Introduction

Background. Transcatheter Aortic Valve (TAV) implantation is a novel technique for the endovascular replacement of stenotic aortic valves (AVs) (Fig. 1). Despite its increasing application, TAV still presents some complications: severe vascular injuries, heart block and prosthesis insufficiency [1]. Clinical studies showed that AV calcifications may affect the outcomes of TAV implantation procedures.

Aim: Recently, finite element analysis (FEA) were used to analyze the mechanics of TAV implantation and its in situ function. Here, for the first time we simulate both, within a realistic model of the aortic root with calcified AV.

Materials and Methods

The aortic root model was based on MRI in vivo measures. AV calcifications were modeled by a layer of stiffened shell elements superimposed to the healthy valvular tissue (Fig. 2.a).

The balloon-expandable Edwards Sapien® (Fig. 2.b), based on the model previously described in [2], was considered. All tissues were modeled as hyperelastic, while the stent was elasto-plastic with isotropic hardening.

Using LS-DYNA® 971 (LSTC, Livermore, CA, USA), four phases were modeled. First, the crimping of the device: rigid planes placed around the aortic root (Fig. 2.d) were moved radially, reproducing the action of the iris attachments of TAV leaflets, where higher risk of prosthesis failure could be expected.

TAV function. TAV orifice area throughout the cardiac cycle was within the range of physiological AVs and comparable to in vivo echo-Doppler measurements following TAV implantation [4]. Due to AV calcifications, asymmetric stress concentration was observed on the lateral attachments of TAV leaflets, where higher risk of prosthesis failure could be expected.

Conclusions

FEA allowed to simulate the implantation and the function of a real TAV device within a realistic aortic root with AV calcifications, which represents the actual clinical scenario. Future efforts will be focused on simulating TAV dynamics through a fluid-structure interaction (FSI) approach.

References