Great Ormond Street Hospital for Children NHS Foundation Trust

Great Ormond Street Hospital

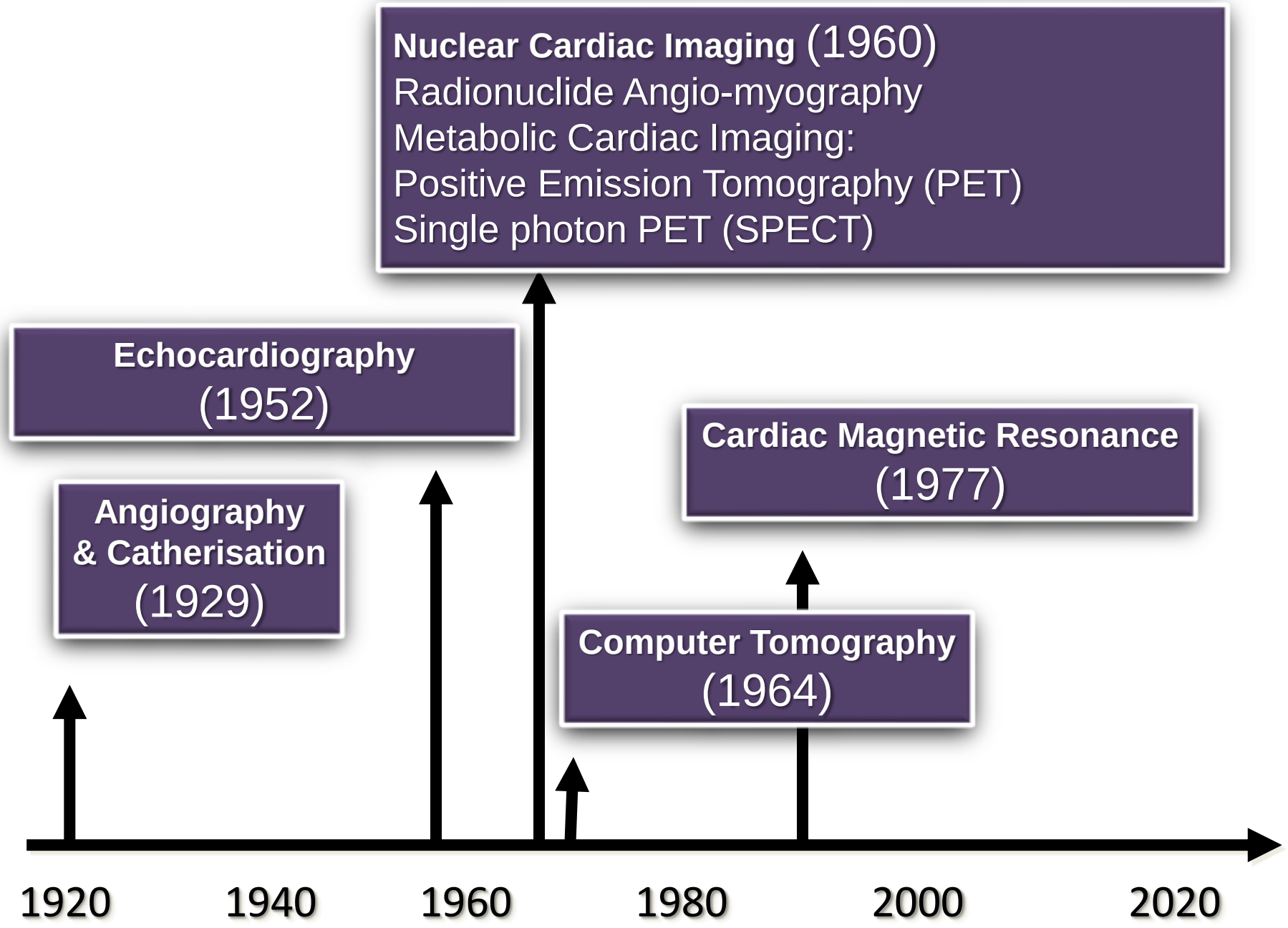
UCL

Imaging! Imaging! Imaging!

Jan Marek

Great Ormond Street Hospital
&
Institute of Cardiovascular Sciences,
University College London

No disclosures


Nuclear Cardiac Imaging (1960)
Radionuclide Angio-myography
Metabolic Cardiac Imaging:
Positive Emission Tomography (PET)
Single photon PET (SPECT)
Echocardiography
(1952)
Cardiac Magnetic Resonance
(1977)
Angiography
& Catherisation
(1929)
Computer Tomography
(1964)
1920
1940
1960
1980
2000
2020


digital
Jaguar Aircraft

Imaging in 2017

Echocardiography

- 2D Imaging
- 3D RT Imaging
- M-Mode
- Doppler
- Colour Tissue Imaging
- Spectral Colour Doppler Imaging
- 2D Speckle Tracking
- 3D Speckle Tracking
- 3D Vector Imaging
- Colour Vortex Imaging
- Colour Doppler Speckle Tracking
- Fetal 3D STIC

Cardiac MR

- Black-blood
- Bright-blood
- Angiography
- 3D/4D CMR Angio
- Late gadolinium enhancement
- Edema
- Cine
- Stress
- Strain
- Perfusion
- Flow
- Iron

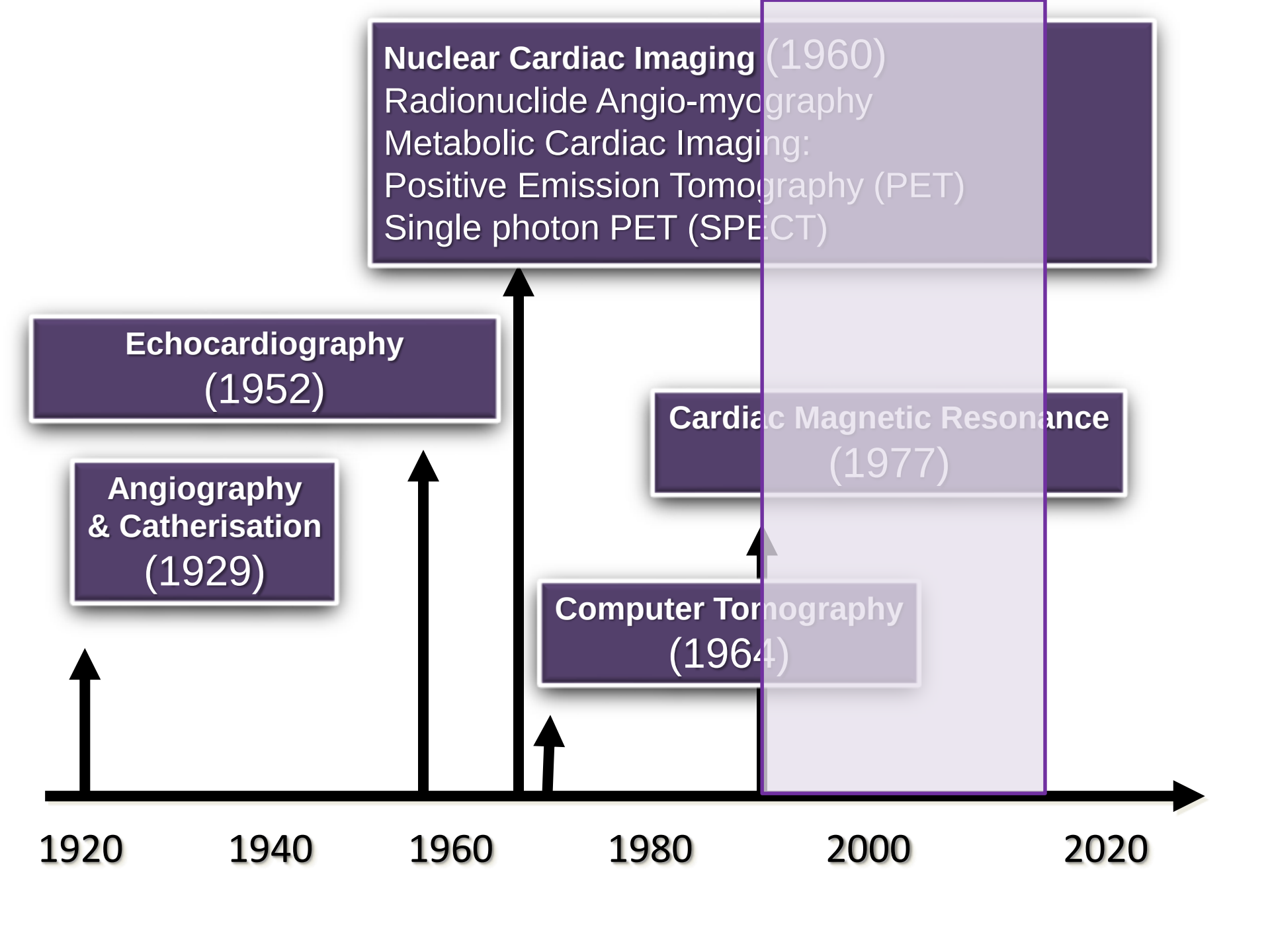
CT

- Multi-Detector Angiography
- Optical CT Scanning
- 3D CT
- Virtual Endoscopy
- Virtual Histology

NUCLEAR Im.

