Current role of CMR in paediatrics

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Current role of CMR in paediatrics

- Congenital heart disease
- Cardiomyopathy/Myocarditis COVID/PIMS
- Aortopathy
- Arrhythmia - ICC
- Pulmonary hypertension
- Heart failure
- Tumours
- Fetal MRI

- Anatomy
- Functional data
- Tissue characterization
- Stress perfusion
- Prognostic parameters

Current role of CMR in paediatrics

Paediatric CMR normal values

- Biventricular volumes derived from different contouring techniques
- Atrial volumes assessed by SSFP MRI using monoplane and biplane area-length methods
- MAPSE and TAPSE
- Biventricular wall thickness and mass
- Myocardial deformation: strain and strain rate using 2D MR feature tracking

S Krupickova, Inga Voges, Dudley J Pennell, JMRI, JCMR, Int J Cardiovasc Imaging, 2021, 2022

Kawel-Boehm *et al. J Cardiovasc Magn Reson* (2020) 22:87
https://doi.org/10.1186/s12968-020-00683-3

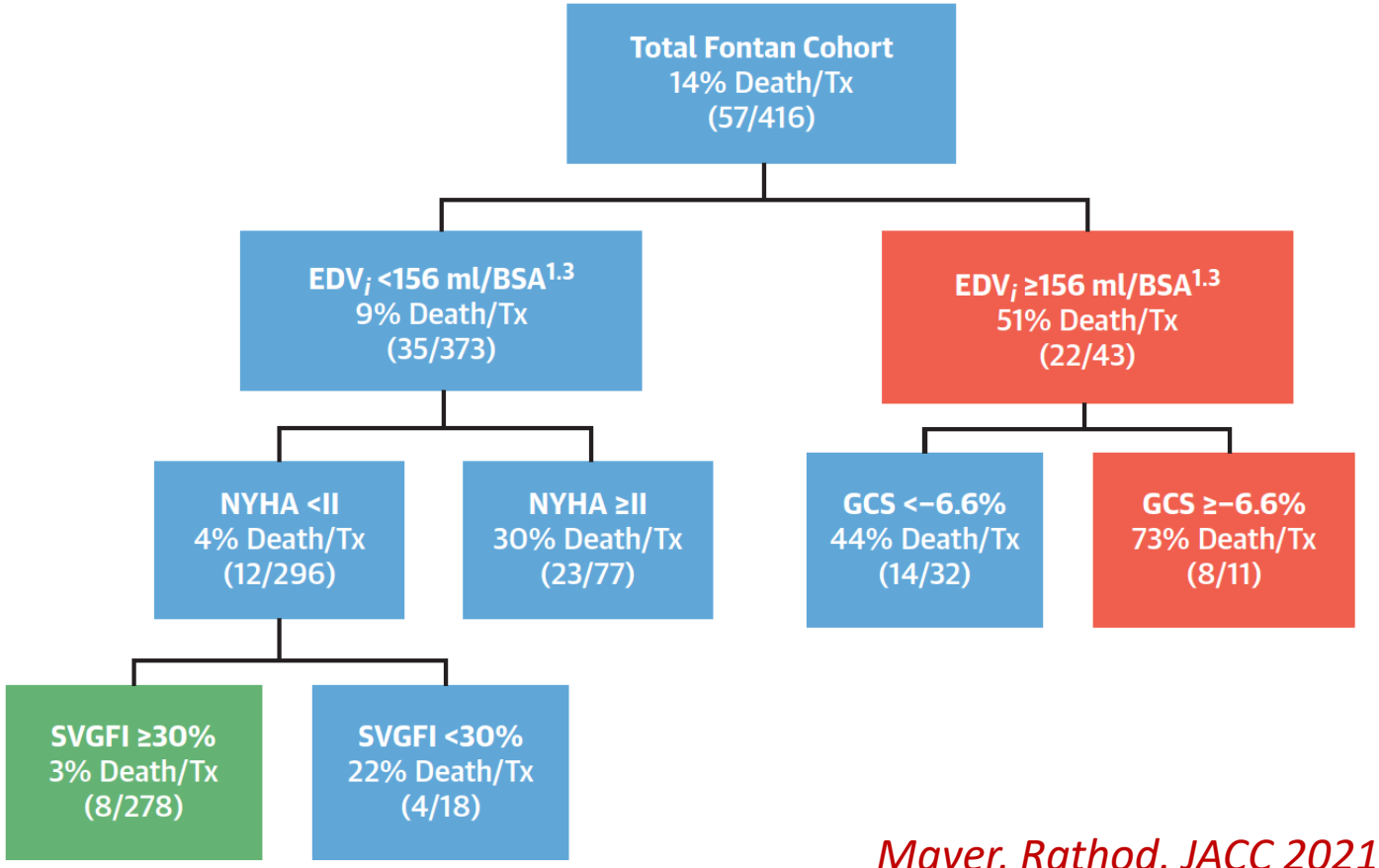
Journal of Cardiovascular Magnetic Resonance

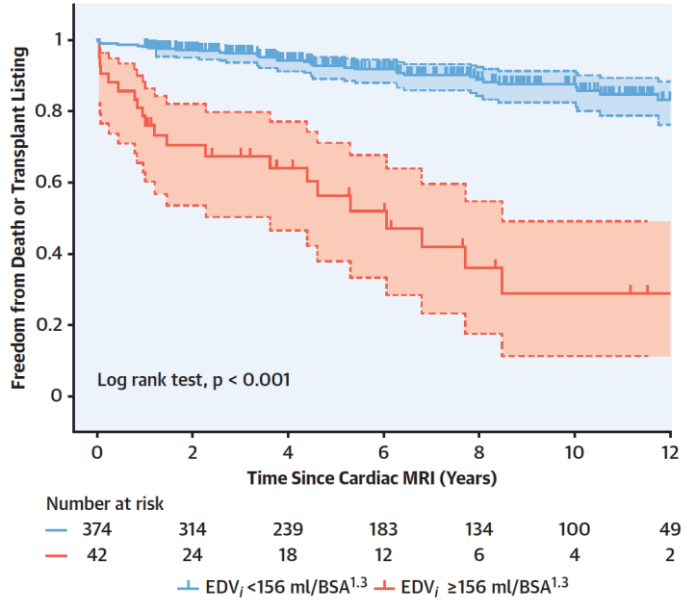
REVIEW Open Access

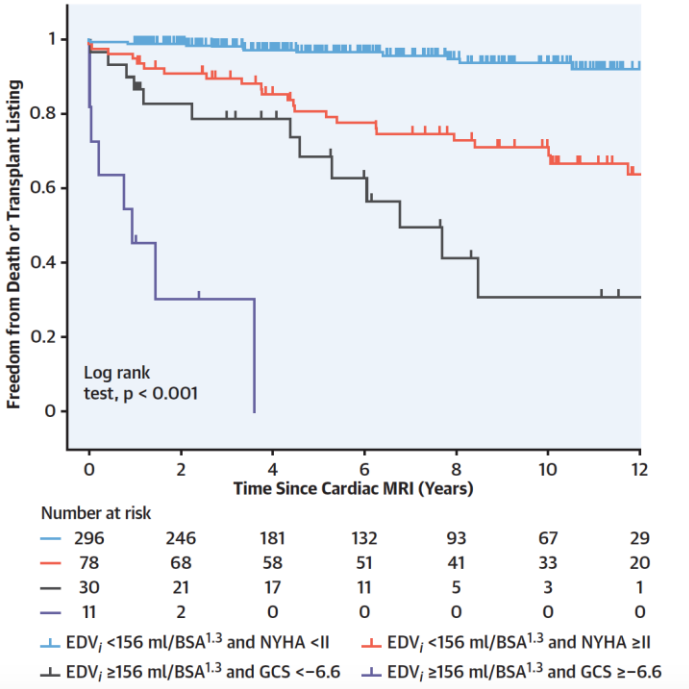
Reference ranges ("normal values") for cardiovascular magnetic resonance (CMR) in adults and children: 2020 update

Current role of CMR in paediatrics
Congenital heart disease

Primary endpoint death or heart transplant for Fontan patients
N=416 patients, median age 16 years (IQR 11-23)



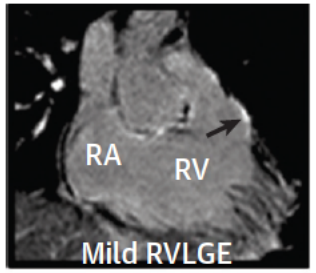


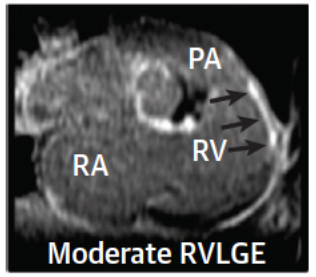


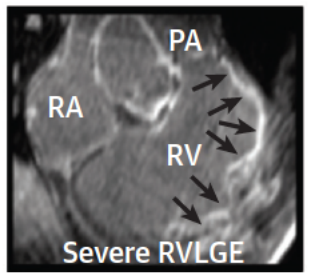
Mayer, Rathod, JACC 2021

Current role of CMR in congenital heart disease
Tetralogy of Fallot

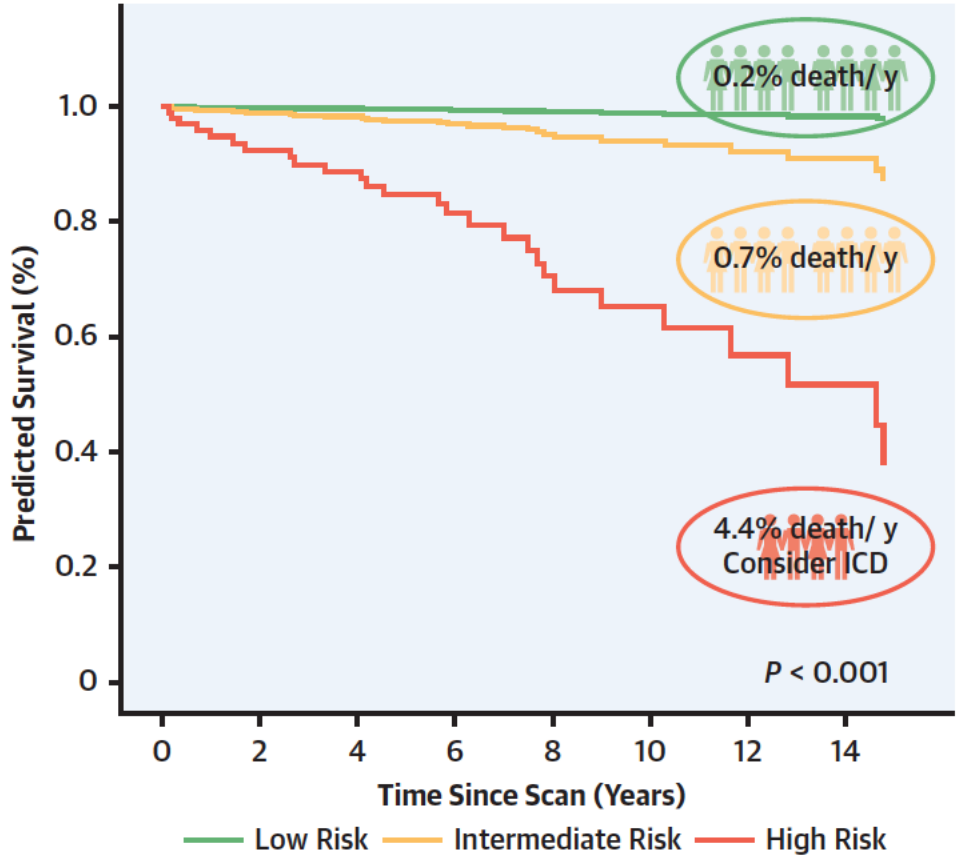
N = 550
Median age 32 years
(IQR 23-42 years)







