To Tell the Truth: “Will the Real Measurement Please Stand Up?”

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Disclosures

Philips Healthcare:

Grant support

Speaking Bureau / Teaching

Asked for Clarification of the Topic

- “Is measuring off of 3D reconstruction accurate or do we need to use MPRs?"
- “Do we need 2D angio also to get pulsatility?”
- “Which is the "real" measurement?”
- ‘Is 3D "good enough” ’

Cardiovascular Quantification

3-DRA Reconstruction

Cardiovascular Quantification

3-DRA Reconstruction

Cardiovascular Imaging
Quantitative Analysis

- QA: “Examination of measurable and verifiable data”
- Requirements in CV QA
  - Clear visualization of structures of interest
    - Spatial resolution
    - Temporal resolution
  - Impact of 2D vs. 3D datasets
  - Measurement tools
    - Accurate
    - Reproducible
    - Simple to use

Cardiovascular Imaging

- Spatial resolution: “Ability of the imaging modality to differentiate between two objects”
- Temporal resolution: ”Duration of time for acquisition of a single frame of a dynamic process”

Table 1

Spatial, contrast, and temporal resolutions of cardiac imaging methods

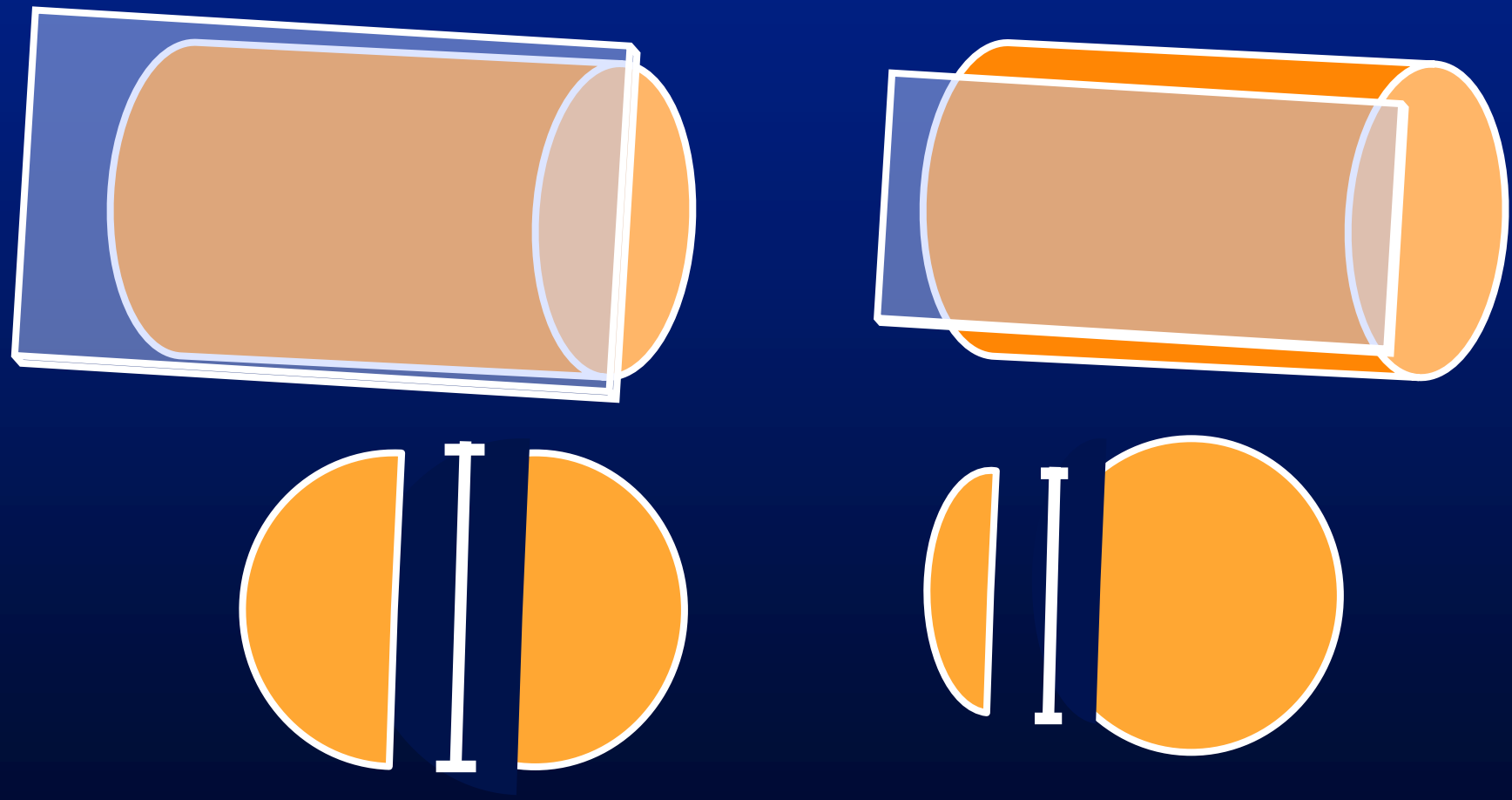
	Spatial resolution (FWHM), mm	Contrast resolution	Temporal resolution
CT	0.5-0.625	Low to moderate	83-135 ms
MRI	1-2	High	20-50 ms
Catheter angiography	0.16	Moderate	1-10 ms
PET	4-10*	Very high, varies†	5 s to 5 min*
SPECT	4-15*	Very high, varies†	15 min§
Echocardiography	~0.5-2‡	Low to moderate	>200 frames/s (<5 ms)

