaval valves for the superior (SVC) and inferior vena 36 cava (IVC). However, echocardiographic analyses at 3 months 37 demonstrated a significant increase in right ventricular (RV) and 38 right atrial (RA) volumes, as well as a decrease in RV function². 39 The present analysis focused on the computed tomographic (CT) 40 volumetric imaging of the right heart to provide novel mechanistic 41 insights into right heart remodelling at 6-month follow-up along 42 with any propensity for caval valve leaflet thrombosis or issues 43 with stent frame integrity.

All CT images were analysed and compared at the same phase in all cases. The quality was good or acceptable in 20 cases and poor in 6 cases due to poor contrast distribution; 3D reconstruction could be performed in 25 cases (92.6%). Leaflet motion was determined through a 4D-gated scan. Virtual reconstruction was performed with Mimics (Materialise), in order to understand the anatomical interplay (right to left ventricular ratio). Furosemide administration was recorded as a furosemide equivalent dosage (40 mg oral furosemide=1 mg bumetanide=20 mg torasemide).

Of 35 patients treated with the TricValve system², 26 had baseline and 6-month follow-up computed tomography (CT). The mean age was 76.0 \pm 6.7 years, 84.6% were women, and the baseline tricuspid annulus plane systolic excursion was 13 mm. There was a statistically significant reduction of the RV mid-diameter at **follow-up** from 48.6 \pm 9.9 to 43.0 \pm 7.3 mm (p=0.001) (**Supplementary Figure 1A**) and a trend towards a decrease in tricuspid annular dimensions (mean diameter 49.2 \pm 6.0 to 47.6 \pm 5.4 mm; p=0.078) but both the SVC and IVC sizes remained similar. These findings are in agreement with the echocardiographic findings at 6-month follow-up (**Supplementary Table 1**). The 3D reconstruction demonstrated a significant decrease in the total RV volume at followup (180.5 \pm 77.8 to 147.4 \pm 67.7 cm³; p=0.037) with non-significant changes in the RA volume (289.1 \pm 123.5 vs 292.7 \pm 132.4 cm³; p=0.789) (**Supplementary Table 1, Central illustration**).

Regarding the safety analysis, none of the cases demonstrated SVC prosthesis thrombosis, whereas in 2 cases, stent thrombosis was detected in the IVC prosthesis. Both cases were located at the IVC-RA junction with normally functioning leaflets devoid of thrombosis (Supplementary Figure 2). Contrast leakage towards the IVC was detected in 5 cases; larger IVC dimensions and

*Corresponding author: Instituto de Ciencias del Corazón (ICICOR), Hospital Clínico Universitario de Valladolid, Av Ramón y Cajal 3, 47005 Valladolid, Spain. E-mail: ijamat@gmail.com

EuroIntervention

CENTRAL ILLUSTRATION ???



Study flowchart (A) and main changes in right heart volumes reflected as a patient-level analysis of right atrial and ventricular volumes (C) after 3D reconstruction. 2D/3D: two-/three-dimensional; CT: computed tomography; FU: follow-up; RA: right atrial; RV: right ventricular

a marked angulation of its entrance into the RA were related to
a greater risk of prosthesis leakage (Supplementary Table 2). At
6-month follow-up, 3 patients had died (8.6%), none of whom had
significant paravalvular leakage, and 6 patients had been readmitted because of heart failure (17.1%), one of whom had significant

paravalvular leakage that was successfully percutaneously sealed. The structural integrity of the prosthesis was preserved in all cases. Two cases of leaflet thickening were observed, one in an SVC and another in an IVC prosthesis, **neither of these** presenting with impaired leaflet motion.

