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An hemodynamic study of the intra– and supra–annular implantation of mechanical bi–leaflet aortic valves

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Aortic valve replacement has become a very common surgical procedure to restore the pumping efficiency of the heart when that valve is impaired. Nowadays, most of the prosthetic valves are 'biologic', meaning that the implanted prosthesis reproduces the three–leaflet configuration of the native valve using a biological tissue made of bovine pericardium. In fact, these devices comply with the physiological hemodynamics and allow for a normal lifestyle[1]. On the other hand, biologic valves tend to degrade their performance in time and need a replacement after a decade or so: this decreases their suitability for young patients whose life expectation is several decades and multiple valve replacements should be avoided.

A possible alternative to biologic valves are mechanical valves which are supposed to last lifelong although their altered hemodynamics (1) entails a permanent anticoagulant therapy in turn causing adverse effects. Bi–leaflet mechanical valves are made of a rigid annular frame in which two semilunar rigid leaflets are hinged and they can freely rotate in response of the time–varying hydrodynamic loads.

Once the valve model has been selected, one of the most relevant choices is its size since a too small prosthesis induces undesired pressure drops while a too big device stretches the surrounding biological tissues causing undesired remodeling reactions. This issue is known as 'size mismatch' and it is thoroughly studied in the medical literature.

Given the specific physiological junction of the left ventricle with the aortic root, the implantation or an aortic valve gives the possibility to use larger prostheses by deploying them downstream of the native ostium (supra–annular position) rather then within the ostium (intra–annular position). In the former case the effective orifice area (EOA) of the valve is bigger and the induced pressure drop smaller although the altered hemodynamics can interfere with the flow in the aortic root which is key for the correct perfusion of the coronary arteries.

In this study we use our computational human heart model[2] and our laboratory systemic circulation duplicator[3] to compare flowfields and diagnostic parameters for aortic valves implanted in supra– and intra–annular positions. An assessment of the blood cumulative damage (hemolisis) for the two configurations will also be performed.

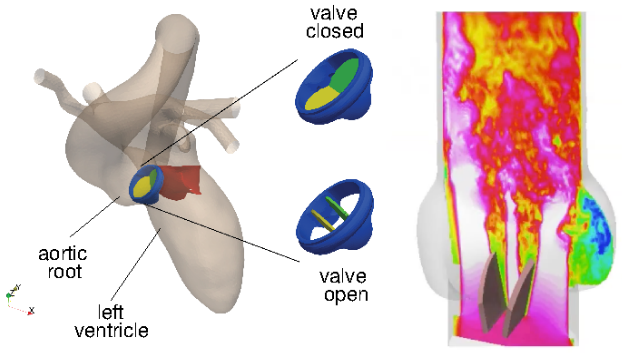

Figure 1: Left: assembly of the left heart with the mechanical aortic valve. Right: instantaneous snapshot of the velocity magnitude at peak systole in a bi-leaflet mechanical valve mounted in intra–annular position.

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[2]Viola et al., *Sci. Rep.* **13**, 8230 (2023)
[3]Viola et al., *Ann. Biomed. Eng.* **47(8)**, 1799 (2019)