Radiopaedia.org

Lin, *J Cardiovasc Comput Tomogr.* 2009 Nov-Dec; 3(6): 403–408

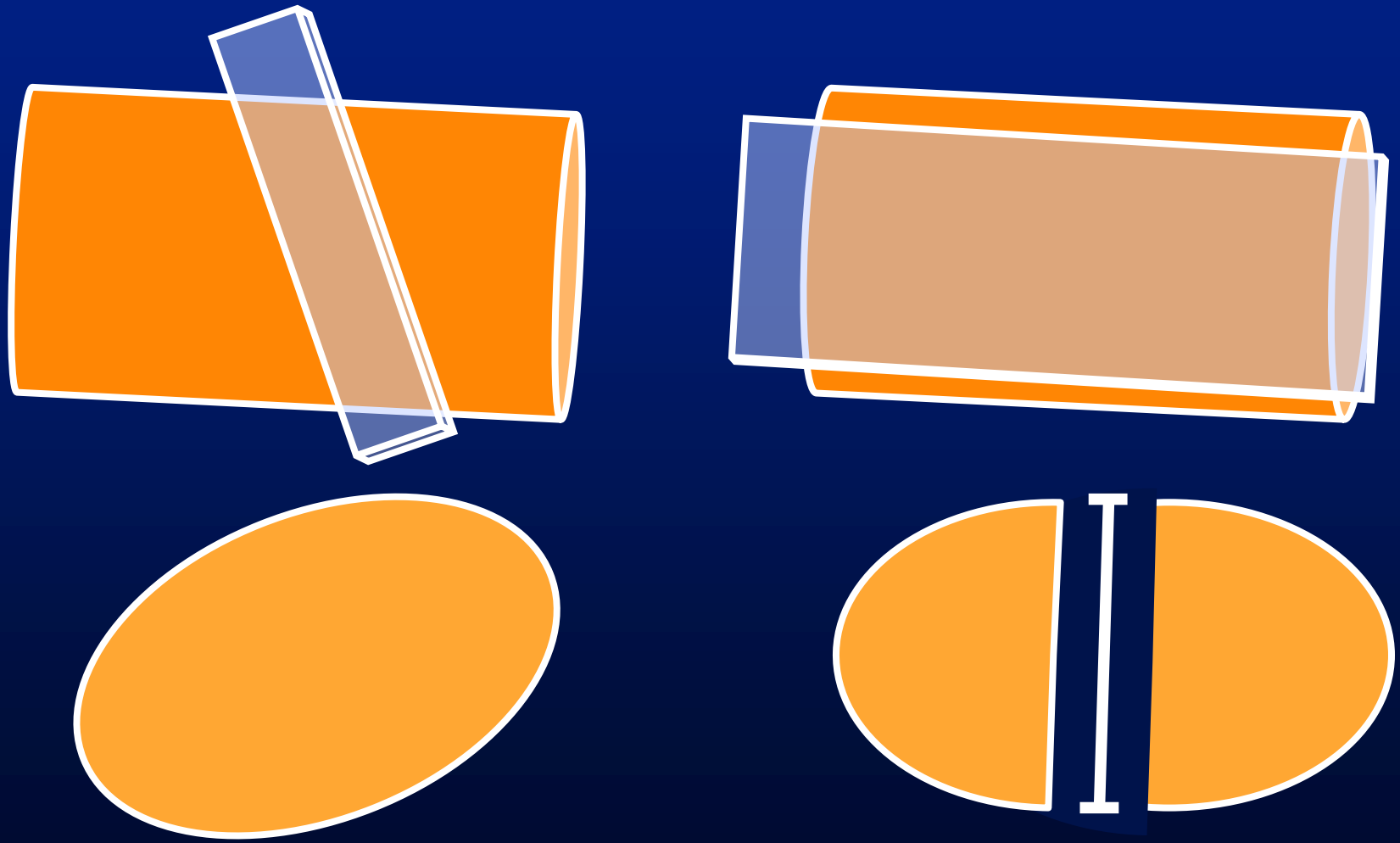
Cardiovascular Imaging
Quantitative Analysis

