From 3D to 4D Rotational Angiography : Technical Feasibility and Clinical Value

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UMC Utrecht

Disclosure

- Gregor Krings : consultant Edwards, Medtronic
  Advisory Board Siemens
- Oliver Taubmann is supported by Siemens Healthcare.
- Günter Lauritsch is employee of Siemens Healthcare.

What do the candies
and 4DRA have in common ?

Disclaimer

The 4DRA concepts and information presented in this talk are based on research and are not commercially available

Introduction

3DRA is routine today

3DRA is **static**

4DRA is **dynamic**

"Imaging of dynamic nature of the heart with congenital defects in the cath-lab"

By courtesy of Daphne Yu, Siemens Medical Solutions USA, Inc., Princeton, NJ

Introduction

4DRA

Vision – Feasibility – Clinical Use

Demonstration of first results of

4DRA Feasibility study

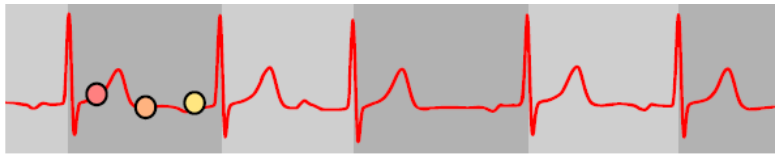
University of Erlangen

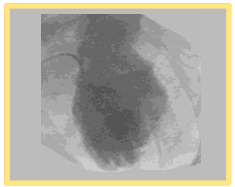
Siemens

UMC Utrecht, Children's Heart Center

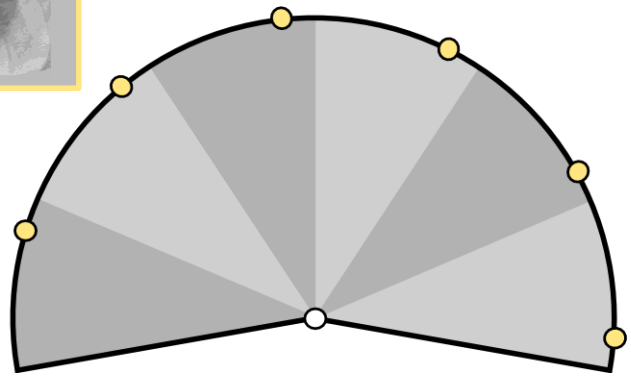
By courtesy of Daphne Yu, Siemens Medical Solutions USA, Inc., Princeton, NJ

