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iCMR in ACHD

Kuberan Pushparajah
King's College London
Evelina London Children's Hospital
Guy's & St Thomas' NHS Foundation Trust
kuberan.pushparajah@kcl.ac.uk



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No conflicts of interest to declare



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Outline

- What can be done now with iCMR?
- What is the (ACHD) population
- What can we offer

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Motivation for change

- Reduced radiation burden
- Reduce procedure time (number of procedures)
- Increase accuracy
- Improve physiological information
- Improve outcomes

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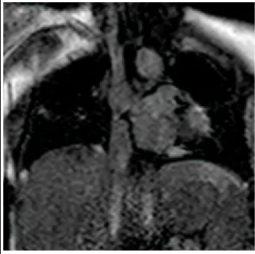
Visualization

- Real-time single shot acquisition with bSSFP readout

(TR/TE=2.6ms/1.3ms, flip angle=60°, fov=370×370mm², voxel size=2.2×2.5mm², bandwidth=1190kHz, SENSE factor=2.5, partial fourier=0.65, acquisition time=145ms, linear ordering).

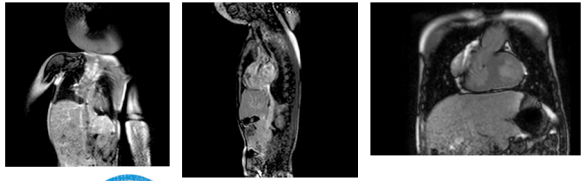

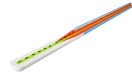
- Each image is acquired immediately after a saturation pre-pulse.
- Temporal resolution of ~7 images/s.

Velasco Forte et al. ISMRM 2017



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MRI guidewires

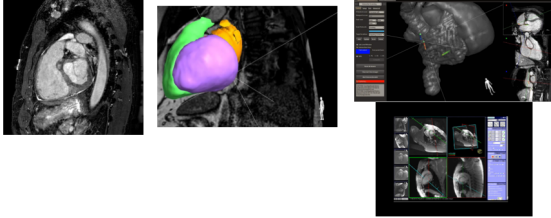
MR-Guide wire 2nd generation
Additional fibre layers and variable stiffness polymers
Courtesy of EPFlex & Andreas Melzer CE Mark Certificate

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Image segmentation and display