- 2-Dimensional datasets



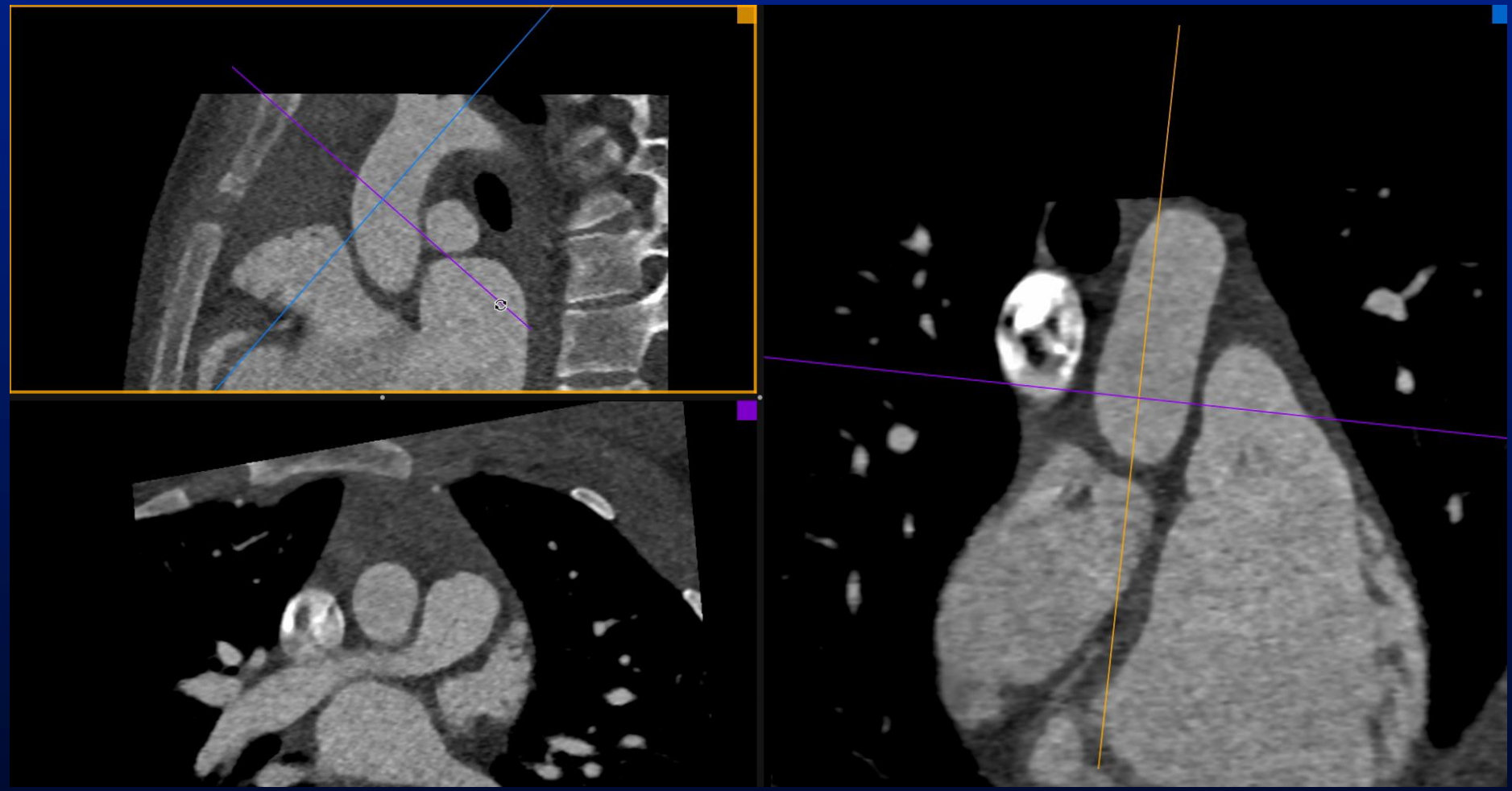
Cardiovascular Imaging
Quantitative Analysis

- 2-Dimensional datasests



Cardiovascular Imaging
Quantitative Analysis

- 3-Dimensional datasets (Not 3-D reconstruction)