- Scintigraphy
- SPECT
- PET

MODELLING PRINTING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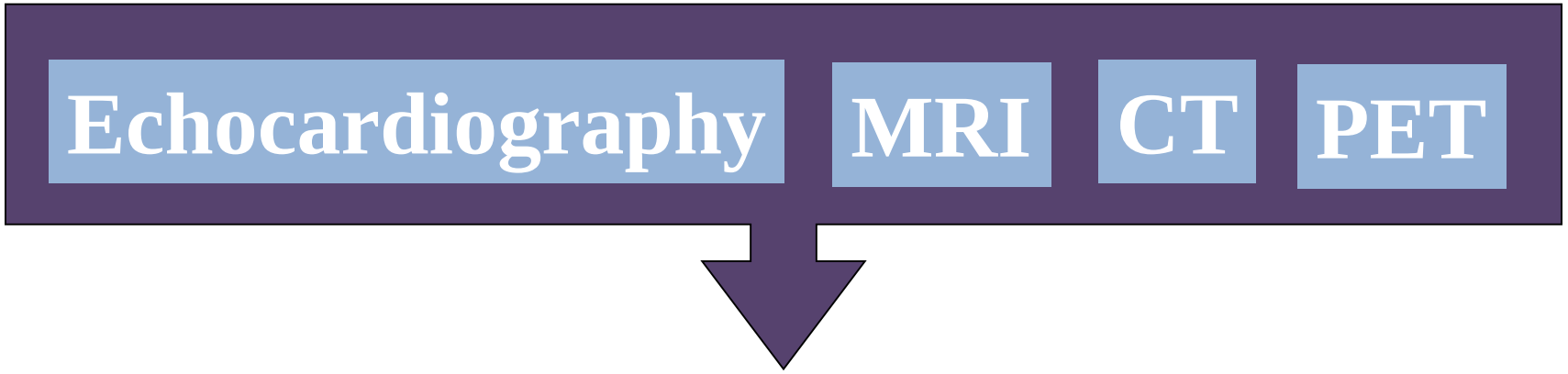
2000
2020




Multimodality imaging



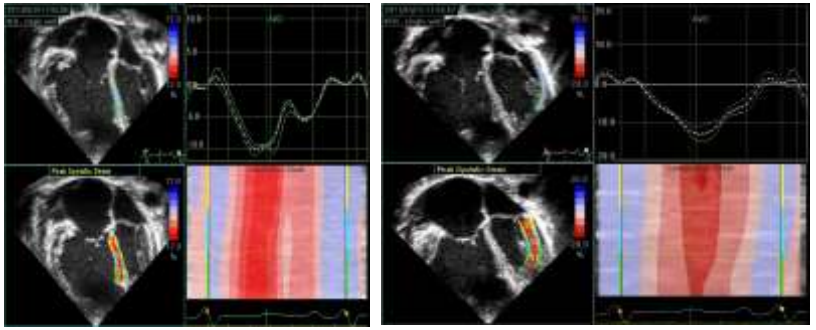
Dynamic cardiac imaging modalities



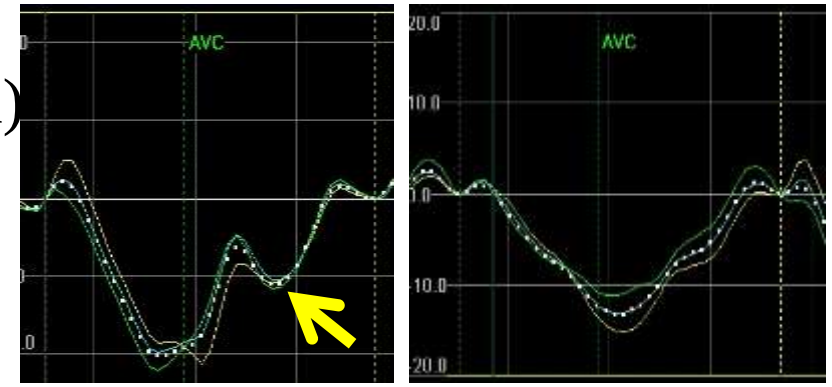
- High resolution 4D imaging
- Blood flow dynamics
- Physiology at rest and exercise
- Metabolic dynamic tissue definition
- Education and modelling

Myocardial Deformation Imaging: Applications

- **Coronary induced ischaemia**
  (ALCAPA, ASO, Kawasaki)

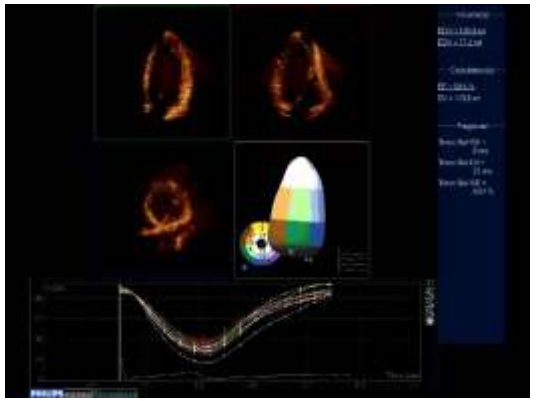


- **Electro-mechanical dyssynchrony**
  (LBBB,RBBB,PM-AVD optimisation)



- **Mechanical dyssynchrony**
  (HOCMP, myocardial fibrosis)

- **Subclinical changes**
  (Anthracycline CMP, HCMP Gene +/Fen-)



- **Research & Education**
  (Existing reference values, understanding physiology)

Paediatric Stress ECHO

Dobutamine & **Dynamic** (bicycle) / GOSH ~30-50/year

Outflow tract obstruction

Hypertrophic cardiomyopathy

Coronary flow reserve

Transposition after ASO

Kawasaki disease

HTx

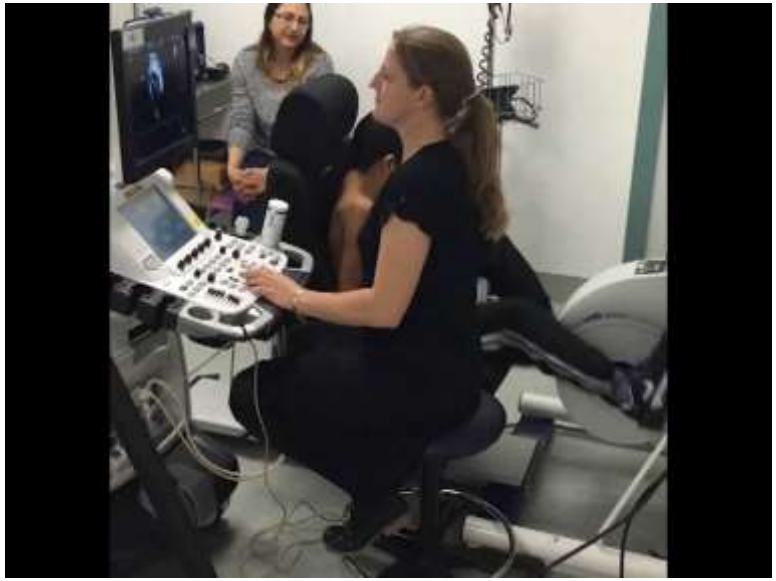
ALCAPA post revascularisation

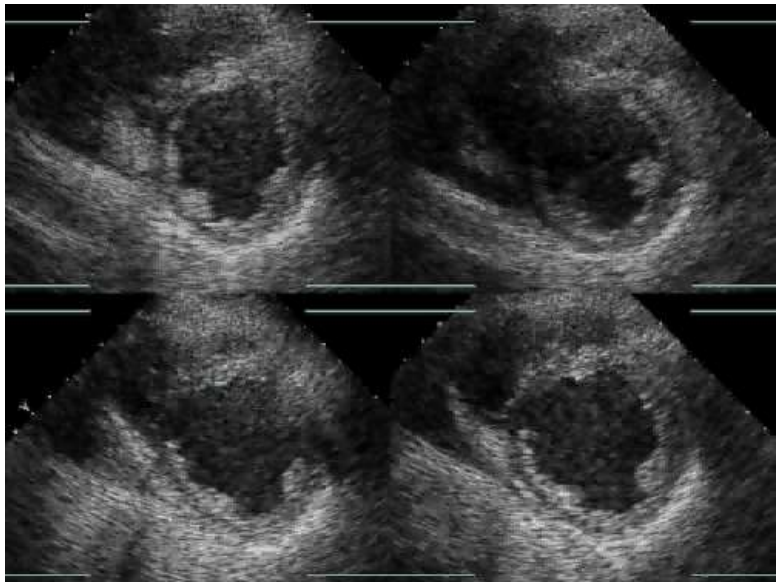
Myocardial fibrosis/ischaemia

HCMP

Non-compaction myocardium

Endocardial fibroelastosis

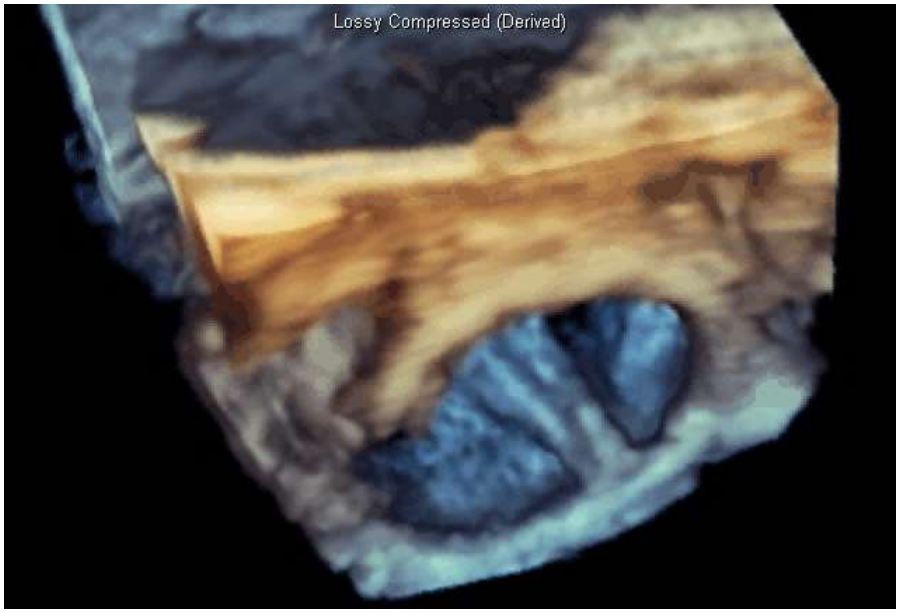




RT- 3D Echocardiography

Current applications :

