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Bi-caval valve implantation to palliate symptoms in a case of massive tricuspid regurgitation

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ABSTRACT

Severe tricuspid regurgitation is associated with the occurrence of right failure and increased morbidity and mortality. Transcatheter heterotopic bi-caval valve implantation might offer symptom relief in these patients that are often at prohibitive surgical risk.

1. History of presentation

A 69-year-old man with a history of surgical mitral and aortic valve replacement with mechanical valves presented to the emergency department of our hospital complaining of worsening dyspnea (New York Heart Association [NYHA] functional class III). Upon arrival, he was normotensive (blood pressure of 110/60 mmHg), with a heart rate was 60 beats/min and oxygen blood saturation was 94 %. Physical examination revealed abdominal ascites, lower-limb edema and hepatojugular reflux. At transthoracic echocardiogram significant tricuspid regurgitation (TR) was diagnosed, and he was admitted to our department with the diagnosis of acutely decompensated heart failure for further management.

2. Past medical history

His medical history included open surgical commissurotomy for mitral rheumatic heart disease in his twenties, subsequent valve replacement of mitral and aortic valve with mechanical protheses 10 years before this episode and a single chamber pacemaker implantation due to atrial fibrillation with slow ventricular conduction. During the previous year he was hospitalized twice for recurrent heart failure due to severe TR and increasing doses of loop diuretics were used (furosemide 750 mg daily when admitted for this episode).

3. Differential diagnosis

The differential diagnoses we considered included decompensated heart failure secondary to TR or dysfunction of the prosthetic valves.

4. Investigations

Transthoracic echocardiography showed preserved left ventricle ejection fraction and normal function of both prosthetic valves. Right ventricle instead appeared severely dilated (basal diameter of 50 mm) but with normal function (fractional area change: 44 %; tricuspid annular plane systolic excursion: 20 mm). Massive TR secondary to anulus dilation and pacemaker lead interference with anterior and septal leaflets coaptation was found (Supplementary Video 1). Pulmonary artery systolic pressure could not be estimated due to fast equalization of pressures in the right chambers.

5. Management

The patient was deemed unsuitable for surgery due to high intraoperative risk (EuroSCORE II 12.9 %) mainly related to previous open-heart surgeries and significant comorbidities, including interstitial lung disease, ischemic stroke and renal insufficiency. Transcatheter edge-to-edge repair was considered unfeasible due to severe right ventricular

Abbreviations: CT, Computed Tomography; IVC, inferior vena cava; NYHA, New York Heart Association; TR, tricuspid regurgitation; SVC, superior vena cava

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and tricuspid annulus dilation and for the risk of entrapping the pacemaker lead (Supplementary Fig. 1). Moreover, intraprocedural echocardiographic guidance was anticipated to be suboptimal because of previous cardiac surgeries with mechanical valve implantations. Therefore, heterotopic bi-caval valve implantation was considered the best option.

Preprocedural computed tomography (CT) scan was performed to assess feasibility and appropriate dimension of the prosthesis. In this case, the TricValve procedure was feasible with a 25 mm and 35 mm stent for the superior (SVC) and inferior vena cava (IVC), respectively (Fig. 1).

Under general anesthesia, bilateral femoral venous access was obtained. A Landerquist superstiff guidewire was advanced in the right femoral vein to the right internal jugular vein and the 27 Fr TricValve delivery system was exchanged to deliver the superior caval prosthesis. The broader portion of the SVC stent was placed just below the confluence of brachiocephalic veins, with the upper end of the stent protruding 1 cm in the right brachiocephalic vein. Angiographic guidance is possible through a pigtail catheter advanced in the left brachiocephalic vein through the left femoral venous access (Fig. 2), as the upper half of the stent is not covered, thus leaving unobstructed access to the left brachiocephalic trunk. The stent was then expanded slowly to allow for early recognition of mispositioning, which is actionable since the TricValve is partially recapturable up to 80 % of deployment.