ECG Gating – Angular Undersampling



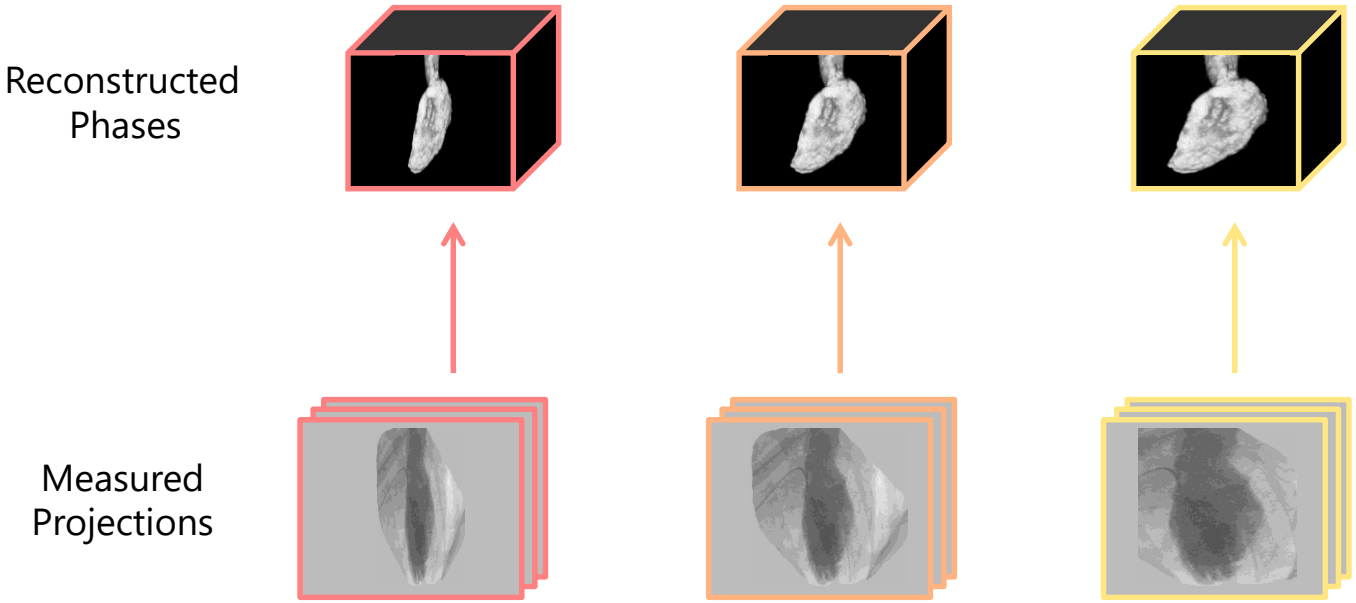


Phase 3: end-diastole

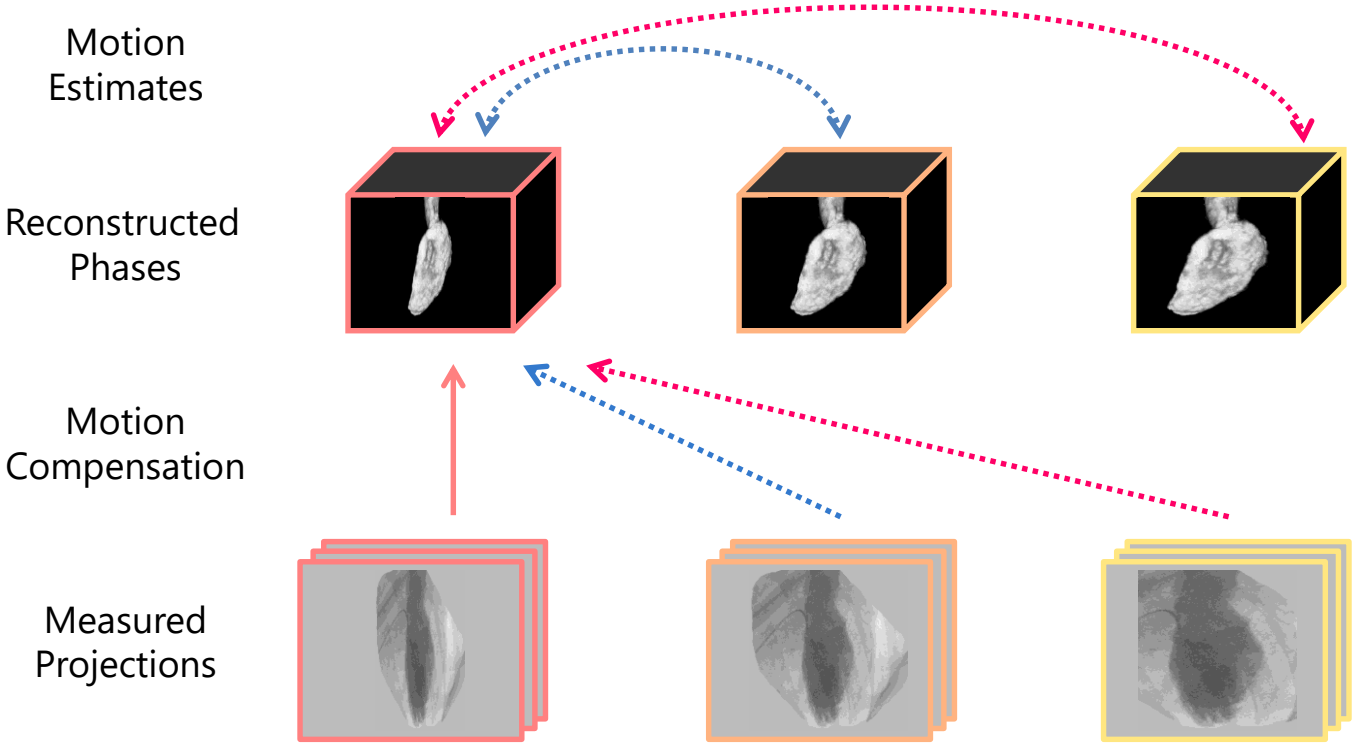


Few Samples Only for Preliminary Reconstruction of Cardiac Phases

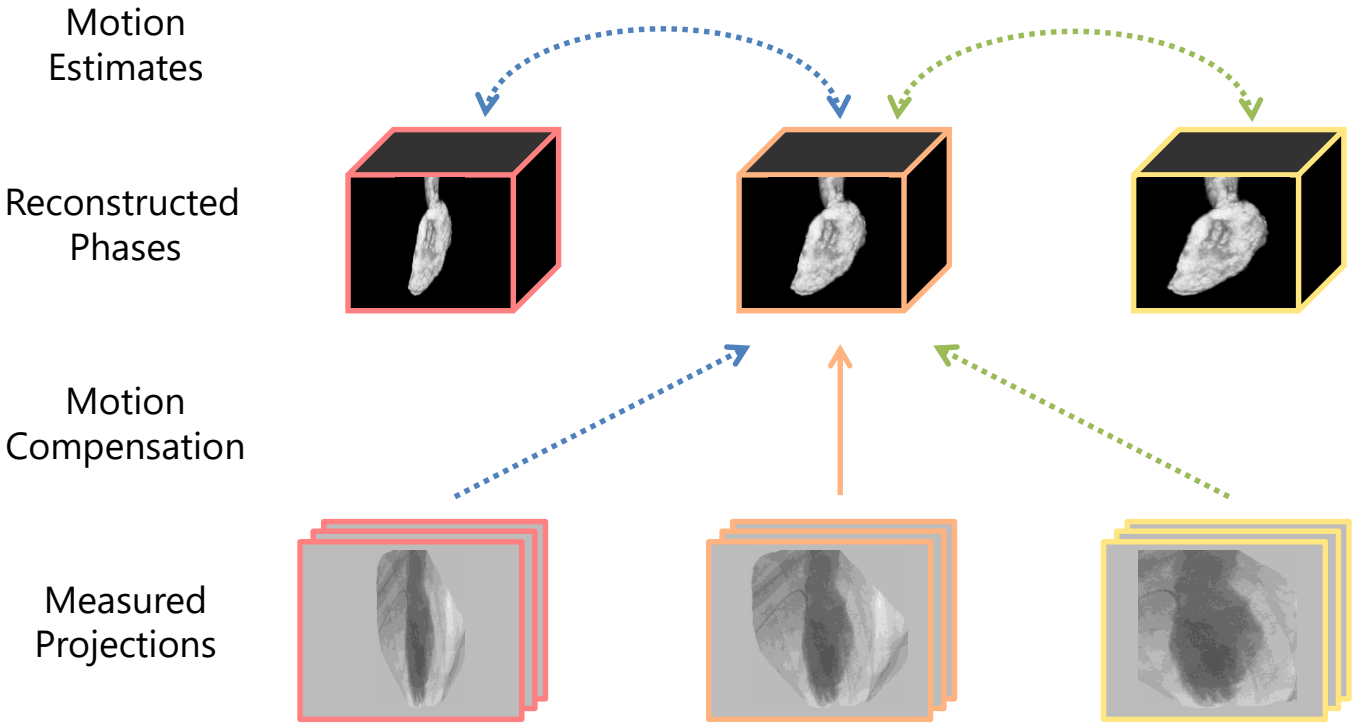
Preliminary images are reconstructed from few projection data only for motion estimating. The pre-images are strongly degraded by artifacts.



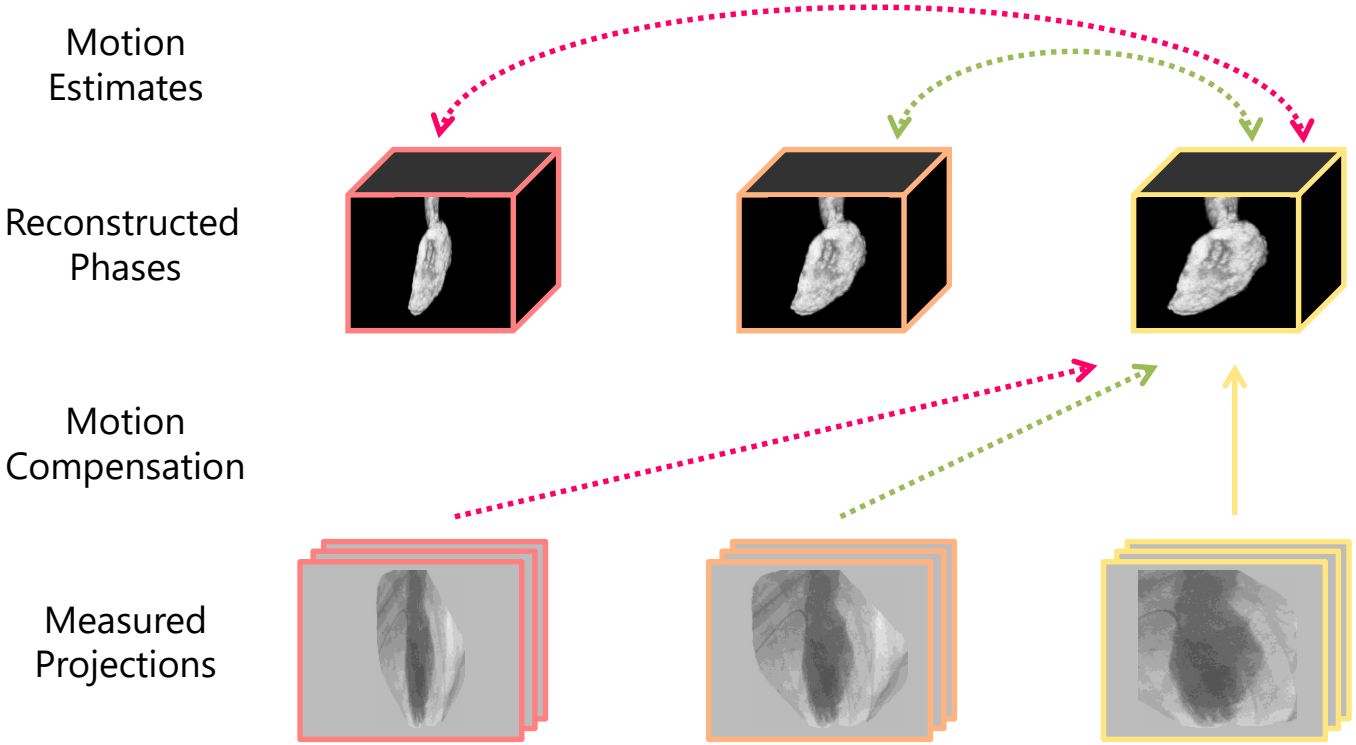
Motion Compensation – Reconstruction of Phase 1