- **Dynamic structure morphology**
  Valves, atrial/ventricular septum, mass lesions
- **Surgical planning, guiding interventions**
  (Valve morphology, DORV, ASD closure, HOCM)
- **Pre- / Post-bypass assessment** (TOE>18kgs)
- **Quantitative data**
  LV volumes, function, shape and mass (progression, remodelling, CRT)
- **Education**
  Real, non-virtual modelling & reconstruction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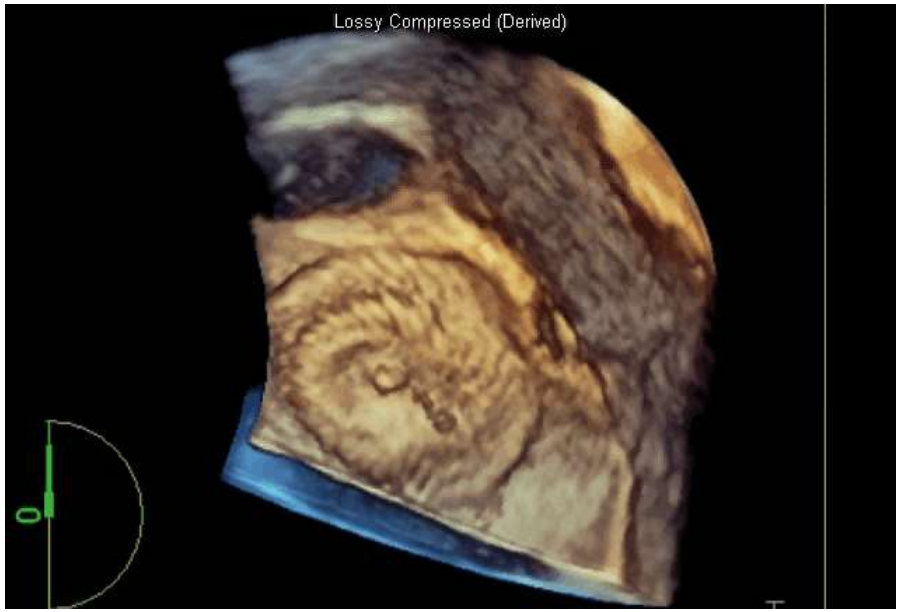
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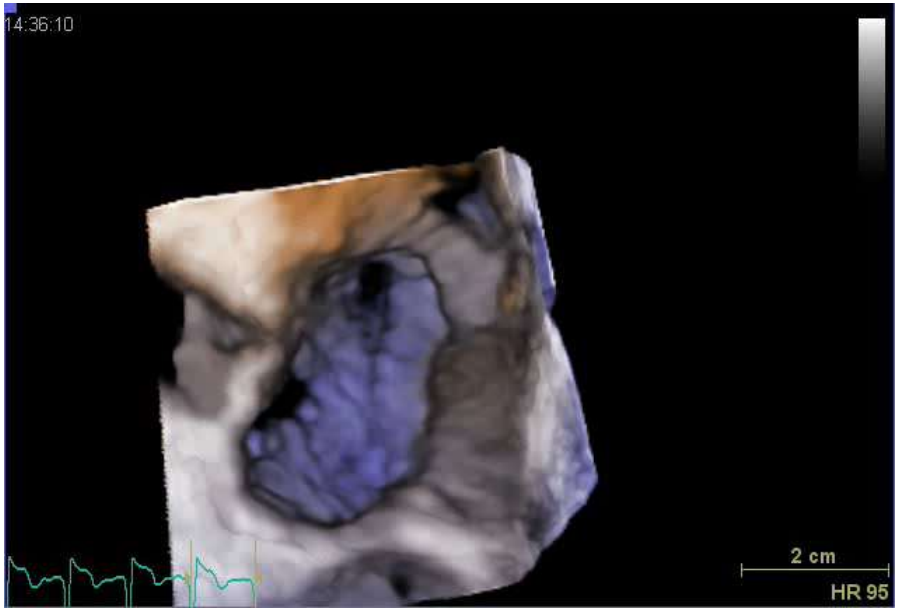
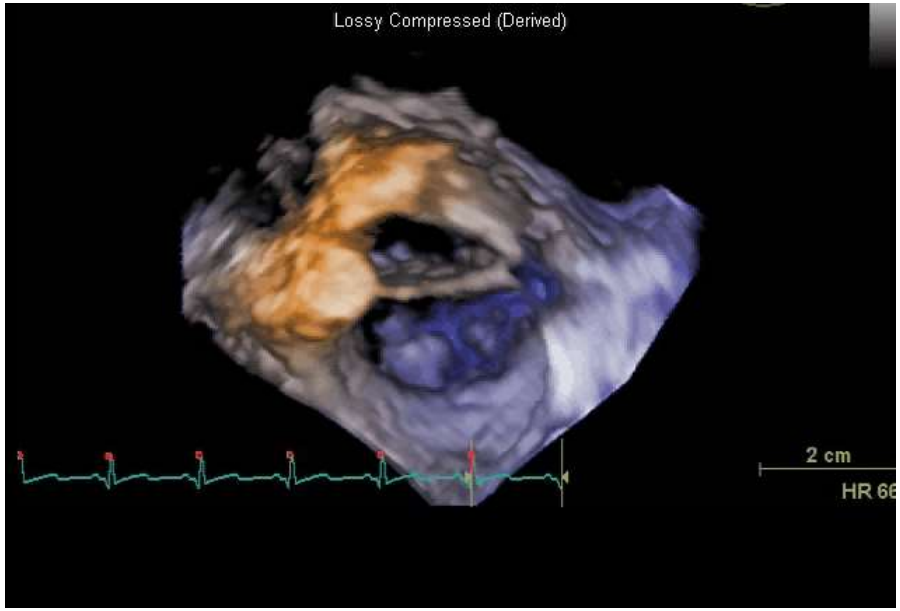
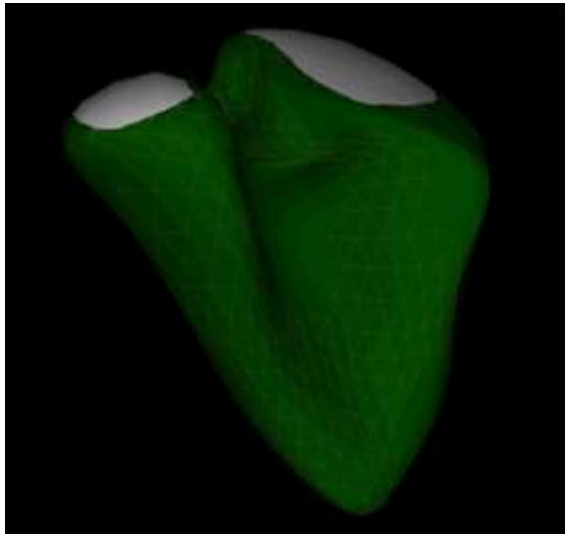

14:36:10
2 cm
HR 95


Lossy Compressed (Derived)
2 cm
HR 66



RV function:

RT-3DE RV software – ready for routine use?

- Twenty-three studies including 807 subjects
  underestimation of RV volumes ($P < .00001$)
  underestimation of RV EF ($P = .03$)

Shimada Y, JASE 2010

- **Larger volumes** and EF were associated with **more underestimation**

Iriart X, Eu J Echo 2009

European Heart Journal – Cardiovascular Imaging (2016) **17**, 1071–1097
doi:10.1093/ehjci/jew172

EACVI/ASE EXPERT CONSENSUS DOCUMENT

Three-dimensional echocardiography in congenital heart disease: an expert consensus document from the European Association of Cardiovascular Imaging and the American Society of Echocardiography

John Simpson*, Leo Lopez, Philippe Acar, Mark Friedberg, Nee Khoo, Helen Ko, Jan Marek, Gerald Marx, Jackie McGhie, Folkert Meijboom, David Roberson, Annemien Van den Bosch, Owen Miller, and Girish Shirali

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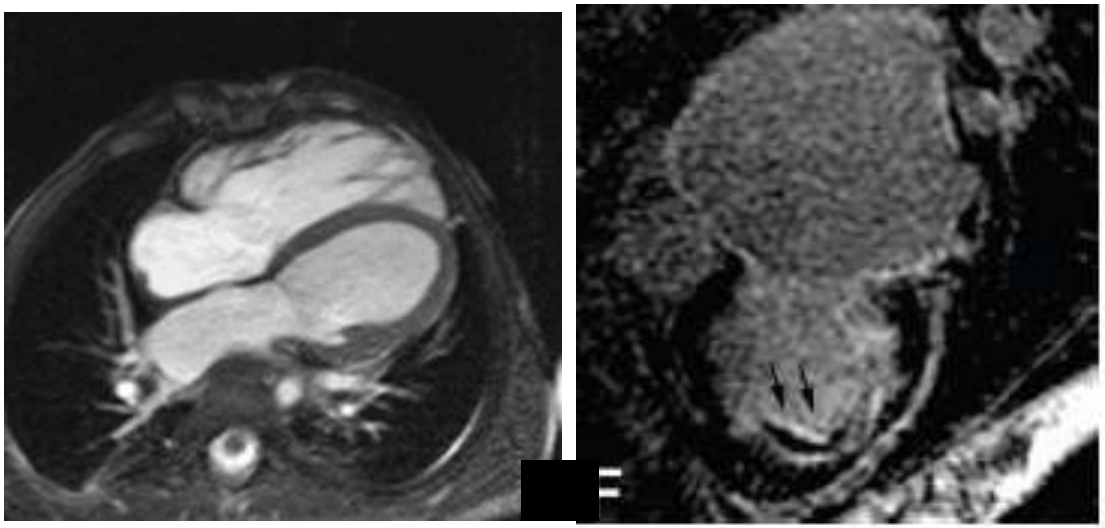
Eu Heart J – Cardiovasc Imaging 2016
J Am Soc Echocardiography 2016

