5th WORLD CONGRESS
ULTRASOUND IN MEDICAL EDUCATION

3D printing heart models to facilitate cardiac ultrasound teaching

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Background: As point of care ultrasound is gradually transforming practice in emergency medicine and primary care, more and more medical schools in North America have incorporated ultrasound teaching in their undergraduate training. However, teaching ultrasound to medical students is not without challenges. First, it is not intuitive for the novice to mentally relate the 2D sonographic image with 3D structures, especially for complex ones such as the heart. Second, learning ultrasound requires time and practice, but as undergraduate curricula are often congested, ultrasound must be taught in an efficient and effective way. Third, any teaching aids must be easy to implement with minimal costs.

To facilitate the teaching of cardiac ultrasound, we propose to use 3D printed models as manipulable references. Inexpensive 3D printed hearts with standard views of the inner structures may ease the 3D 2D correlation, maximize understanding, and decrease studying and teaching time. Moreover, as 3D printing is increasingly used for surgery and imaging, it is also an opportunity for students to familiarize themselves with this technology, which they will almost certainly encounter in their careers.

Materials and methods: The heart model was obtained in STL format from the tf3dm database [1] and virtually cut with the Autodesk Netfabb 2017 software before printing (Fig.1A). The STL model was cut so as to provide a 4 chamber view; a parasternal long axis (PLAX) view; and parasternal short axis (PSAX) views cut at the apical, papillary muscle, mitral valve and aortic valve planes. Each cut was performed by placing three marker points on the heart surface and using the “plane cut” function of Netfabb. The position of the surface markers was determined by trial and error. After the cut, each part of the model was sent to a MakerBot Replicator 2 Desktop 3D printer, which prints by fused filament deposition of polylactic acid (PLA) thermoplastic. After printing, the models were cleaned and prepared for viewing.

Results and discussion: Two to five heart model parts were printed for each view (Fig.1B). Each model required 4 5 h of unsupervised printing time and about 1 h of manual preparation and cleaning. The cost of the PLA material is about 28 USD/kg, so, with each heart model weighing approximately 45 g, each model cost less than 2 USD. The printed models showed appropriate structures and were easy to manipulate and observe.

Qualitative and quantitative studies are planned to evaluate the effectiveness and efficiency of using the models to assist cardiac ultrasound teaching and learning. Expected benefits include improved understanding, consolidated memorization and simple usage.

Reference

[1] http://tf3dm.com/3d model/human heart 2 79840.html

3D Printing Heart Models to Facilitate Cardiac Ultrasound Teaching

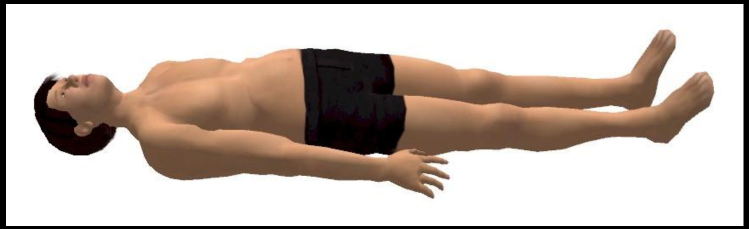
Weimeng Ding, W. Robert J. Funnell, Peter Steinmetz, and Geoffroy Noël