Mortality Risk	Points
RVLGE extent	
Minimal/mild extent	0
Moderate extent	24
Severe extent	40
LVLGE present	
No	0
Yes	6
RV ejection fraction	
>47%	0
36%-47%	4
≤35%	10
LV ejection fraction	
>55%	0
36%-55%	4
≤35%	12
Peak oxygen uptake	
>17 ml/kg/m^2	0
≤17 ml/kg/m^2	6
B-type natriuretic peptide	
<127 ng/l	0
≥127 ng/l	12
Sustained atrial arrhythmia	
No	0
Yes	8
Age over 50 years	
No	0
Yes	6
Total	**/100**

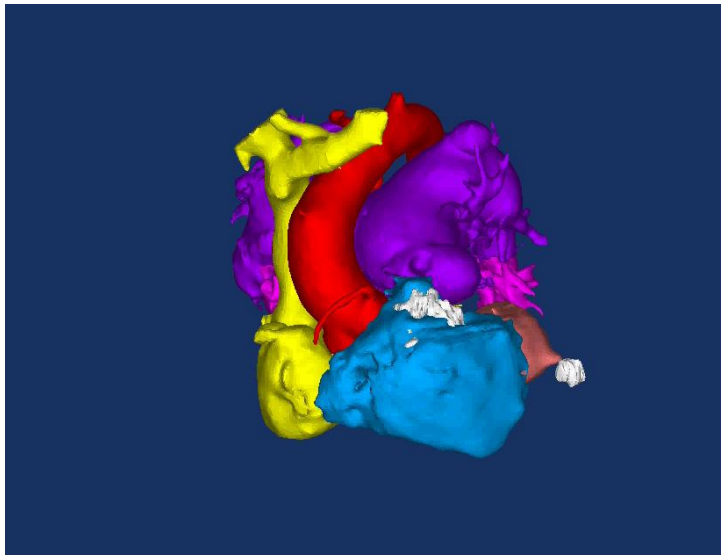


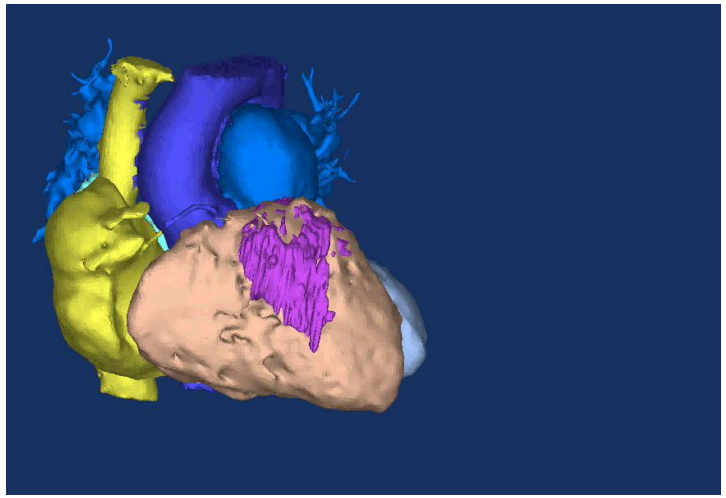
Risk Score	Mortality	%	Mortality/Year
0-20	2/223 (0.9%)	41	0.2%
21-50	9/272 (3.3%)	49	0.7%
≥51	16/55 (29.1%)	10	4.4%

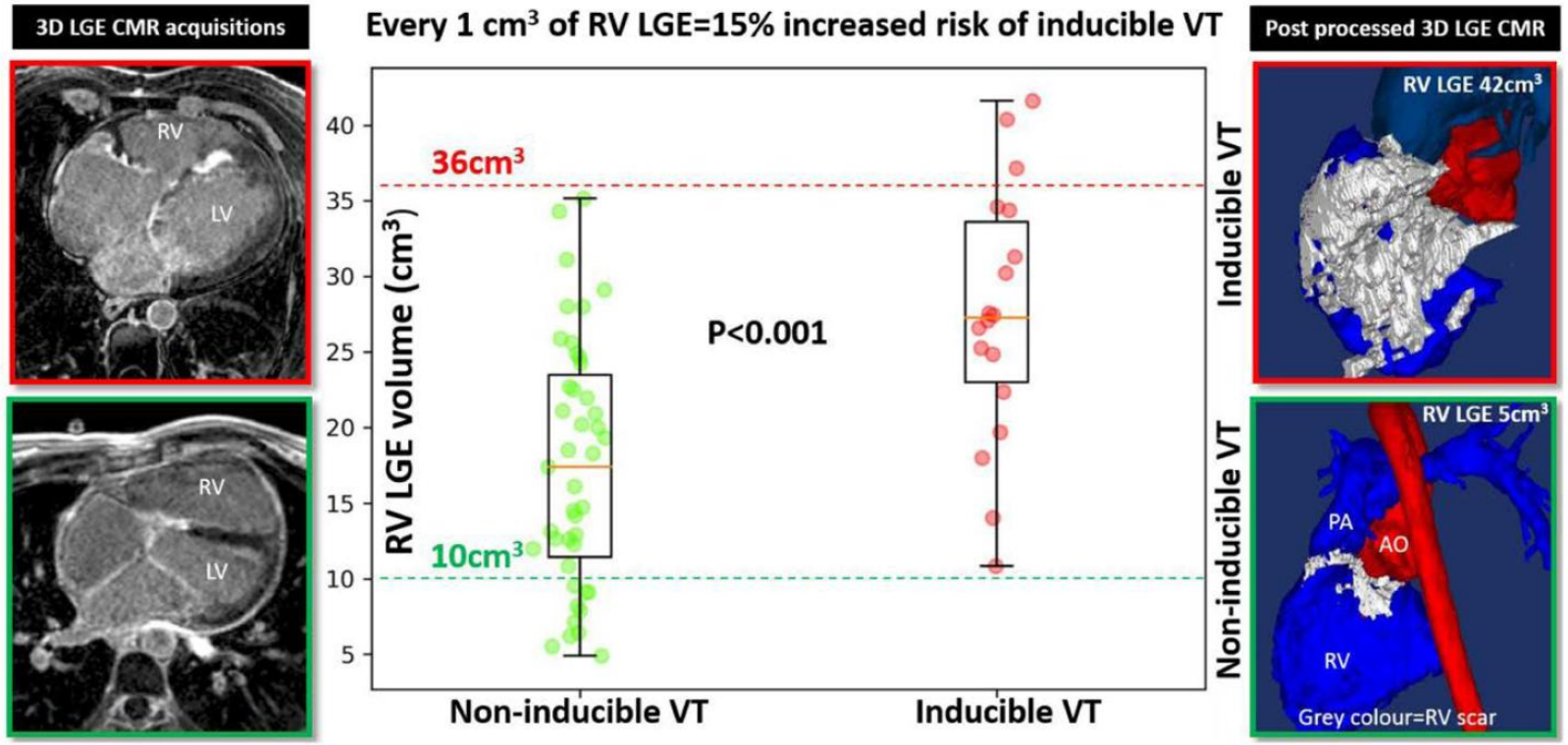
Based on prospective data with follow up 6.4 (±5.8 years); total 3,512 years

S.Gonim, S. Babu-Narayan, JACC 2022

Current role of CMR in paediatrics
Arrhythmias





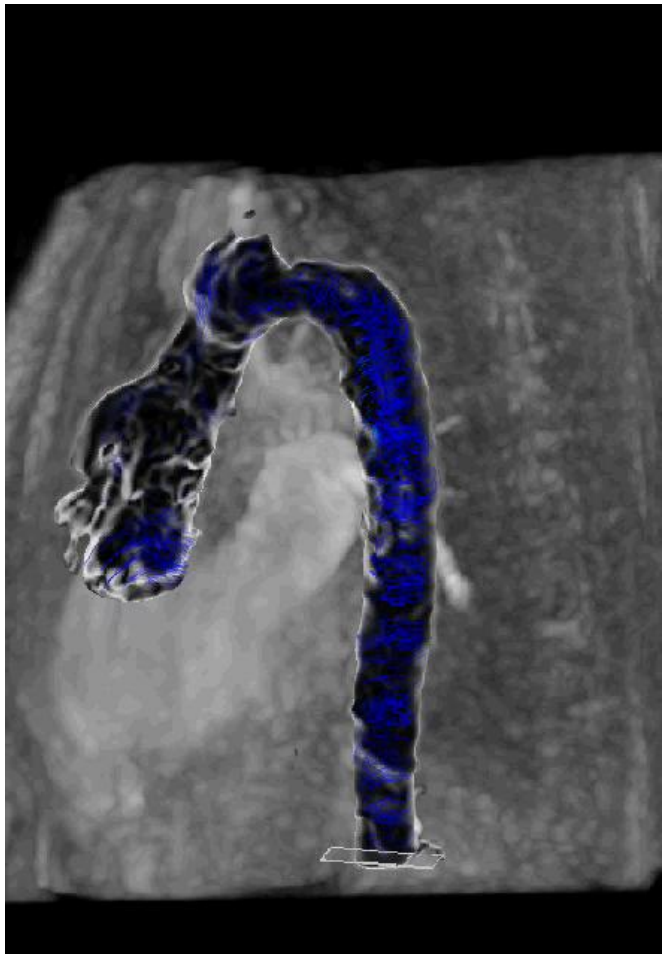


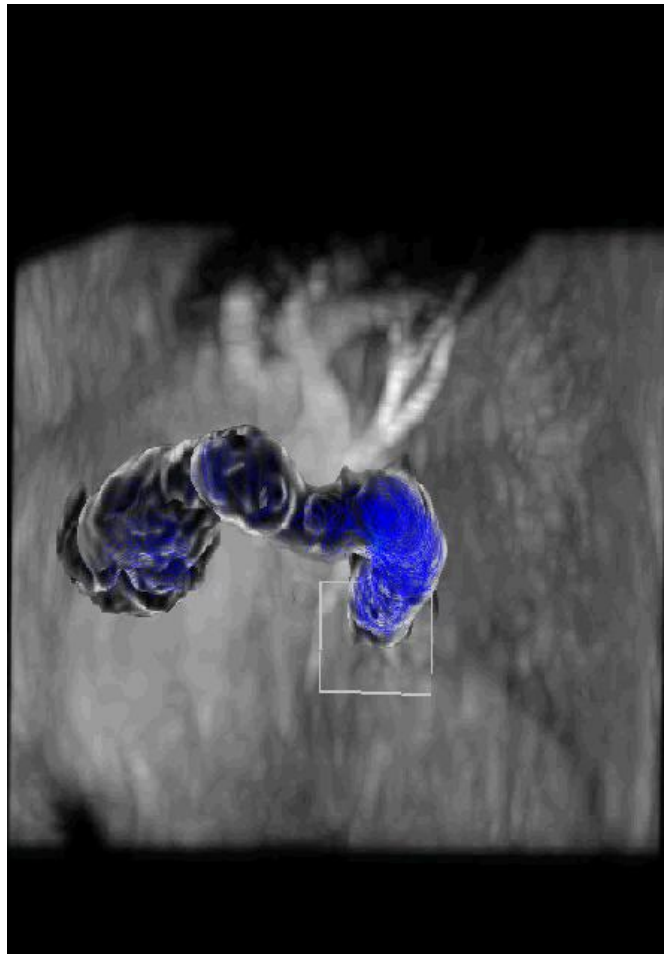
RV scar burden in adult patients with repaired TOF measured using 3D LGE independently predicted inducible VT during invasive programmed electrical stimulation.

