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Geometry of the porcine myocardial microcirculation with and without cardiac microvascular obstruction: preliminary results from an ex vivo study with propagation-based phase contrast tomographic microscopy

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In cardiac microvascular obstruction (MVO), vessels of the myocardial microcirculation are fully or partially occluded such that the affected tissue is under-perfused. MVO may result from a catheter-based removal of a larger thrombus in a coronary artery after a heart attack. During the intervention, this thrombus may be broken up into small microthrombi, which are washed downstream with the re-established blood flow potentially occluding vessels of 200 μm diameter or less.

Blood perfusion of the myocardium with MVO is governed by the geometry of the myocardial microcirculation. Both the distribution of vascular branchings at different vessel diameters and the network topology determine the location of the occluding microthrombi and their effect on blocking the perfusion downstream of the occlusion. For example, the presence of collateral vessels (vascular loops) at the level of arterioles may allow the blood to bypass a local obstruction, whereas an occlusive microthrombus in a tree-like topology will block blood flow in the whole downstream region. Unfortunately, there is only limited knowledge on the geometry of the myocardial microcirculation. Microfluidic models rely on older histological data [1,2]. Moreover, there is even less knowledge about the distribution of microthrombi in MVO and whether they are fully occlusive or only semi-occlusive.

Therefore, we performed an imaging study using propagation-based phase contrast tomographic microscopy at the TOMCAT beamline of the Swiss Light Source (PSI, Würenlingen, Switzerland) on seven samples of pig hearts with and without MVO. These samples were obtained from a large animal trial with a porcine MVO model using microthrombi that were created by dissecting autologous arterial thrombi into small fragments of 150-300 μm [3].

The imaging data with an isotropic voxel size of 1.625 μm is segmented using the nnUnet [4] algorithm, which was trained with manually labeled data. Preliminary results indicate a complex vascular network with larger arteriolar vessels on the outer side of the myocardial wall (epicardium) that are branching into ever smaller vessels toward the inner side (endocardium). Furthermore, we could identify local microthrombi in arterioles of 50 μm diameter. It is the aim to use fully automated segmentation to improve existing microfluidic models of MVO [2] which can help to develop novel treatment strategies for MVO.

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