107 TricValve, the first CE mark (European conformity)-approved 108 CAVI system, demonstrated significant reverse remodelling of the 109 RV and a strong tendency towards tricuspid annulus reverse remod-110 elling - but not of the entire RA - despite the advanced stage of the 111 patients enrolled in TRICUS STUDY Euro; to note, the mean furo-112 semide equivalent dosage was reduced from 10335 mg at baseline to 113 7617 mg at 6 months, with no other relevant changes in medication. 114 No stent fracture or leaflet thrombosis/early degeneration was detected 115 at 6-month follow-up; however, 2 patients developed thrombi adher-116 ent to the stent frame that neither compromised leaflet/caval valve 117 function nor were related to any clinically relevant adjudicated event. 118 CAVI, through a reduction in RV volume overload and, less acutely, 119 through a reduction in pulmonary arterial pressures, may induce 120 a delayed reverse right heart remodelling. Indeed, systolic pulmonary 121 pressure changed from 41.5±13.3 at baseline to 36.7±10.7 mmHg at 122 6-month follow-up, although this numerical decrease did not reach 123 statistical significance. The detection of caval backflow in only 5 124 patients according to CT findings contrasts with the vein backflow 125 reported in the 3-month echocardiographic follow-up in half of the 126 patients², suggesting that the endothelialisation process and/or the 127 right heart remodelling might help to minimise this longer term. 128 Further patients with longer-term follow-up are required to 129 establish this evolving concept.

130 These findings may have implications for selecting the most 131 appropriate transcatheter tricuspid therapy for each patient. 132 Orthotopic tricuspid valve replacement in patients with RV dysfunc-133 tion poses a certain risk for acute RV decompensation and the need 134 for inotropic therapy³. It is plausible that CAVI offers a better-tol-135 erated alternative by gradually promoting reverse RV remodelling, 136 utilising the RA as a reservoir to accommodate the acute afterload 137 mismatch faced by the RV typically seen with acute TR abolition.

Funding

138

139

The participating institutions received a non-conditioned grant from
 P&F Products and Features for the TRICUS STUDY Euro study.

Conflict of interest statement

R. Puri serves as a consultant to **P&F** Products and Features and V-Dyne. I.J. Amat-Santos, I. Cruz-Gonzalez, A. Sánchez-Recalde, and O. Abdul-Jawad Altisent have served as consultants to **P&F Products and Features**. R. Estevez-Loureiro is proctor for Abbott Vascular. The other authors???

References.

1. Aparisi Á, Amat-Santos IJ, Serrador A, Rodríguez-Gabella T, Arnold R, San Román JA. Current clinical outcomes of tricuspid regurgitation and initial experience with the TricValve system in Spain. *Rev Esp Cardiol.* 2020;73:853-4.

2. Estévez-Loureiro R, Sánchez-Recalde A, Amat-Santos IJ, Cruz-González I, Baz JA, Pascual I, Mascherbauer J, Abdul-Jawad Altisent O, Nombela-Franco L, Pan M, Trillo R, Moreno R, Delle Karth G, Salido-Tahoces L, Santos-Martinez S, Núñez JC, Moris C, Goliasch G, Jimenez-Quevedo P, Ojeda S, Cid-Álvarez B, Santiago-Vacas E, Jimenez-Valero S, Serrador A, Martín-Moreiras J, Strouhal A, Hengstenberg C, Zamorano JL, Puri R, Íñiguez-Romo A. 6-Month Outcomes of the TricValve System in Patients With Tricuspid Regurgitation: The TRICUS EURO Study. *JACC Cardiovasc Interv.* 2022;15:1366-77.

3. Santos-Martínez S, Redondo A, San José Crespo I, Sevilla T, Figulla HR, Amat-Santos IJ. Caval valve implantation for percutaneous treatment of tricuspid regurgitation: preprocedural anatomical assessment. *Rev Esp Cardiol.* 2021;74:803-5.

Supplementary data

Supplementary Table 1. Comparison of computed tomography and echocardiographic findings before and 6 months after a successful TricValve procedure.

Supplementary Table 2. Baseline factors associated with leakage of contrast into the inferior vena cava at 6-month follow-up post-TricValve implantation.

Supplementary Figure 1. One- to 6-month changes in right ventricular dimensions according to computed tomography.

Supplementary Figure 2. Presence of thrombus adhered to the inferior vena cava stent frame of the prosthesis in two patients.

The supplementary data are published online at: https://eurointervention.pcronline.com/ doi/10.4244/EIJ-D-23-00077