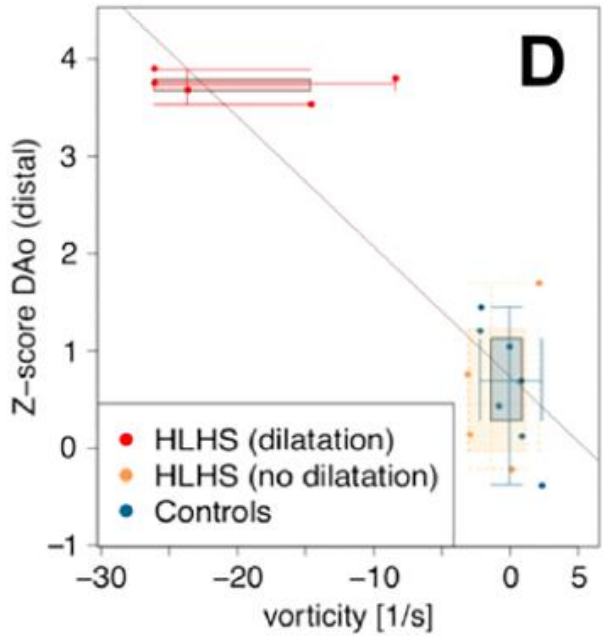
S Babu-Narayan, S. Ernst, Circ Arrhyth Electrophysiol, 2020

Current role of CMR in paediatrics
Congenital heart disease

- Patients with HLH and DAo dilatation
- Patients with HLH without DAo dilatation
- Healthy controls





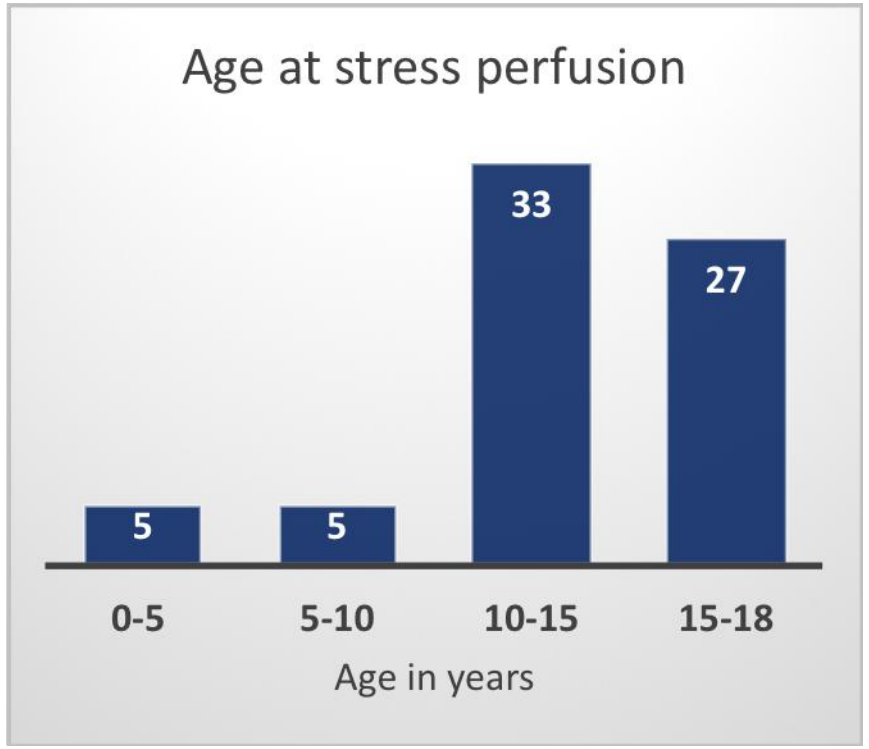


Vorticity in the DAo in patients with DAo dilatation and calibre change in aortic arch was significantly increased in magnitude compared to patients without DAo dilatation and controls.

Inga Voges, Dominik Gabbert, Int J Cardiol, 2020

Current role of CMR in paediatrics
Stress perfusion

- Assessment of myocardial ischemia
- 2017-2022, 70 scans in 65 pts
- Adenosine N = 34
- Regadenoson N = 36



- Structurally normal heart, N=33
- Congenital heart disease, N=26
- Cardiomyopathy, N= 6
- Acquired heart disease, N=5

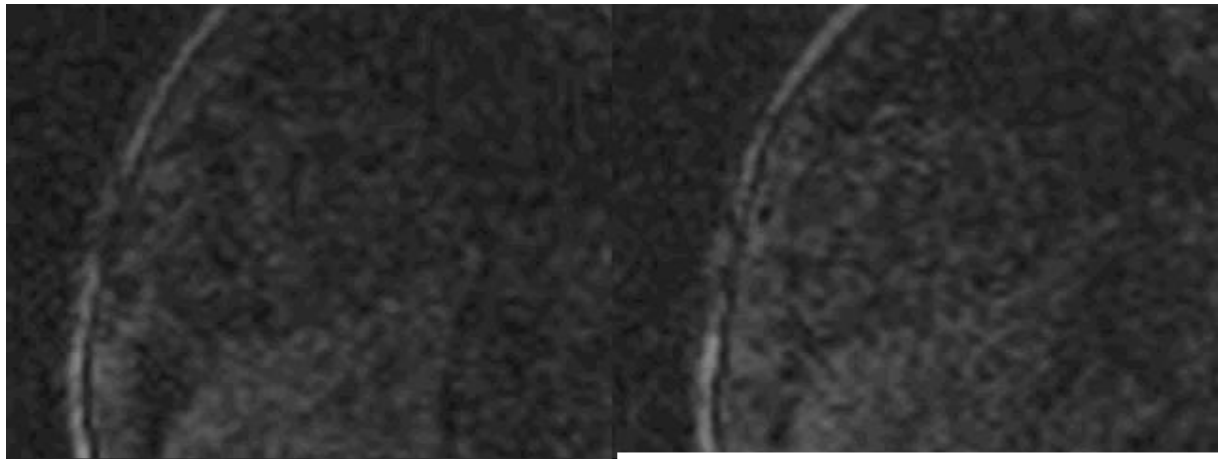
Positive findings in 8 patients:

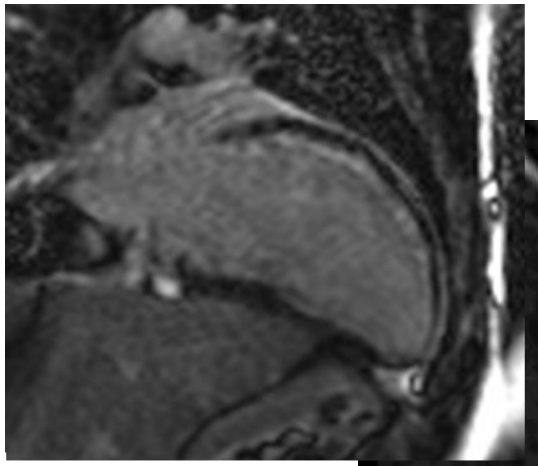
- 4 CHD: 2 TGA
  1 ALCAPA
  1 S/P surgery - LCA from RCS, intramural course
- 3 Cardiomyopathy (HCM)
- 1 Kawasaki disease

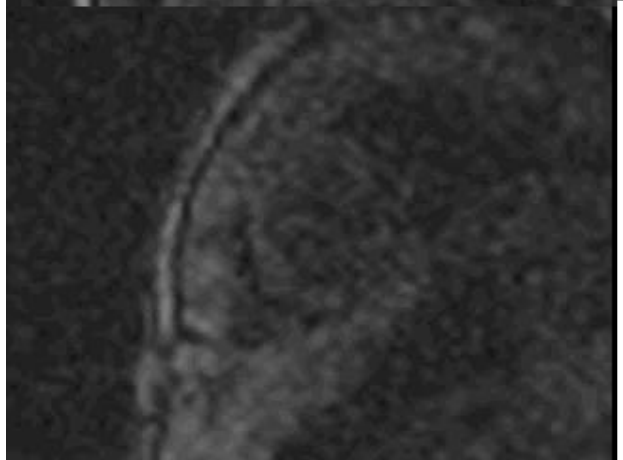
Current role of CMR in paediatrics

Stress perfusion

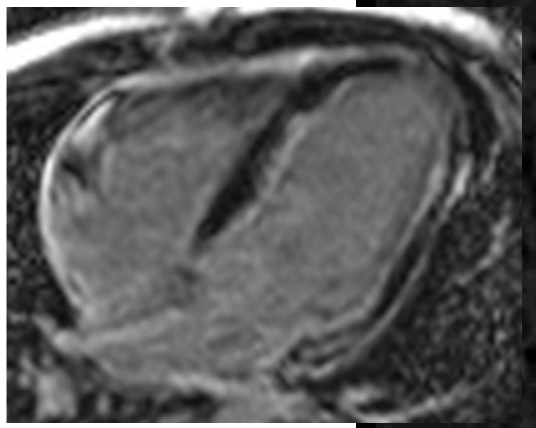
- Out of hospital arrest secondary to LCA stenosis at 18 months
- ECMO, Percutaneous angioplasty with stenting Nov 2019
- Surgical implantation of LIMA to LAD coronary graft June 2021
- Percutaneous LMCA angioplasty with re-stenting of LMCA

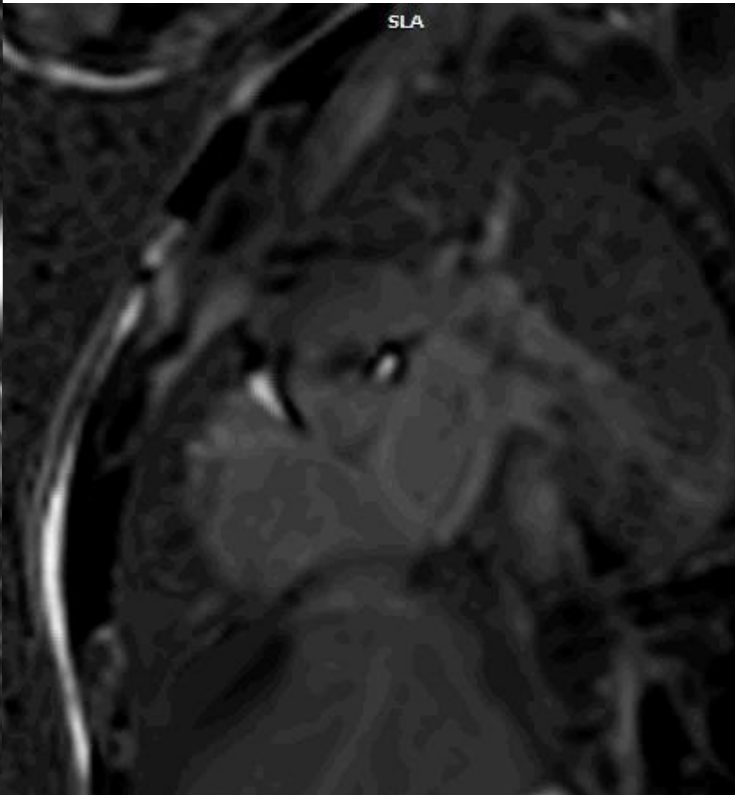






- Cines
- Stress perfusion
- LGE



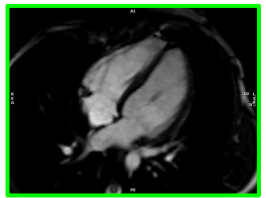
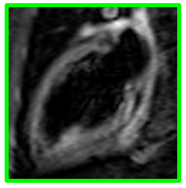
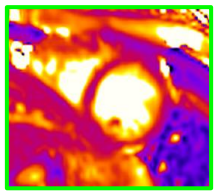
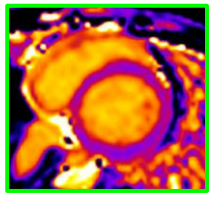
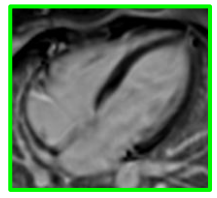


Current role of CMR in paediatrics

COVID/ PIMS/ vaccine related myocarditis

Globally, as of **5:43pm CEST, 28 October 2022**, there have been **626,337,158 confirmed cases** of COVID-19, including **6,566,610 deaths**, reported to WHO. As of **26 October 2022**, a total of **12,830,378,906 vaccine doses** have been administered.