Courtesy of Brian Fonseca, MD

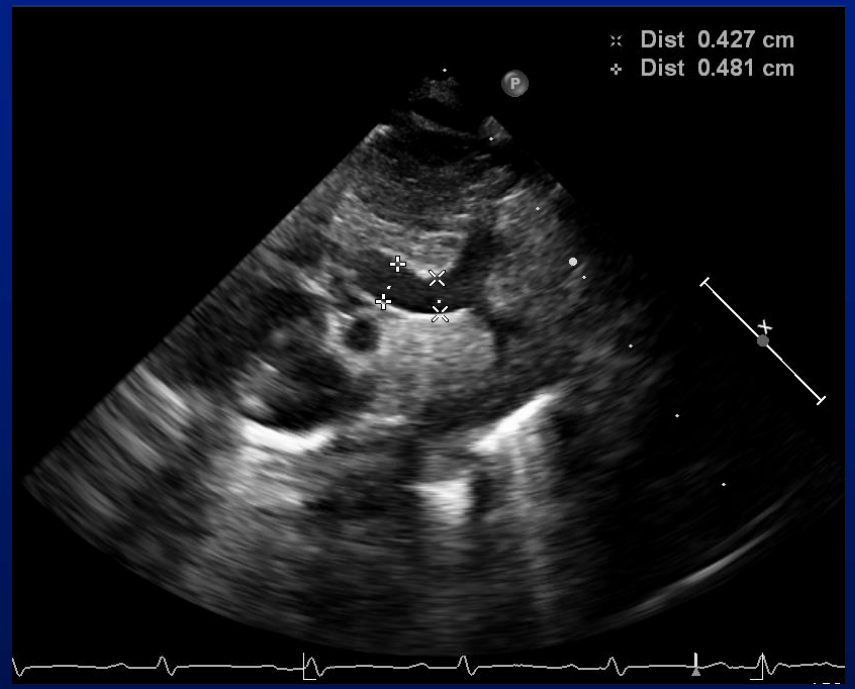
Cardiovascular Quantification
"For The Interventionalist"

- **Interventionalist's perspective**
  - **Standards for measurement derived from stationary projection angiography**
  - **Management decisions based on largest dimension of the cardiovascular structure of interest**
    - **Systole for arteries and valves**
    - **Diastole for VSD**

Cardiovascular Quantification

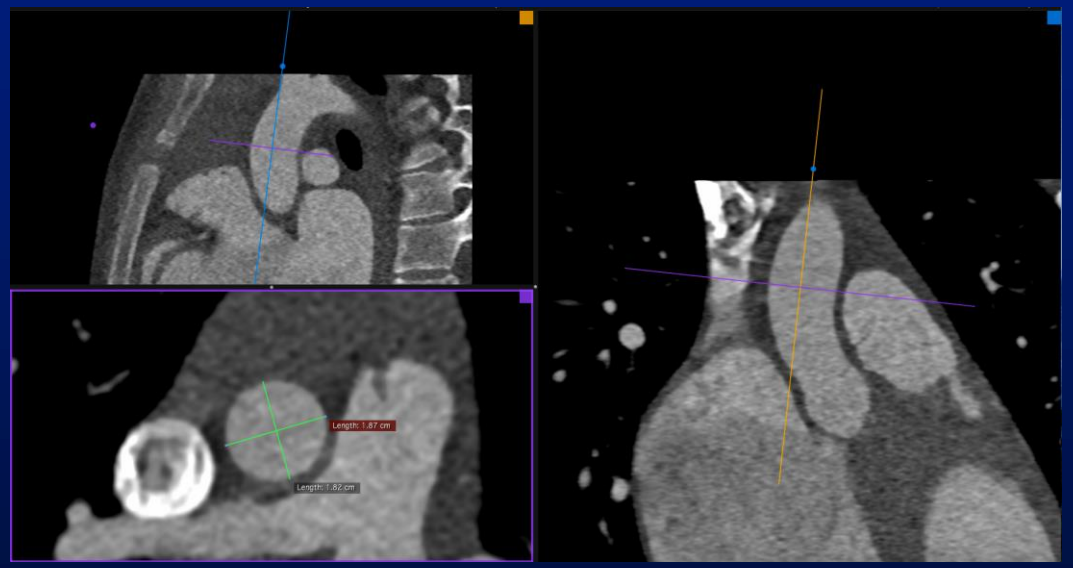
"For The Interventionalist"

- **Echocardiography**
  - **Advantages**
    - Very high temporal and reasonable spatial resolution
    - Readily obtainable
    - Measurement tools facile and accurate
  - **Disadvantages**
    - 2-Dimensional imaging