Imaging modalities

CMR

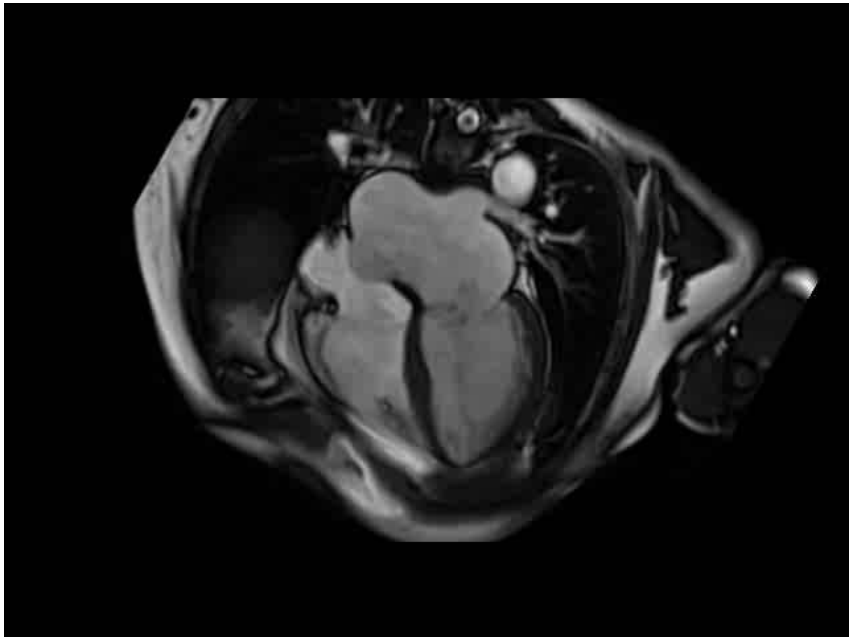


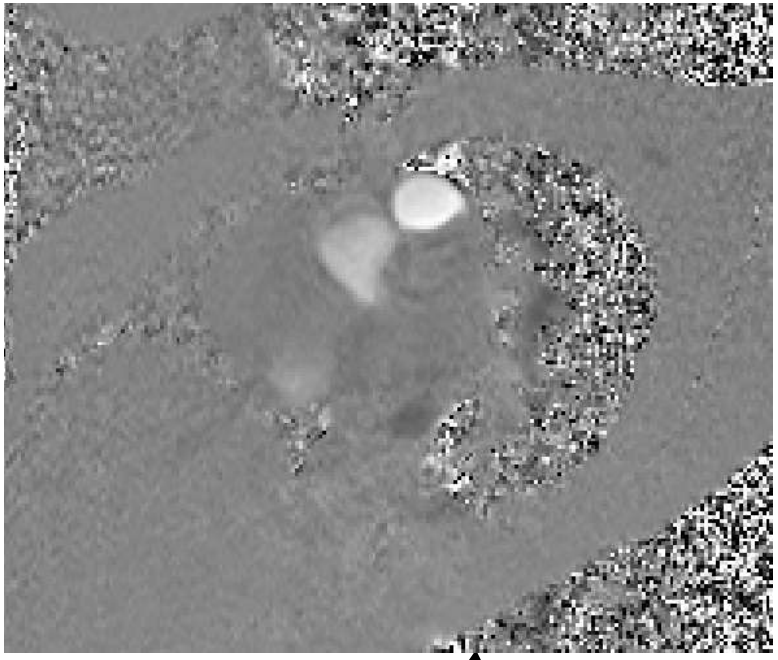
- Morphology
- Ventricles (morphology, volumes, function)

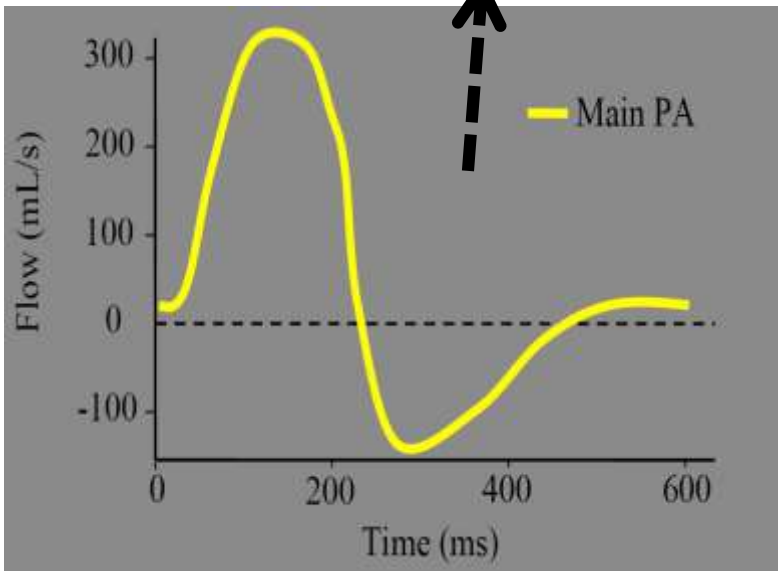
  LGE: coronary ischaemia, myocardial fibrosis, EFE
- Proximal coronaries (morphology)
- Chest topology (RV-PA conduit/aorta relation to sternum)

CMR

- Function (RVEDV, LVEDV, RVEF, LVEF)
- Regurgitation fraction (%)
- Flow (Qp:Qs, split flow, collaterals)
- PVR (hybrid approach in PAH)