- **Cines**
  - Volumes
  - Global systolic function
  - Regional wall motion abnormalities
- **Tissue characterisation**
  - **STIR T2**
    - Positive
      - Acute oedema Inflammation
    - Negative
  - **Parametric imaging**
    - **T2 mapping**
      - Positive
        - Acute oedema Inflammation
      - Negative
    - **T1 mapping**
      - Positive
        - Pathological process
      - Negative
  - **Gadolinium images**
    - Positive
      - Pathological process
    - Negative

Short-term sequelae of PIMS assessed by CMR

44 patients reviewed at RBH PIMS clinic between April and June 2020:
22 fulfilled the inclusion criteria:

1) 11 (50%) patients due to myocardial dysfunction
2) 6 (27%) patients had dilated coronary arteries
3) 5 (23%) patients had increased inflammatory markers

CMR performed at 12-72 days (mean 27 days) from the onset of symptoms

Volumes and function - all patients normal volumes, 1 patient mildly decreased LV EF
STIR – all negative
EGE – all negative
LGE - 2 patients positive late gadolinium enhancement
T2 mapping – mean global values normal in all patients
T1 mapping – mean global values normal in all but 1 pt (mild increase at midventricular level)

I. Altamar, S. Krupickova, JACC-CVI, 2

Myocardial deformation assessed by CMR in children after PIMS

30 patients after PIMS

- Onset-to-scan mean 27 days (range 9-72)
- Median age 9.0 years (range 0.9-14.4)
- CMR May 2020 and February 2021

30 healthy controls

- Median age 9.8 years (range 4.7-14.9)

Inclusion criteria:
Myocardial dysfunction
and/or dilated coronary arteries
and/or increased cardiac inflammatory markers

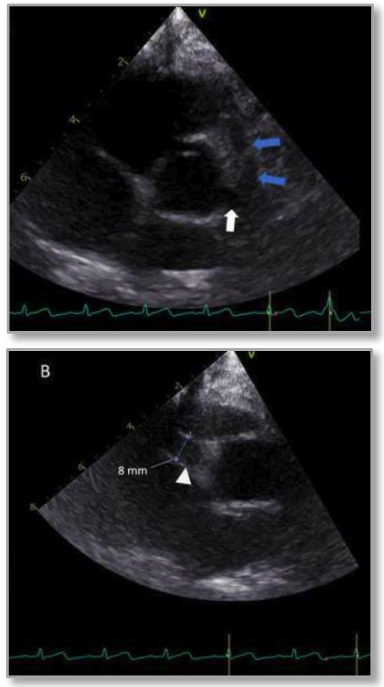
Conventional CMR parameters were normal
in majority of the patients

STRAIN	Patients Mean (SD) N=30	Controls Mean (SD) N=30	p value
SAX basal radial	26.1(7.2)	31.9(5.7)	**0.002**
SAX mid radial	29.4(9.1)	32.7(7.2)	**0.060**
SAX apical radial	45.5(12.4)	53.3(14.6)	**0.058**
SAX GLOBAL RADIAL	29.7(7.7)	34.6(5.9)	**0.016**
SAX basal circumferential	-16.2(3.1)	-18.7(2.1)	**0.003**
SAX mid circumferential	-17.8(3.5)	-19.1(2.4)	**0.077**
SAX apical circumferential	-22.6(3.3)	-24.6(3.4)	**0.043**
SAX GLOBAL CIRCUMFERENTIAL	-17.7(3.0)	-19.7(1.9)	**0.012**
LAX 4CH longitudinal	-13.6(3.9)	-16.0(3.0)	**0.014**
LAX 2CH longitudinal	-15.7(4.9)	-17.9(2.9)	**0.008**
LAX 3CH longitudinal	-13.5(3.3)	-17.2(2.8)	**<0.001**
LAX GLOBAL LONGITUDINAL	-14.2(3.5)	-16.9(1.8)	**<0.001**

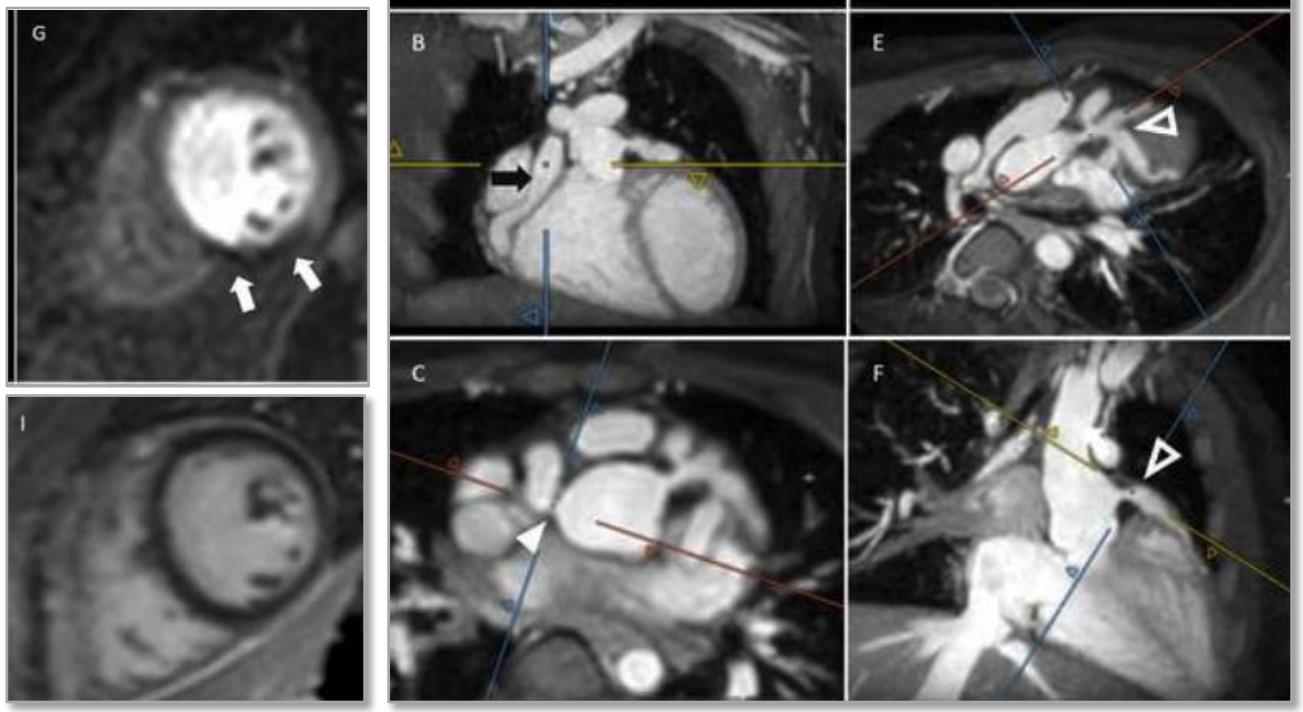
S Krupickova,I Voges, IJC, 2022

Coronary artery ectasia in a child with TGA after arterial switch operation and PIMS

- 22-month old child
- Presented with signs similar to KD
- SARS COVID-2 PCR negative
- SARS COVID-2 IgG antibodies positive
- Treated with Ig, aspirin and corticoids

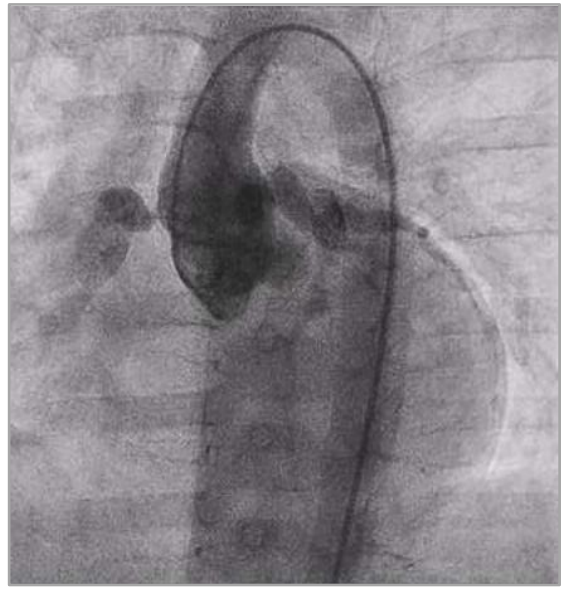


11 days after the onset of symptoms



26 days after the onset of symptoms

Cath at the age of 13 months



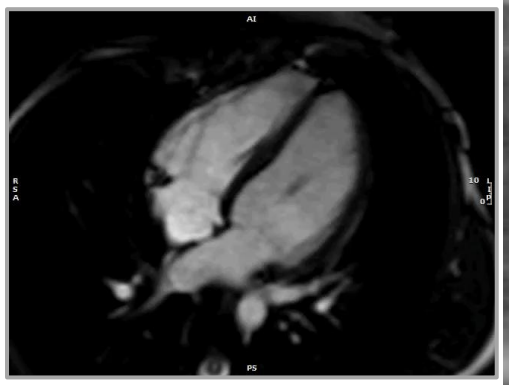
Cath 28 days after onset of symptoms
23 months of age

