REVEALING CARDIAC MICROSTRUCTURE IN A HUMAN FETAL HEART OF 8 WEEKS OF GESTATION WITH SYNCHROTRON-BASED X-RAY PHASE CONTRAST TOMOGRAPHIC IMAGING

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Motivation

Understanding the complexity of heart morphogenesis and the associated functional consequences of congenital heart disease is essential for providing appropriate treatment strategies. Since our knowledge on the microstructure of the whole fetal & paediatric heart is limited, novel imaging approaches offered by **synchrotron** facilities can provide structural detail currently not available otherwise.

Our **aim** is to **visualise and quantify cardiac microstructure in fetal hearts** at different stages of development using synchrotron-based **X-ray Phase-Contrast tomography Imaging** (X-PCI).

Methods

- A normal fetal heart of **8 weeks and 6 days of gestation** was selected from the from the Ospedale Maggiore Policlinico (Milan, Italy).
- X-PCI was performed at **1.625µm pixel size** at the TOMCAT Beamline (Swiss Light Source, Paul Scherer Institut, Villigen, Switzerland) using an **energy of 20 keV**.
- **Orientation of bundles of myocytes** was assessed using an in-house structure tensor algorithm. Helical angle (HA), fractional anisotropy (FA), and intervoxel coherence index (IVC) were computed in a mid-ventricular image slice.

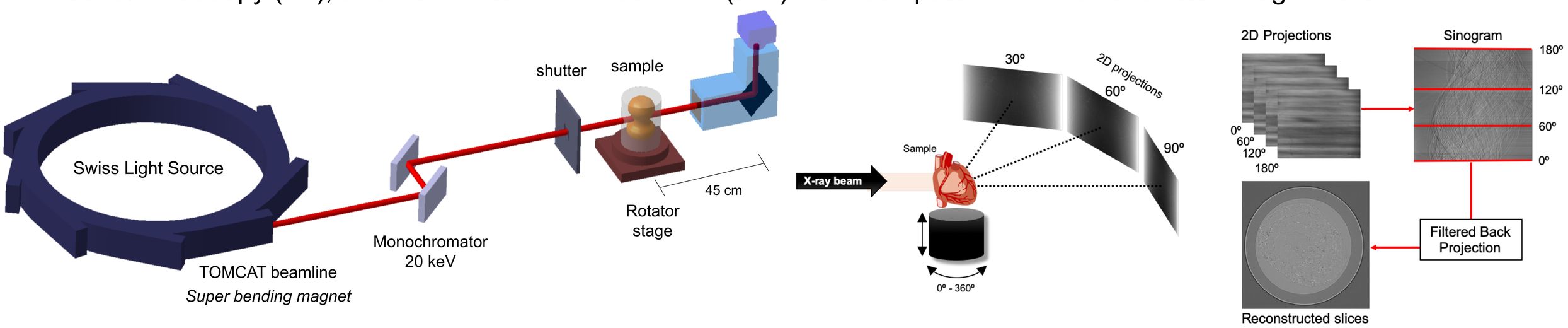

Figure 1. Synchrotron X-PCI imaging set-up

Results

The ventricular myocardium is composed mainly of trabeculations while the compact myocardium is thin and under-developed. Taking both trabecular and compact myocardium together there is organisation even at this early gestation (see Fig.4) with a clear change in helical angle (from 60º to -60º) from endo to epicardium, especially the septal wall (higher values of IVC demonstrated also more organisation). Low values of FA correlated with the under-development of the myocardium.

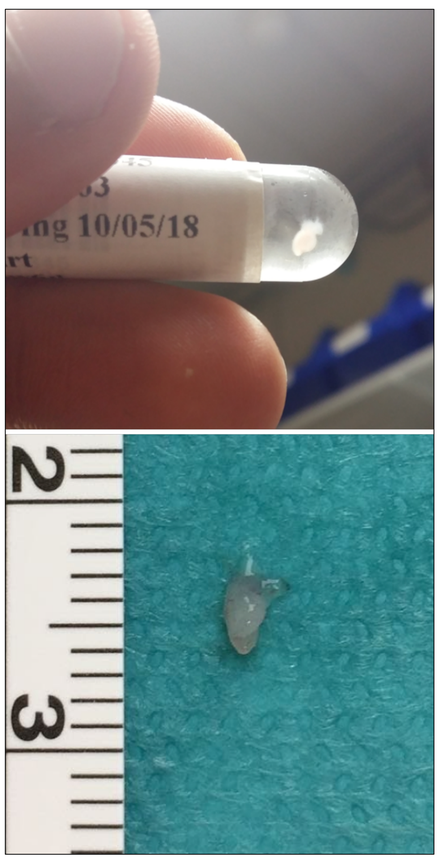

Figure 2. Two images of the gross specimen with scale - base to apex 2mm.

