The Future of 3D Imaging for Intervention

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  – None
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The Future of 3D Imaging

• Look at what was presented at this conference:
  – 3DRA
  – 4DRA
  – MR 4D Flow
  – MR T2 Relaxometry & O2 sats
  – Computational Fluid Dynamics from 3DRA
  – 3D Fusion
  – Vessel Navigator & CT Overlay
  – 3D ICE
The Future of 3D Imaging

• 3D Printing & Modeling
• ICMR
• Holography
CARDIOVASCULAR 3D PRINTING, when will it be useful?

Rapidly growing, disruptive technology in medicine

Fabrication of graspable objects from digital models
CARDIOVASCULAR 3 D PRINTING, when will it be useful?

3 D printing - Work flow

- Volumetric Image set
- CT, MRI, Rotational Fluroscopy
- 3D echo!

- Cropping, Cleaning
- Anatomy of interest

- Process segmented data
- Create models
- Convert to STL file format

- Technology
- Materials

Materialise
Mimics
3 Matic
CARDIOVASCULAR 3 D PRINTING, where will it be useful?

CAD model

Information

CT

MRI

Rotational angiography

SLA printed model
ADDED VALUE OF THE PRINTED MODELS

- 3D Rotational Angiography
- 3D Echo, MRI, CT angiography
- 3D Mult-Modality fusion
CARDIOVASCULAR 3 D PRINTING, when will it be useful?

ADDED VALUE OF THE PRINTED MODELS

Tactile objects  We still look at 2 D screen
Wet desktop testing ..

First 29 mm Edward implanted in Native RVOT in Human , 2014 PICS
The Medtronic Harmony TPV EFS
Dual Source Flash CT
We take pictures & movies of the virtual SLA implant in systole & diastole.
Simulating Implant in the SLA Model
PA Angiogram Post Implant
May 30th, 2013 FIM Implant: ICE

PRE

POST
Hybrid Per-Atrial MVSD Closure

- 4 mo/old with a large apical MVSD, abnormal TV and MV, and CHF
- Close MVSD vs PA band?
- How to close MVSD
  - Surgical? No way
  - Per-Ventricular? Large moderator band “guarding” MVSD and no room in RV apex
  - Per-Atrial? Use 3D printing to “practice”
Hybrid Per-Atrial Apical MVSD Closure
Large Apical MVSD
Hybrid Per-Atrial Apical MVSD Closure Sheath from RA and 16mm MVSDO
Hybrid Per-Atrial Apical MVSD Closure
No significant residual flow
CARDIOVASCULAR 3 D PRINTING, where will it be useful?

Custom design Device for intervention..

3-Dimensional Printing of Models to Create Custom-made Devices for Coil Embolization of an Anastomotic Leak After Aortic Arch Replacement

3-dimensional printing of models to create custom-made devices for coil embolization of an anastomotic leak after aortic arch replacement

Left Atrial Appendage Guided by Personalized 3D-Printed Cardiac Reconstruction
James M. Otton, MBBS, PhD; Roberto Spina, Romina Sulas, J Am Coll Cardiol Intv. 2015;8(7):1004-1006
Surgical Planning for complex repair


May decrease Mortality ..
CARDIOVASCULAR 3 D PRINTING, WHERE WILL IT BE USEFUL?

Patients Communications

BMJ Open 3D-manufactured patient-specific models of congenital heart defects for communication in clinical practice: feasibility and acceptability

Giovanni Biglino,1 Claudio Capelli,1 Jo Wray,2 Silvia Schievano,1 Lindsay-Kay Leaver,2 Sachin Khambadkone,2 Alessandro Giardini,2 Graham Derrick,2 Alexander Jones,1 Andrew M Taylor1


Conclusions: Patient-specific models can enhance engagement with parents and improve communication between cardiologists and parents, potentially impacting on parent and patient psychological.
Final Thoughts

- It is useful adjunct to performing complex and Novel hybrid interventions
- Improves the ability to understand complex relationships
- Ability test various treatment strategies
- Improve communications among teams
- Potential to shorten procedure time, and precision, thus improving outcome
- Teaching
- Many New 3D technology triggers, will enhance its utility, and presence in Cardiovascular therapeutics
Interventional Cardiovascular MRI is perfect for Structural Heart Disease
Radiation exposure significant

- AHA Science Advisory (Circ 2009)
- Children are radiosensitive; carry lifetime risk
- Fluoroscopy times are 5-10x longer than adult procedures
- Cancer & leukemia risk (Kleinerman, Ped Rad 2006)
- Chromosomal damage evident in the peripheral blood of children exposed to catheterization-related radiation (Andreassi, EHJ 2006; Beels, Circ 2009)
ICMR = cardiac imaging core

Diagnostic

Intervention

MRI inspired

3D printing

Cardiac Mechanics

• Sedation Free MRI
• Function:
  – Heart Failure
  – Cardiomyopathy
• Perfusion
  – Kawasaki’s, Coronary
• Adult Congenital Heart Disease
• Fetal
• Clinical trials
  – Duchenne Muscular Dystrophy
  – Obesity
ICMR = cardiac imaging core

- Radiation Free diagnostic catheterization
  - Pulmonary Hypertension Center
- Radiation Free interventional radiology
- Structural heart procedures
  - Conventional
  - Novel
- Electrophysiology
- XFM (Xray Fused with MRI)
  - Other Fusion (CT, U/S)
ICMR = cardiac imaging core