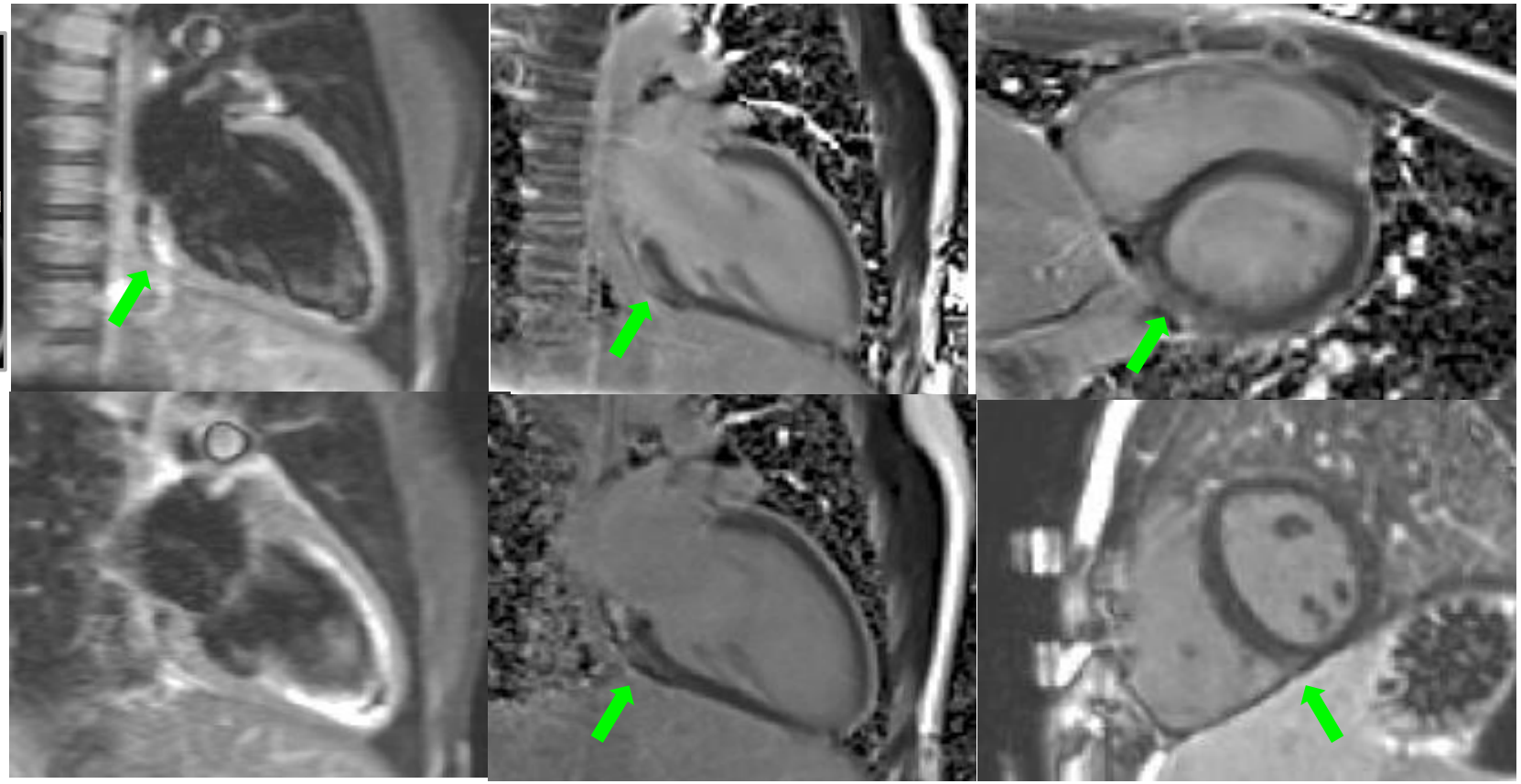
Inga Voges, Mohamed Sobh, EHJ-CR

Vaccine related myocarditis

Presented with chest pain, increased troponin and normal echocardiogram

At presentation



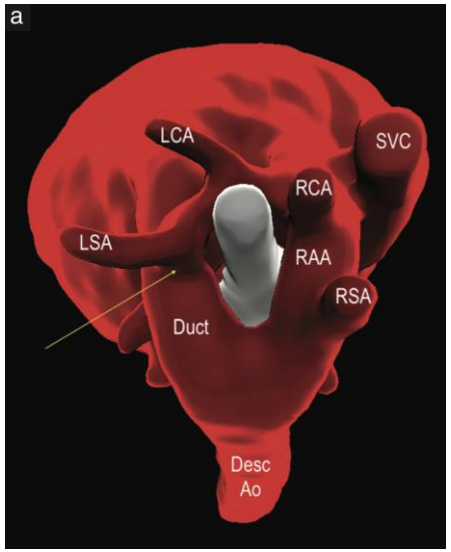


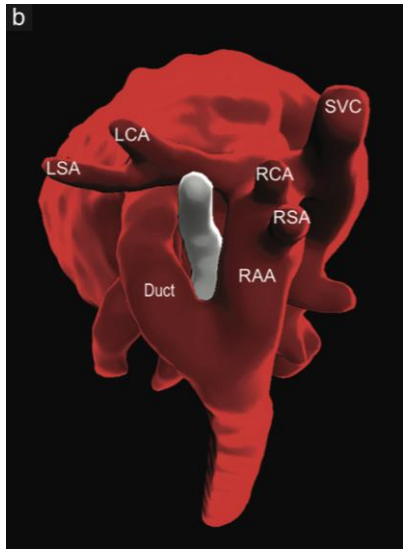
Follow-up, 2 months later

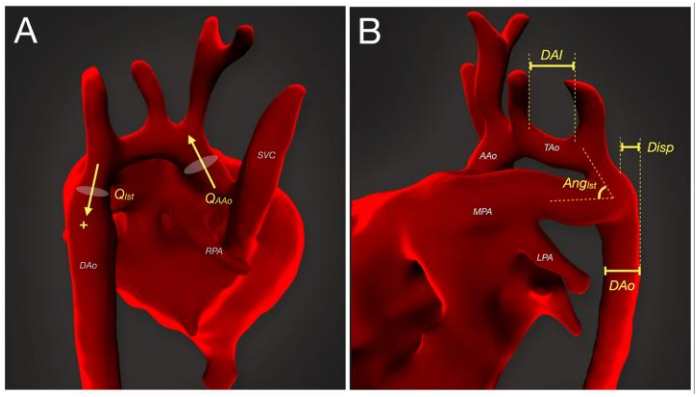
Normal LV and RV indexed volumes and normal ejection fraction
No regional wall motion abnormalities

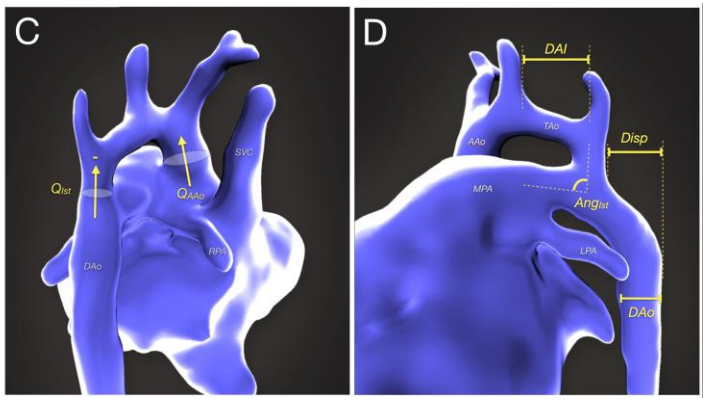
Current role of CMR in paediatrics

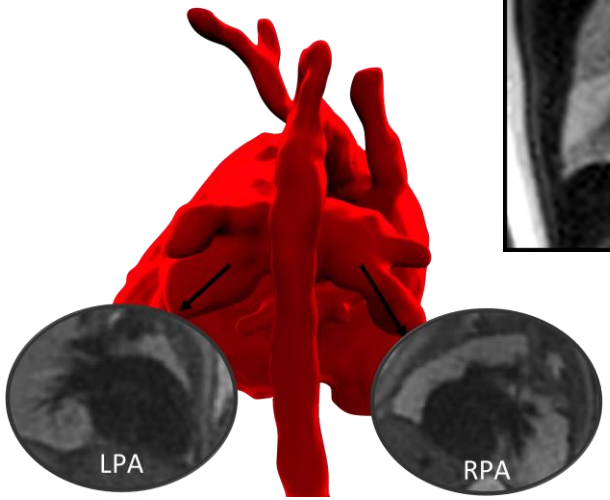
Fetal MRI

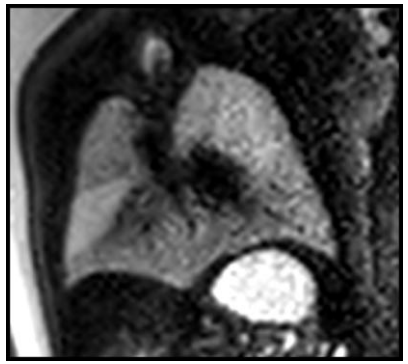


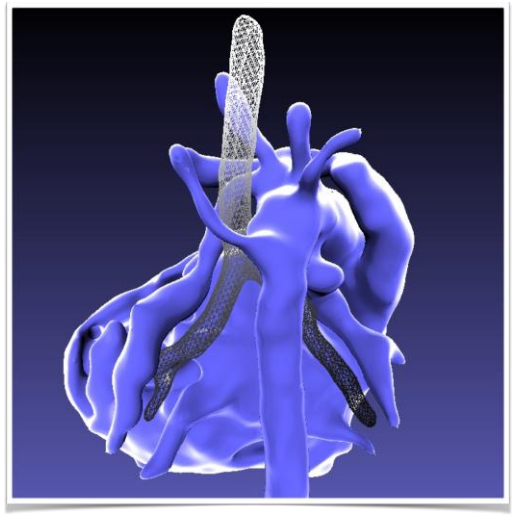


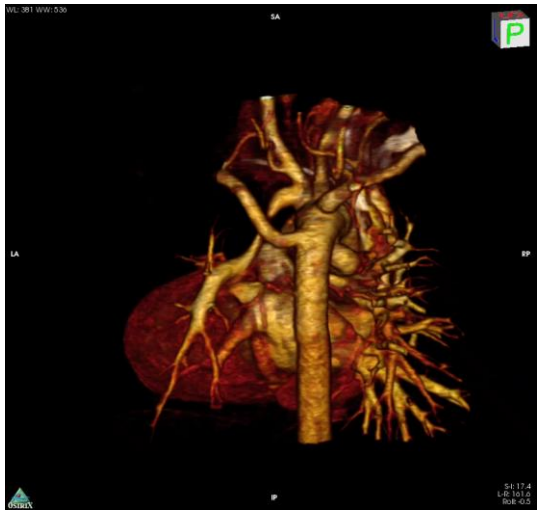






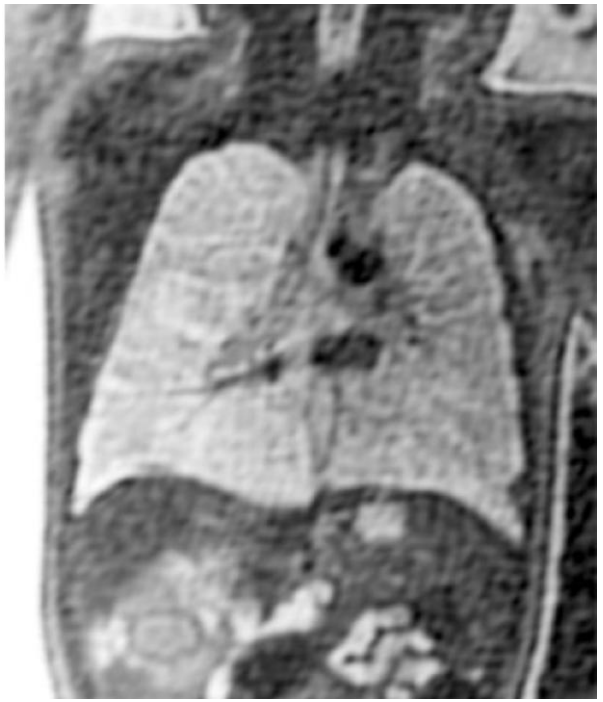






Courtesy of Kuberan Pushparajah

Current role of CMR in paediatrics
Fetal MRI



Pulmonary lymphangiectasia – “nutmeg lung”