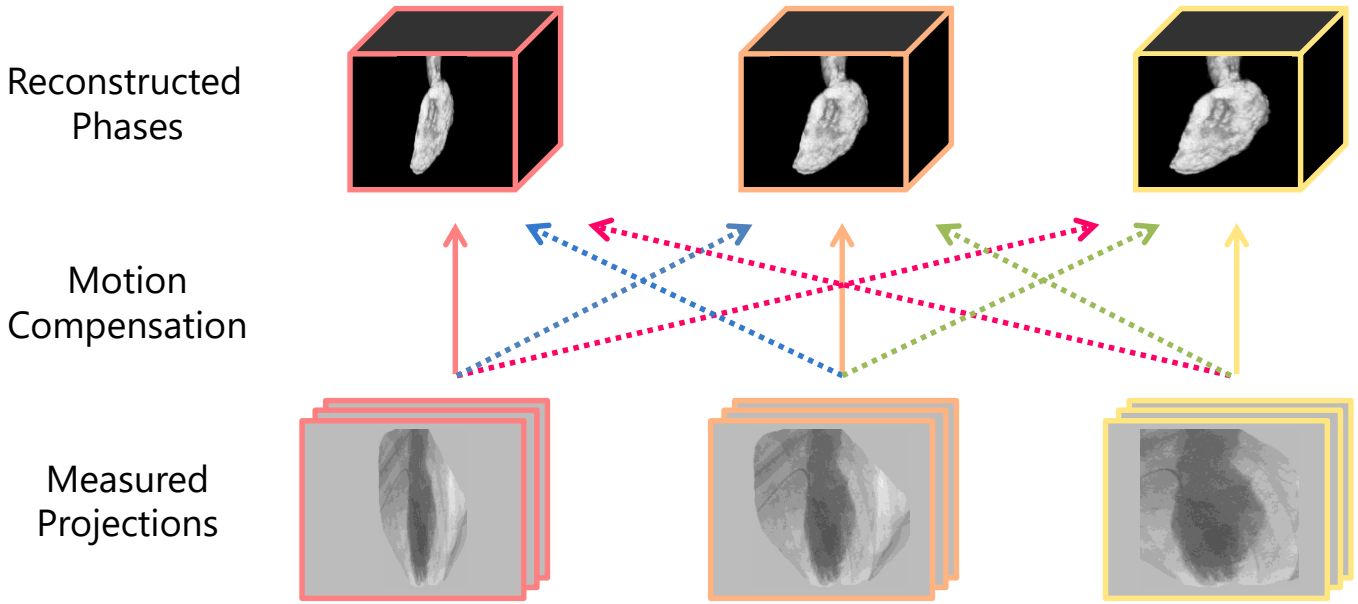
Motion Compensation – Reconstruction of Phase 2



Motion Compensation – Reconstruction of Phase 3

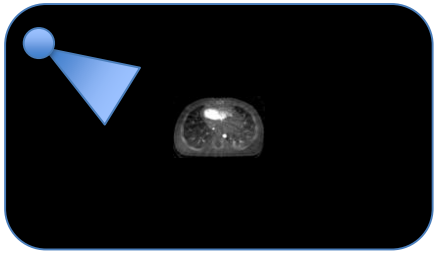


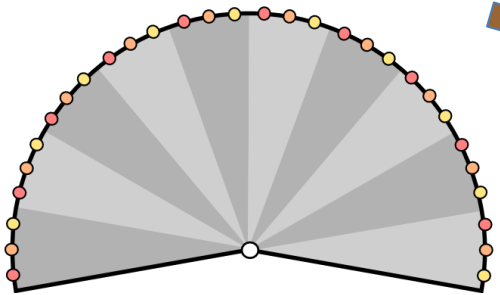
Motion Compensation – Making Use of All Data