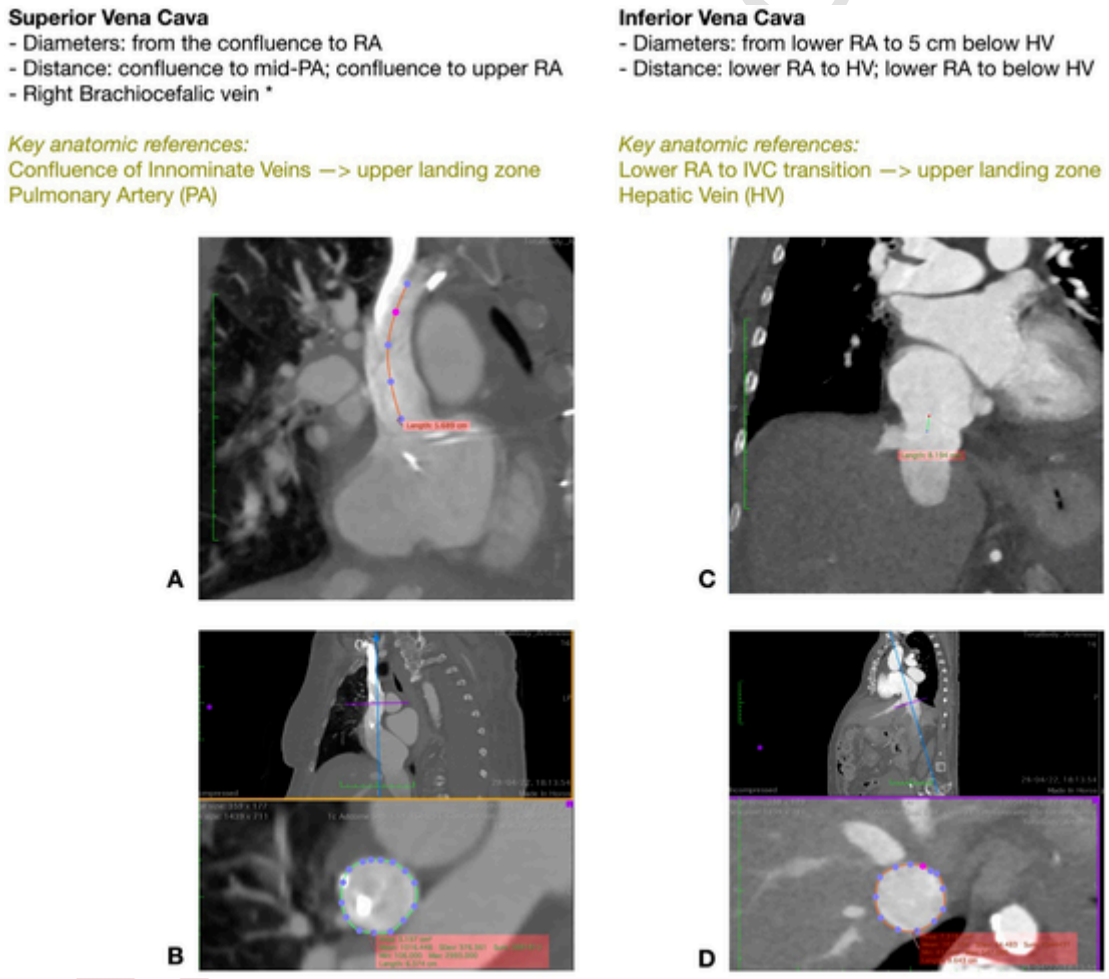

Fig. 1. Key CT measurements to consider in planning for a TricValve procedures.

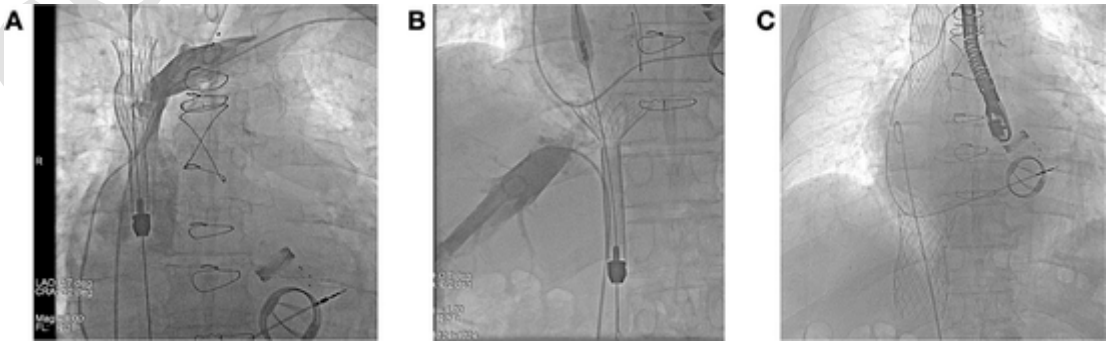

Fig. 2. Angiographic deployment of TricValve prosthesis.

The Landerquist guidewire was then exchanged with a Safari S and the inferior prosthesis was advanced. Since the IVC stent is covered from its upper edge to 2 cm below, it is important not to completely obstruct the hepatic vein with it. Therefore, a pigtail is advanced in the hepatic vein and it is used as a landmark, aiming at the proximal edge of the stent to be deployed above this landmark and protruding 1 cm into the right atrium.

Final angiographic images revealed no residual regurgitation from the right atrium into the jugular and caval veins, which was confirmed also at echocardiography (Supplementary Video 2). Hemostasis was achieved with a ProGlide.

