Synchrotron-based X-ray phase contrast imaging of transmural cardiac tissue in patients treated for advanced heart failure

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Background: Cardiac imaging is essential in identifying structural changes in advanced heart failure (HF) enabling understanding of the underlying pathophysiology. Synchrotron radiation-based X-ray phase contrast imaging (X-PCI) is a novel non-destructive imaging modality that can provide high resolution three-dimensional (3D) visualization of cardiac tissue on the macro- and microstructural level, enabling analysis from the epi- to the endocardium, as well as collagen matrix reconstruction[1,2]. We aimed to explore the feasibility of utilising X-PCI for the imaging of full thickness myocardial samples and to explore microstructural features of cardiac tissue in different advanced HF aetiologies.

Patients and Methods: Eight patients were included - two receiving a left ventricular assist device (LVAD) (LVAD group), and six undergoing heart transplantation (HTx) (HTx group). Aetiology of advanced HF in the LVAD group was ischaemic heart disease (IHD) and dilated cardiomyopathy (DCM). In the HTx group, 2 patients had IHD, while one patient had each of the following: DCM, restrictive cardiomyopathy, toxic cardiomyopathy, and adult congenital heart disease. Transmural tissue samples were obtained by left ventricular apical coring (LVAD group) and from the explanted hearts (HTx group). The tissue specimens were imaged by X-PCI at the Paul Scherrer Institute (Villigen, Switzerland) using a multi-scale setup resulting in low (LR) and high resolution (HR) imaging, at 5.8 and 0.65 µm effective pixel size, respectively. Imaging datasets were used to visualize morphological features and an open-source software (Ilastik) was used for semi-automatic collagen segmentation.

Results: The images resulting from the apical coring samples are shown in **Figure 1.** X-PCI enabled multiscale exploration of transmural myocardial tissue samples providing 3D virtual histopathology. Additionally, reconstruction of the collagen matrix highlighting microstructural features and potential differences amongst different aetiologies of advanced HF was shown to be feasible without further sample preparation.

Conclusion: X-PCI is a non-destructive, 3D imaging method that can extend the amount of information available from ex-vivo tissue analysis and potentially improve disease phenotyping.

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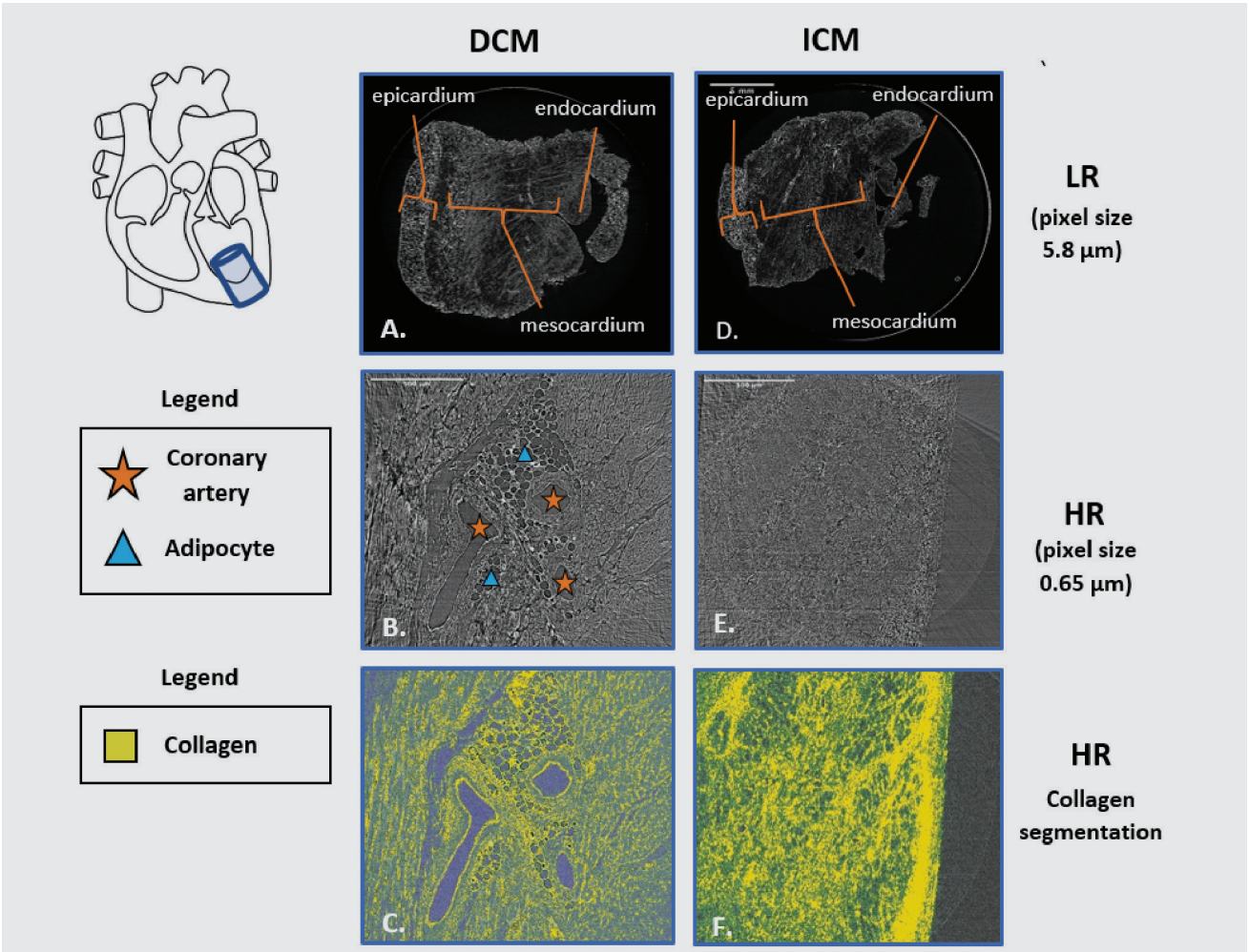

FIGURE 1. Examples of X-ray phase contrast imaging images of different aetiologies of advanced heart failure in the left ventricular assist device group (dilated cardiomyopathy – panels A, B, C; ischaemic cardiomyopathy – panels D, E, F). Panels A and D show low resolution images, B and E high resolution images, and C and F show collagen segmentation.

LITERATURE

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