Cardiovascular Quantification
"For The Interventionalist"

- **cMR / CT**
  - **Advantages**
    - **High spatial and acceptable temporal resolution**
    - **3-Dimensional dataset imaging**
    - **Measurement tools facile and accurate**
  - **Disadvantages**
    - **Non-gated or gated to diastole**

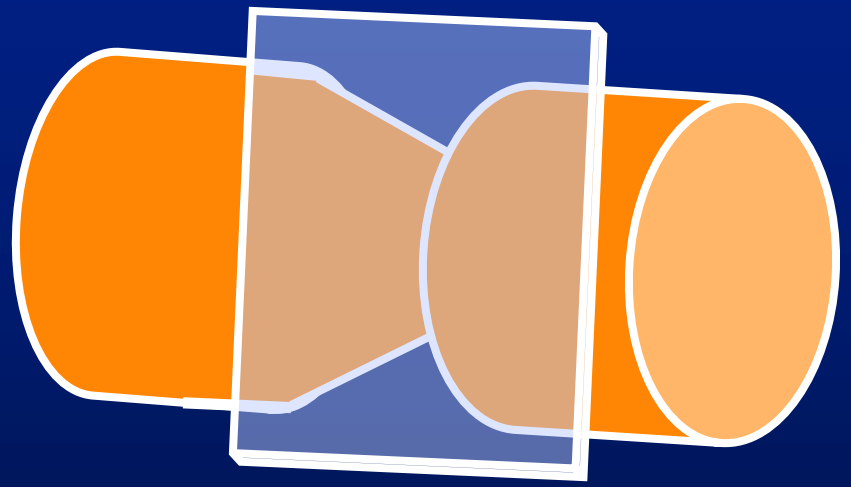


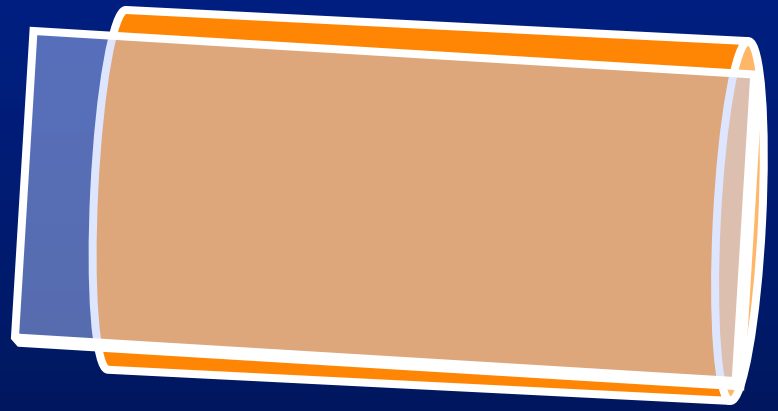
Cardiovascular Quantification
"For The Interventionalist"

- Static projection digital cineangiography (*"Planimetry"*)
  - Advantages
    - It is our "gold standard"
    - Extremely high spatial resolution and high temporal resolution
    - Can choose specific point in cardiac cycle
    - Measurement tools facile and accurate (Auto-calibration*)
  - Disadvantages
    - 2-Dimensional quantification*
    - Area obscured by other contrast filled structures
    - Calibration (object of known dimension) may be required

