MODELING OF BICAVAL TRANSCATHETER SYSTEM IN SEVERE TRICUSPID REGURGITATION

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Introduction

Tricuspid regurgitation (TR) is a type of heart valve disease in which tricuspid valve (TV) does not close properly [1]. Consequently, blood leaks backward into the right atrium incrising atrial pressure and leading to heart dilatation. The development of non-invasive therapeutic strategies of the replacement of the TR has gained a remarkable attention. TR can be indirectly treated by caval valve implantation using device implanted in the caval anatomy to alleviate congestive signs of heart failure and the hemodynamic impairment [2]. To perform caval valve implantation, the transcatheter bicaval system (TricValve) is the first type clinically-used device to treat TR by reducing caval pressure and improve the functional status at the 8-week follow-up [3, 4]. The TricValve system is composed of two valves, one implanted in the superior vena cava (SVC) and the other one in the inferior vena cava (IVC). The aim of the study is to carry out a computational analysis of the structural and hemodynamic performance of the TricValve system in patient-specific model.

Materials and methods

The case of a 72-yrs old gentlemen with severe TR and sings of heart failure was investigated. The simulation performed consisted of a) delivering both the IVC and SVC devices in the human host, followed by an elastic recoil, b) computational fluid dynamic analysis of post-TricValve deployment. A 3D model was created from the patient's computed tomography (CT) images [5]. Patient's geometry was then meshed with triangular shell element (S3) and uniform thickness of 1.5 mm. The model of the two valves was developed from a single wire replicated in polar series and then wrapped on a primitive surface. The devices were then positioned in the patient vena cava anatomy with the support of CT images. Both SVC and IVC devices were meshed with size 0.5 mm resulting in 149939 and 167729 hexahedral-structured elements, respectively (C3D8).

Results

Figure 1 shows a comparison between the final deformed shape of TricValve in the anatomic part and the fluoroscopic image taken during the intervention. We also found high velocities magnitude at the two systolic peaks rather than the diastole. During diastole (0.44 s), when the valve leaflets of both SVC and IVC devices are closed, the velocity drastically reduces.

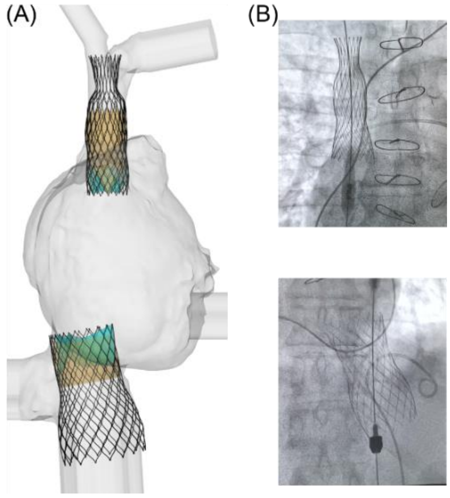

Figure 1: (A)Final deformed shape of TricValve; (B) fluoroscopic images

Discussion

To the best of our knowledge, this is the first study describing the biomechanical performance of the new TricValve system to treat severe TR. The most striking findings are the contact pressure as indicator of the risk of stent frame migration and the low flow velocity alleviating the hemodynamic impairment during diastole. Computational flow analysis has allowed us to quantify the flow velocity during the cardiac beating. We speculate that the low flow velocity seen in diastole may allow to outflow the cardiac flow in a larger time period with respect to the pre-TricValve hemodynamic conditions. This may reduce the hemodynamic impairment with the left heart and then the pressure into the right atrium, thereby portending remodeling of the right atrial chamber. This study can bring new insights on the biomechanics of the TricValve system to better understand device positioning and flow hemodynamic. Findings may also be used to improve the design of novel transcatheter heart valve for the treatment of severe TR in the context of complex clinical conditions.

References

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