44 patients with HLH

“Nutmeg lung” – 4 patients - all died within 5 months
Without nutmeg lung – 40 patients – 35% died / heart transplant

Saul D et al. Pediatr Radiol (2016) 46:483-489

Courtesy of Kuberan Pushparajah

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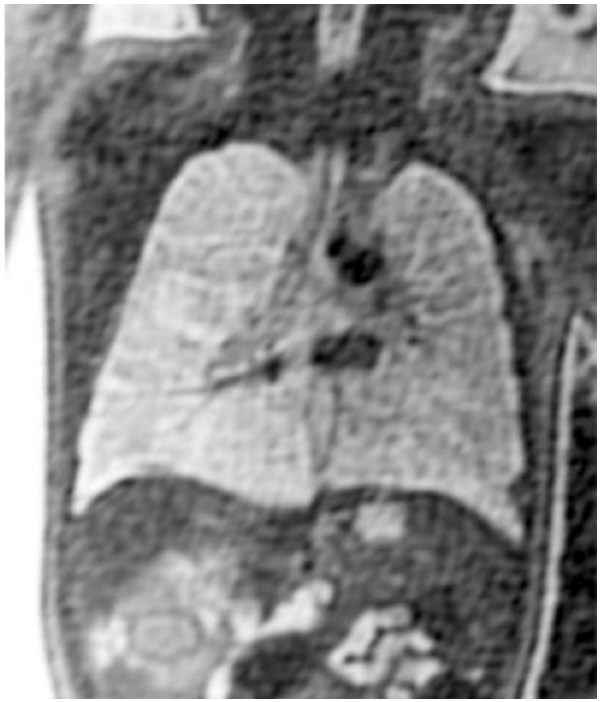

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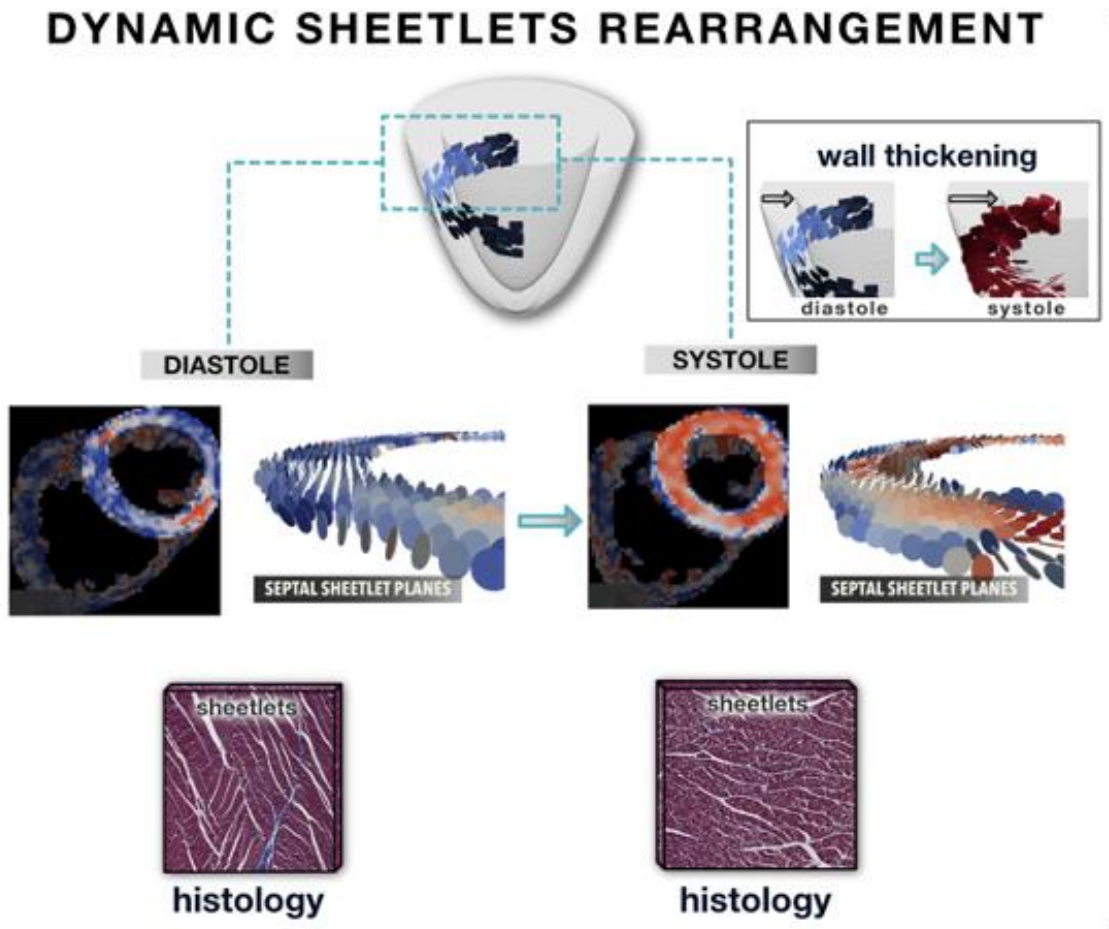
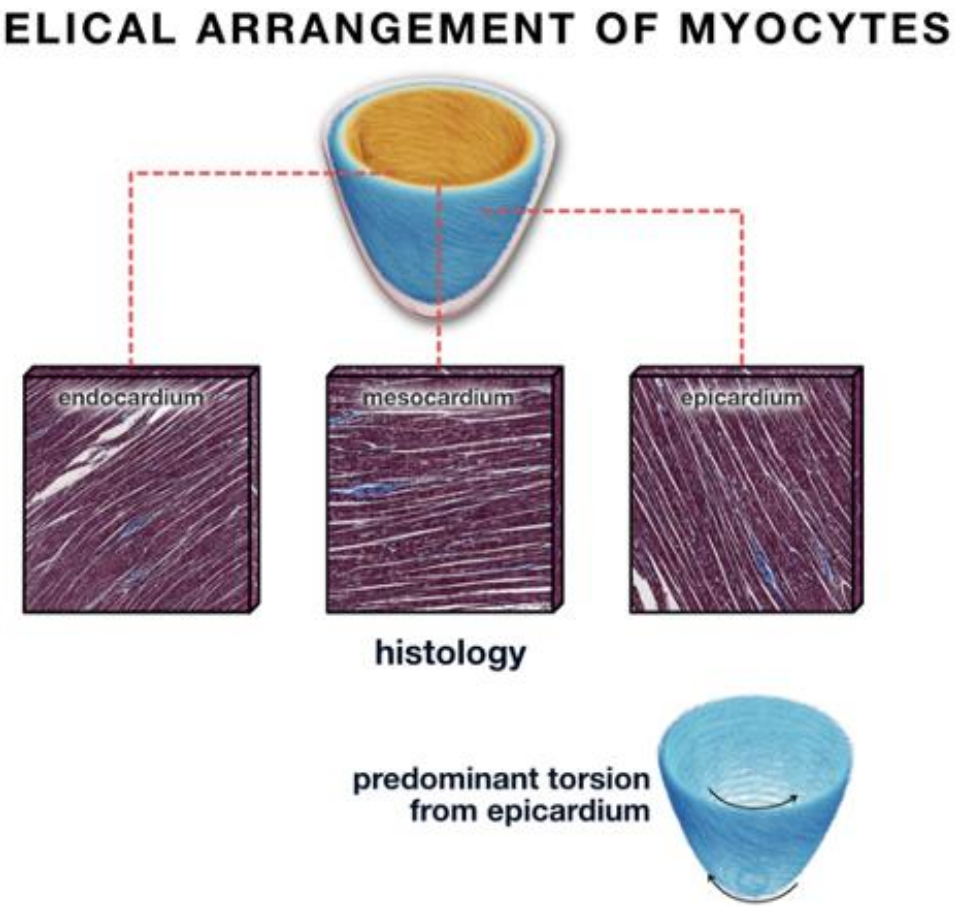
Courtesy of Kuberan Pushparajah

