the arrival of the mobile ECMO unit. Mean and median arterial lactate concentrations before ECMO were 7.4 ± 3.7 mmol/L and 7.0 [5.0] mmol/L, respectively. Mean and median values for the modified Sequential Organ Failure Assessment scale[4] (mSOFA) were 10 ± 2 and 9 [3], and the corresponding values for the Wernovsky inotropic index were 159 ± 145 and 107 [127]. The mean and median times from ECMO unit activation to the arrival of the patient at our center were 212 ± 74 minutes and 240 [135] minutes, respectively. None of the patients had transit-associated complications or morbidity, and there were no device-related logistical or technical complications. Mean treatment time was 7.5 (range, 1-19) days. ECMO was successfully removed from 55.9% (5/9) of the patients; 3 patients died during treatment and 1 required heart transplant (with prior implantation of a Centrimag biventricular assist device after 10 days of ECMO). In-hospital survival was 66.7% (6/9), and all 6 survivors were alive at the time of writing. Of the deceased patients, 2 died due to bleeding complications (1 due to hemorrhage at the femoral artery cannula and 1 due to intracerebral hemorrhage), and the other died of multiorgan failure during treatment.

There is little accumulated experience in Spain with programs for the interhospital transfer of patients on VA-ECMO.[5] Most interhospital transfers of this type have been of patients implanted with the device at a lower-level hospital and transferred to a referral center for heart transplant evaluation. Our findings demonstrate the feasibility of an ECMO rescue program focused on percutaneous access and run by a cardiology service. The success of such a service requires staff training not only in the implantation technique, but also in device control and the clinical treatment of the patient. The establishment of this type of unit is essential for centralizing expertise and resources to optimize the networked treatment of CS.

Aitor Uribarri,[a,b,*] Alexander Stepanenko,[a,b] Javier Tobar,[a,b] Carlos M. Veras-Burgos,[a] Ignacio J. Amat-Santos,[a,b] and José A. San Román[a,b]

[a]*Servicio de Cardiología, Hospital Clínico Universitario de Valladolid, Valladolid, Spain*
[b]*Centro de Investigación en Red de Enfermedades Cardiovasculares (CIBERCV), Spain*

[*] Corresponding author:
E-mail address: auribarrig@gmail.com (A. Uribarri).

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Caval valve implantation for percutaneous treatment of tricuspid regurgitation: preprocedural anatomical assessment

Implante de prótesis en cavas como tratamiento percutáneo de la insuficiencia tricúspide: evaluación anatómica preprocedimiento

To the Editor,

Moderate to torrential tricuspid regurgitation (TR) is estimated to affect 1.6 million people in the United States.[1] The classic treatment for TR is optimal medical therapy—mainly diuretics or surgery. However, surgical mortality in isolated tricuspid valve interventions is significantly higher than in any other single valve (~9%).[1] Across the growing range of percutaneous therapeutic alternatives for TR, heterotopic caval valve implantation (CAVI) including Tricento (NVT, Germany) and TricValve (Products&Features, Austria) systems[2,3] might be the preferred option when right chamber dilation is more advanced or in patients with prior pacemaker leads. Evaluation of caval anatomy is crucial. Therefore, we aimed to analyze the computed tomography (CT) scans of candidates for this therapy as well as cadaveric models in order to: *a)* describe main variations of right heart and caval anatomy relevant for CAVI candidates; and *b)* develop a standardized CT evaluation prior to CAVI procedure.

CT scans from 32 patients with severe to torrential TR eligible for CAVI procedure after exclusion of alternative therapies were centrally analyzed. Images were obtained on a 128-detector row CT scanner (Revolution CT, GE Healthcare, Waukesha, Wisconsin, United States). We tailored the protocol by injecting 75 mL of iodixanol (Visipaque 320 mg/mL) via an antecubital vein. We manually started the acquisition when the pulmonary artery was completely opacified. Additionally, we prepared a delayed acquisition to be started 70 to 90 seconds after contrast material injection (portal phase) to be performed if the inferior vena cava (IVC) and the hepatic veins were not well opacified in the first study. Finally, 3 cadaveric models were used for structural direct analysis. All patients provided informed consent and the study was approved by local ethics committee.

