The future of imaging: 3D Printing

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Introduction
Cardiologist uses 3D heart models to test, perfect difficult operations

By Mike Hixenbaugh  Updated 1:55 pm, Wednesday, April 19, 2017
Introduction

Press release

3 April 2003

New engineering methods turn medical scans into anatomical replicas

Medical scans give us an idea of what is happening to our bodies. Now a University of Sussex engineer has developed a way of using these scans to make accurate plastic replicas of our insides.

Dr Panos Diamantopoulos is confident that his three-dimensional models, manufactured by a process known as rapid prototyping, will become invaluable tools to health professionals for diagnosis and surgical procedures and in the design of medical appliances.

"Medical anatomical models have been demonstrated to help understanding and awareness of medical problems," he says. "They can also contribute to faster intervention, reduce operation time, minimise patient discomfort, improve treatment success rate, increase the speed of recovery and limit cost."
Echocardiography Laboratory
3D-Printing Laboratory

- High end capability 3D printer
- Commercial software for the post processing steps
3D-Printing Laboratory
3D-Printing Libraries

• 3D-printing Libraries in medical education.
• Online 3D Libraries.
3D-Printing
Non Invasive Imaging

- From image acquisition to the generation of a hand held model.
3D-Printing Laboratory Post-processing

- Manual or automated segmentation.
- Anatomical representation is transformed into an STL file.
- STL file format is to 3D printers the equivalent of DICOM.
- Computer-aided design software.
- A 3D printer interprets data in a STL file to manufacture a physical object.
3D-Printing Laboratory
Post-processing

- Experience and time for image segmentation.
- Minimal artifact at the anatomy of interest.
- Sufficient signal intensity and contrast.
3D-Printed Models in Interventional Cardiology

- Patient-specific models can lead to patient-specific implants.
- Devices can be tailored, designed and tested.
3D-Printed Models in Interventional Cardiology

**ASD occlusion**

Yan Chaowu et al. Circulation. 2016;133:e608-e610

**LAA closure**

James M. Otton et al. JCIN 2015;8:1004-1006
3D-Printed Models in Interventional Cardiology

Mitral Valve perforation repair

Marija Vukicevic et al. JIMG 2017;10:171-184
3D-Printed Models in Interventional Cardiology

Transcatheter Aortic Valve

- TAVR Simulation
- Crossing Stenotic Aortic Valve
- Valve Deployment
- Depth 4 mm
- Valve Expanded Within Model
3D-Printed Models in Interventional Cardiology

Implanted TMVR

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**CENTRAL ILLUSTRATION:** Creation of a Patient-Specific Multimaterial 3D Model of the Mitral Valve Apparatus

**3D PRINTED MODELING**

- Imaging Data
- Segmentation
- Digital Model
- Multi-material 3D Printed Model

**PROCEDURAL PLANNING**


Marija Vukicevic et al. JIMG 2017;10:171-184
3D printing the future of surgery for Houston Methodist

Seeing image without opening patient is direction of medicine, doctor says
3D-Printed Models in Cardiac Surgery

Hypertrophic Cardiomyopathy

Dong Hyun Yang et al. Circulation. 2015;132:300-301
3D-Printed Models in Cardiology

- Communication between physicians, imagers and technologists.
- Patient education and communication.
3D-Printed Models in Cardiovascular research

AS Patient-specific Model In Flow Loop
3D-Printed Models in Cardiovascular research

2D Cine Long Axis

2D Cine Short Axis

Flow Loop Setup

Ao

AoV

LVOT
3D-Printed Models in Cardiovascular research

Velocity Field

Streamlines

Flow Pathlines and Particles
3D-Printed Models in Cardiovascular research

Aortic Regurgitation

Mitral valve disease

Marija Vukicevic, Dimitrios Maragiannis, Matthew Jackson, Stephen H Little Circulation. 2015;132:A18647

Feroze Mahmood et al. JIMG 2015;8:227-229

Figure 1. Modeling of patient-specific aortic regurgitation and Doppler comparison
Future goals for 3D-Printing

- 3D-Printing centers of excellence.
- 3D-Printing Libraries.
- Guidelines and appropriateness criteria.
- Clinical trials.
- Development of new materials with appropriate properties.
- 3D Bioprinting.
Current Limitations

- Intraoperator and interoperator variability are unknown.
- Protocols for image acquisition and post-processing are lacking.
- Cost-effectiveness.
- Suboptimal materials to mimic cardiovascular tissue properties.
- Roles of technologists, engineers and physicians in the printing Lab are not defined.
3D-Printing is a potential game changer.
3D-Printing is a great tool for the new generations of cardiovascular imagers.
3D-Printing has revolutionized personalized medicine.
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