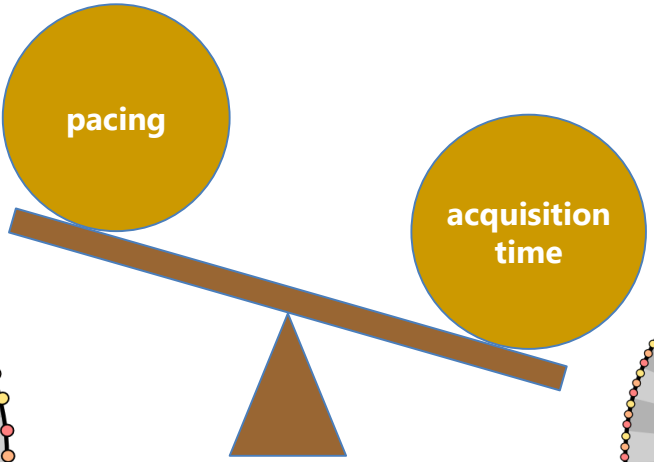
Usage of Pacing

Baby

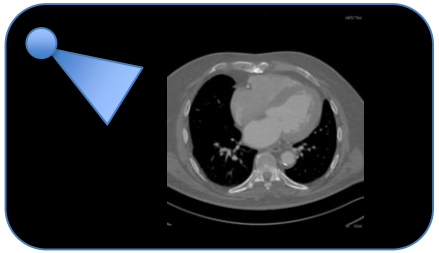


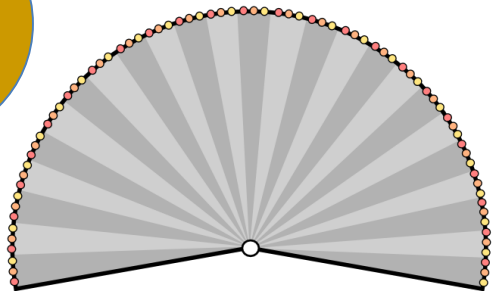


10 cardiac cycles required →
5s acq. time at 120bpm



Adult





25 cardiac cycles required →
10s acq. time at 150bpm

Trade-off in 4DRA Imaging Protocol

ALARA

minimal dose
few frames

image quality

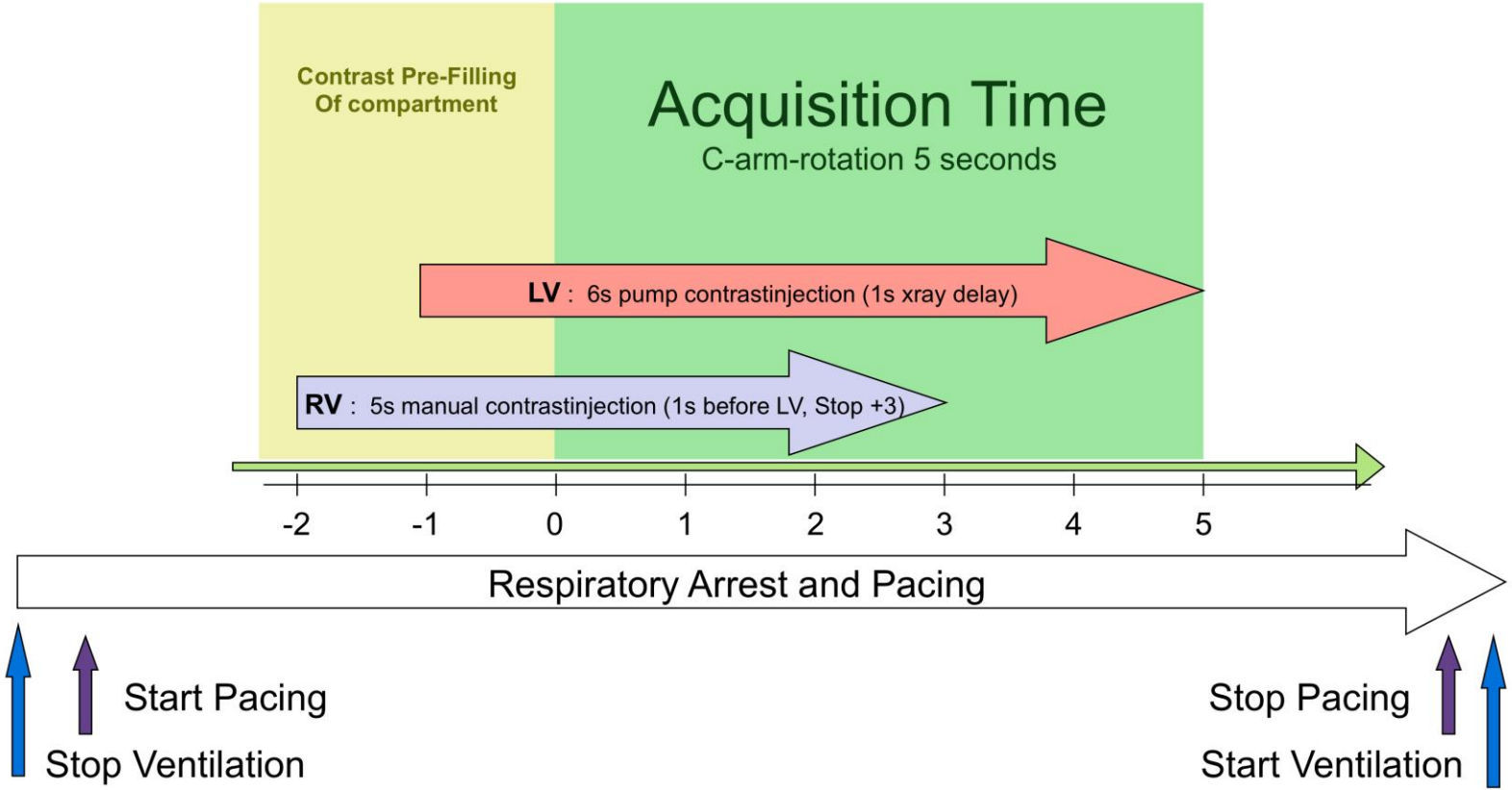
good temporal resolution
many frames per heart cycle

functional information in therapy

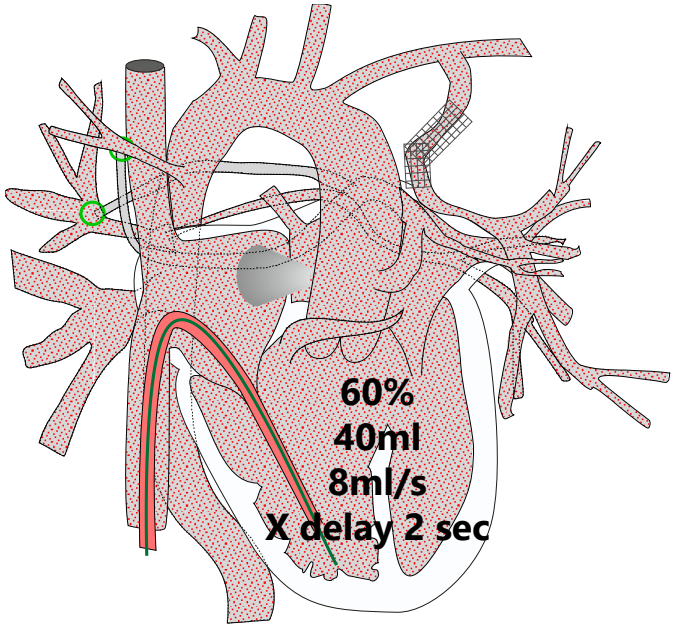
minimal contrast load
short acquisition time
→ pacing

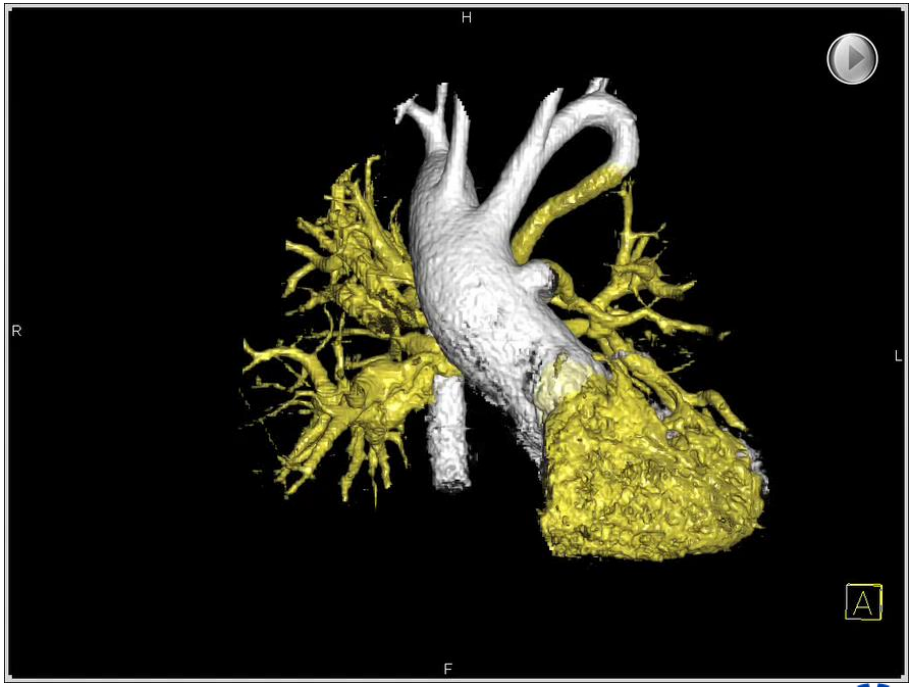
natural heart motion
no pacing
→ long acquisition time