Current role of CMR in paediatrics

Diffusion tensor CMR in-vivo microstructure

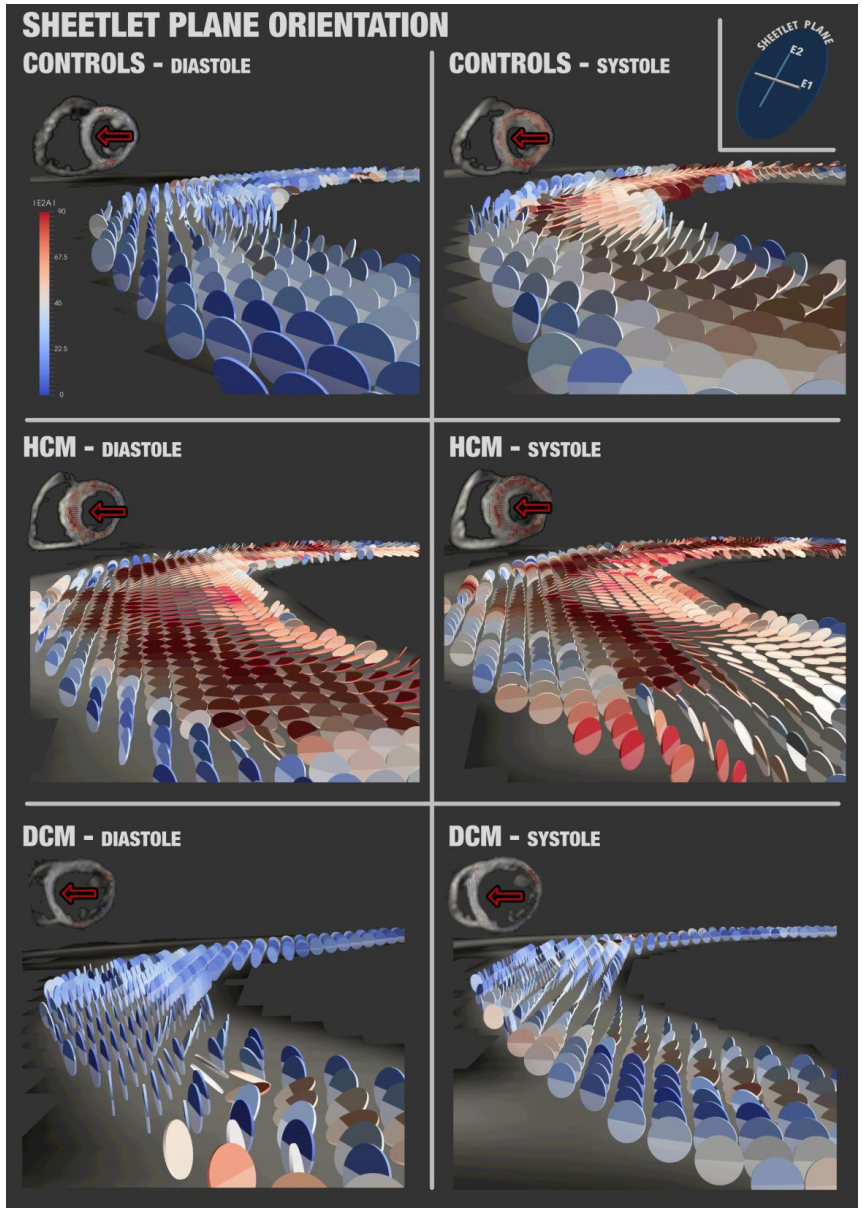




Khalique, JACC CVI, 2019

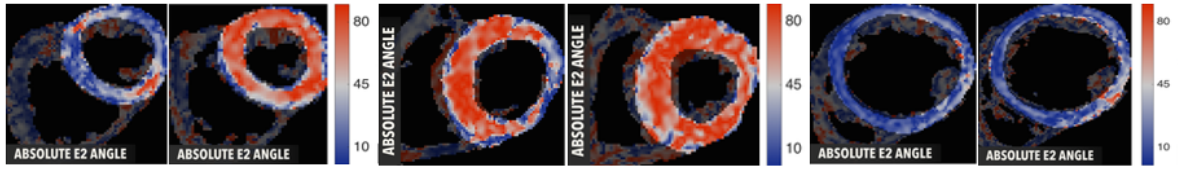
Diffusion tensor CMR

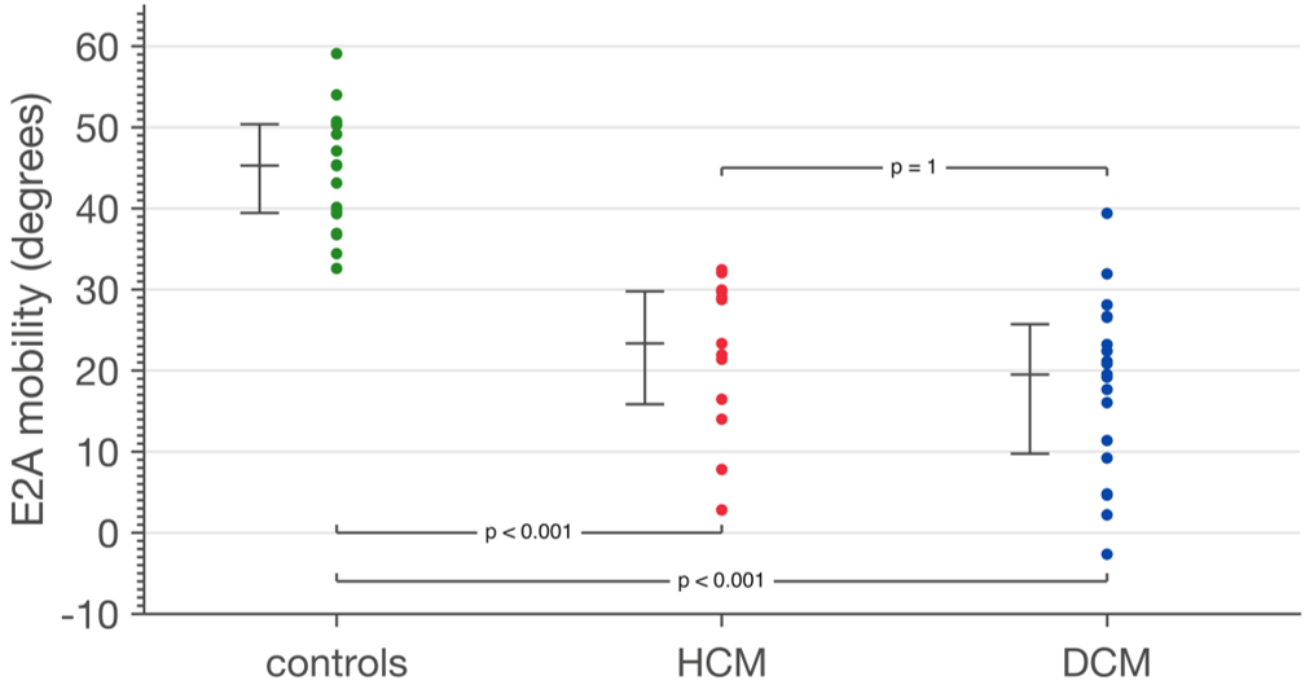
Cardiomyopathy: sheetlet impairment



Nielles-Vallespin, JACC 2017

HEALTHY **HCM** **DCM**

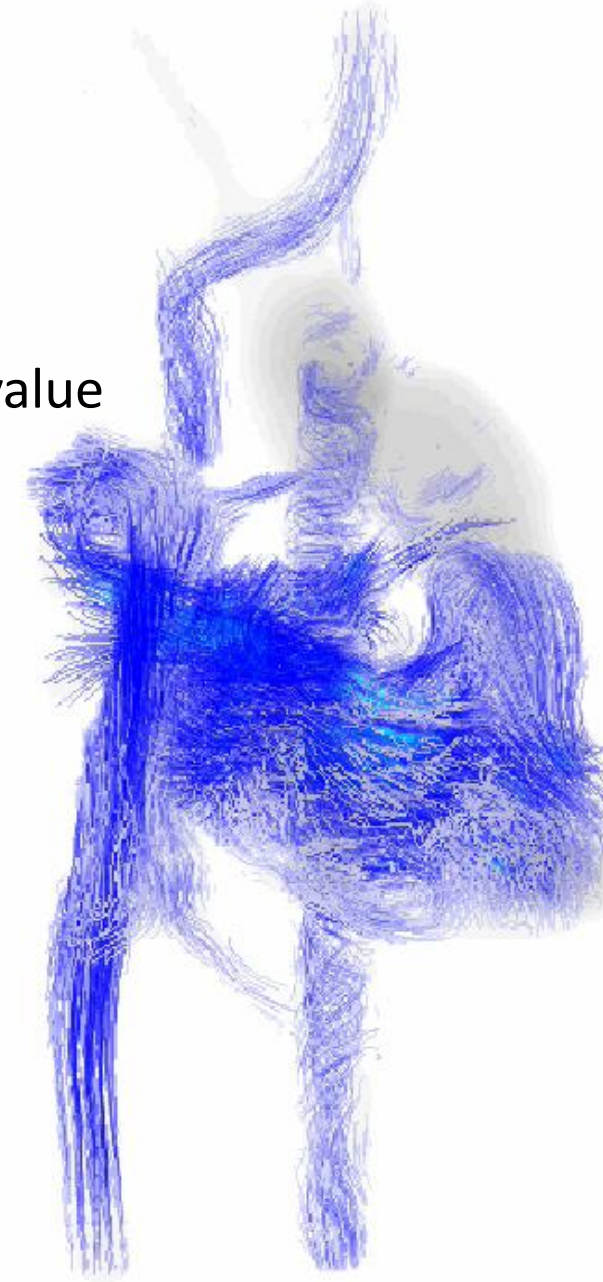




RADIAL STRAIN	0.64 [0.25]	0.24 [0.32]	0.24 [0.12]

Conclusion

- CMR is a very fast developing imaging method
- Provides anatomical, functional data, tissue characterization and prognostic value
- Providing clinically important information from fetal life to adulthood
- Tool providing inside in pathomechanisms
- Arteficial intelligence
- Acceleration techniques



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Thank you for your attention

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Current role of CMR in paediatrics
Cardiomyopathy

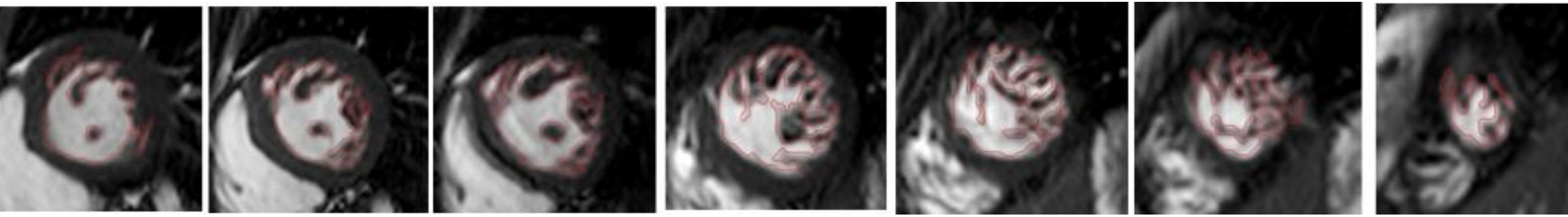
Left ventricular non-compaction

84 children, CMR scan between 2011-2018:

- 28 subjects with LVNC
- 28 with hyper-trabeculation
- 28 healthy controls

Patients divided into 3 groups based on Petersen criteria, NC:C ratio:

- LVNC ≥2.3
- Hyper-trabeculation ≥1.8 and <2.3
- Controls <1.8



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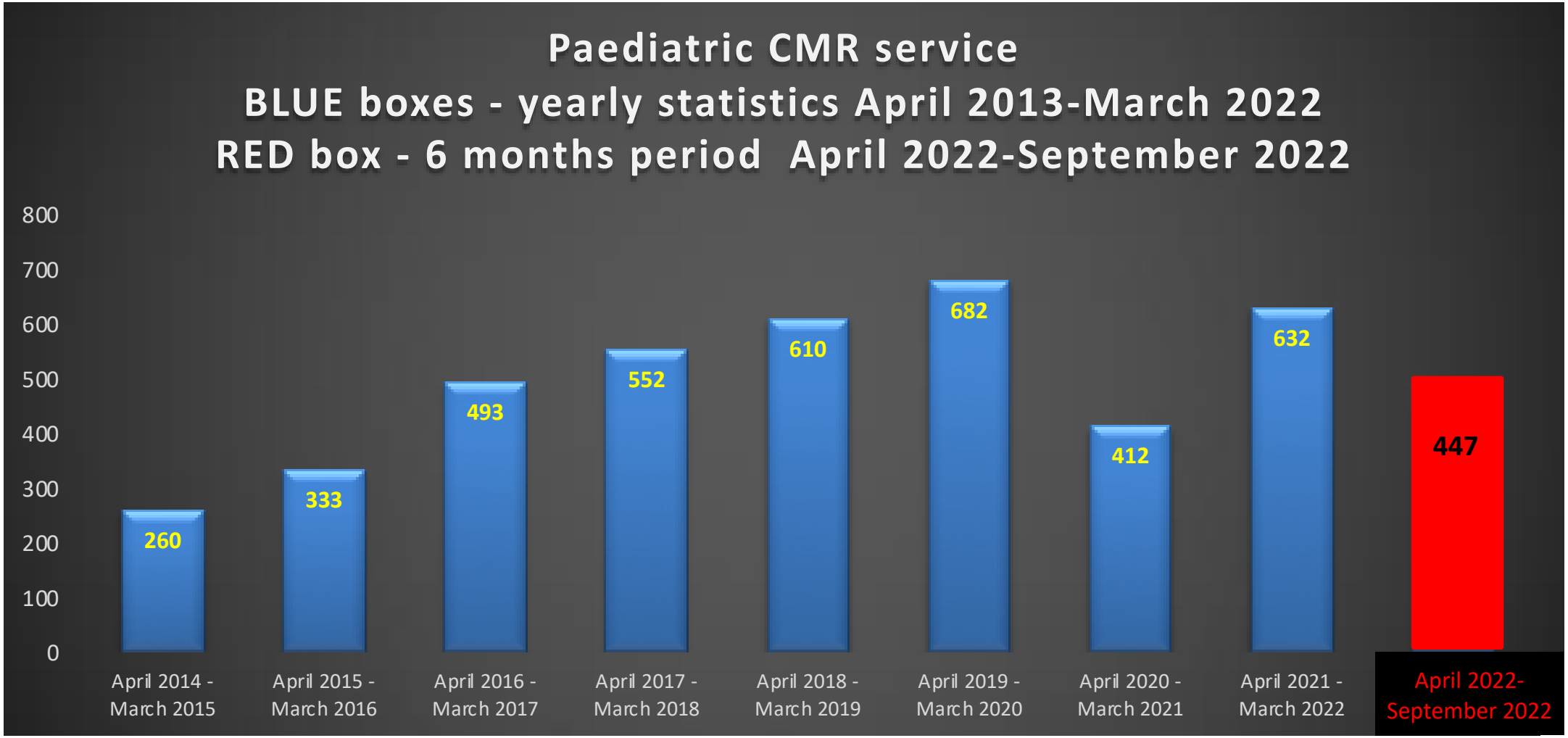
Current role of CMR in paediatrics
Royal Brompton Hospital, London