The main measurements and risk thresholds for superior vena cava (SVC) and IVC are summarized in figure 1. The mean cranial-caudal length of SVC was 59.3 ± 10.5 mm potentially leading to mean protrusion into the right atrium of 8 mm, but up to 31.6 mm with the self-expanding TricValve device (simulated in figure 1C). In addition, 7 patients (21.9%) showed marked tapering (confluence-junction index < 0.6). Both might condition a higher risk of leak and/or valve embolization suggesting the need for higher device implantation. However, this might be associated with a higher risk of azygous vein occlusion during the procedure as identified in the cadaveric model (figure 2C,D). The clinical relevance of this complication is currently unknown. Finally, in 11 patients (34.4%), a pacemaker lead was present.

The mean distance from IVC to upper part of hepatic veins was 8.9 ± 2.5 mm, potentially excluding 30 patients (93.75%) from receiving a self-expanding Tricento device whose current limit is 12 mm. However, in none of them was this distance prohibitive for TricValve. In addition, the angle determined by the IVC segments

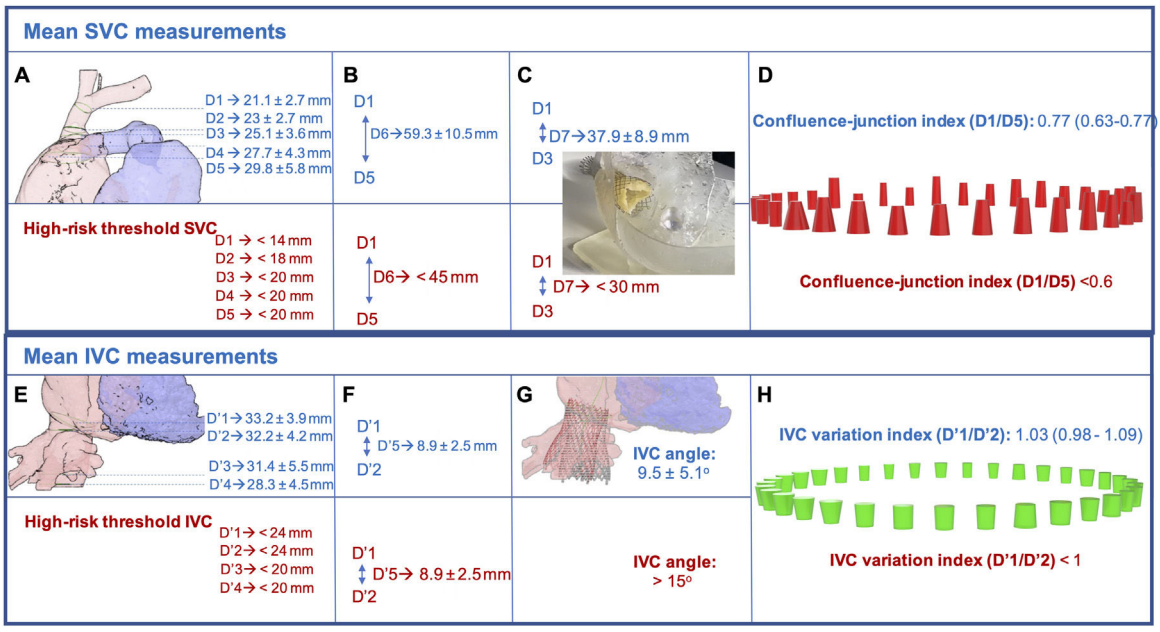

Figure 1. Superior (A to D) and inferior (E to H vena cava measurements based on computed tomography and suggested thresholds for high-risk of complications. A: confluence between LIV and SVC (D1); SVC at top of PA (D2); SVC at middle of PA (D3); SVC at bottom PA (D4); SVC at RA junction (D5). B: length from D1 to D5 (D6). C: length from D1 to D3 (D7) and example of printed biomodel of a short and tapered SVC. D: confluence-junction index and different SVC morphologies according to this index and D7. E: diameter at the confluence between IVC and RA transition (D'1); IVC at top of HV (D'2); IVC at the bottom of HV (D'3); 5 cm below LIV-RA transition (D'4). F: length from D'1 to D'2 (D'5). G: simulation of the angle determined by lower and upper segments of IVC on TricValve final position. H: IVC variation index and different IVC morphologies according to this index. HV, hepatic veins; IVC, inferior vena cava; LIV, left innominate vein; PA, pulmonary artery; RA, right atrium; SVC, superior vena cava.