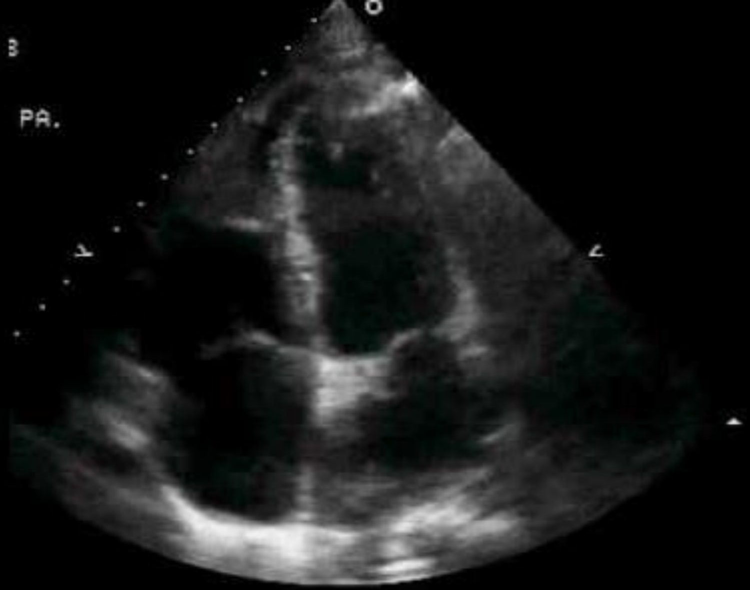
McGill

The speaker has no conflicts of interest to disclose

Why use 3D printing
How to do 3D printing

Why use 3D printing

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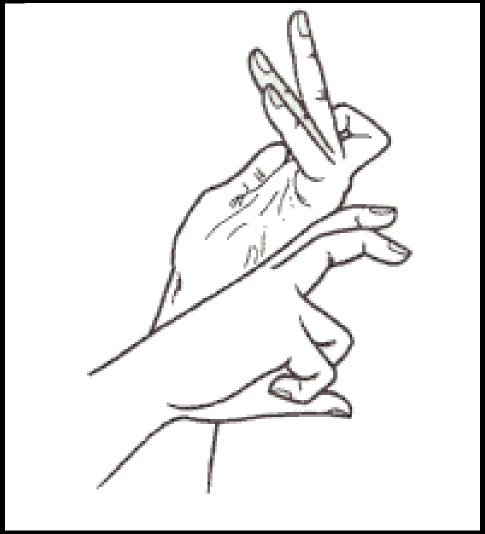


Physical object

- Correlate 2D-3D
- Manipulate

Efficient

- Shorter learning & teaching time
- Help memorization

Easy to implement

- Low cost
- Handy for all settings

(Images from CNN.com)

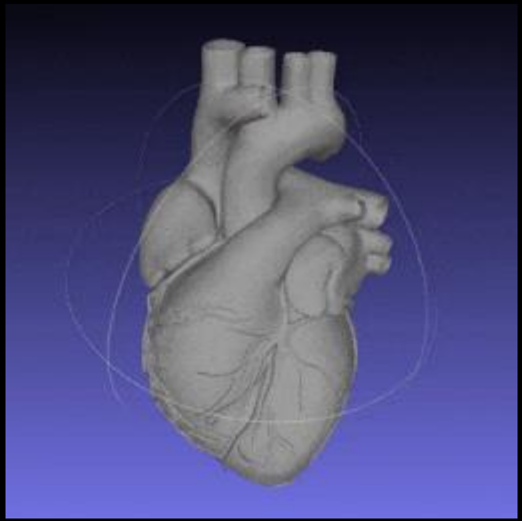
(Image from Project Daniel)

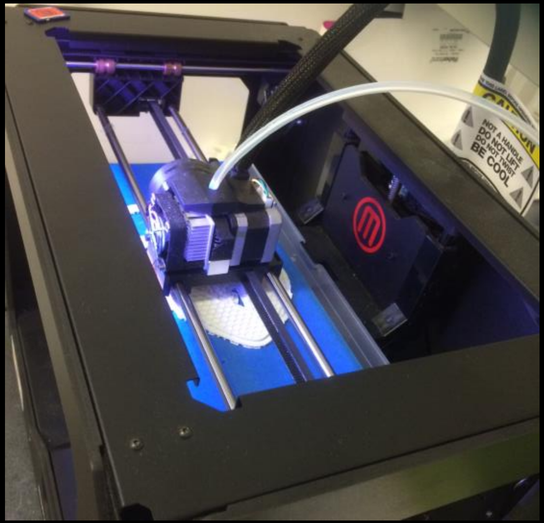
(Image from *digital engineering*)

