Atrial fibrillation effects on coronary perfusion across the different myocardial layers: a computational analysis

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Aims: Atrial fibrillation (AF) patients may present ischaemic chest pain in the absence of classical obstructive coronary disease. Among the possible causes, the direct haemodynamic effect exerted by the irregular arrhythmia has not been studied in detail.

Methods and results: A computational fluid dynamics analysis was performed by means of a 1D-0D multiscale model of the entire human cardiovascular system, characterized by a detailed mathematical modelling of the coronary arteries and their downstream distal microcirculatory districts (subepicardial, midwall, and subendocardial layers). Three mean ventricular rates were simulated in both sinus rhythm (SR) and AF: 75, 100, 125 b.p.m. We conducted inter-layer and inter-frequency analysis of the ratio between mean beat-to-beat blood flow in AF compared to SR ($\overline{Q}_{AP}/\overline{Q}_{SR}$ Inter-layer analysis showed that, for each simulated ventricular rate, $\overline{Q}_{AP}/\overline{Q}_{SR}$ progressively decreased from the epicardial to the endocardial layer in the distal left coronary artery districts (*P*-values < 0.001 for both left anterior descending artery—LAD, and left circumflex artery—LCx), while this was not the case for the distal right coronary artery (RCA) district. Inter-frequency analysis showed that, focusing on each myocardial layer, $\overline{Q}_{AP}/\overline{Q}_{SR}$ progressively worsened as the ventricular rates increased in all investigated microcirculatory districts (LAD, LCx, and RCA) (*P*-values < 0.001 for all layer-specific comparisons).

Conclusions: AF exerts direct haemodynamic consequences on the coronary microcirculation, causing a reduction in microvascular coronary flow particularly at higher ventricular rates; the most prominent reduction was seen in the subendocardial layers perfused by left coronary arteries (LAD and LCx).