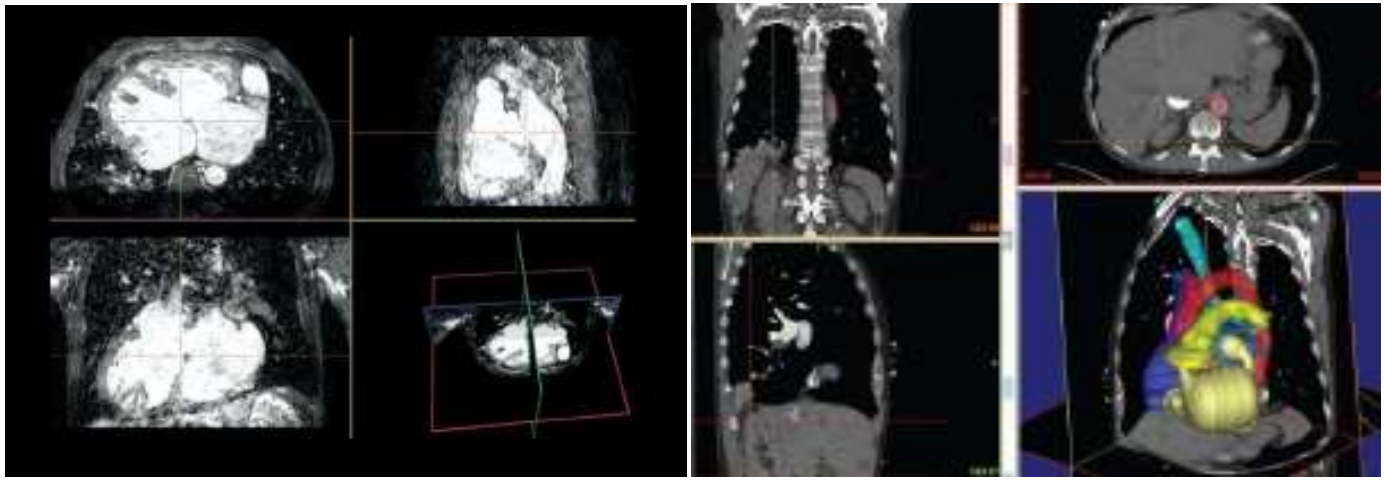






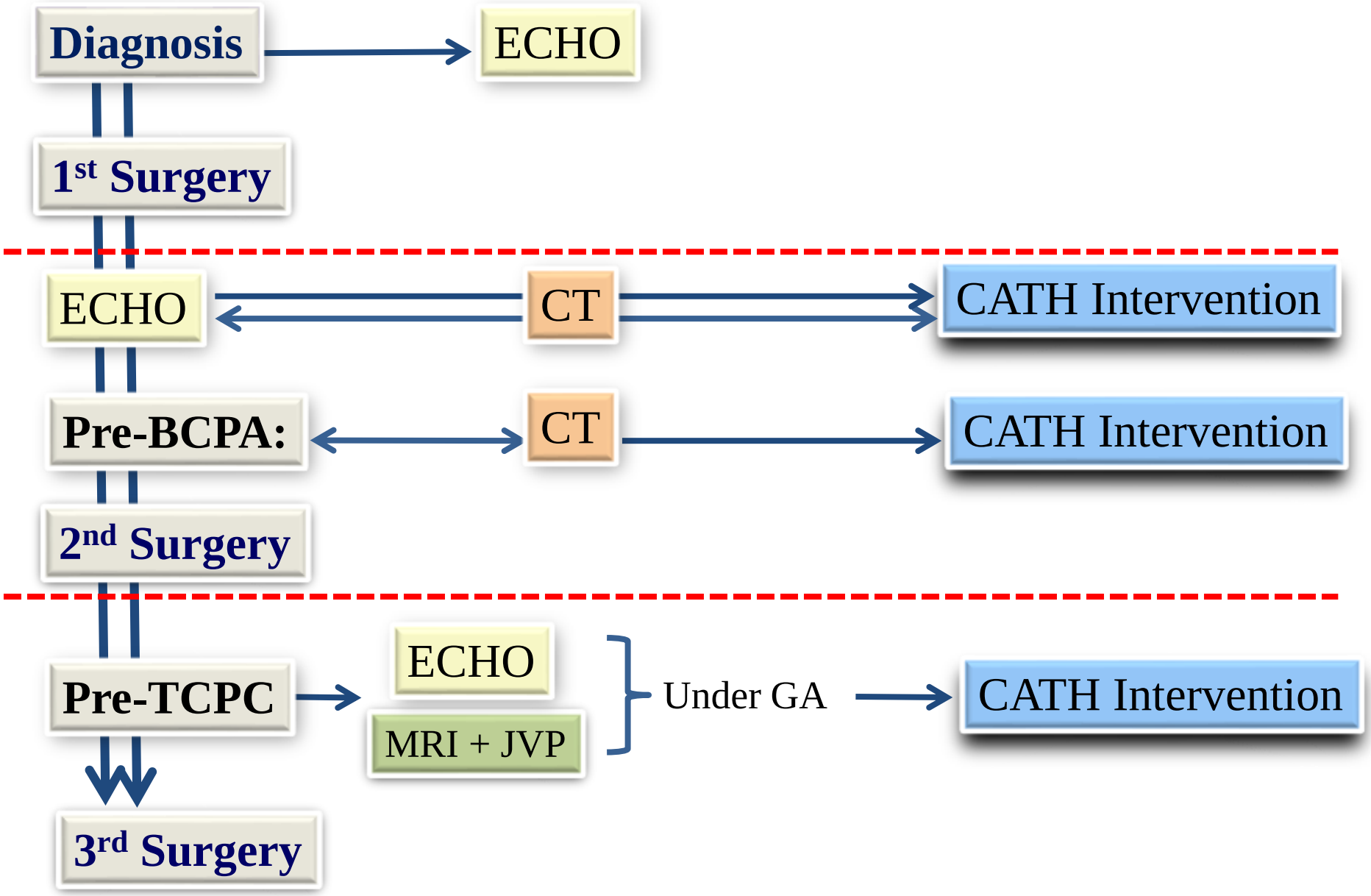
Imaging modalities

CT



- Branch PA's (routine pre-Glenn)
- AO-PA collaterals (MAPCA)
- Whole of coronaries (morphology)
- Airway abnormalities
- Vascular rings
- Previously implanted stents (PA branches, aortic arch)
- 3D reconstruction, segmentation, modelling, 3D printing

Cross-section imaging: GOSH protocol pathway (2017)



Imaging in 2017

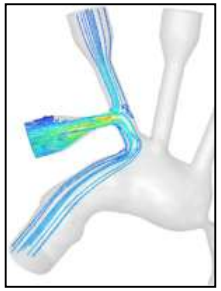
- 3D Reconstruction
- Rapid prototyping
- Printing
- Modelling

3D printed patient specific models

for Engineers

for Patients/Parents

for Clinicians

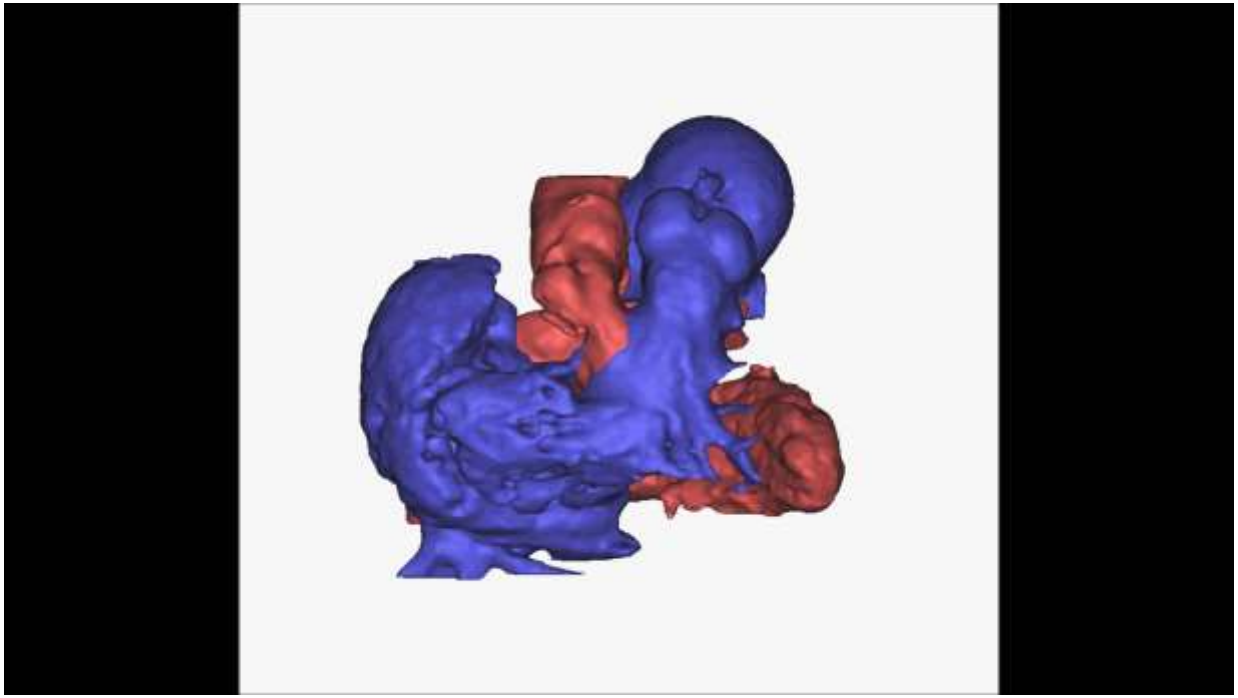


- Complex anatomy
- Bespoke devices and procedures
- Procedural planning
- Teaching
- Communication

Complex DORV

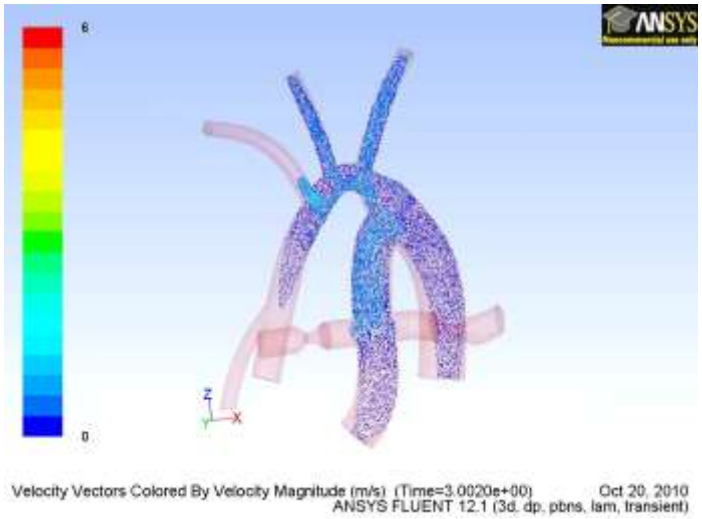
Preoperative 3D Modelling

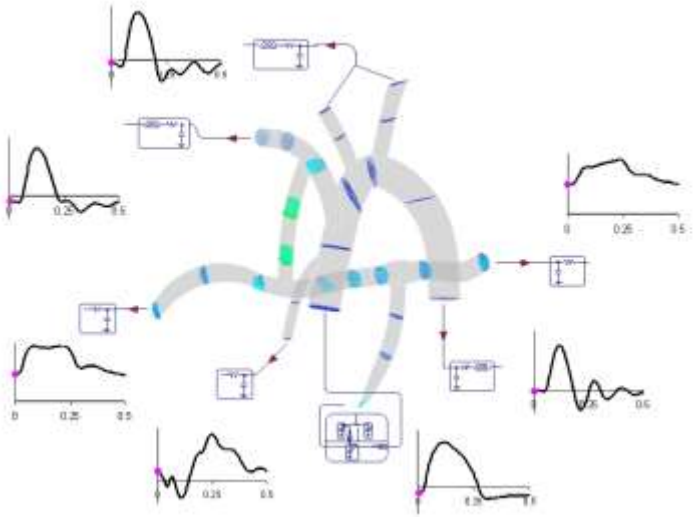
Postoperative 3D Reconstruction

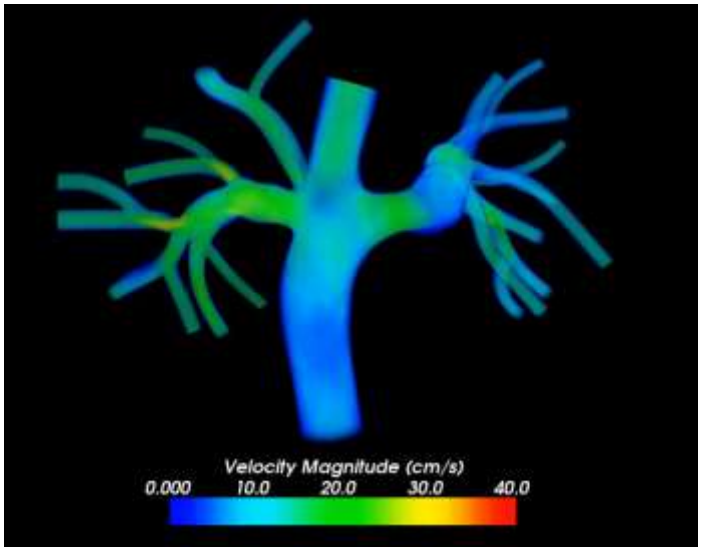


Computer Modeling
Computer Flow Dynamics (CFD)