4DRA Protocol – Utrecht Cookbook



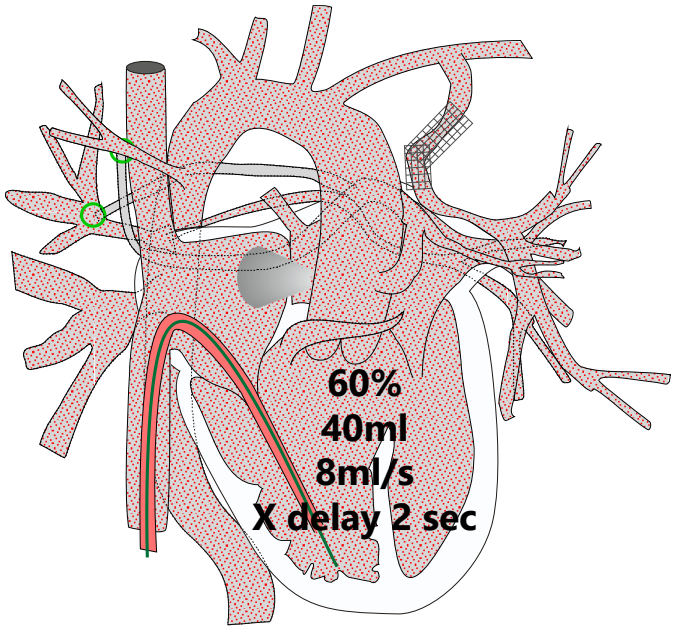
Case 1: Single Ventricle

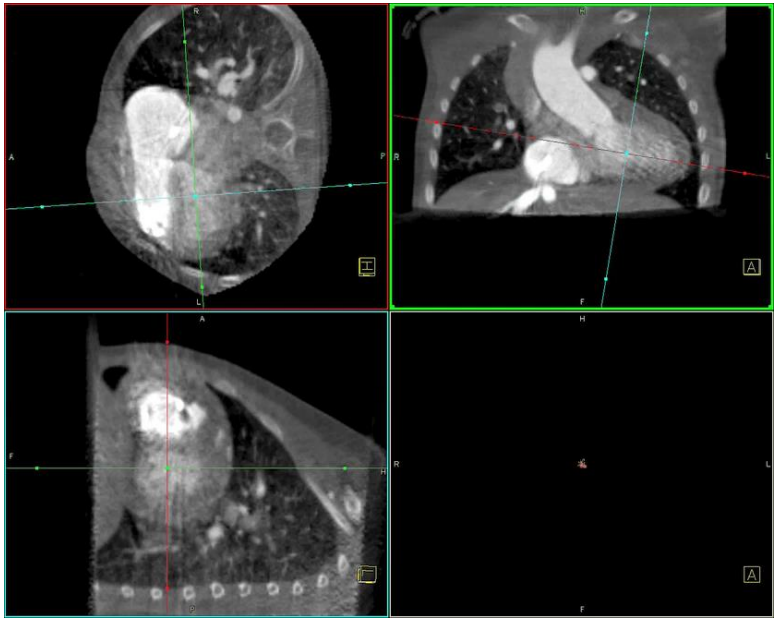




10kg, PA, Melbourne shunt
Pacing 210/min, cycles 18,
acquisition 5 sec, DAP 63 (242) μGym^2

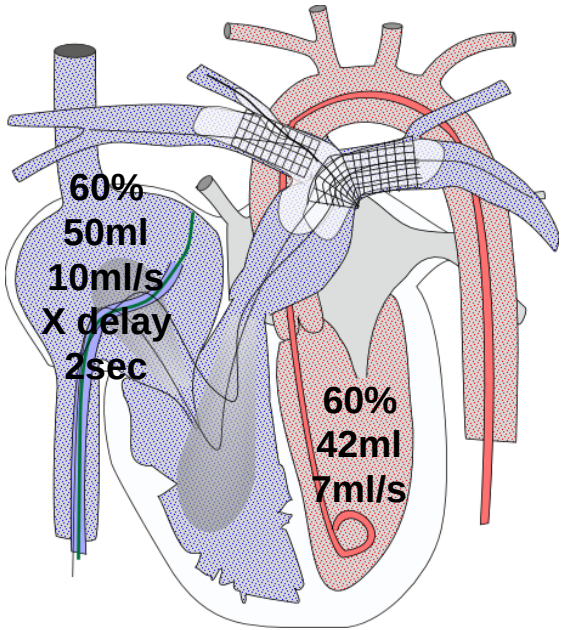
Case 1: Single Ventricle

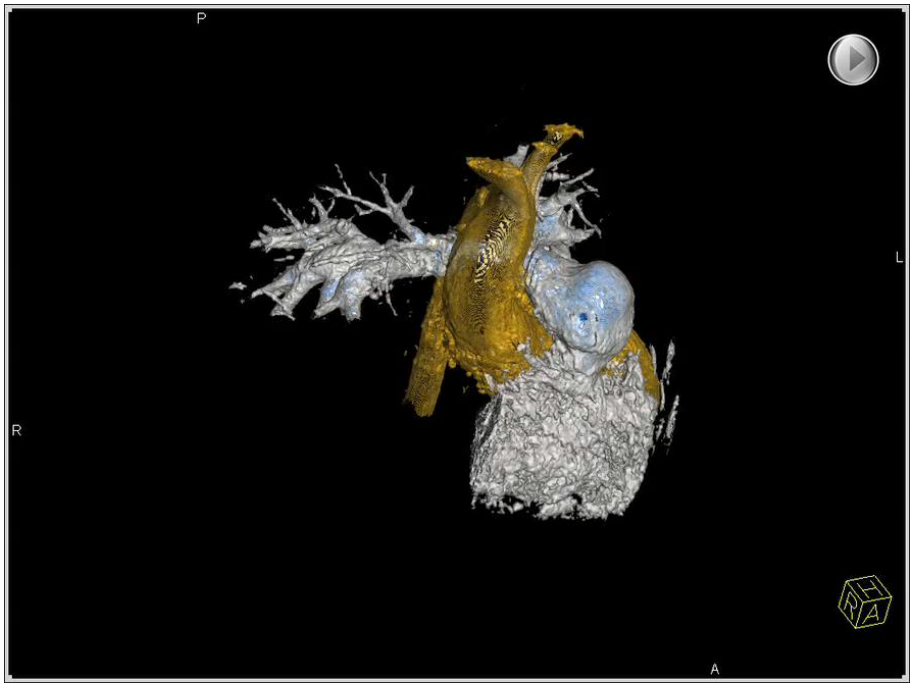




Pacing 210/min, cycles 18,
acquisition 5 sec, DAP 63 (242) μGym^2

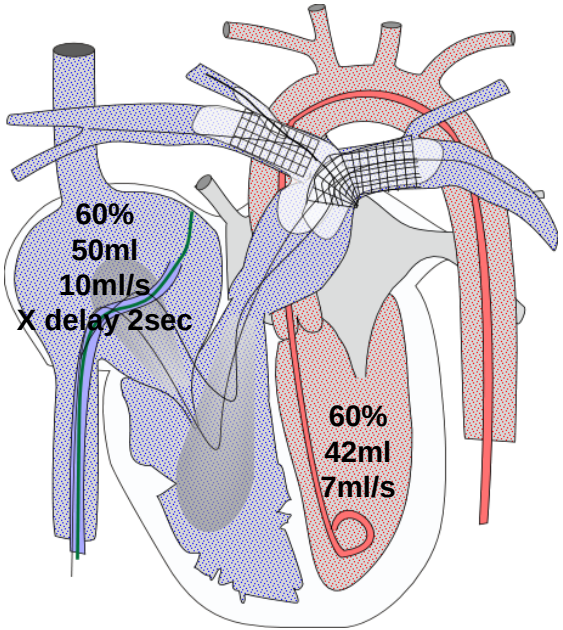
Case 2: Pulmonary Artery Stenoses

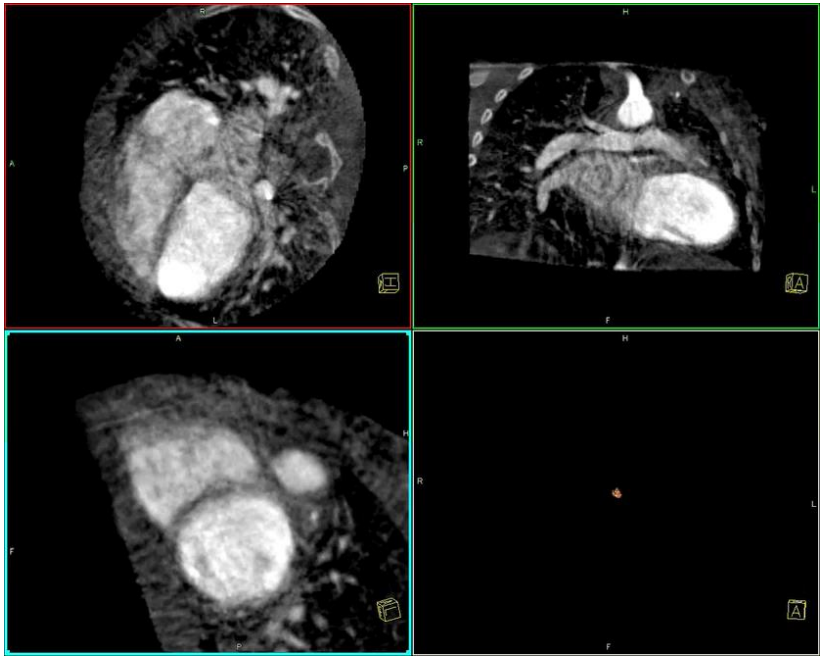




15 kg, PA VSD, Y stent PA Bifurcation
Pacing 140/min, cycles 12,
acquisition 5 sec, DAP 129 (305) µGym^2