6. Discussion

TR secondary to advanced myocardial or left-sided heart valve disease is associated with reduced survival and progressive signs and symptoms of right heart failure. These patients with severe TR are often at prohibitive surgical risk and with scarce prognosis are often offered medical therapy alone [1].

With the recent advancements in transcatheter treatments for structural heart intervention and the development of novel devices, low-risk percutaneous correction of TR is safe and feasible [2].

Besides tricuspid plasty and orthotopic valve implantation with dedicated devices [3], heterotopic bicaval stenting, or caval valve implatantion (CAVI), is an alternative approach to indirectly relieve systemic venous congestion and that is relatively streamlined both in its pre- and intra-procedural steps. The TricValve system (P&F, Vienna, Austria) consists of a set of 2 self-expanding stents that are partially covered and with embedded bovine pericardial leaflets to be positioned in the inferior and superior vena cava. Promising results have been reported from a European registry, including high procedural success rate and significant improvement in symptom control at mid-term follow-up [4].

In this paper, we present a simple case of TricValve implantation that was used to palliate symptoms in a patient with advanced right heart failure and without other surgical or transcatheter options. The procedure was safely and effectively performed without any angiographic reflux in the superior jugular vein and inferior vena cava. Of note, we highlight some important points that testify how procedure is relatively streamlined, with an easy pre-procedural planning that requires only a CT scan. Importantly, this procedure can be performed under angiographic guidance only, thus avoiding the need of transesophageal echocardiogram and of general anesthesia altogether. Moreover, and especially compared to other transcatheter tricuspid valve procedures, it is relatively easy to perform and with a shallow learning curve and therefore might represent an attractive option for those centers that want to initiate a transcatheter tricuspid program.

From the technical standpoint, implanters should bear in mind the importance of not to occlude the brachiocephalic vein confluence and the hepatic vein with the covered portion of the SVC and IVC stents, respectively. In particular, the covered segment of the SVC stent is localized below the middle of the larger portion of the stent, thus obstruction of the brachiocephalic vein confluence is avoidable with angiographic guidance. Instead, the covered portion of the IVC stent is not visible and the operators should bear in mind its length (20 mm for 31 and 35 mm IVC stents; 28 and 30 mm for 41 and 45 mm IVC stents, respectively) in order to protrude sufficiently in the right atrium to avoid obstructing the hepatic vein. Finally, it is generally recommended to release the stents applying a slight tension to minimize the risk of prosthesis migration.

The selection of patients and the size of the prostheses is based on the measurements made with CT scan. Pre-procedural CT scan should analyze several measurements (key parameters in Fig. 1; references in Table 1). The dimensions of the SVC and IVC may be particularly dilated following chronic volume overload, but an expanded range of stent measures are currently under CE and FDA approval. The CT scan should be synchronized to the heart rate and the contrast should properly opacify the right cavities, the superior cava from the confluence with the brachiocephalic vein, to the inferior cava 5 cm below the junction with the right atrium (Fig. 3). The usual protocol requires a bolus of 60–100 ml volume contrast medium injected into a speed of 4–5 ml/s. If in the arterial phase acquisition, it has not been possible to adequately contrast the necessary length of the inferior vena cava (at least 5 cm below the hepatic vein), a non-ECG-pitch-synchronized venogram can be performed 80–100 s after the acquisition in arterial phase; his should be previously programmed and it is generally recommended in the run-in cases of the centers to avoid repeat CT scan. Finally, being TR heavily dependent on volume status, in heavily diuretized patients a same-day transthoracic echocardiography could be performed before the CT scan to ascertain that TR severity is sufficient for appropriate backward opacification of inferior and superior vena cava.

Table 1
Key CT measurements for references and sizing.

	SVC prosthesis		
	25 mm	29 mm	33 mm[b]
Diameter: Confluence of brachiocephalic veins	>14 mm	>14 mm	>14 mm
Diameter: SVC at top of PA	19–31 mm	22–34 mm	25–40 mm
Diameter: SVC at mid PA[a]	22–31 mm	27–34 mm	25–40 mm
Distance: SCV to RA	>50 mm	>50 mm	>50 mm
Distance: SVC to mid PA	>35 mm	>35 mm	>35 mm

	IVC prosthesis			
	31 mm	35 mm	41 mm[b]	45 mm[b]
Diameter: IVC-RA junction	24–31 mm	28–35 mm	33–41 mm	38–45 mm
Diameter: IVC at top HV	24–31 mm	28–35 mm	33–41 mm	38–45 mm
Diameter: IVC below HV	21–35 mm	27–43 mm	30–48 mm	35–50 mm
Diameter: IVC 5 cm below RA junction	21–35 mm	27–43 mm	30–48 mm	35–50 mm
Distance: IVC-RA junction to HV	>10 mm	>10 mm	>10 mm	>10 mm

Abbreviations: HV, hepatic vein; IVC, inferior vena cava; SVC, superior vena cava; PA, pulmonary artery; RA, right atrium.