Cardiovascular Quantification
Static Projection Angiography

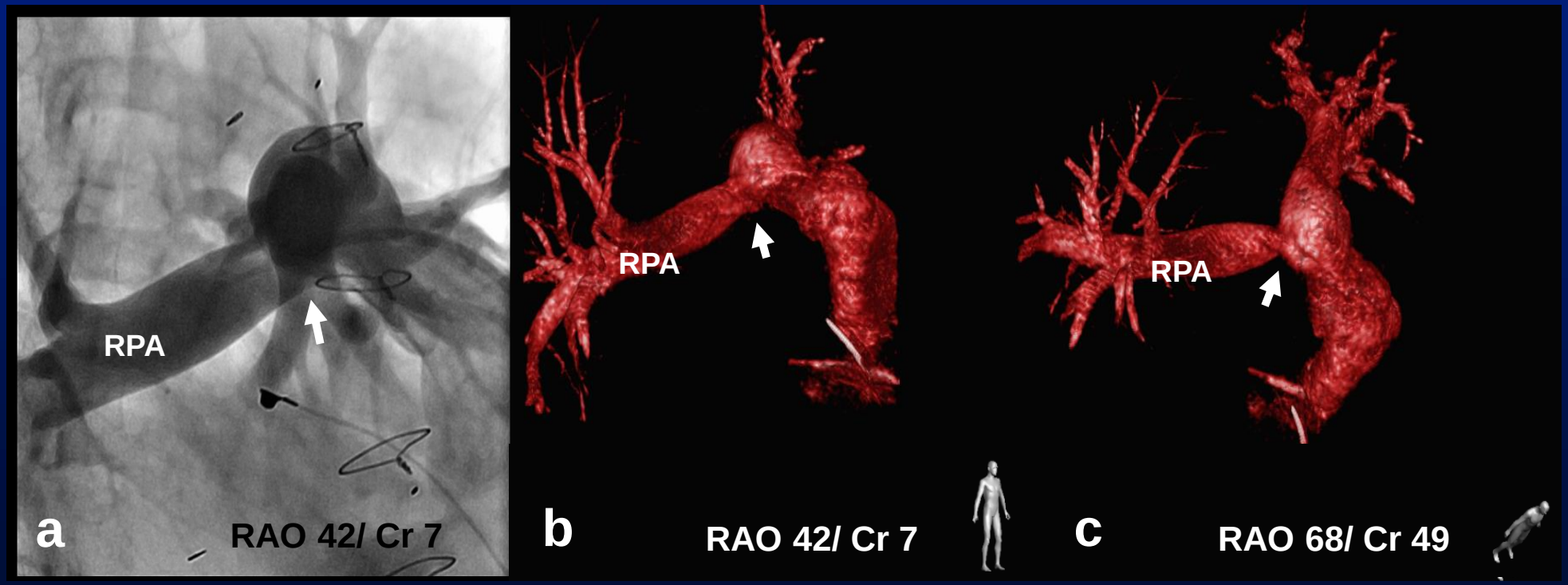
- 2-Dimensional Quantification





Cardiovascular Quantification
3DRA Reconstruction

- 3-Dimensional image dataset
- High spatial resolution but low temporal resolution
- Overcomes some limitations of static angiography



