Using micro-CT and X-PCI to visualize coronary morphology and ventriculo-coronary arterial connections in the setting of Pulmonary Atresia with Intact Ventricular Septum

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Introduction

Background

Pulmonary atresia with intact ventricular septum (PA-IVS) is a rare, morphologically heterogenous cyanotic form of congenital heart disease (CHD).

Ventriculo-coronary arterial connections (VCACs) are commonly found in patients with this condition, which can further worsen their prognosis[1].

The morphogenesis of this CHD as well as associated coronary anomalies remains unclear.

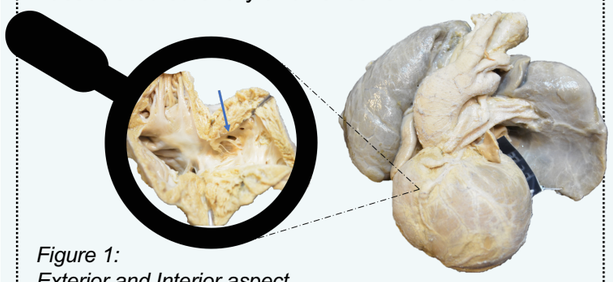


Figure 1: Exterior and Interior aspect of an abnormal PA-IVS heart with VCACs

State-of-the-art Imaging

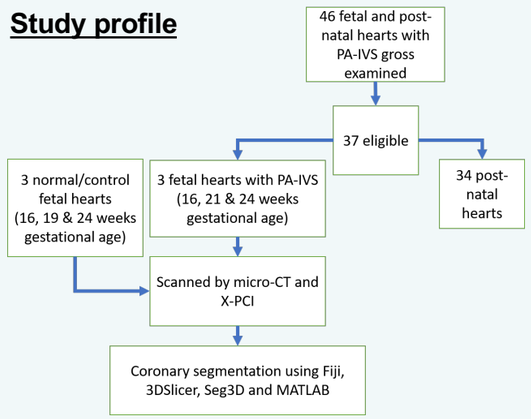
Novel imaging modalities such as Synchrotron X-Ray Phase Contrast Imaging (X-PCI) and micro-Computed Tomography (micro-CT) have emerged, providing a means for 3D visualisation of morphological characteristics in small hearts at near histological resolution, without the need for dissection. As such, we are better equipped to retrospectively study VCACs and coronary arteries in archived fetal and post-natal cardiac specimens with PA-IVS.

Aim & Hypothesis

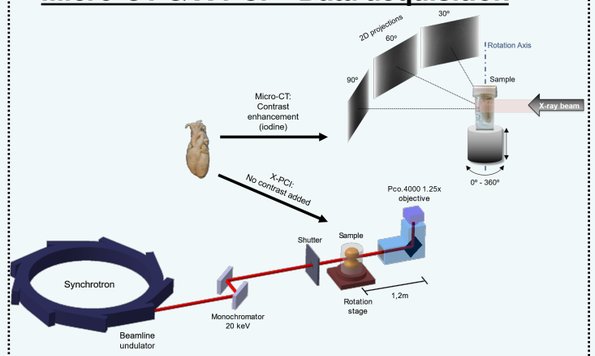
To **assess** and **compare** whether contrast enhanced **micro-CT** and **X-PCI** can provide **additional information** on **coronary artery morphology in PA-IVS** compared to standard gross examination.

Materials & Methods

Study profile



Micro-CT & X-PCI – Data acquisition



Data analysis – Coronary segmentation

- Coronary arteries manually labelled in 3DSlicer[2] once in every 5 images
- Automatic 3D interpolation and smoothing in MATLAB[3] and Seg3D[4]
- Semiautomatic quantification of coronary arteries (skeletonisation & quantification of branches) in VMTK[5]