(Image from *Nature biotechnology*)

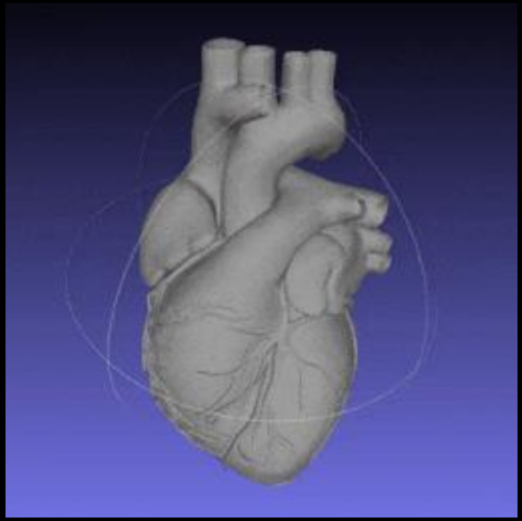
How to do 3D printing

Ingredients: STL + Printer + Filaments





Ingredients: STL + Printer + Filaments



DICOM - CT, MRI, 3D ultrasound etc.

Model bank
(http://tf3dm.com/3dmodel/humanheart279840.html)

3D-Design DIY

3D HUBS   3D Print   CNC   Resources

Sign Up   Log in   Start a 3D Print

Search

Manufacturer or model..

Price ($)

Min   Max

Technology

- FDM (105)
- SLA + DLP (9)
- SLS (6)
- CFF (3)
- Jetting (3)
- PolyJet (2)
- Metal Sintering (1)

Ideal for

- Intermediates (52)

