TAVI PROGNOSTIC ASSESSMENT COUPLING IMMUNOLOGICAL PROFILE AND HIGH-FIDELITY MODELING

Benedetta Grossi (1,2), Giulia Luraghi (1), Sara Bridio (1), Riccardo Terzi (2), Matteo Sturla (2), Alessandro Villaschi (2), Ottavia Cozzi (2), Anna Ramella (1), Marinos Kallikourdis (2), Josè Felix Rodriguez Matas (1), Gianluigi Condorelli (2), Giulio Stefanini (2), Francesco Migliavacca (1)

1. Politecnico di Milano, Italy; 2. Humanitas Research Hospital, Italy

Introduction

Transcatheter aortic valve implantation (TAVI) has evolved into the treatment of choice for most patients with severe aortic stenosis (AS) [1]. A close link between inflammatory status and degenerative AS has been established [2] and associated with hemodynamic alterations [3]. In vivo evidence about the benefit of TAVI on the inflammatory background via amelioration of the hemodynamic environment is still lacking. Thanks to advances in computational modelling, such as Fluid-Structure Interaction (FSI) patient-specific simulations, such cause/effect link may be approached using systems biology coupled with in silico modelling. We developed an FSI-based methodology to simulate valve implantation and our preliminary findings showed a robust prediction of procedural success. The aim of this project is to evaluate the inflammatory response after TAVI in patients whose hemodynamic conditions have been evaluated through the employment of FSI models.

Methods

Using cardiovascular imaging techniques, detailed anatomical and physiological data have been obtained and subsequently analyzed using patient-specific FSI modelling [4]. The in silico model simulates the implantation of the prosthetic valve, the interaction of the device with the patient-specific domain and the hemodynamics during systolic-diastolic cycles after the implantation (Figure 1). In particular, the model considers three components: i) patient-specific anatomical characteristics (e.g., valves calcifications), ii) the TAVI valve and iii) the hemodynamic parameters (pressures) of the patient. The FSI model allows to evaluate and quantify the post-implant aortic regurgitation due to paravalvular leak. The validation of the model has been performed using post-procedural imaging (echocardiography and cardiac MRI). To evaluate the link between aortic stenosis treatment and a reduced immune response, the neutrophil-to-lymphocyte ratio (NLR) has been measured at three different treatment stages: pre-operative phase, acute phase (at 3 days) and post-operative phase (at 30 days).

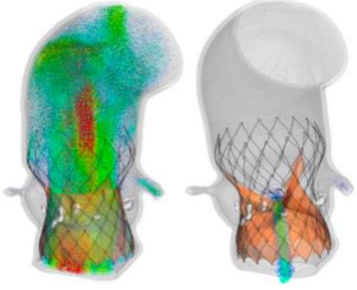

Figure 1: Post-TAVI fluid dynamic simulation: blood velocity representation at systolic and diastolic peaks.

Results

Twenty patients have been enrolled in the study. In six patients, the NLR was available at all time points. Mean baseline NLR was 2.27 ± 0.89, which increased to 3.82 ± 2.09 in the acute phase. One month after the procedure, mean NLR was 1.97 ± 0.85, with an average decrease from baseline of 18% (p=0.027) (Figure 2). In five patients, mild aortic regurgitation post TAVI was noted, while in one patient moderate regurgitation (regurgitant fraction = 22%) was observed. FSI simulations are still underway, but the model of this latter patient has already been performed, providing an accurate quantification of the paravalvular leak; of interest, in that single case a lower decrease of NLR (9%) with respect to the pre-operative data was found.

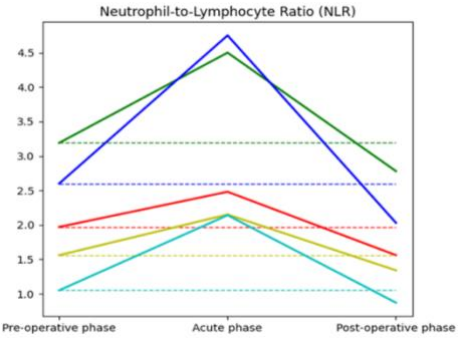

Figure 2: NLR trend in patients with mild regurgitation.

Discussion

A decrease of the inflammatory response after the restoration of physiological hemodynamic conditions was found in a small subset of patients undergoing TAVI, but such effect may be limited in patients with a suboptimal result. Further analysis will delve deeper into this correlation with the aim of combining biological data with FSI models to create a patient-specific profiling for AS treatment.

References

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