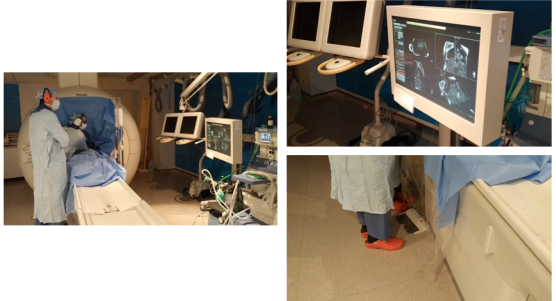
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    graph LR
      A[Acquisition: prior and r-t MR images] --> B[Segmentation: 3D shell, scars, RF lesions]
      B --> C[Registration: motion models]
      C --> D[Visualization: data handlers & display platforms]
  
```



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Interaction



Philips isuite system

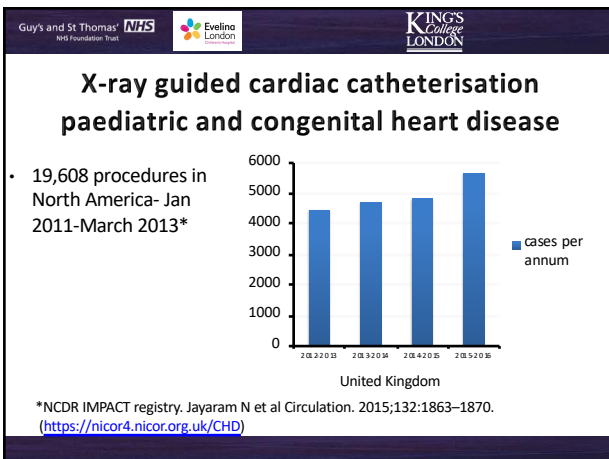
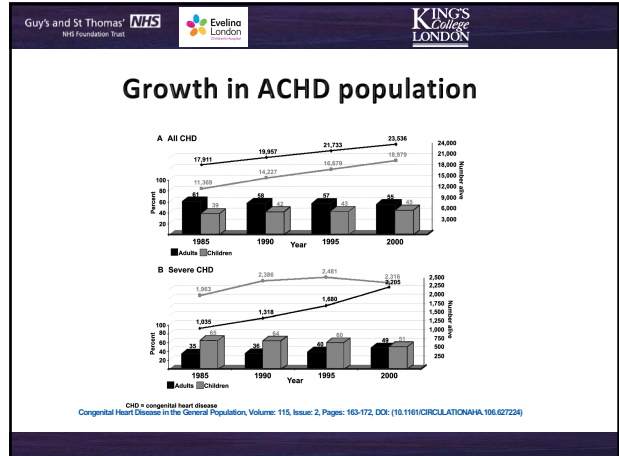
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SCMR EACVI European Association of Cardiovascular Imaging 5th Edition Improving Clinical Value by Technical Advances

CMR 2018

THE JOINT EUROCMR* / SCMR MEETING
5th EDITION
Improving Clinical Value by Technical Advances

Barcelona, Spain
31 January - 3 February 2018



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KCL experience

- Pulmonary vascular resistance (79% of ECH historical caseload)
- Pharmacological stress
 - Dobutamine
- XMR intervention
- MR guided interventions

221 procedures. n = 196 patients,
Median age = 4.5 yr (4d - 64.7yr),
Median Wt 15.4 kg (2.3 - 106kg)

57 Functionally Univentricular
176 PVR studies, 74 Pharmacological Stress (9 had both)

Pushparajah K, et al. Interventional Cardiology. 2014;6:335-346.

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PAH in ACHD

Prevalence of PAH*

- PAH-CHD (30.2% of PAH)
- idiopathic PAH (33.6%)
- connective tissue disease-related PAH (28.3%),

Prevalence of PAH within the adult CHD population may be as over 10% for any PAH

*2012 report of the UK National Pulmonary Hypertension Audit

Eur Heart J. 2013;35(11):691-700. doi:10.1093/eurheartj/eh437

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ACHD

- 32 yrs M
- Partial (ostium primum) AVSD
- Dilated RV (RVEDV 194 ml/m², RVEF: 44%)
- Mild right AV-valve regurgitation (RF 8%)
- RV systolic pressures (33mmHg)RV EDP 12 mmHg
- LVEF 51%, LV EDP 10mmHg

- Qp:Qs = 3.1:1
- Pulmonary artery pressure 30/7 mmHg
- PVR at rest 1.02 WU.m²

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ACHD: Complex

Hypoplastic left heart
Lateral tunnel fontan

Tricuspid atresia
Atriopulmonary fontan

Transposition of great arteries
Atrial switch

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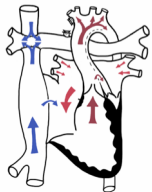
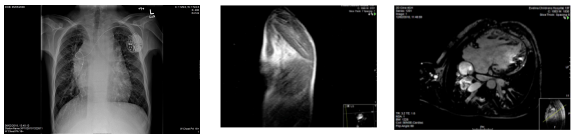
ACHD - complex

- 18yrs M
- Left atrial isomerism
- Interrupted IVC, azygos continuation to single RSVC.
- Hypoplastic left heart syndrome
- **Non- cardiac diagnoses**
- Biliary atresia s/p Kasai procedure 2000
- Chronic renal insufficiency
- Recurrent bleeding
- Low platelet count

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ACHD - complex

Procedures:
 Norwood 1 procedure 8/3/2000
 Kawashima procedure 15/08/2001
 Hepatic vein redirection 10/6/2002