- Diagnostic
- Intervention
- MRI inspired
- 3D printing
- Cardiac Mechanics

• Novel procedures
  - Backstabbing
  - Caval-aortic
  - Valve repair

• Innovation pathway
  - Devices
  - Patents
  - Grants, Contracts
ICMR = cardiac imaging core

- Great data set
- Surgical/interventional planning
- Future: biologic “inks” / bioprinting

Diagnostic  Intervention  MRI inspired  3D printing  Cardiac Mechanics
ICMR = cardiac imaging core

- Great data set for computational fluid dynamics
- 4D Flow
Diagnostic MRI Cardiac Catheterization

IVC → RA
RA → SVC
RV → MPA
MPA → RPA → LPA
# MRI Catheterization World Experience

<table>
<thead>
<tr>
<th>Location</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIH</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>Kings College London</td>
<td>&gt; 300</td>
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<tr>
<td>Great Ormond Street Hospital London</td>
<td>&gt; 350</td>
</tr>
<tr>
<td>Berlin Charite</td>
<td>32</td>
</tr>
<tr>
<td>Other Literature reports</td>
<td>&gt;200</td>
</tr>
<tr>
<td><strong>Total World Experience</strong></td>
<td>&gt; 950 cases</td>
</tr>
</tbody>
</table>

* ***Now Clinical Standard for Right Heart Catheterization***

* ***All Pediatric Pulmonary Hypertension Patients***
Procedure Time

Mean catheterization time = 31 mins
Heart operation using MRI is world first

A British six-year-old boy has become the first person in the world to have a heart valve widened using an MRI scan for guidance rather than X-ray imaging.

Jack Walborn was born with the heart condition pulmonary valve stenosis, which reduces blood flow to the lungs.

Using MRI means patients are not exposed to radiation – particularly important for children.

The scan also provides a clearer image, and information about the body's tissues, in real time during surgery.
Real-time MRI TAVR
Direct Aortic CoreValve

Diagnostic Intervention XFM EP Novel MRI Inspired
Left Ventricle to Right Atrium Intracardiac Shunt
XFM: Intracardiac Mass Biopsy

NHLBI/NIH clinical

Diagnostic | Intervention | XFM | EP | Novel | MRI Inspired | NIH
Real time MRI guided mVSD closure

Ratnayaka, JACCInter 2011
MRI Glenn (SVC – PA Anastomosis)
MRI Glenn: Concept

(Ratnayaka, under review)
“Active” Needle Puncture

Diagnostic Intervention XFM EP Novel MRI Inspired

(Ratnayaka, under review)
Backstabbing

Lung Deflation

LA Access

Large Sheath

LA Device Closure

Diagnostic Intervention XFM EP Novel MRI Inspired (Rogers, Under Review)
Transcatheter cerclage annuloplasty for mitral valve regurgitation

Kim, JACC 2009

Diagnostic Intervention XFM EP Novel MRI Inspired
Caval-aortic access for TAVR
80 patients as of 2/10/2015 in 12 medical centers

Severe bioprosthetic aortic valve failure, inadequate femoral arteries, failed transapical access

Delivering a 26Fr sheath from IVC to aorta for TAVR

“A conventional” valve-in-valve transcatheter aortic valve replacement

Tract closure with Amplatzer Duct Occluder, minimal residual shunt

Halabi, JACC, 2013; Greenbaum, JACC, 2014

Diagnostic | Intervention | XFM | EP | Novel | MRI Inspired
New Method for Fetal Intervention?

CNMC clinical

Diagnostic | Intervention | XFM | EP | Novel | MRI Inspired
Conclusions
Real-time MRI is a promising interventional imaging modality
– Information Rich & Radiation Sparing

Interventional Cardiac MRI
– Enhances conventional interventional procedures
– Enables novel real-time MRI guided procedures
– Inspires novel X-Ray guided procedures
RealView Imaging

October 2016
3D Medical Imaging - The Path to Holography

- Exponential advancement with 3D acquisition technologies and image processing capabilities
- Current imaging provides high quality volumetric images, however still presented on flat 2D screens only
3D Volumetric Medical Data

3D Acquisition Modalities

“In-Air” Holographic Display and Interface System
The Needs in the Modernized Interventional Suite

- 100% reliance on imaging
- Volumetric visualization of complex anatomy
- Navigation and device-tissue interaction
- Operator independence
- Communication within the medical team
• Extremely realistic 3D holograms floating in “mid air”
• Easily accessible and interactive real time images
• 3D holograms accurately registered to free space
• Advanced optics allowing adjustable hologram location

Configuration subject to change as part of the R&D process - not commercially available. Product launch planned for 2017.
3D Holography: image intimacy™ Capabilities

* Partial list of interaction capabilities
Interactive Live Holography - Interventional Cardiology
(from RealView Lab)

Datasets Courtesy of St. Jude Medical
A virtually deployed Corevalve (Medtronic, USA) simulated with the TAVIguide™ technology (FEops, Gent, Belgium)
Interactive Live Holography - Example Holographic Images
Future for Holography

Current work with Philips
Plans for non-proprietary use
Use any 3D data set
Anticipated commercial release: 3rd quarter 2017
Cost ????????????
Conclusions

• The future of 3D imaging will be limitless as advanced technology evolves

• To our sponsors, the costs of such technology needs to be affordable

• Our patients will directly benefit from this technology, so we need to “push on”
THANK YOU

Willa         Olivia

Stella

The Heart Center

A Grandson in 2017

Mya

Cooper