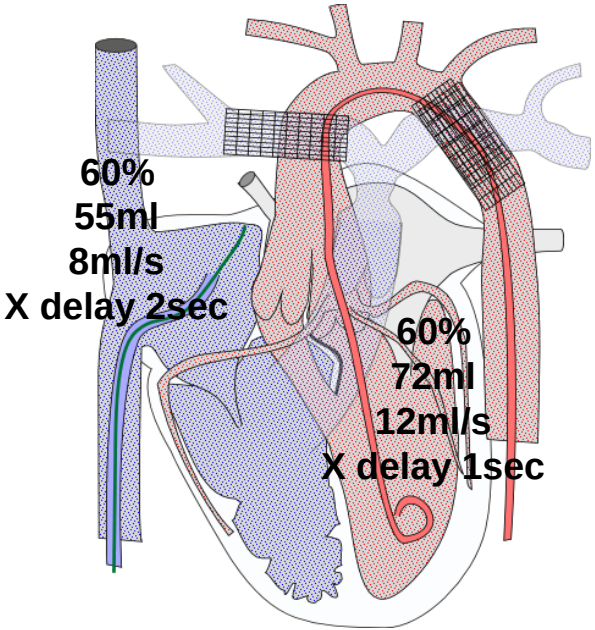
Case 2: Pulmonary Artery Stenoses

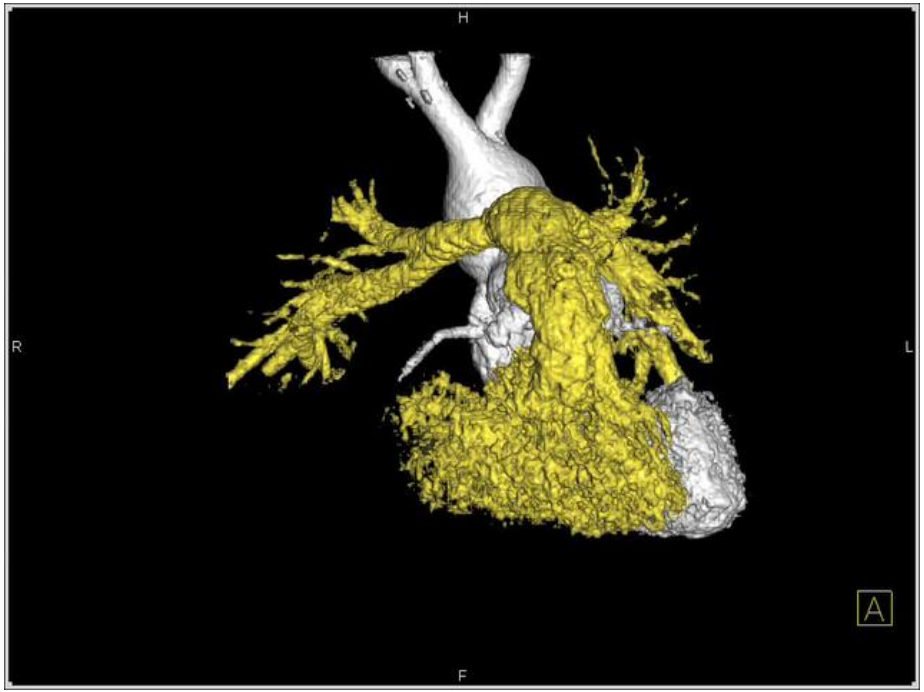




Pacing 140/min, cycles 12,
acquisition 5 sec, DAP 129 (305) μGym^2

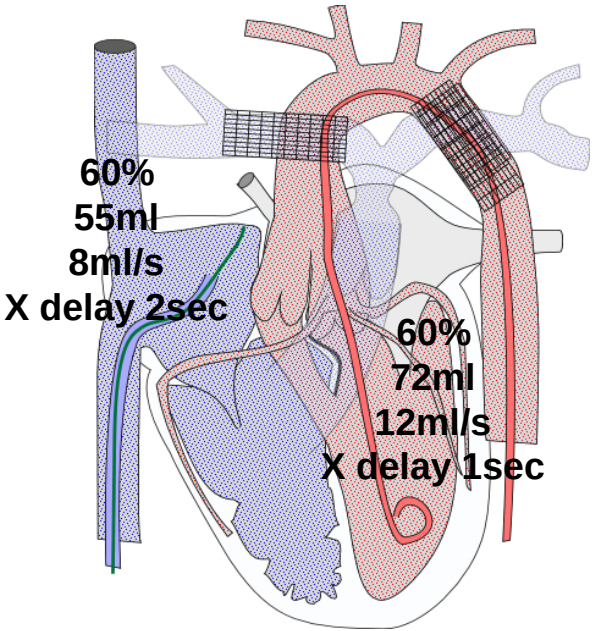
Case 3: Aortic Coarctation

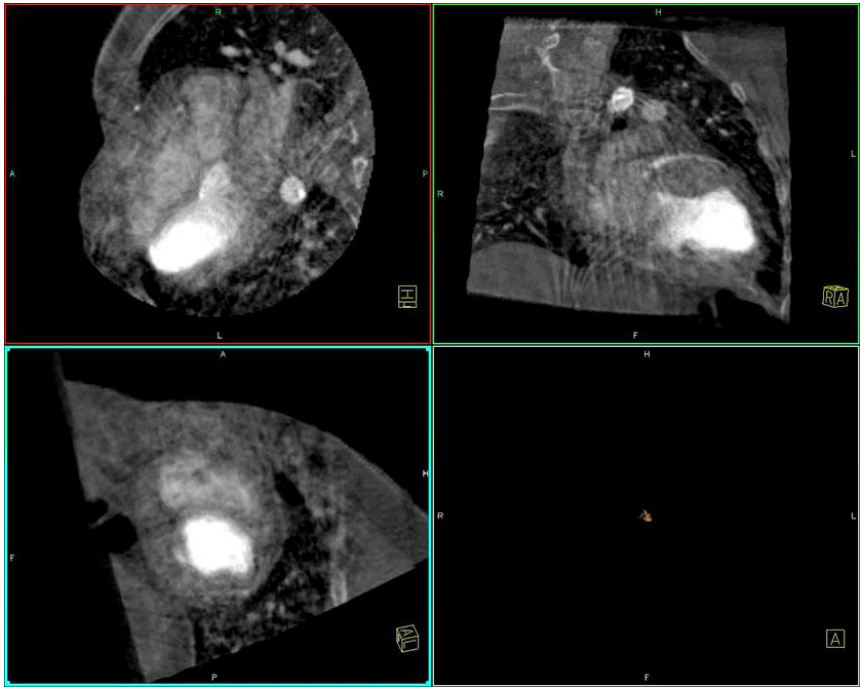




33 kg, HLHC, IAA, Norwood Rastelli, Pacing 170/min, cycles 14,
acquisition 5 sec, DAP 615 (1493) μGym^2