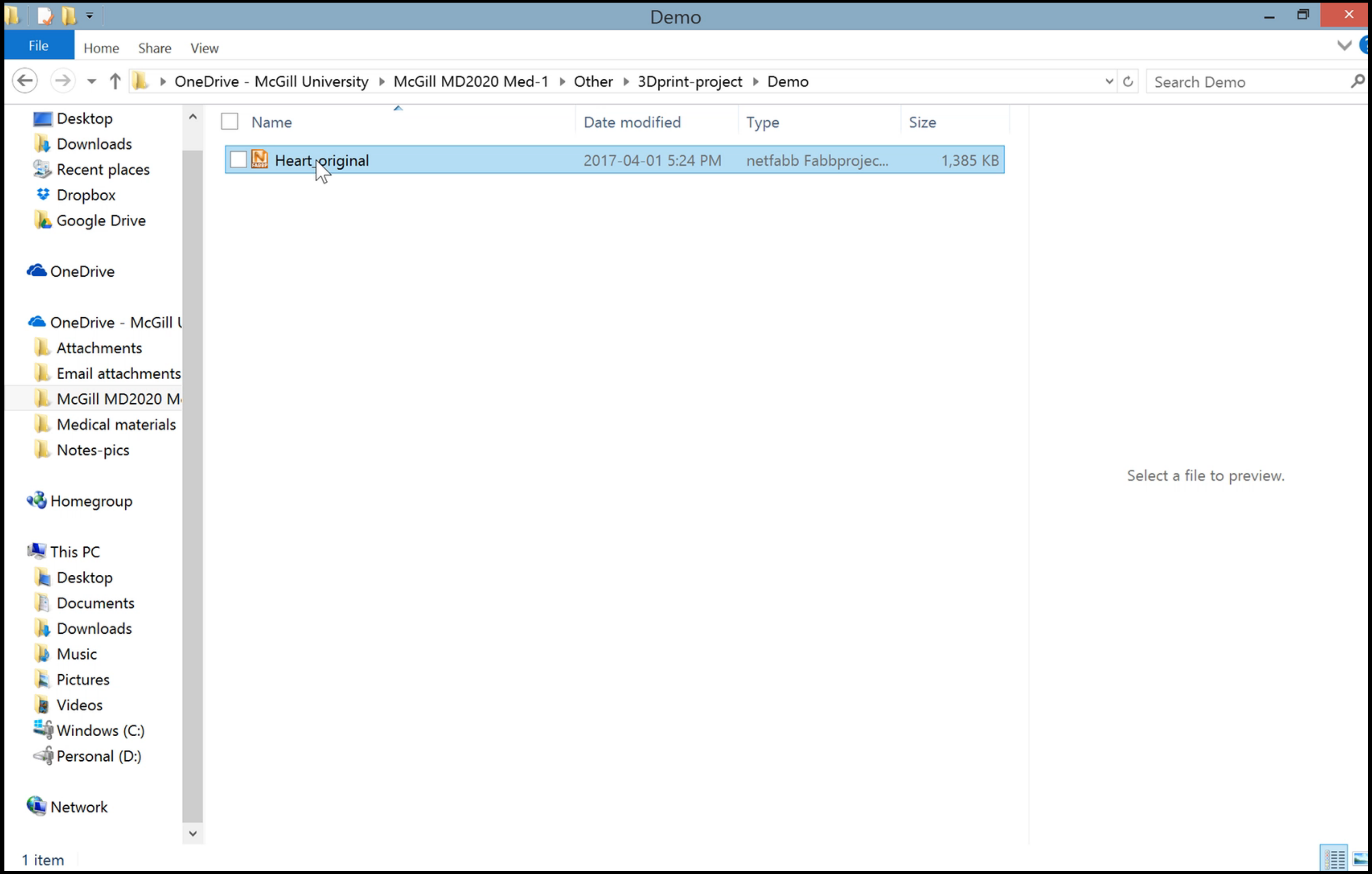
Printer		Tech	Build size	Rating	Price	
	Makergear Makergear M2	FDM	25.4 × 20.3 × 20.3 cm	9.2	$1,825.00	Read reviews
	Ultimaker Ultimaker 2+	FDM	22.3 × 20.5 × 22.3 cm	9.1	$2,499.00	Read reviews
	Prusa Research Original Prusa i3 MK2	FDM	25 × 20 × 21 cm	9.1	$699.00	Read reviews
	Aleph Objects LulzBot Mini	FDM	15.2 × 15.8 × 15.2 cm	9.1	$1,250.00	Read reviews
	CraftUnique CraftBot PLUS	FDM	25 × 20 × 20 cm	9.1	$1,099.00	Read reviews
	Aleph Objects LulzBot TAZ 6	FDM	28 × 25 × 28 cm	9.1	$2,500.00	Read reviews
	Formlabs Form 2	SLA + DLP	14.5 × 17.5 × 14.5 cm	9.0	$3,299.00	Read reviews