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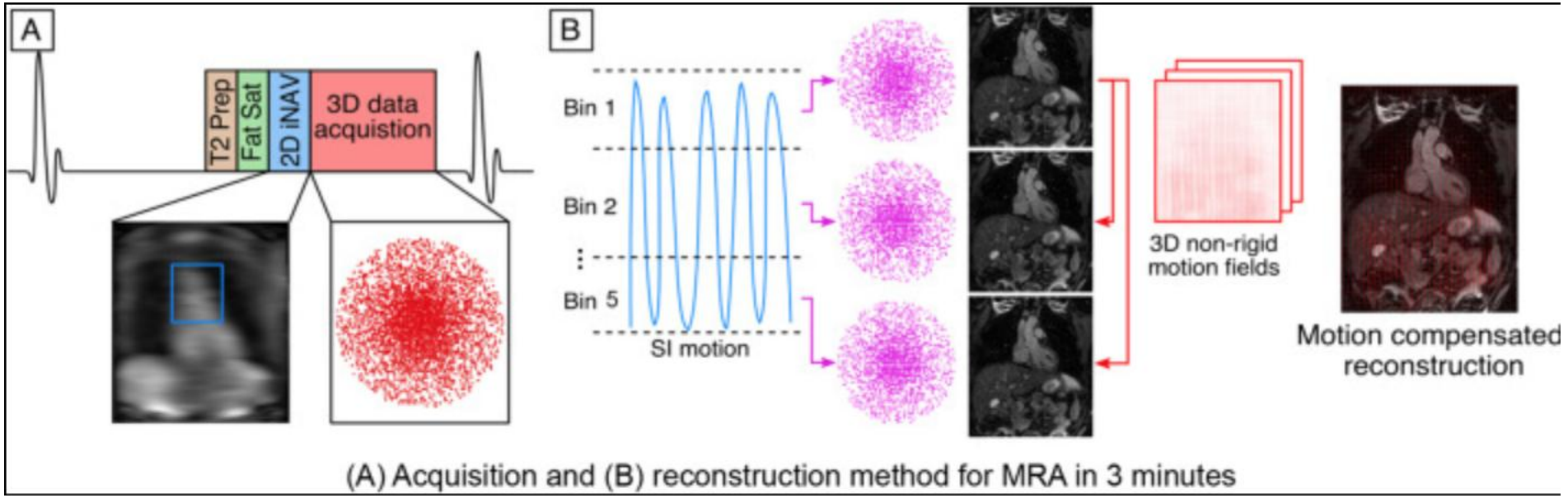
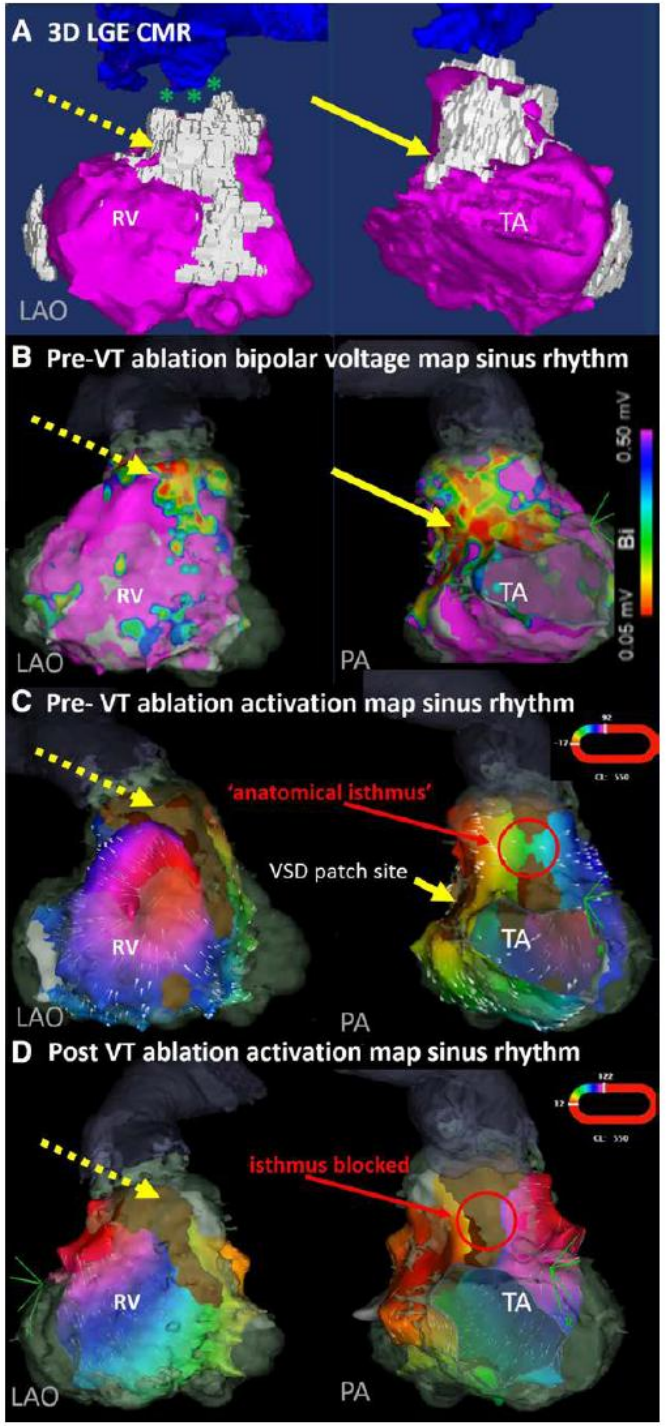
Reliability of pediatric ventricular function analysis by short-axis "single-cycle-stack-advance" single-shot compressed-sensing cines in minimal breath-hold time.
Hatipoglu S, Gatehouse P, Krupickova S, Banya W, Daubeney P, Almogheer B, Izgi C, Weale P, Hayes C, Firmin D, Pennell DJ.Eur Radiol. 2022 Apr;32(4):2581-2593.

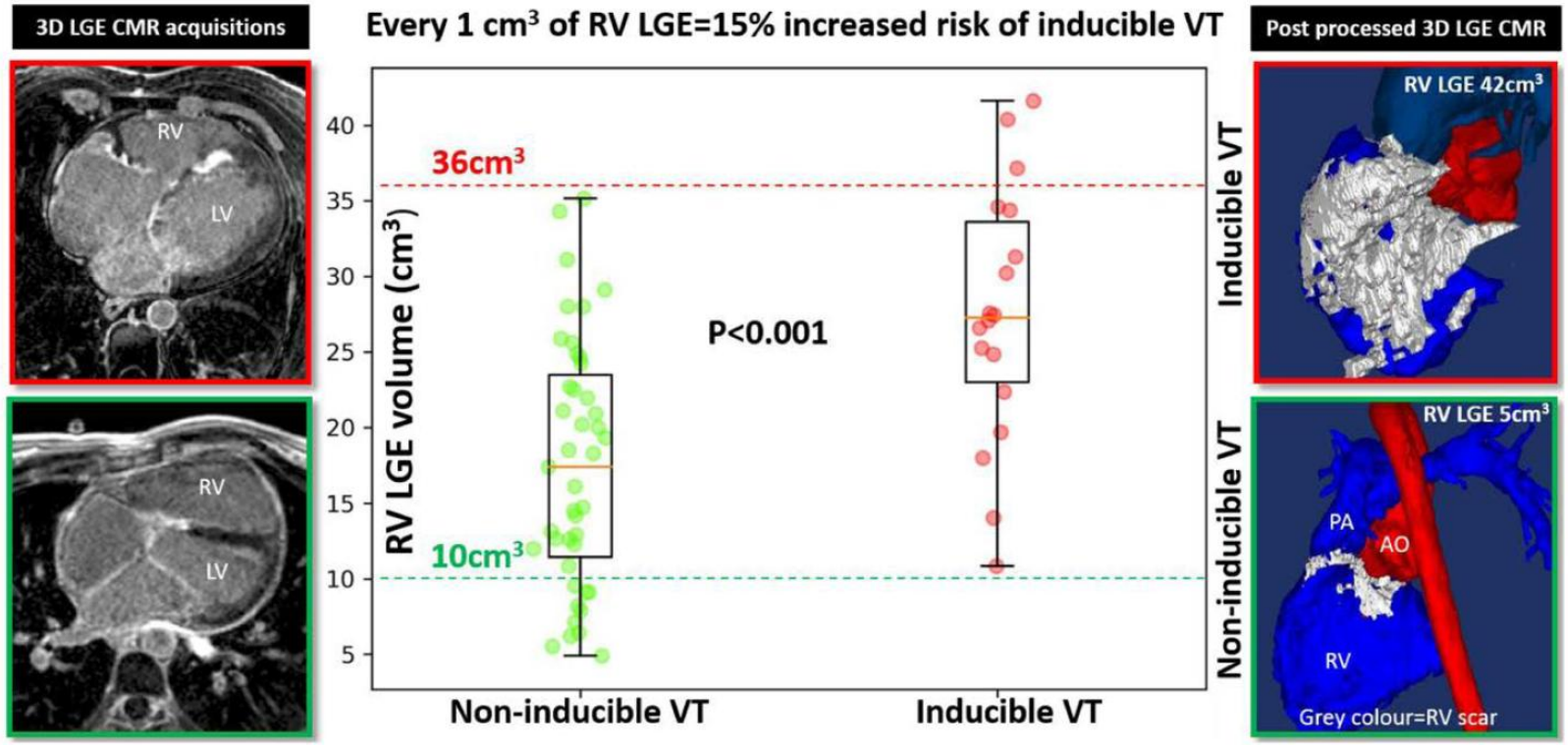
CS flow Sara



(A) Acquisition and (B) reconstruction method for MRA in 3 minutes

Current role of CMR in paediatrics Arrhythmias





RV scar burden in adult patients with repaired TOF measured using 3D LGE independently predicted inducible VT during invasive programmed electrical stimulation.

S Babu-Narayan, S. Ernst, Circ Arrhyth Electrophysiol, 2020