# HEMODYNAMIC IMPACT OF VALVE DISEASES DURING PERSISTENT ATRIAL FIBRILLATION: A COMPUTATIONAL APPROACH

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**Background.** To date, atrial fibrillation (AF) literature mostly refers to patients without concomitant valvular heart diseases, which are instead a relevant cohort. Aim of the study was to shed light into the hemodynamic impact of mitral and aortic valve diseases during AF by a computational modelling approach.

**Methods.** The cardiovascular model here used has been validated over more than thirty clinical data regarding AF and relies on a lumped parameterization of the four heart chambers, together with the systemic and pulmonary circulation. Cardiac and circulatory regions are described through electric components, such as compliances, resistances and inductances, in terms of pressure P [mmHg], volume V [ml], flow rate Q [ml/s], and valve opening angle $\vartheta$ [°]. The fibrillated beating is simulated paying particular attention to the stochastic modeling of the irregular heartbeats, and to the missing contractility function of the atria. Regarding the valve dynamics, three different grades of severity (mild, moderate, severe) are simulated for each of the four valvulopathies (AS: aortic stenosis, MS: mitral stenosis, AR: aortic regurgitation, MR: mitral regurgitation), by varying - through the valve opening angle - the valve area, according to thresholds recommended in current valve diseases guidelines.  The computational approach allowed long time series (e.g. 5000 cardiac cycles), thereby yielding statistically significant results.

**Results.** With respect to lone AF simulation values, mean pulmonary vein pressure ($P_{pvn}$) increased by 31.4%, 27.7%, and 23.2%, in case of severe MR, AR, and MS, respectively. Similarly mean left atrial pressure ($P_{la}$), increased by 34.4%, 30.7% and 25.2% in case of severe MR, AR and MS. Mean left ventricular volume ($V_{lv}$) increased due to severe AR (+28.8%) and MR (+7.4%), and decreased in case of severe MS (-18.7%). Stroke volume (SV) showed an upsurge in severe AR (+102.7%) and MR (+88.0%), and a decrease in severe MS (-12.9%). Mean systemic pressure ($P_{sas}$) declined in severe AR (-24.1%), MR (-22.8%) and MS (-12.4%), with a concomitant decrease of cardiac output (CO) in the severe MR (-22.5%), AR (-20.5%) and MS (-13.8%) simulations. Concerning grading of valve diseases, regurgitations already have strong hemodynamic impact when mild, while MS displays a progressively greater influence as the grading increases.

**Conclusions.** Regurgitations presented the strongest impact on hemodynamics, immediately followed by MS; conversely, AS was the less-impacting between the studied valvular diseases. These findings, if clinically confirmed, hold the potential to impact AF management (e.g. adoption of a rhythm control strategy) in case of a specific valvular disease.