Ingredients: STL + Printer + Filaments

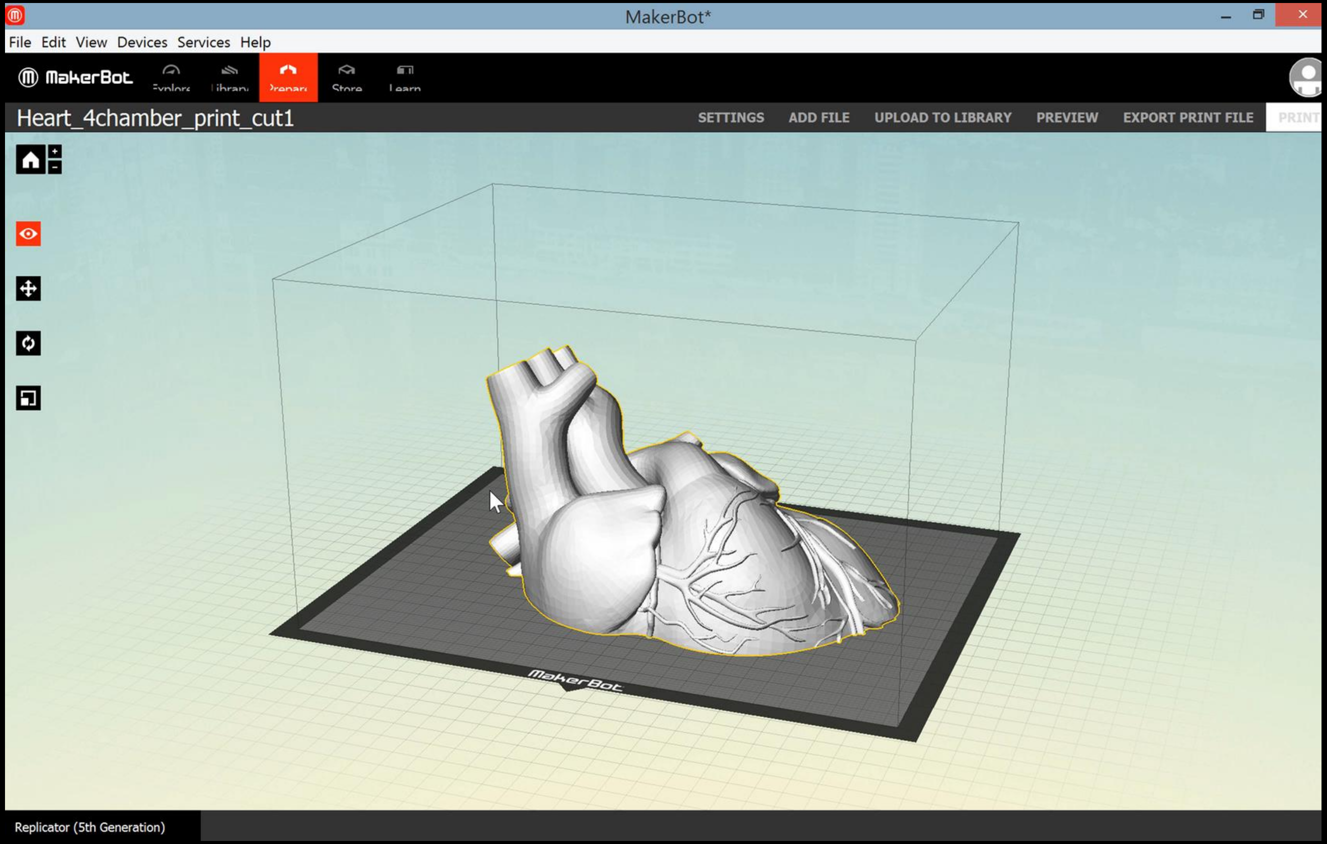
Plastic, metal, resin, rubber, glass…

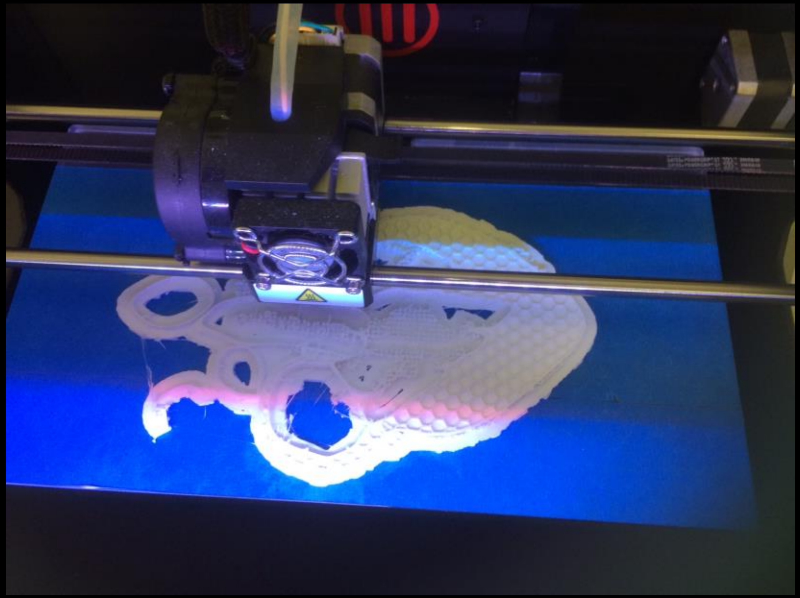
PLA: 30$/kg

Preparation: cutting



Printing:

