Research Fellowship

FEM before FIM, Finite Element Modelling prior to First-In-Man in heart valve technology

Co-funded by EPSRC

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Clinical background

A non-surgical technique for heart valve replacement has been recently developed. The procedure involves transcatheter placement of a valved stent within the existing dysfunctional right ventricular outflow tract (RVOT). The device is constructed using a bovine jugular venous valve, sewn into a balloon-expandable stent, and mounted on a balloon catheter for delivery (Fig. 1a). Once at the desired implantation site, inflation of the balloon deploys the valved stent and anchors it within the RVOT (Fig. 1b,c).

Although this technique has proven successful, the shape of the dysfunctional RVOT means that only a small number of patients can benefit from the device in its current design.

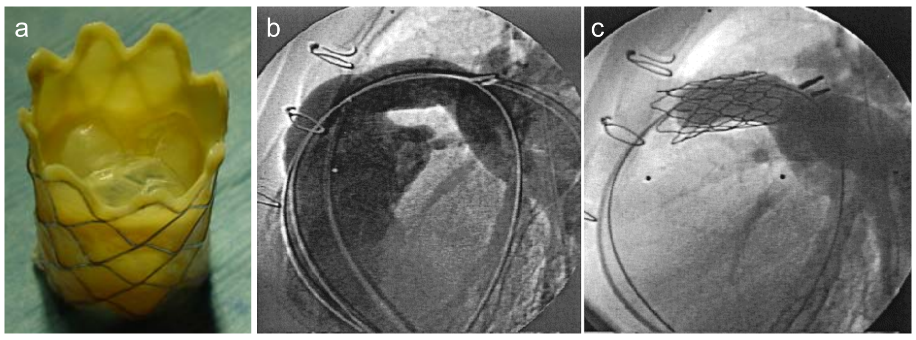


Figure 1 *– Valved stent (a) and pulmonary angiograms pre- (b) and post-PPVI (c).*

Objectives

In order to progress the valve transcatheter field further, I plan to develop a modelling methodology to study the implantation site/device interaction which can be used as a tool to test newly designed devices, suitable for the entire anatomic spectrum of possible RVOTs.

By using models tailored for each patient, it will be possible to predict the device success or failure before the actual implantation. This will improve patient selection and enhance the success of this minimally invasive technique.

Methods

<u>RVOT analysis</u>: Magnetic resonance/computerized tomography data will used to analyse the implantation site morphologies (Fig. 2) and dynamics, by image processing and 3D volume reconstructions.

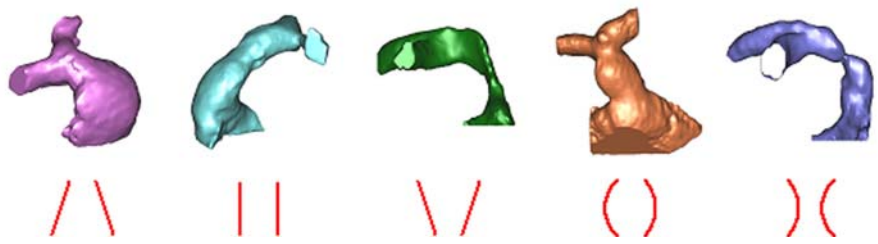


Figure 2 *– RVOT morphological classification.*

<u>Finite element modelling</u>: The finite element method will be used to model different stents to evaluate their mechanical performance, risk of fracture in the short and long-term, and optimize the design of the next generation device for percutaneous valve implantation.

Furthermore, finite element analysis of stent inflation into selected patient RVOT models will allow the evaluation of the stresses induced in the RVOT wall by the deployment of the device, and on the stents in realistic boundary conditions (Fig. 3).

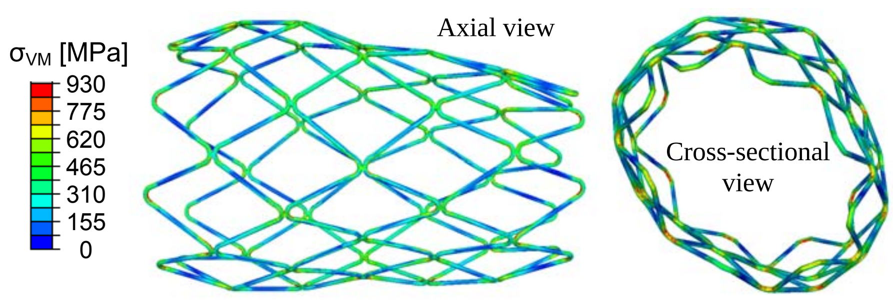
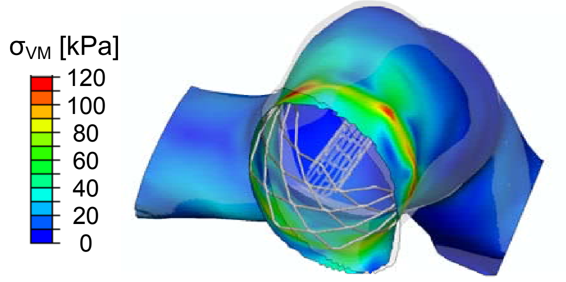


Figure 3 *– Von Mises stress distribution in the current stent, deployed in a patient specific RVOT, and in the RVOT wall.*



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