[a] If <35 mm, the SVC delivery catheter will be positioned in the right brachiocephalic vein, which should have a minimum diameter of 14 mm.

[b] Pending CE mark and FDA approval.

7. Follow-up

The patient was discharged after 10 days and at 3-months follow-up he was alive and with an improvement in his functional status and heart failure symptoms (NYHA class II). Renal and liver function did not worsen while a significant reduction of loop diuretic dosage was possible (furosemide 125 mg daily).

8. Conclusion

Heterotopic tricuspid valve implantation with TricValve is a relatively simple procedure that indirectly palliates systemic venous overload in cases of severe TR. Being relatively easy to perform and with a streamlined pre-procedural protocol, it can be attractive especially for those centers that want to start a structural tricuspid valve program. Moreover, general anesthesia and live transesophageal echocardiography are not strictly required as the procedure can be performed with only angiographic guidance. Further studies are needed to asses long-

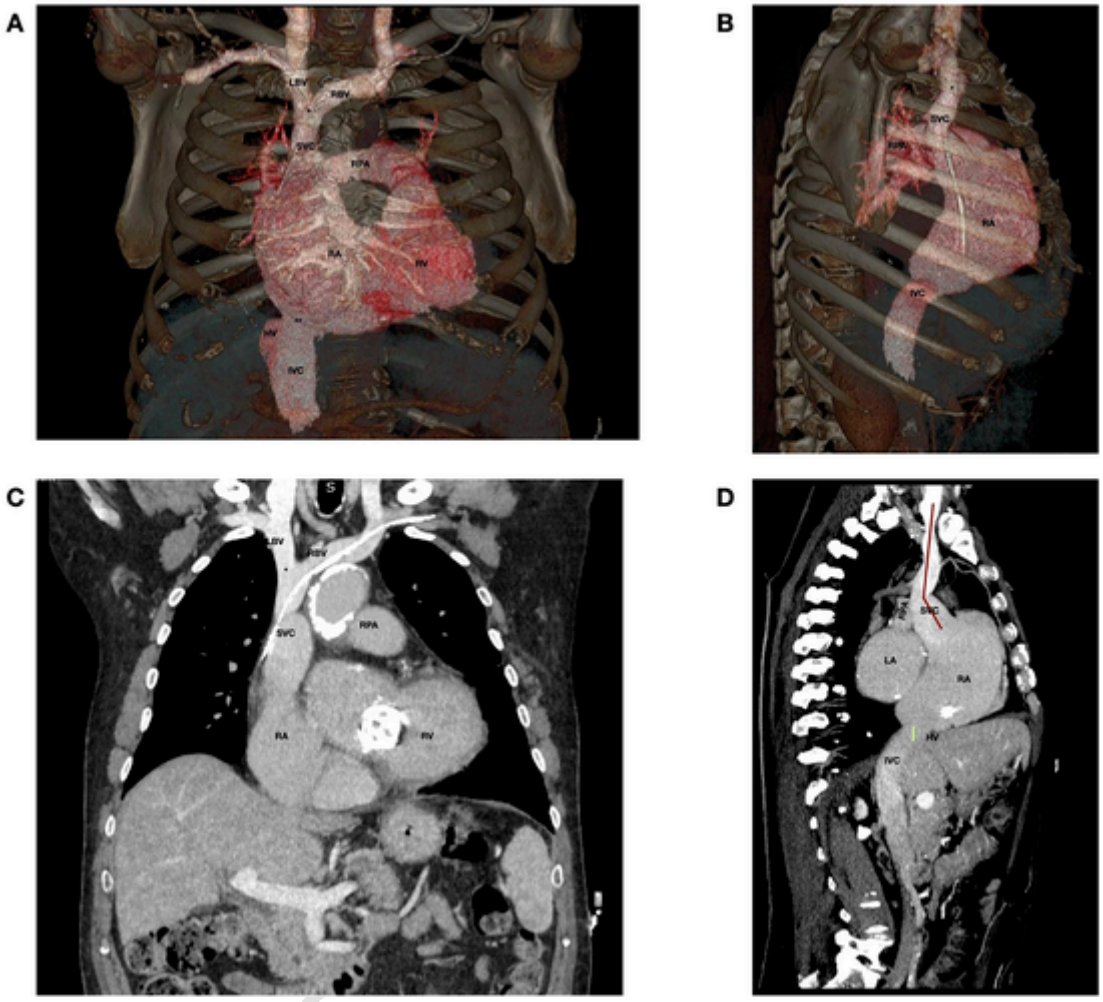

Fig. 3. Venous CT reconstruction and main anatomical landmarks for pre-procedural planning.

term clinical benefit and reduction of mortality and possibility to extend the treatment to patients in earlier phase of the disease.

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Declaration of competing interest

None.

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