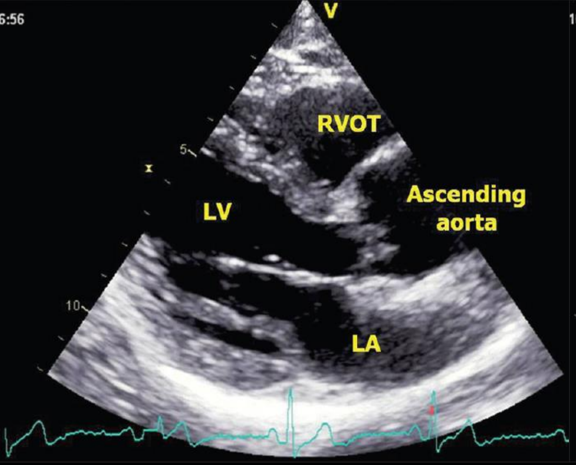


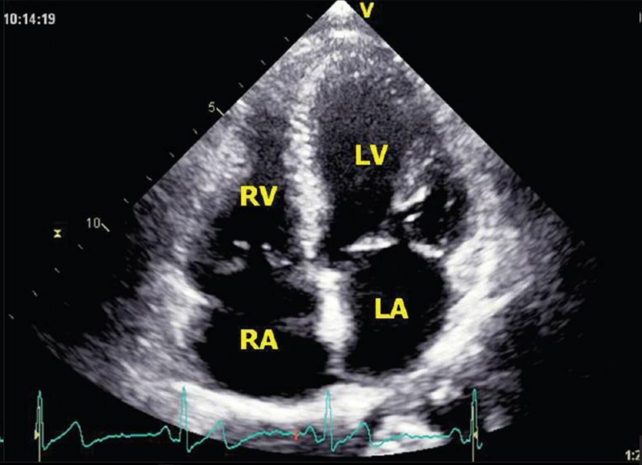


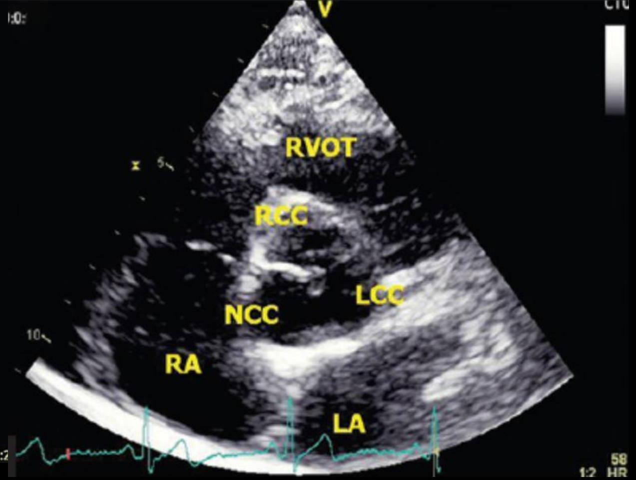
MakerBot

Finishing: cleaning, fixing, colouring…

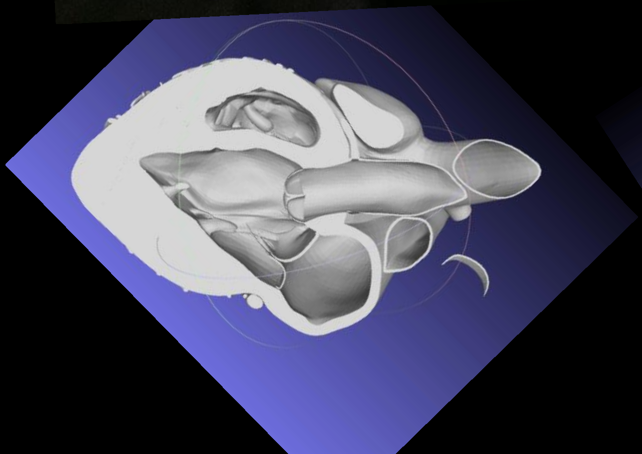
Results: PSAX, PLAX, 4-chamber/subxiphoid