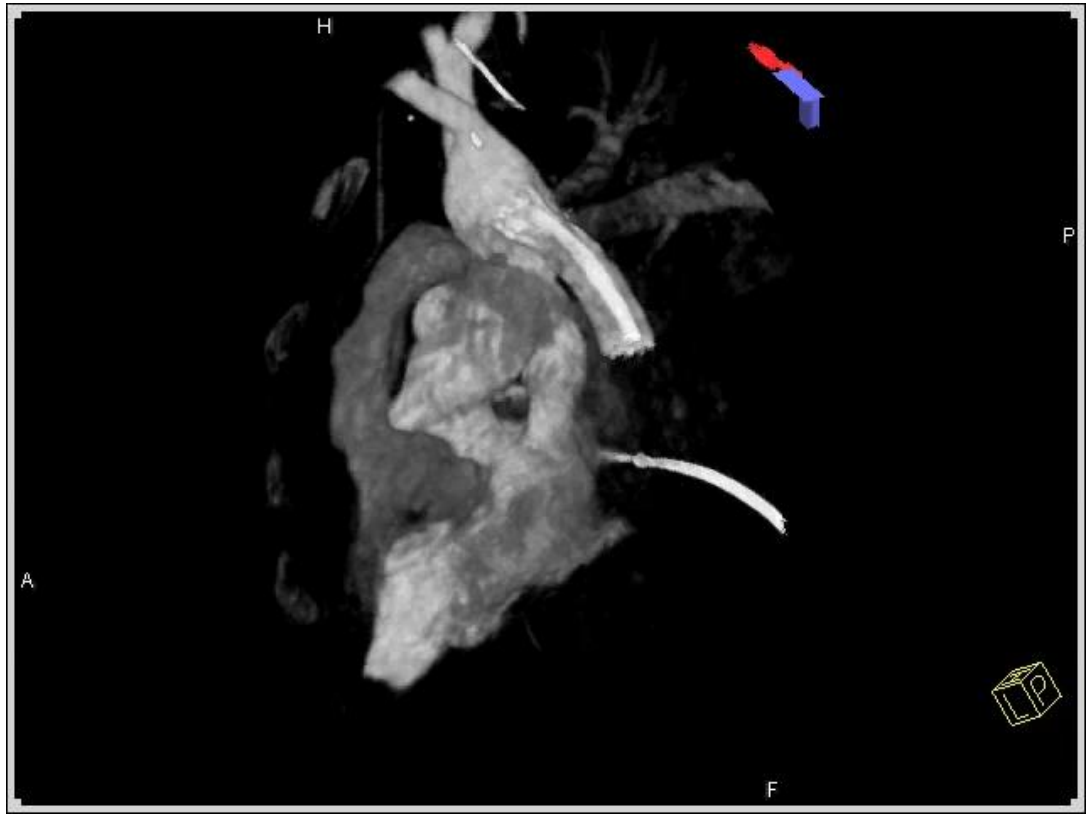
Case 3: Aortic Coarctation





Pacing 170/min, cycles 14,
acquisition 5 sec, DAP 615 (1493) μGym^2

Case 3: Functional Analysis

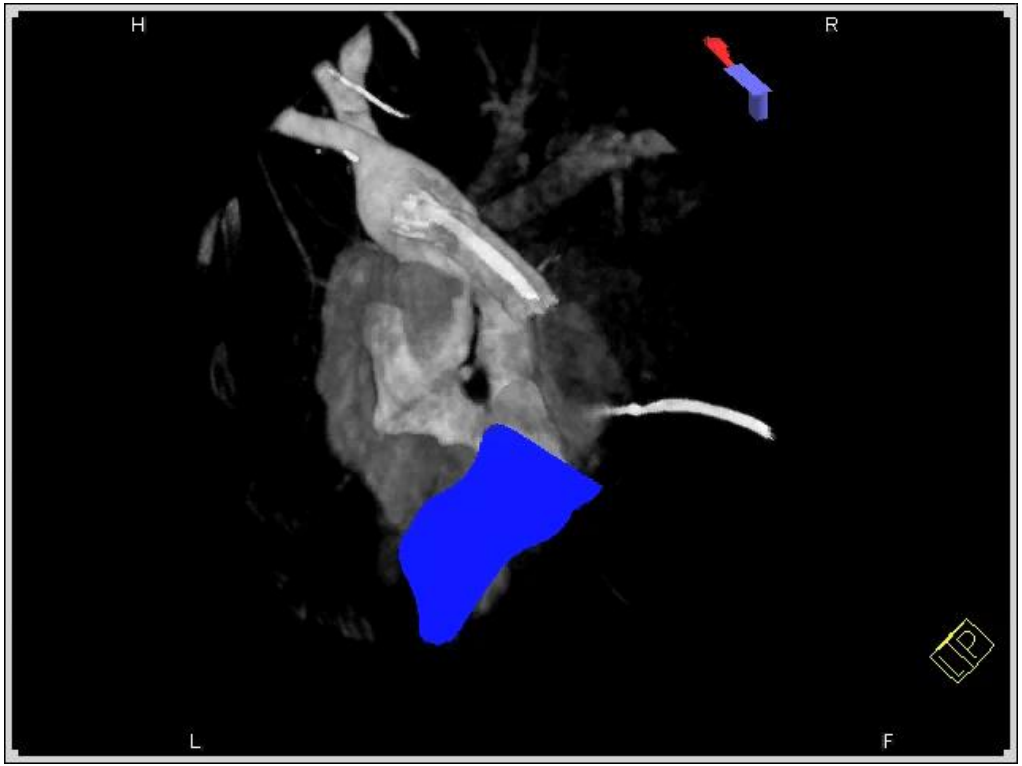


4DRA is **dynamic**

"Imaging of dynamic nature of the heart with congenital defects in the cath-lab"

4DRA does offer the entire range of functional analysis

Case 3: Functional Analysis
Volumetric Output Parameters



Volumetric Analysis :

