IMPACT OF PATIENT MORPHOLOGY ON VALVE THROMBOSIS – COMBINING PATIENT DATA AND COMPUTATIONAL MODELING

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Introduction

Clinically apparent transcatheter heart valve thrombosis (THVT) is rare (<3% incidence), while subclinical THVT is more frequently found (7-35%). THVT may affect prosthetic valve function and lead to early valve degeneration [1-3]. The specific relevance of aortic root geometry on the occurrence of THVT and the etiology of THVT is largely unknown. Disturbed blood flow past prosthetic valves has been linked to thrombus formation [4]. Aortic morphology and dimensions and location of coronary ostia are known to influence the aortic flow field [5,6,7]. In this pilot study, our objective was to (1) investigate the aortic morphology of THVT patients compared to unaffected transcatheter aortic valve implanted (TAVI) patients, and (2) to investigate how the differences impact the aortic root flow using a dedicated computational model. We hypothesize that some aortic morphological features might promote THVT by affecting the wash-out efficiency of the sinus and the high shear stress regions downstream of the valve.

Methods

Aortic root morphology: 8 patients with THVT and 16 unaffected controls (2 controls per THVT patient with the same valve type and size) from the Bern-TAVI registry (clinicalTrials.gov Identifier: NCT01368250) were included. Aortic root dimensions were assessed from pre-TAVI multi-detector computed tomography scans and compared.

Computational model: The effect of the identified morphological differences on the flow field in the aortic root were investigated in a computational study. Two idealized aortic root geometries were used with sinotubular junction (STJ) and ascending aortic (AAo) diameters selected according to the observed patient dimensions (one THVT model and one control model). Typical pressure gradients seen in THVT patients, and the general TAVI patient population were imposed in the two models, respectively [1].

Results

The THVT patients were implanted with five different valve types and three different valve sizes. In THVT patients the right coronary artery height was significantly lower (-40%) and the STJ and AAo diameters tended to be larger (9% and 14%, respectively) compared to the controls.

In the computational study, the larger AAo and STJ diameters of the THVT model led to lower backflow velocities (-11%) at the STJ and lower velocity magnitudes (-5%) in the sinus compared to control. The systolic turbulent dissipation rate (Figure 1) was higher (8%) in the AAo and lower in the sinus (-9%) compared to control.

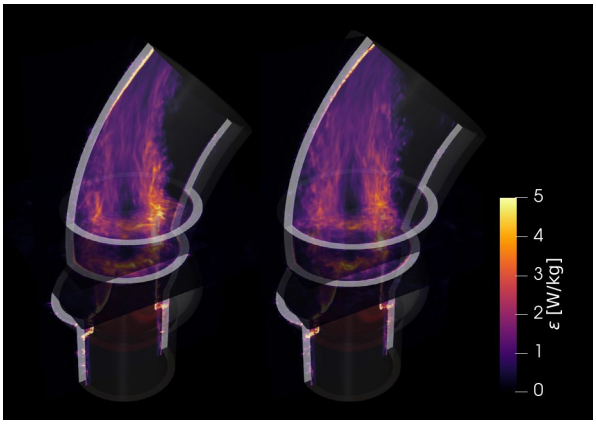

Figure 1: The systolic turbulent dissipation rate in the control (left) and THVT patient model (right).

Discussion

This pilot study suggests that the individual aortic morphology might have a direct impact on clinically apparent THVT. In the computational study, the observed anatomical differences in THVT patients led to blood flow patterns potentially favoring thrombus formation by reducing wash-out efficacy in the sinus and promoting platelet activation in the turbulent jet distal to the valve. The observed anatomical parameters may be used to identify patients at risk for THVT but require validation in a larger clinical study.

References

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