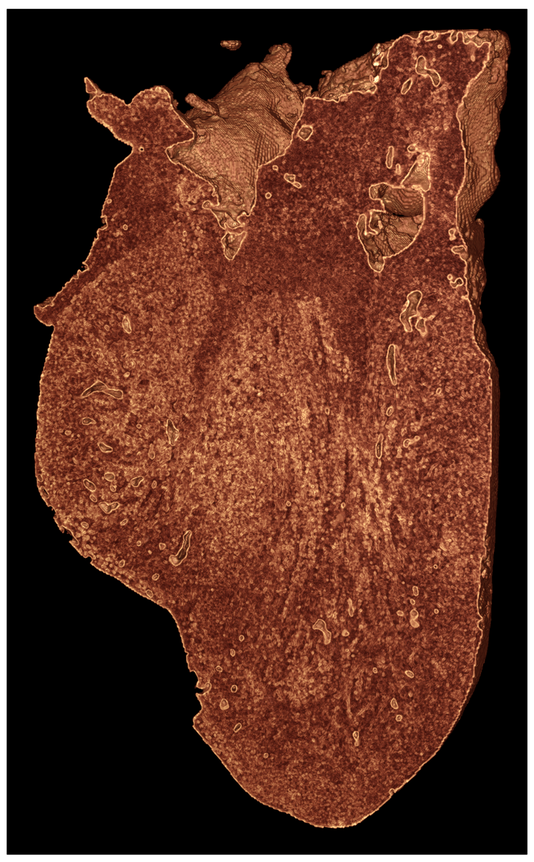

Figure 3. Volumetric rendered image of the fetal heart

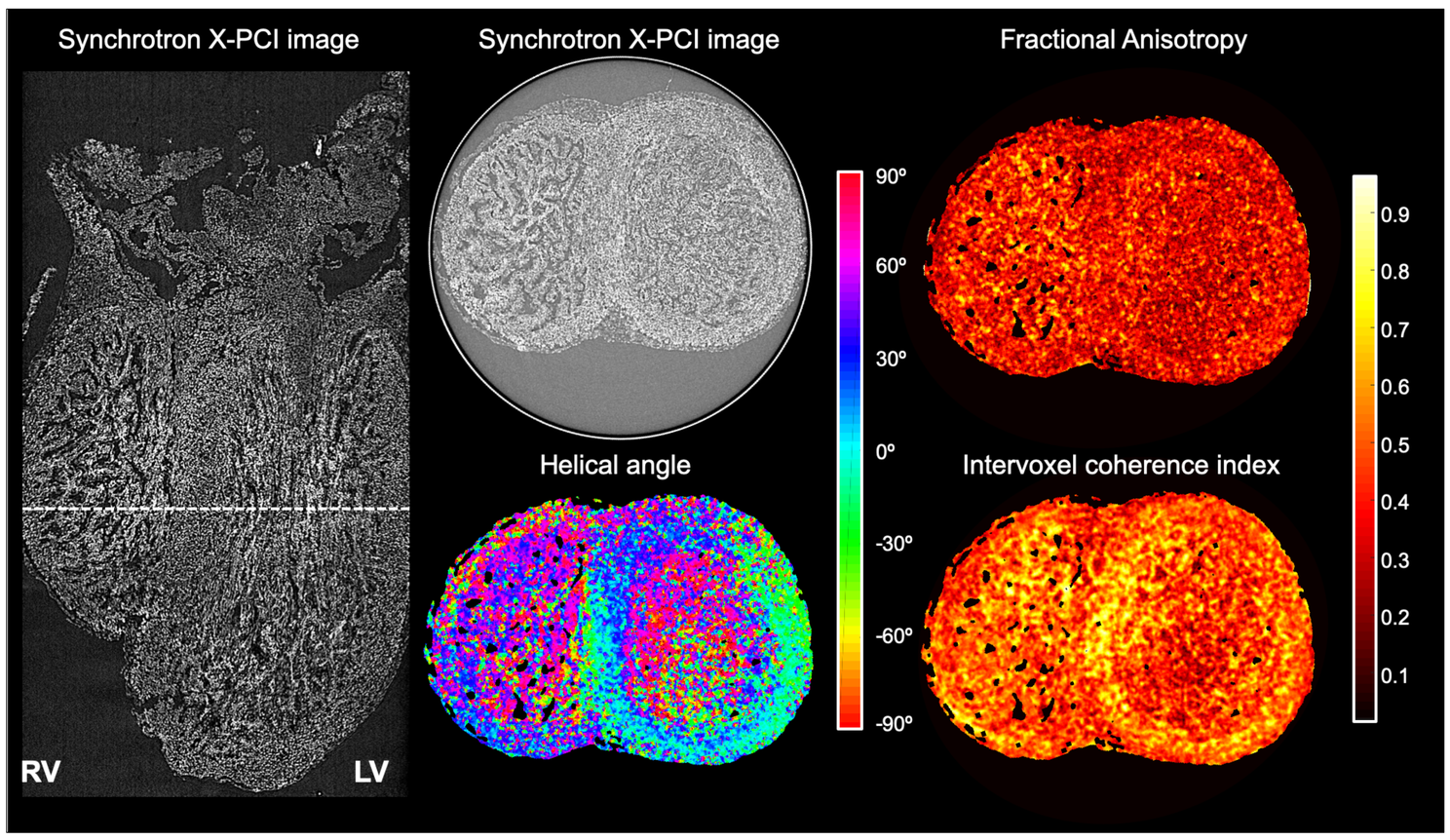

Figure 4. Left: Longitudinal (4-chamber) and short axis maximum intensity projection slices (mid-top) from the X-PCI image dataset showing detail of myocardial structure. Estimation of HA (mid-bottom), FA (right-upper) and IVC (right bottom) in the short axis slice indicated with a white dashed line.

We managed for the first time to image a normal fetal heart with high-resolution and in 3D at an early stage of development, resolving detail of myocyte aggregates and providing information on cardiac microstructure without the need for sample processing or sectioning.

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