 Closure of lateral tunnel fenestration by device & ablation of intra-atrial re-entry tachycardia
 MRI conditional AAIR pacemaker 2015

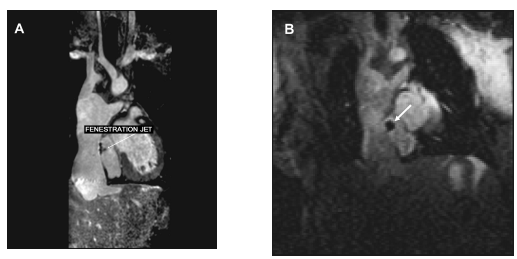
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ACHD - complex


- Fontan pathways- unobstructed
- Progressive ventricular dilation with impaired function
- No significant collateral burden
- Elevated mean Fontan pressure with concomitant elevated ventricular end-diastolic pressure.
- Low PVR (1WU.m²) and very low SVR (4.3WU.m²)
- Qp:Qs 1:1
- High resting cardiac index at 8.5L/min/m²
- Referred for transplantation

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Dynamic fenestration occlusion



Aphrodite Tzifa, and Reza Razavi Heart 2011;97:89

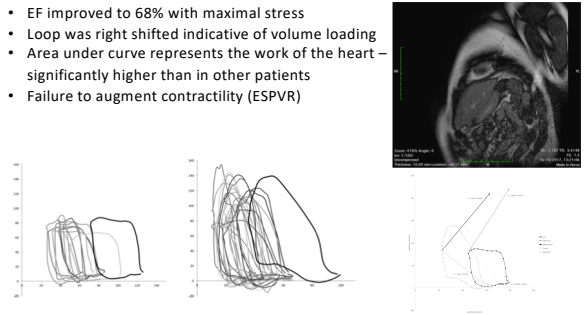


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Myocardial dysfunction


- EF improved to 68% with maximal stress
- Loop was right shifted indicative of volume loading
- Area under curve represents the work of the heart – significantly higher than in other patients
- Failure to augment contractility (ESPVR)



Wong et al . Int J Cardiol 230;2017; 439-446


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Exercise MRI catheterization



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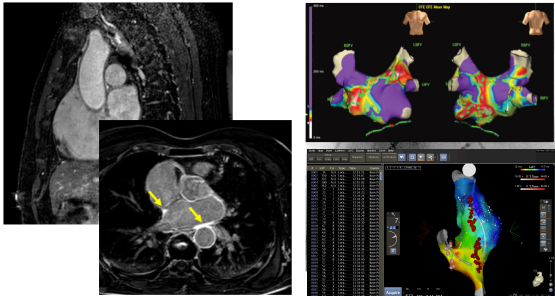
MRI lymphangiography



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MR-Guided Electrophysiology

MRI | Conventional



Images courtesy of Henry Chubb, KCL.

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Clinical utility

ESC | Imaging the adult with congenital heart disease: a multimodality imaging approach—position paper from the EACVI

In complex cases, optimal calculation of pulmonary vascular resistance is derived from a hybrid approach with CMR providing flow

combined CMR-Catheter procedures are being used to provide enhanced diagnostic data in complex ACHD patients who may often require multiple cardiac catheterizations.^{37–39} This approach to diagnosis offers the advantages of a radiation-free or minimal radiation examination for catheter guidance. Hybrid measurements provide a more accurate and comprehensive haemodynamic assessment than other traditional techniques.^{37–39} While hybrid CMR-catheterization laboratories can still benefit from separate diagnostic pulmonary flow (CMR) and pressure (catheter) acquisitions from adjacent facilities.

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Conclusions

- The problem is growing
- Technology available
- Adapt to patient factors
- Focus on diagnostic capabilities with one-stop-shop solution for improved outcome measures
- Goal for MRI guided interventions remain

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Collaborators



Radiographers at GSTT and KCL | Dallas team