THREE-DIMENSIONAL PRINTING OF FETAL MODELS OF CONGENITAL HEART DISEASE DERIVED FROM MICROFOCUS COMPUTED TOMOGRAPHY: A CASE SERIES

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INTRODUCTION

Post mortem microfocus computed tomography with iodine preparation of specimens allows the evaluation of fetal cardiac structures. Three-dimensional printing in CHD is gaining increasing interest in the clinical and bioengineering communities alike, considering the breath of its applications (medical education, surgical, and catheter-based procedural individualized planning, and manufacturing research for device innovation). Applications of 3D printing in fetal cardiology are limited.

AIM

To present a feasibility study of 3D printing normal and pathological fetal hearts from micro-CT datasets.

METHODS

Post mortem micro-CT of isolated fetal heart or heart-lungs is offered to patients who decided for termination of pregnancy. Specimens were stained by immersion in Lugol solution 15% for 24 hour, then washed with alcohol to remove free iodine and blotted dry and ultimately scanned. Micro-CT data served as the input for the 3D printing process. Images were imported in commercial software and reconstructed following steps of thresholding, region growing and semi-automatic image segmentation with manual editing where required, and the final volume meshes were exported as.stl files. All models were 1:1 in size as well as scaled with a 5-fold factor to provide more insight such small-sized cardiovascular structures.

RESULTS

Table 1: General information about the studied population (CHD: congenital heart disease; GA: gestational age; TOP: termination of pregnancy).

Samples	N = 21 Heart: 19/21(90%) Heart-lungs: 2/21 (10%) CHD: 18/21 (86%)
Mean GA at TOP	16.0±3.0 weeks (range 12–22 weeks)
Mean diameter	Longitudinal 1.05±0.37 cm (range 0.4–1.7 cm) Transverse 0.95±0.36 cm (range 0.4–1.8 cm)
Mean weight	0.88±1.06 g (range: 0.39–4 g)

Figure 1: All cases were successfully reconstructed and are reported in figure 1.

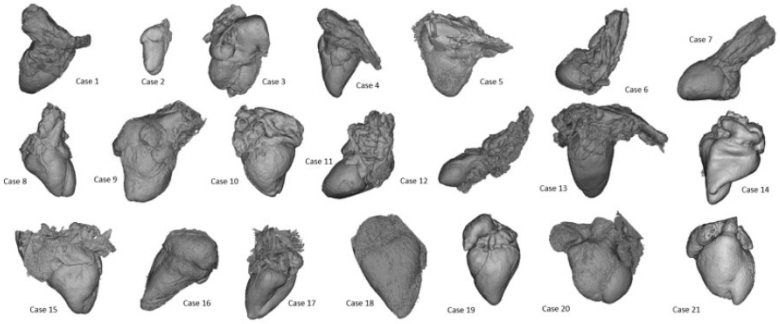
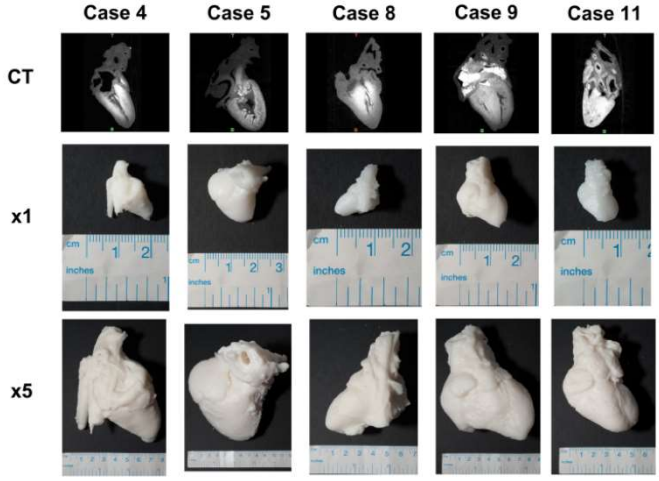


Figure 2: Examples of 3D printed models. When printed with the 5-fold magnification, models were also cut in a four-chamber view equivalent section, to provide insight into the intra-cardiac structures.



TAKE HOME MESSAGE

- **Micro- CT dataset of both normal and pathological hearts of different gestational ages can be used for 3D printing**
- **Segmentation and printing processes are the same for normal and pathologic specimens**
- **Reconstruction of complex structures may require expert guidance in the identification of anatomical features of interest**
- **Educational, research and clinical implications remain to be addressed in the future**