- Mathematical solution to complex problem
- Examine dynamics of pressure and flow
- Effects of surgery, anatomy and physiology
- Supplement clinical decision-making





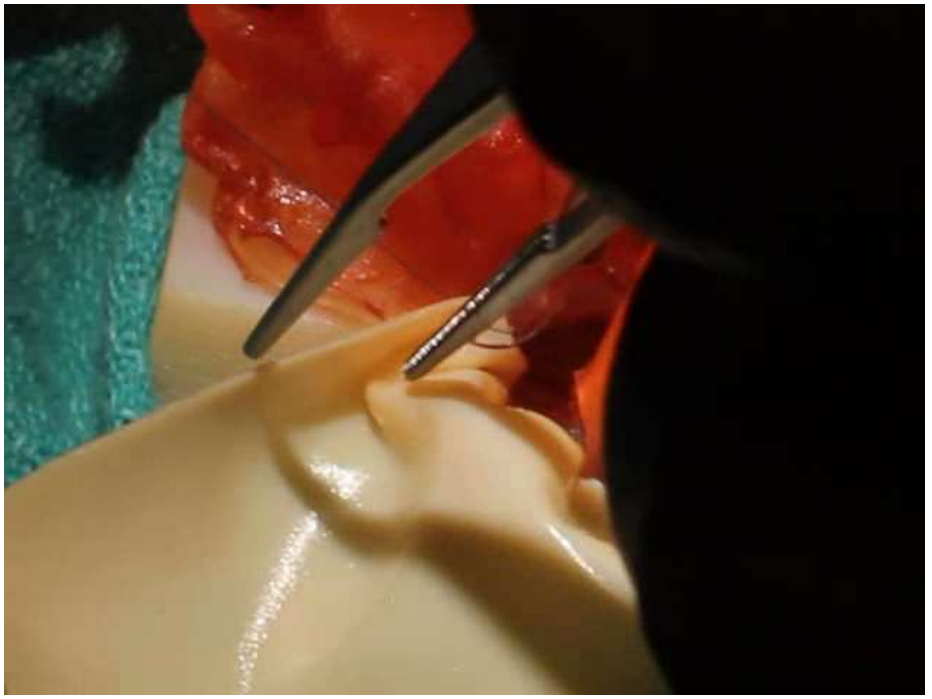


Courtesy T.Y.Hsia

3D Printing

- Understanding 3D topology
- Choosing best strategy
- Access to VSD(s)
- Identification outflow tracts
- Intraventricular baffling
- Sizing VSD patch
- Suturing

3D Printing: practising operation



Courtesy Glen Van Arsdell

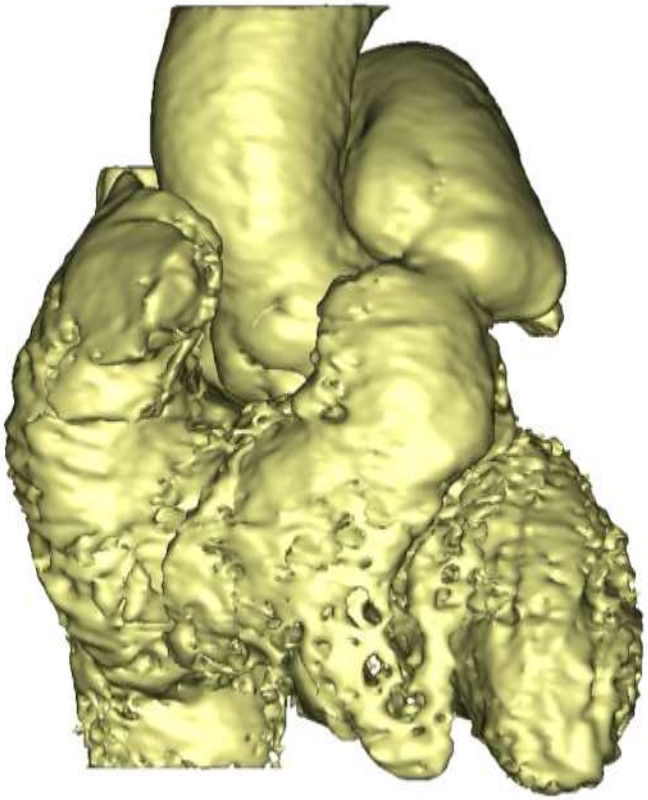
Issues

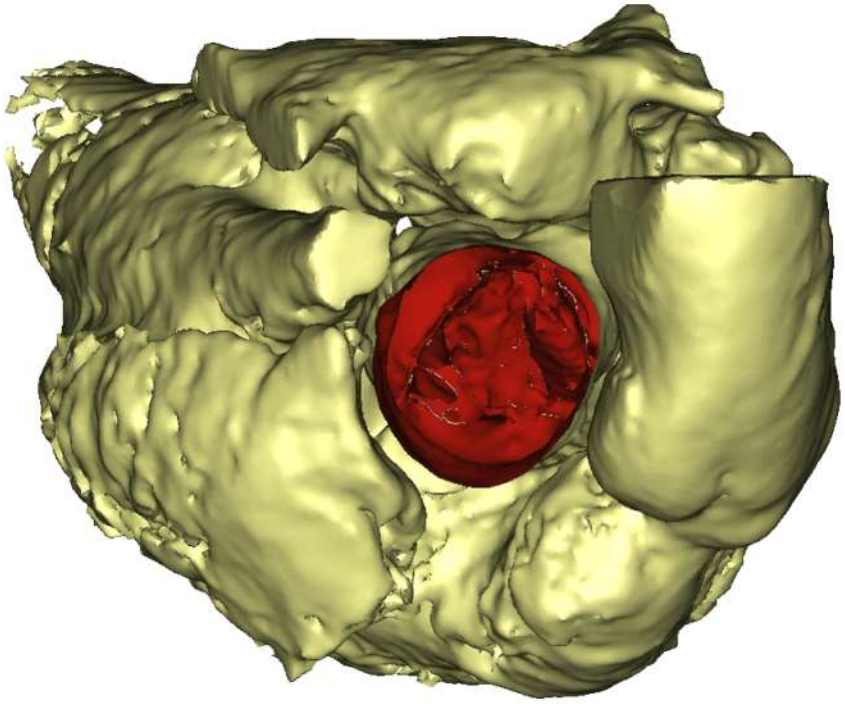
- Time cost
- Labor intensive
- Processing software not fully developed
- More cases needed
- **No fine structures – valves!**

Imaging > 2017 …coming soon

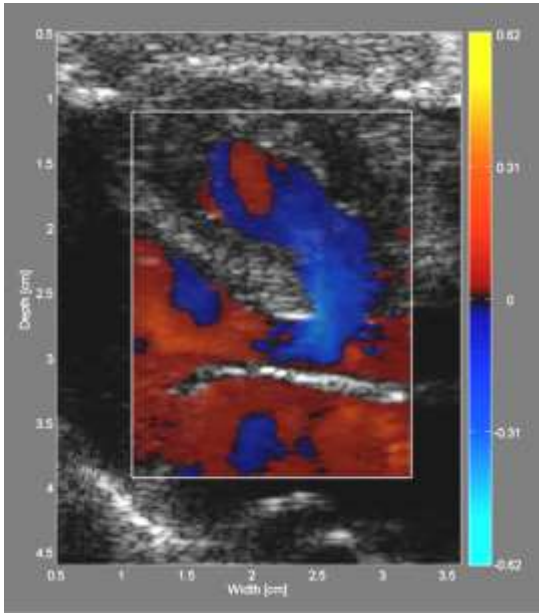
- Real-time CT angiography
- Blood Speckle Imaging
- Ultrafast Echocardiography
- Imaging Fusion

Real-Time 3D CT (4D CT)





Blood Speckle Imaging (BSI)



- Blood flow imaging based on **high-frame rate imaging** (plane-wave imaging) in combination with speckle-tracking technology

- Allows direct visualization of 2D velocity vectors **without contrast** and **mathematical assumptions**

- **Currently on GE Vivid E95**
  6S-D and 12S-D probes
  Adult 6VT-D TEE probe

ST. OLAVS HOSPITAL UNIVERSITETSSYKEHUSET I TRONDHEIM | NTNU Kunnskap for en bedre verden