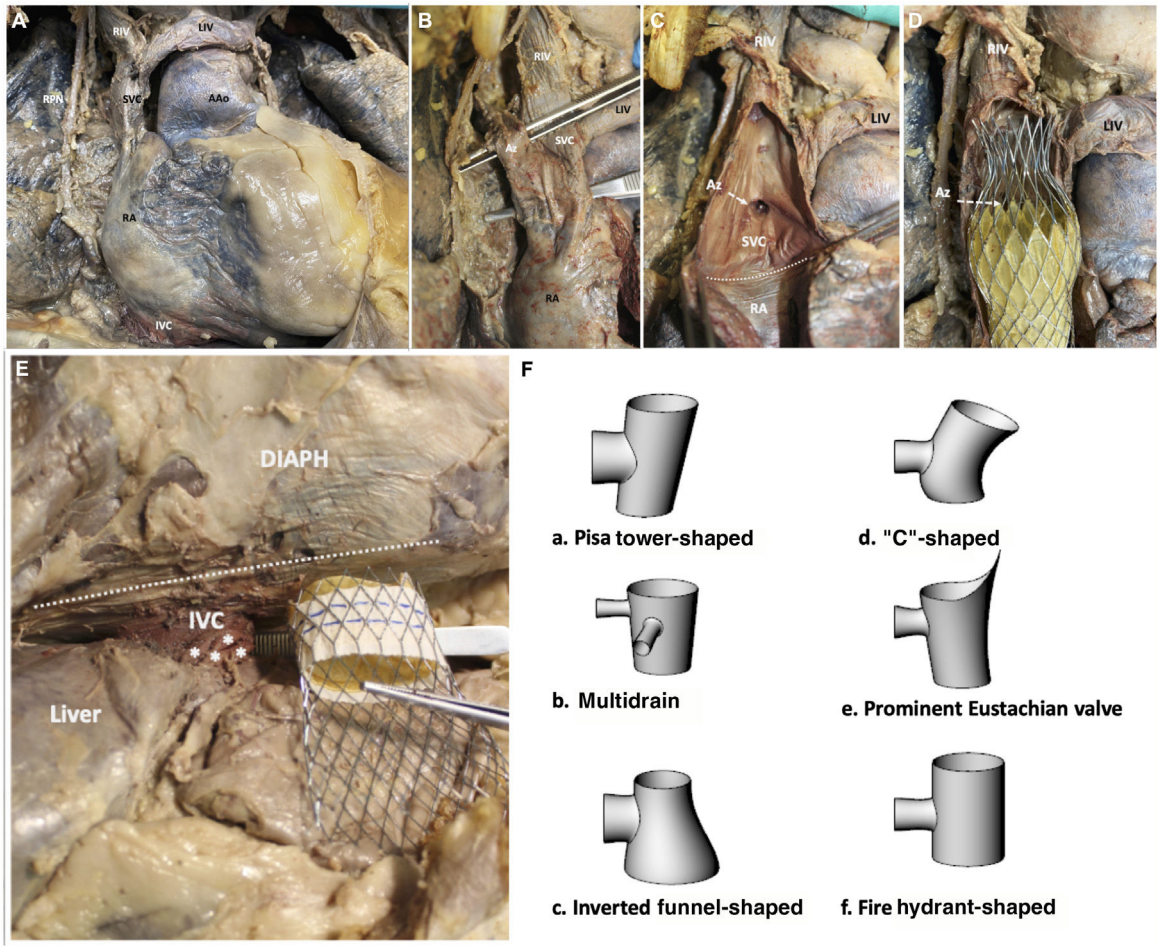

Figure 2. Cadaveric model of SVC (A to D) and IVC (E) and schematic potential shapes of IVC (F). Celiac plexus fibers (asterisk). AAo, arteria aorta; Az, azygos vein; DIAPH, diaphragm; IVC, inferior vena cava; LIV, left innominate vein; RA, right atrium; RIV, right innominate vein; RPN, right phrenic nerve; SVC, superior vena cava.

above and below the hepatic veins (mean: 9.5 ± 5.1°) widely varied (range: 4.4°-18.4°) and might influence the final landing zone and the risk of valve migration and residual leak (figure 1G). The presence of celiac plexus fibers surrounding the IVC was identified in the cadaveric model (figure 2E) and might explain the common presence of temporary radiated pain often detected in the next few hours after IVC prosthesis implant due to overexpansion. Several morphological patterns of IVC were identified and have been schematically depicted in figure 1H and figure 2). There was wide variability in the length of the Eustachian valve, leading to poorly contrasted IVC despite repeat CT in 3 patients (9.4%), suggesting a greater value of echocardiography for IVC prosthesis sizing if a long Eustachian valve is present.