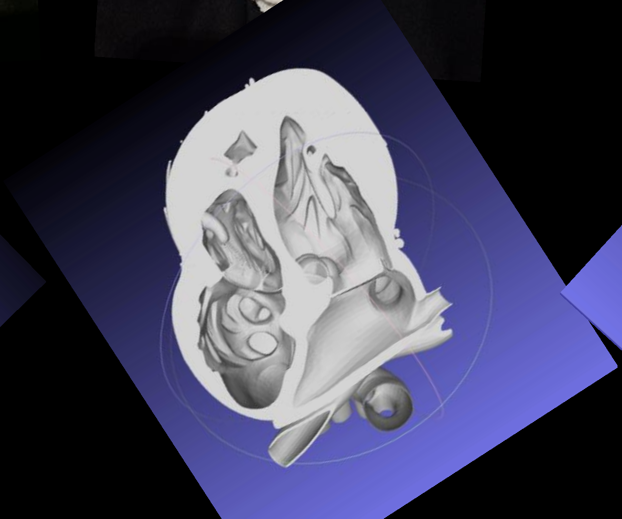


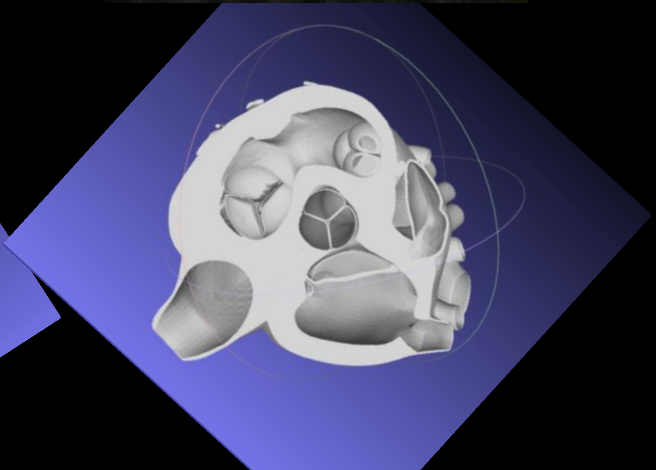


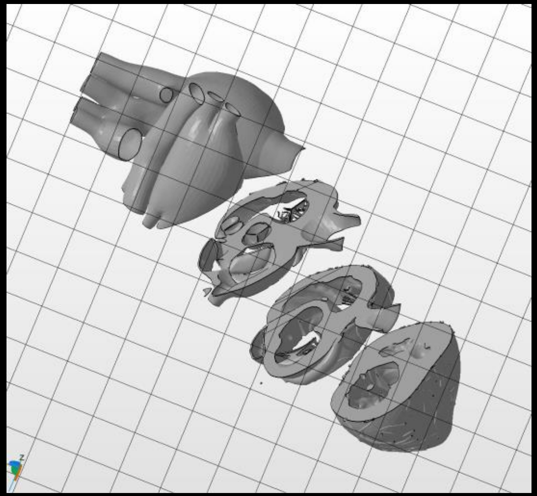


(Ultrasound images from Burkule 2017, **DOI:** 10.4103/ jiae.JIAE_27_17)









Future studies

Study population

- Med students
- Residents
- Instructors
- Non-medical users

Qualitative tools

- Surveys
- Trainee/trainer comments

Quantitative tools

- Timed teaching/learning
- Structure recognition
- Problem solving
- Long-term memory

Q: How (much) 3D printed models improve ultrasound teaching & learning

→ Other organs / imaging modalities / personalized medicine

Conclusion

Why 3D printed models?
Physical, inexpensive and easy to implement

How to make 3D printed models?
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Thank you!