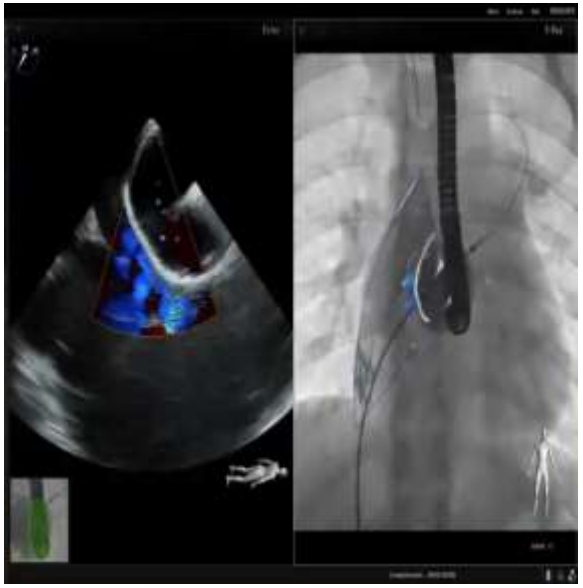
SickKids THE HOSPITAL FOR SICK CHILDREN

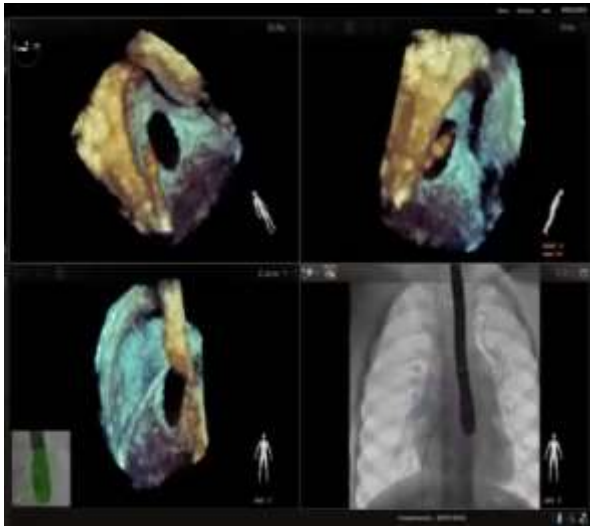
Courtesy Luc Mertens

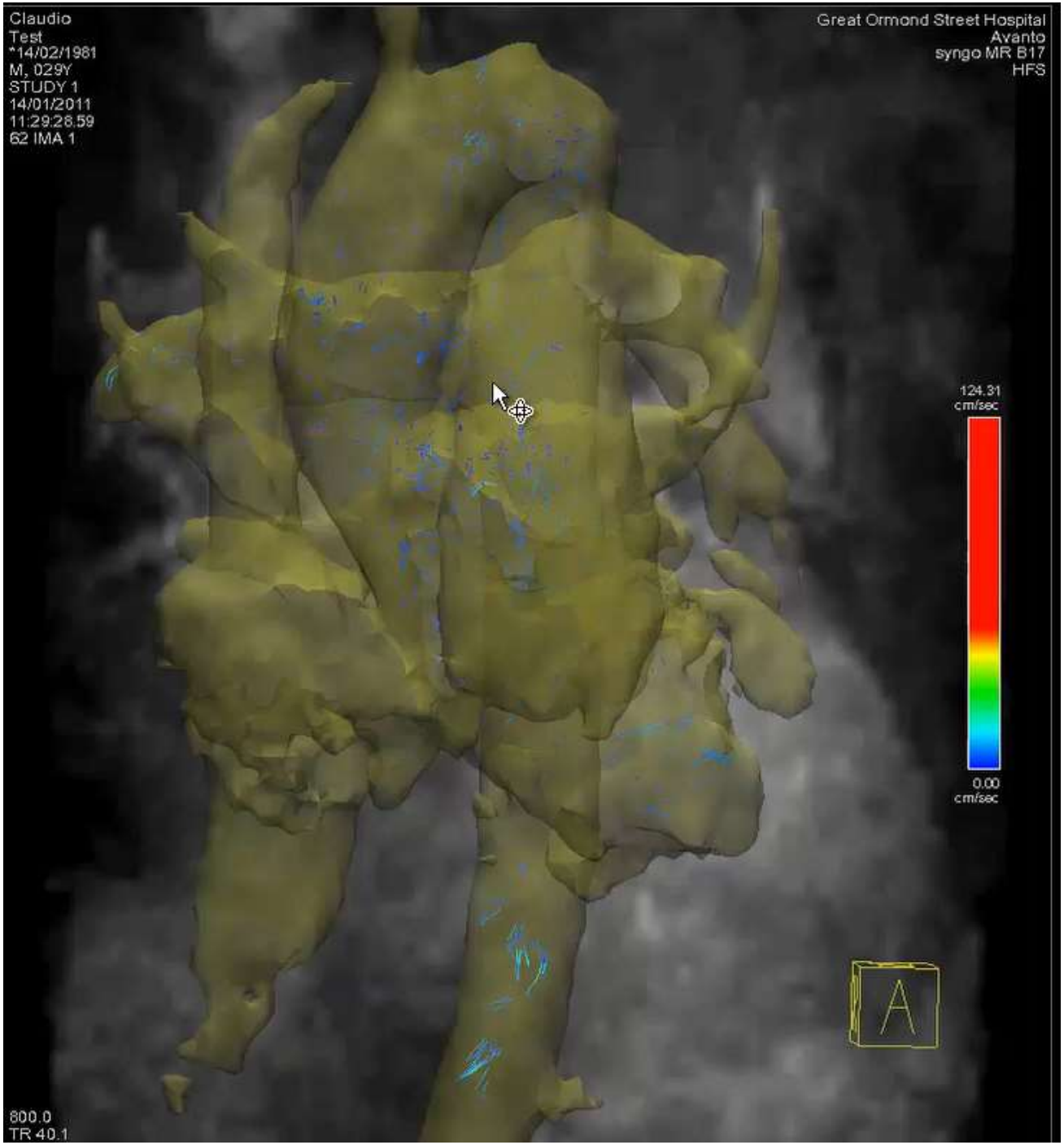
Cardiac Imaging Fusion

= integration of multi-modality imaging

- 3D ECHO + Fluoroscopy
- Rota angio + Fluoroscopy
- CT + Fluoroscopy
- CMR + Fluoroscopy
- CMR + CT + Fluoroscopy

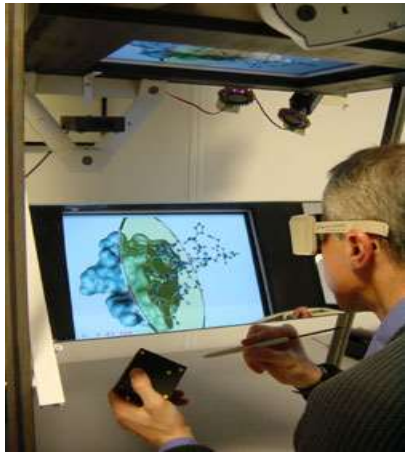


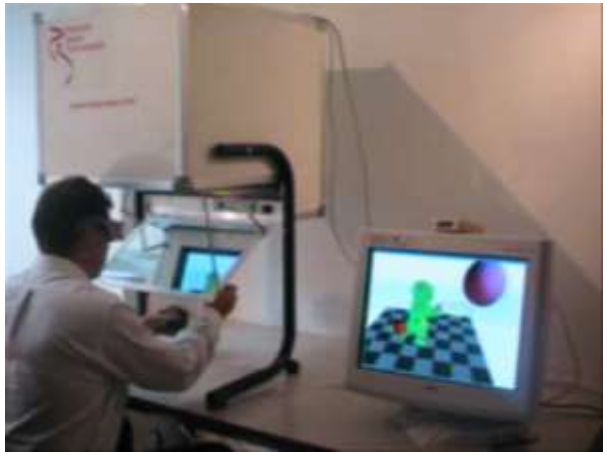



Claudio
Test
*14/02/1981
M, 029Y
STUDY 1
14/01/2011
11:29:28.59
62 IMA 1
Great Ormond Street Hospital
Avanto
syngo MR B17
HFS
124.31
cm/sec
0.00
cm/sec
A
800.0
TR 40.1