43.1ml end diastolic volume

12.2ml end systolic volume

30.8ml stroke volume

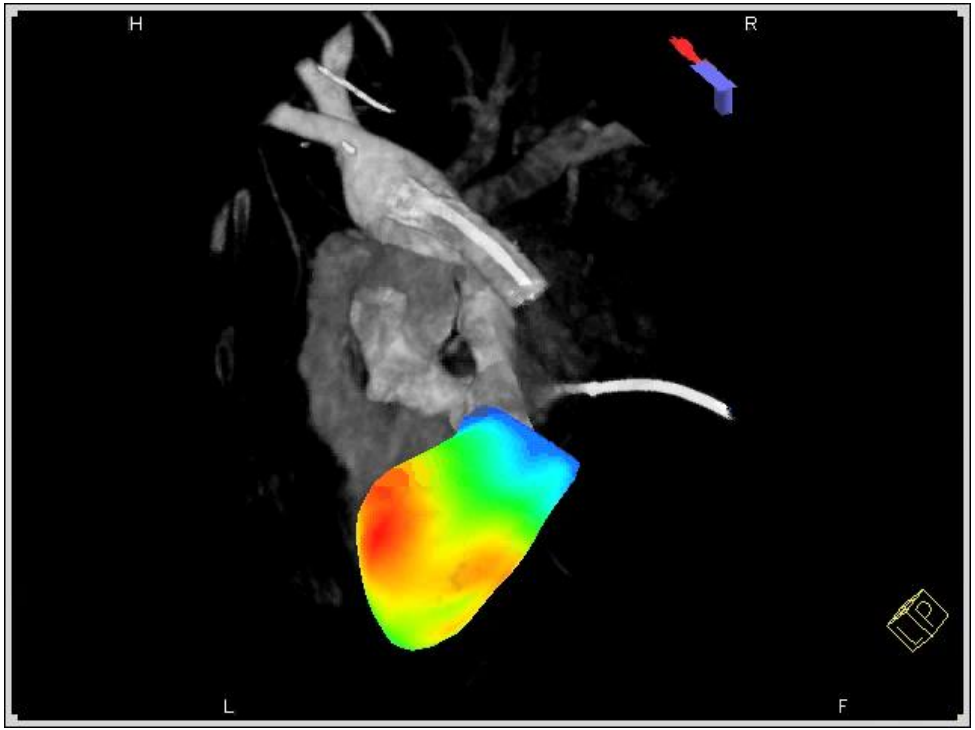
72% ejection fraction

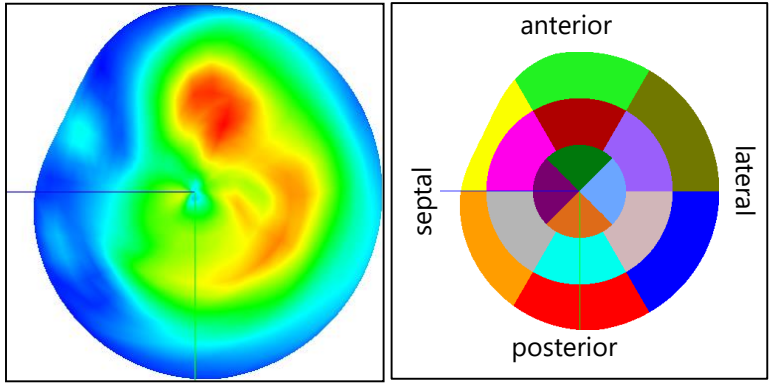
5.2 l/min cardiac output

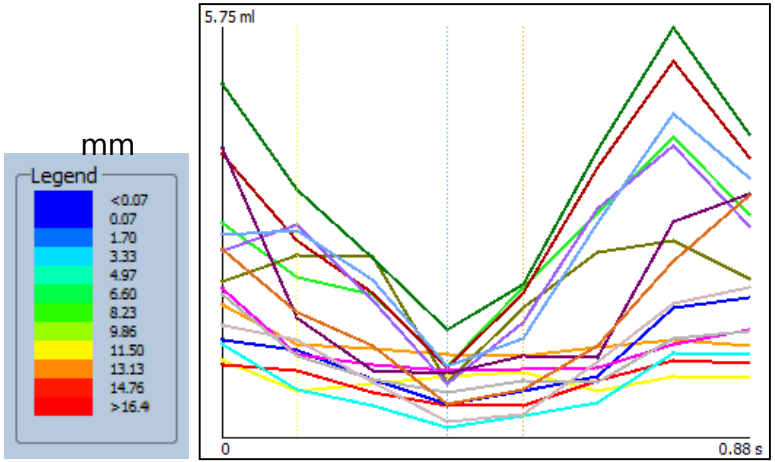
4.7 l/min/m^2 cardiac index

Chamber segmentation by courtesy of Yefeng Zheng, Siemens Medical Solutions USA, Inc., Princeton, NJ

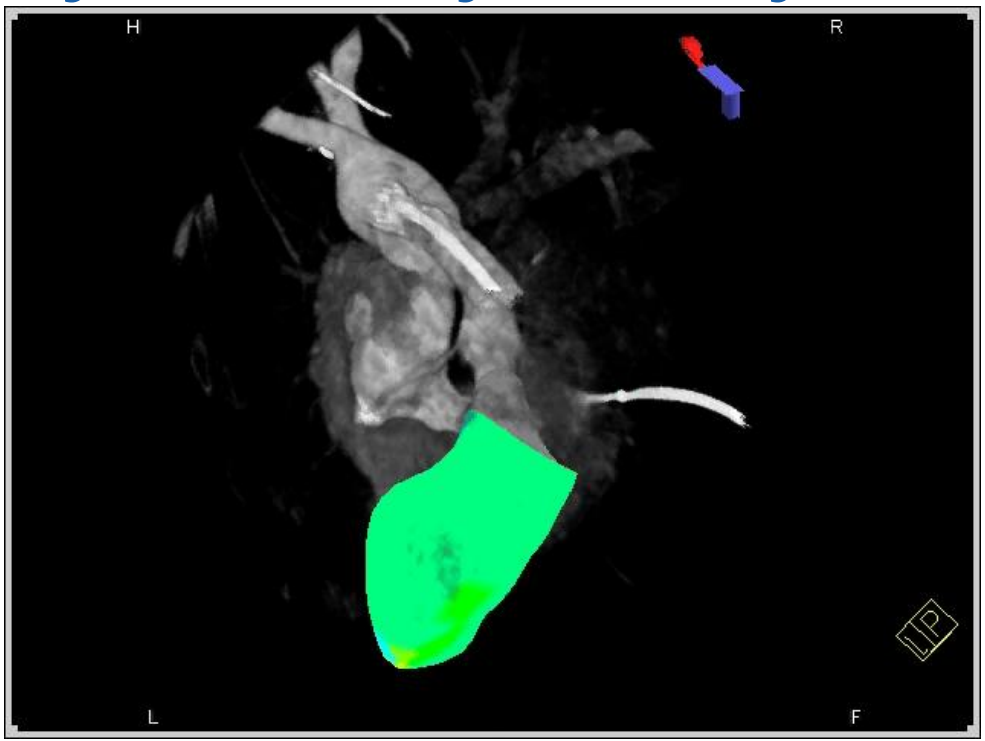
Case 3: Functional Analysis
Radial local wall motion

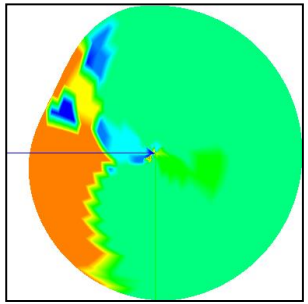


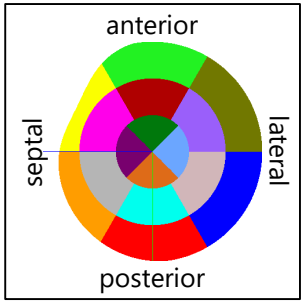


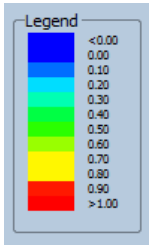


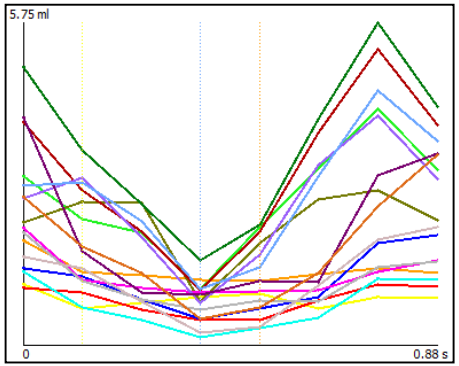
Case 3: Functional Analysis
Synchronicity – End Systolic Heart Phase











Conclusion and Outlook

Intention

- **Feasibility** of 4DRA
- Generate **dynamic anatomic datasets high spatial and temporal resolution**
- Develop tools for functional 4D **analysis** (volumes, kinetic, regional)

Shortcomings

- Restricted to current 3DRA protocol (ethic reasons)
- **Rapid pacing => unnatural contraction pattern**

Future

- **Physiological contraction pattern** in Sinus rhythm
- Optimization of frames / cycles (ALARA Low radiation, low contrast, short scan time)
- Adaptation current HW & SW
- **Improve interventional outcome by understanding 4D dynamics / interaction**

Faaaar away

- Preform **CFD Flow analysis at CathLab based on 3D and 4DRA** to understand obstruction
- **Use 4D kinetics to virtually predict device suitability**

Conclusion

- 4D toolbox ready
- Current data – derived from 3DRA – are not ideal

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