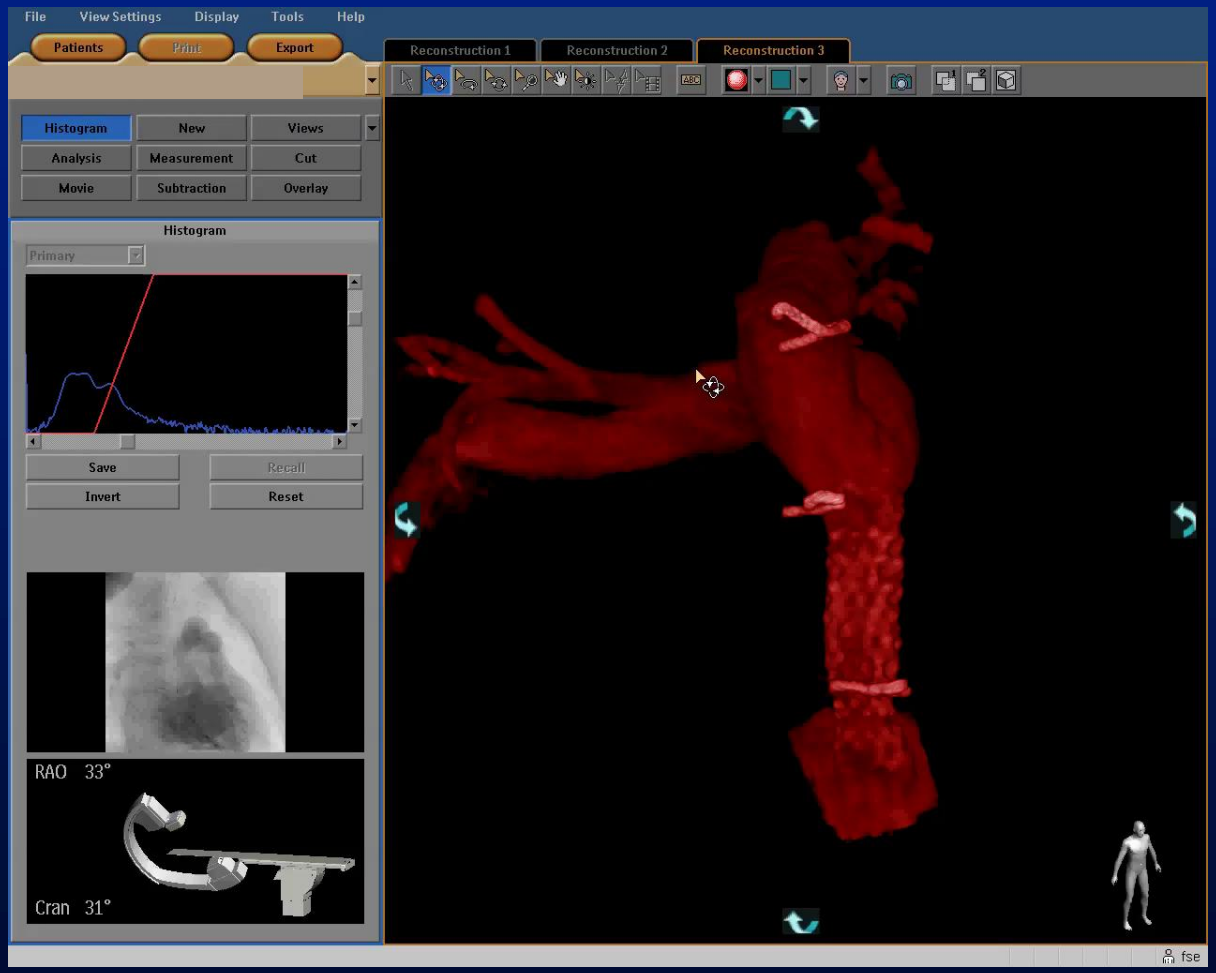
- Tetralogy of Fallot with RPA Stenosis

Schwartz, *Int J Cardiovasc Imaging*. 2011 Dec;27(8):1205-22

Cardiovascular Quantification

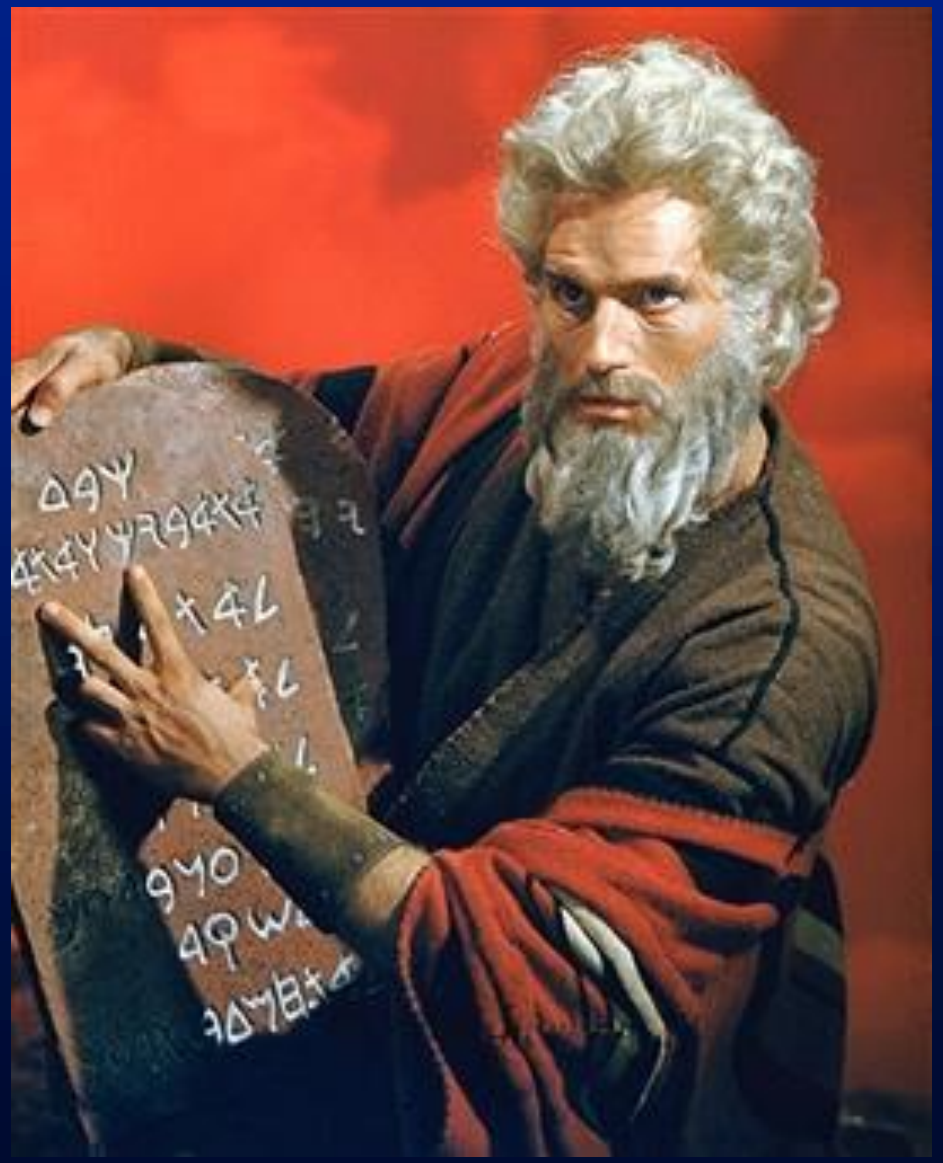
3-DRA Reconstruction

- Signal averaged image dataset



- Window leveling

Commandment of Imaging Quantification



Thou shalt
not make
measurements from
3-dimensional
reconstructions!