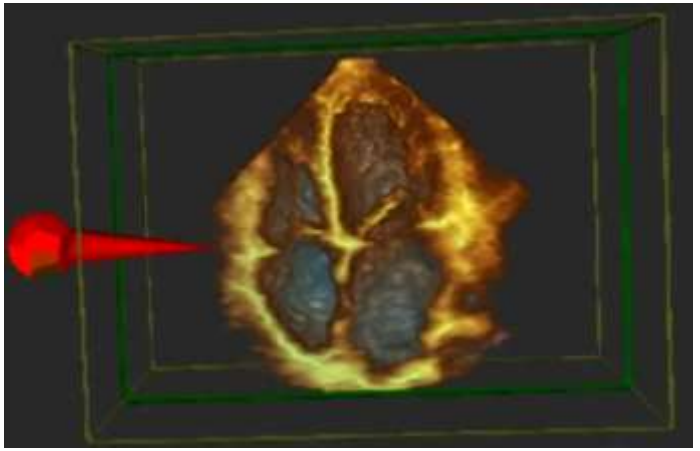
Cardiac imaging tomorrow

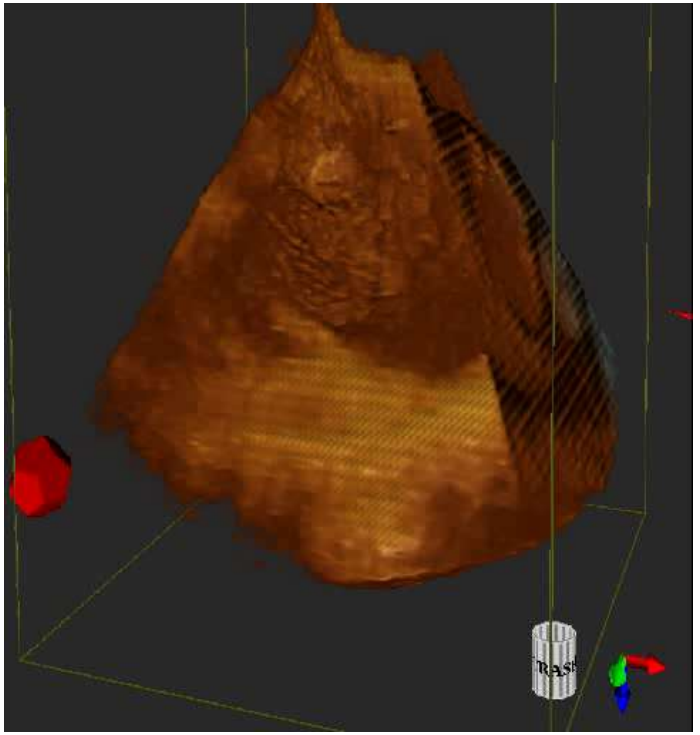
- **Holographic imaging**





Van den Bosch, Cardiovascular Ultrasound 2005





- **Internet data transmission**

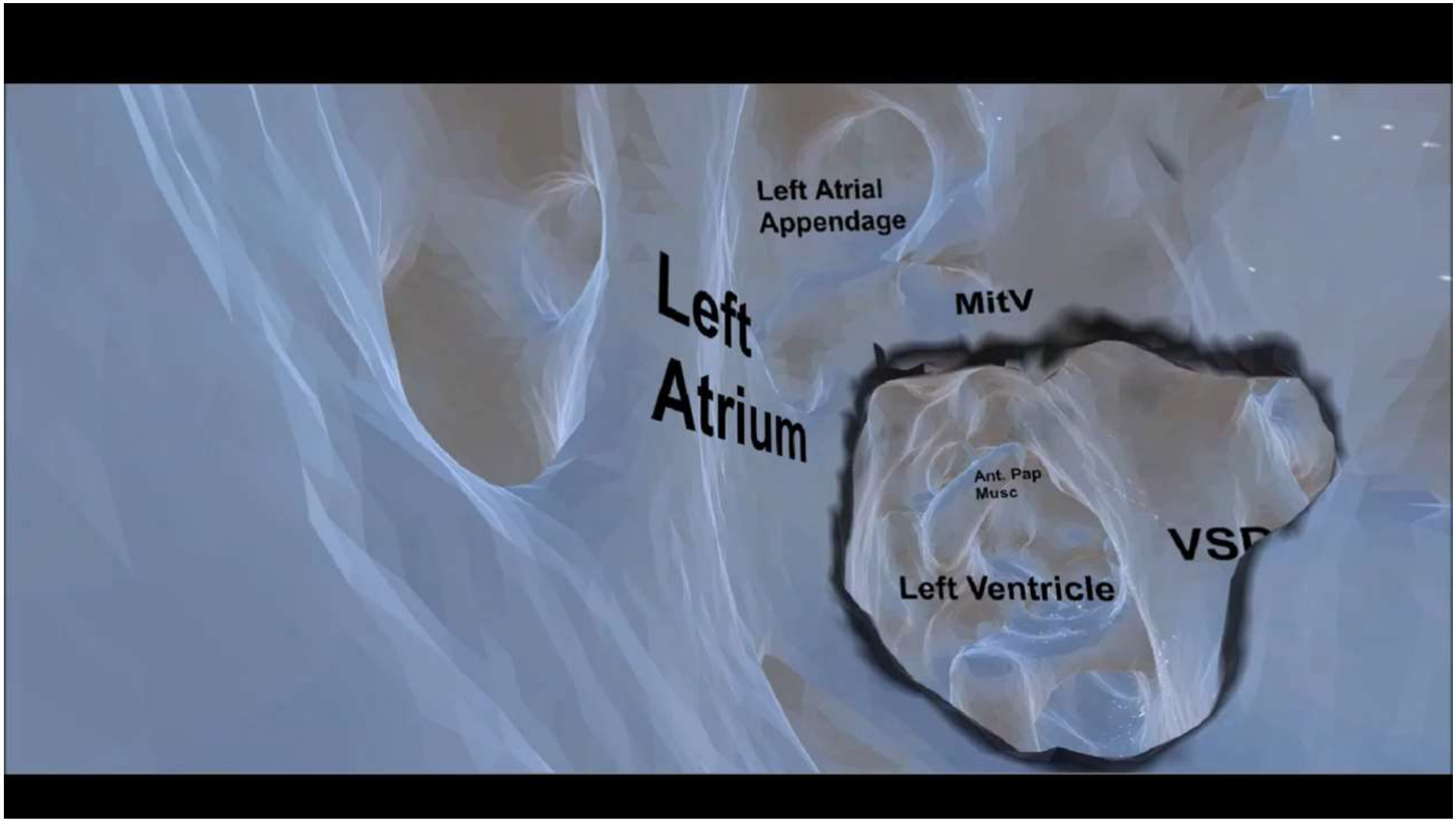
  Scans performed home

  (high definition portable ECHO system)

  Data analysed in expert core lab

  …or home

Cardiac imaging:
Virtual and Augmented Reality

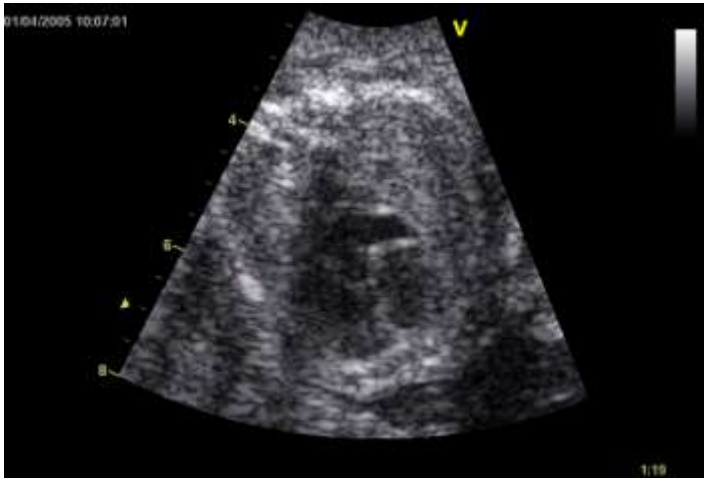


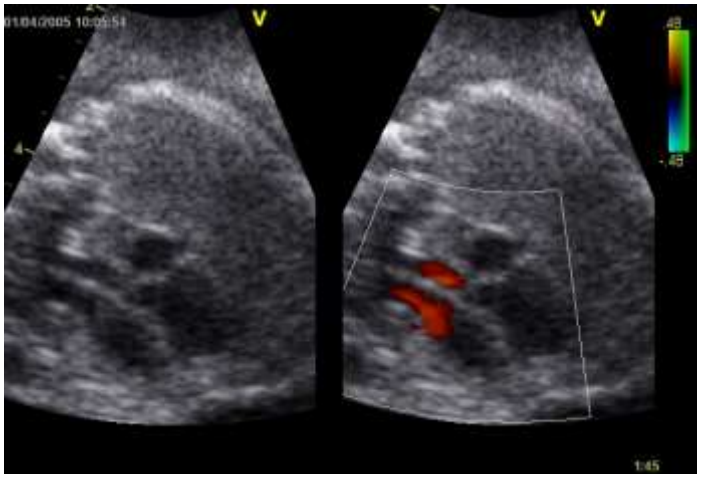
Courtesy: Syed Faaz Ashraf, T-Y Hsia (GOSH)

Cardiac imaging: is it too much?

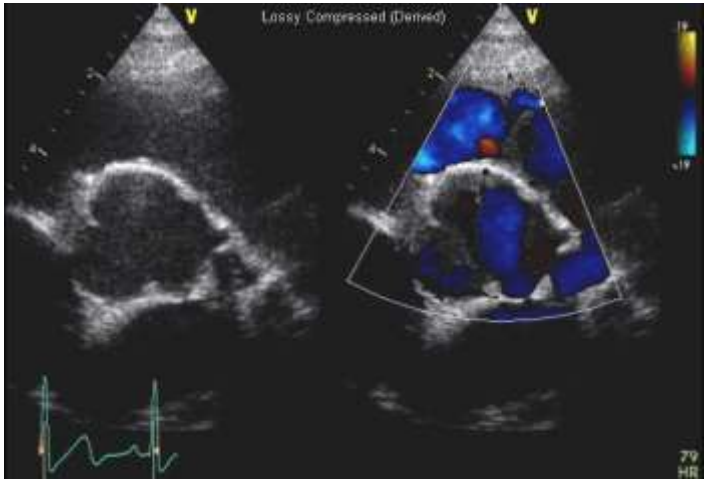
Learning from unknown, victims of our own success?

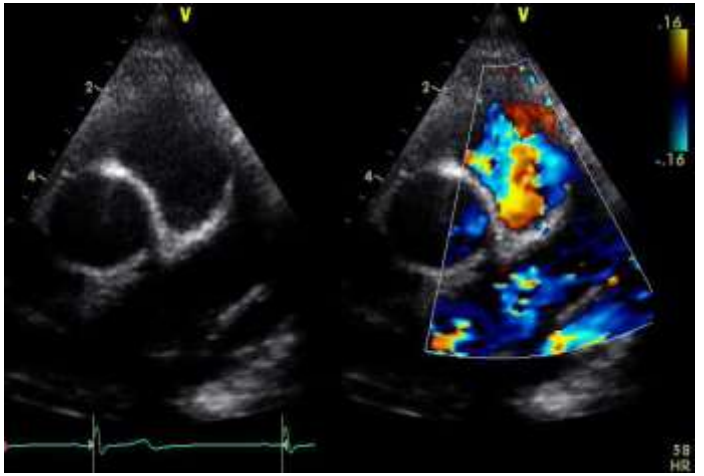
Isolated CcTGA:
Antenatal detection
2nd trimester screening





Isolated AAOCA
Right from left sinus
Left from right sinus
Asymptomatic patients
Screening for murmur





… and what now?

Echocardiography & Prenatal Cardiology

Director Jan Marek

Clinical ECHO Consultants

Michelle Carr

Ram Awat

Georgi Christov

Clinical Prenatal Cardiology Consultants

Ian Sullivan

Robert Yates

Shankar Sridharan

Rachel Andrews

Fetal Sonographers

Jo Wolfenden

Nicola Callaghan

Cardiac Sonographers

Gill Riley

Rebecca Banks

Sarla Kataria

Kalaiiarasi Janagarajan

Jabeen Bibi

Sally Punzal

Sharmila Govinde

Emma Chokdar

Victoria Cable

ECHO Research Fellows

Beatrice Bonnello

Elodie Perdreau

Ilaria Bo

Anna Argiolas

Specialists Registrars

William Regan

Filip Kucera

Sadia Qyam

Salim Jivanji

Corina Pauls

William Regan

Gabrielle Norish