Patient-specific finite element analysis of transcatheter aortic valve implantation: towards reliable predictions to support procedure planning

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In the last decades, transcatheter aortic valve implantation (TAVI) has gathered great success, being a minimally-invasive procedure to restore aortic valve function which can be performed even for critical and old patients, leading to significantly reduced rates of death [1]. Within this context, computer-based simulations have recently shown their ability in virtually reproducing the surgical procedure, thus representing a potential tool to support preoperative planning [2].

Herein, we present a novel simulation framework based on finite element analysis which represents a step forward towards reliable predictions of postoperative TAVI outcomes. Several strength points characterize the present study: (i) the patient-specific geometry of the host aortic root is based on CT-A scan data; (ii) the patient's native leaflets are included in the model; (iii) calcifications are also included based on CT information; (iv) the prosthetic stent is reconstructed from micro-CT images of real devices available on the market; (v) the prosthetic leaflets are included in the model allowing a complete evaluation of prosthesis post-implant performance.

The proposed approach has been tested on 2 patients affected by severe aortic stenosis; in both cases, the created models have shown a very good agreement with 3D reconstructions from medical images. Moreover, since the aim of the study is to support clinical practice and procedure planning, we have evaluated medical parameters related to the success (or failure) of the performed procedure. Among others, one of the most significant values is the risk of paravalvular leakage [3]. Validation with post-operative image records and measurements is under development.

References

Figure 1. Simulation steps for transcatheter aortic valve implantation.