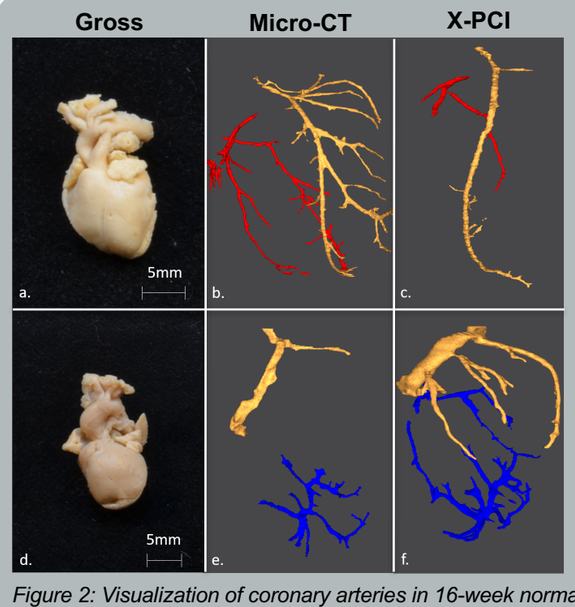


Figure 2: Visualization of coronary arteries in 16-week normal (a-c) and abnormal PA-IVS (d-f) fetal hearts, viewed in anatomical position. (Yellow – Left anterior descending coronary artery; Red – Right coronary artery; Blue – VCAC)

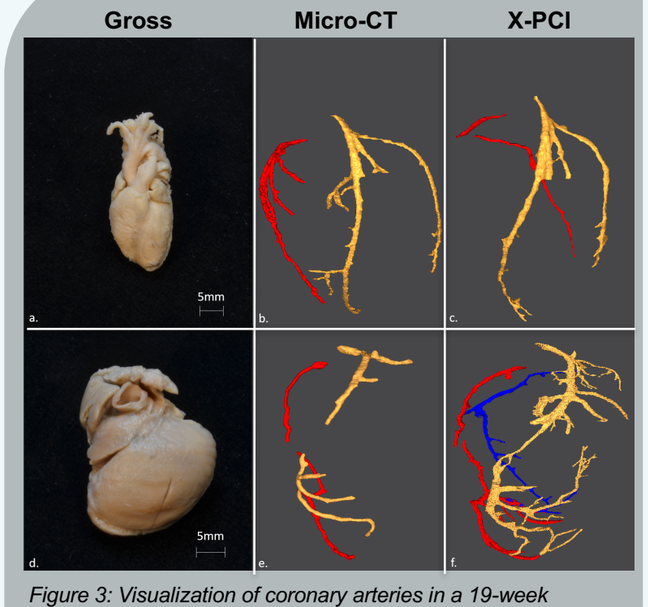


Figure 3: Visualization of coronary arteries in a 19-week gestation normal fetal heart (a-c) and a 21-week abnormal PA-IVS fetal heart (d-f), viewed in anatomical position. (Colour scheme as for Fig 2)

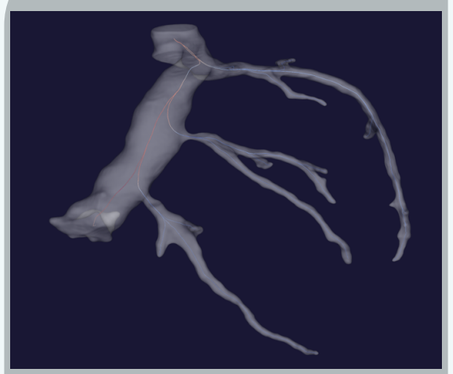


Figure 5: Skeletonisation of abnormal left coronary artery from X-PCI images in an abnormal human PA-IVS fetal heart (16 weeks gestational age)

Results & Discussion

- 8,097 micro-CT and 14,164 X-PCI image slices were analyzed during segmentation of coronary arteries in 6 fetal hearts
- **X-PCI** proved **better** for tracing coronaries in **abnormal hearts** – higher resolution
- **Additional coronary detail** traced in **normal fetal hearts** on **micro-CT** → Learning curve for X-PCI
- Abnormal coronary patterning may be **more frequent** than is recognized by gross inspection or other diagnostic techniques

Conclusion

- Micro-CT/X-PCI provided **more detail** of coronary arteries and VCACs compared to standard gross examination
- This will allow further study of **vascular development in PA-IVS** → Leading to **new developmental hypotheses** for both PA-IVS and perhaps VCACs

References:

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Acknowledgements:

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