Mathematical Transcatheter Aortic Valve Replacement

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Transcatheter Aortic Valve Replacement (TAVR) is an emerging treatment opportunity for treating aortic valve stenosis. The TAVR technology consists of a stent with an integrated valve sutured to the stent, which is implanted using catheterization, into the aortic annulus to replace the function of the failing native valve. Paravalvular aortic regurgitation is a common complication following TAVR. An imperfect seal of the aortic annulus can lead to regurgitation of blood around the new valve, and to sub-optimal function of the prosthetic valve leaflets. As of today, the patient-specific anatomic factors such as non-uniform aortic annulus geometry due to calcification, are not being used to select the type of transcatheter aortic valve implanted, or to select the ideal depth for TAV deployment relative to the aortic annulus. Our group at the University of Houston, together with the TAVR experts at the Valve Clinic at the Methodist DeBakey Heart and Vascular Center in Houston, have begun working on modeling and simulation of TAVR. The goals of the study are to help select patients for TAVR, to select the ideal depth for TAV deployment, and to improve ultrasound diagnosis and quantification of severity of paravalvular regurgitation following TAVR. In this talk a review of the mathematical problems involving partial differential equations related to the modeling of TAVR will be presented. They include fluid-structure interaction between blood flow and cardiovascular tissue including heart valves, stent modeling, and modeling of contact between the TAVR stent holding the valve and the native aortic annulus, the latter leading to a mathematical free-boundary problem involving an elastic obstacle. The mathematical modeling and computer simulations are paralleled with in vitro experimental validation that uses patient-specific anatomic models of the aortic root, manufactured using a 3D printer, and coupled to our pulsatile flow loop. The experimental set-up has been used for virtual, *in vitro* TAVR procedures, performed using the Medtronic's Core ValveTM platform. Preliminary results in mathematical modeling, computer simulations, and experimental results will be presented. This is a joint research with M. Bukac and P. Zunino (U of Pittsburgh), S. Basting (U of Erlangen and UH), A. Quaini and R. Glowinski (UH), B.Muha (U of Zagreb), A. Veneziani (Emory), Dr. S. Little and M. Jackson (Methodist Hospital). Partial research support by NSF, NIH, AHA, and Medtronic Inc. is acknowledged.