Preliminary positive results with dedicated devices have promoted high expectations on the results of the ongoing TRICUS study (NCT04141137). Our results highlight the relevance of CT measurements (above other imaging techniques) for optimal procedural planning. Moreover, the success of CAVI alternatives lies not only in the device chosen, but also in correct identification of relevant parameters of the anatomy and physiology to predict the risk of complications and efficacy, respectively.

In conclusion, according to our imaging analysis, TricValve might be preferred over Tricento in a large proportion of cases due to short distance to hepatic veins (HV) but Tricento could be a better alternative in patients with excessive tapering of SVC or marked angulation of the IVC as both increase the risk for valve leakage or embolization.

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CONFLICTS OF INTEREST

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Sandra Santos-Martínez,[a] Alfredo Redondo,[a,b] Isabel San José Crespo,[c] Teresa Sevilla,[a,b] Hans R. Figulla,[d] and Ignacio J. Amat-Santos[a,b,*]

[a]*Departamento de Cardiología, Hospital Clínico Universitario, Valladolid, Spain*
[b]*Centro de Investigación Biomédica en Red de Enfermedades Cardiovasculares (CIBERCV), Spain*
[c]*Departamento de Anatomía y Radiología, Facultad de Medicina, Universidad de Valladolid, Valladolid, Spain*
[d]*University Hospital, Friedrich Schiller University Jena, Jena, Germany*

* Corresponding author:
E-mail address: ijamat@gmail.com (I.J. Amat-Santos).

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Prognostic value of 3D area strain in moderate or severe aortic regurgitation with preserved ejection fraction

Valor pronóstico del área de strain *3D en insuficiencia aórtica moderada o grave con fracción de eyección conservada*

To the Editor,

Aortic regurgitation (AR) is a highly-prevalent valve disease in our setting. Surgery is indicated in cases of clinical deterioration or worsening of parameters on 2-dimensional (2D) echocardiography.[1] Patients with AR may remain asymptomatic for decades, so early detection of subclinical deterioration may improve outcomes.[1] Myocardial deformation parameters on 3-dimensional (3D) imaging represent a promising tool that provides additional information besides left ventricular ejection fraction (LVEF), integrating ventricular geometry from a single apical window, but its usefulness in AR is not yet known.

Between March 2013 and July 2014, we carried out a prospective single-center observational cohort study of consecutive patients with at least moderate AR (≥ III/IV) and LVEF > 55%. The patients were asymptomatic and did not meet the classic criteria for surgery. The study was approved by the ethics committee at our hospital.

We performed 2D echocardiography and 3D assessment of ventricular strain and determined global longitudinal strain (GLS), global circumferential strain (GCS), global radial strain (GRS), and global area strain (GAS) using a Vivid E9 scanner (General Electric Vingmed Ultrasound, Norway) and the software EchoPAC (4DAutoLVQ-EchoPAC BT12, General Electric Vingmed Ultrasound). The same operator performed all studies, meaning that intraobserver and interobserver reproducibility could not be assessed. The primary outcome was the composite of cardiovascular death, hospitalization for heart failure (HF), or ventricular dysfunction during follow-up with LVEF < 50% or symptoms attributable to the valve lesion such as deterioration in New York Heart Association (NYHA) functional class, syncope, or angina recorded in the clinical notes.

The study included 31 patients (mean age, 61 ± 18 years; 74.2% were male), 61.3% had a tricuspid aortic valve and 16 (51.6%) had grade IV AR. Up to July 2019, cardiac surgery was indicated in 12 patients (38.7%), all of whom had grade IV AR. The indication was based on clinical deterioration in 7 patients (4 with HF, 3 with NYHA deterioration), worsening ventricular function in 2, and a combination of clinical and echocardiographic factors in 3 (LVEF + NYHA). All hospitalizations for HF met the criteria for surgery. No patients died from cardiovascular causes.

The study was repeated in asymptomatic patients who did not undergo surgery, at 6 months in 17 patients and at 1 year in 10. No significant differences were observed in any of the 3D strain parameters when baseline echocardiogram was compared with those at 6 and 12 months.

Table 1 shows the comparison according to incidence of the composite outcome. Regarding 3D strain, the only parameter associated with the composite event was GAS. After study of the diagnostic yield using the ROC curve, the optimal cutoff point was a