Commandment of Imaging Quantification

Thou shalt
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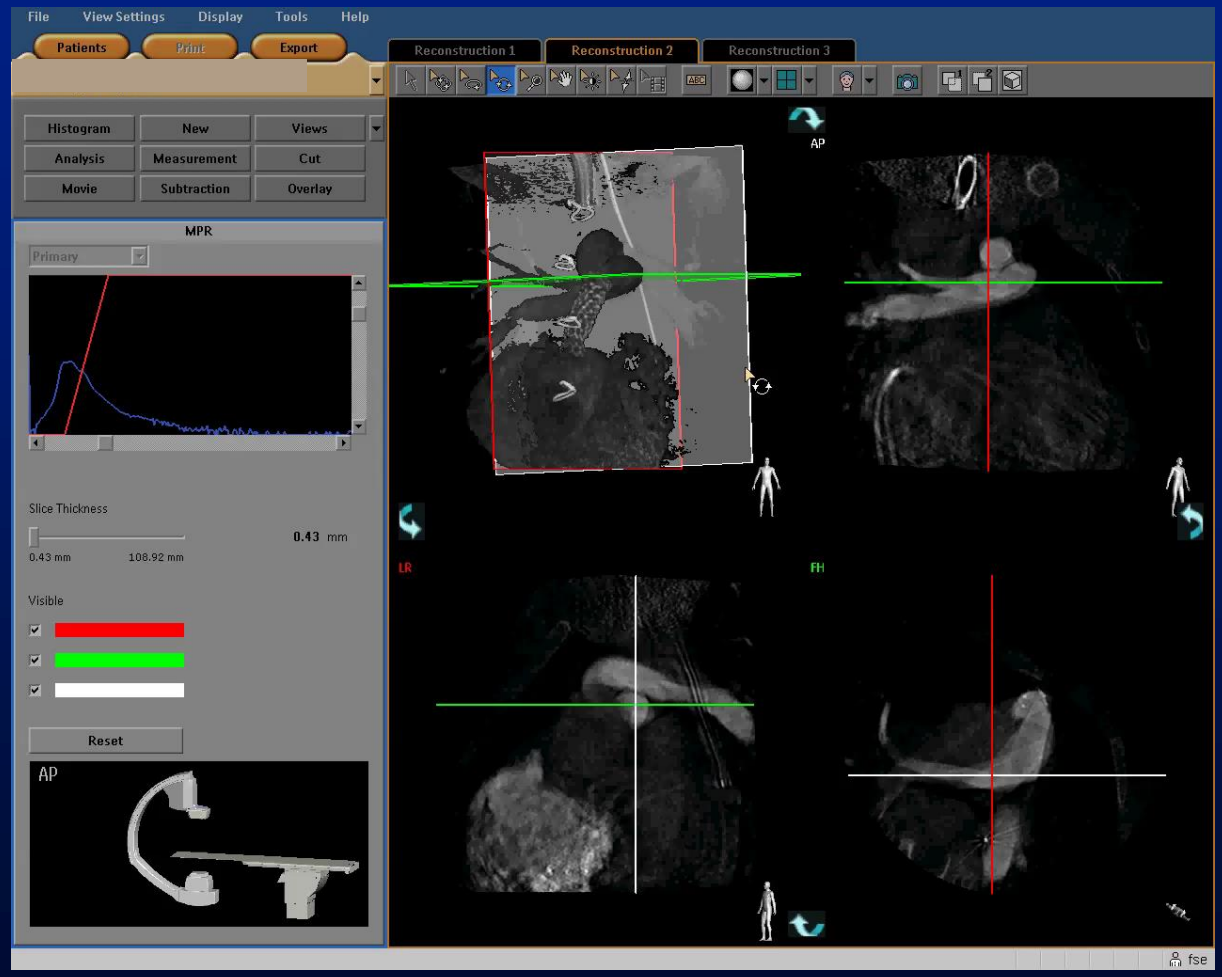
Cardiovascular Quantification

3DRA Multiplanar Reformat

- 3-Dimensional image dataset

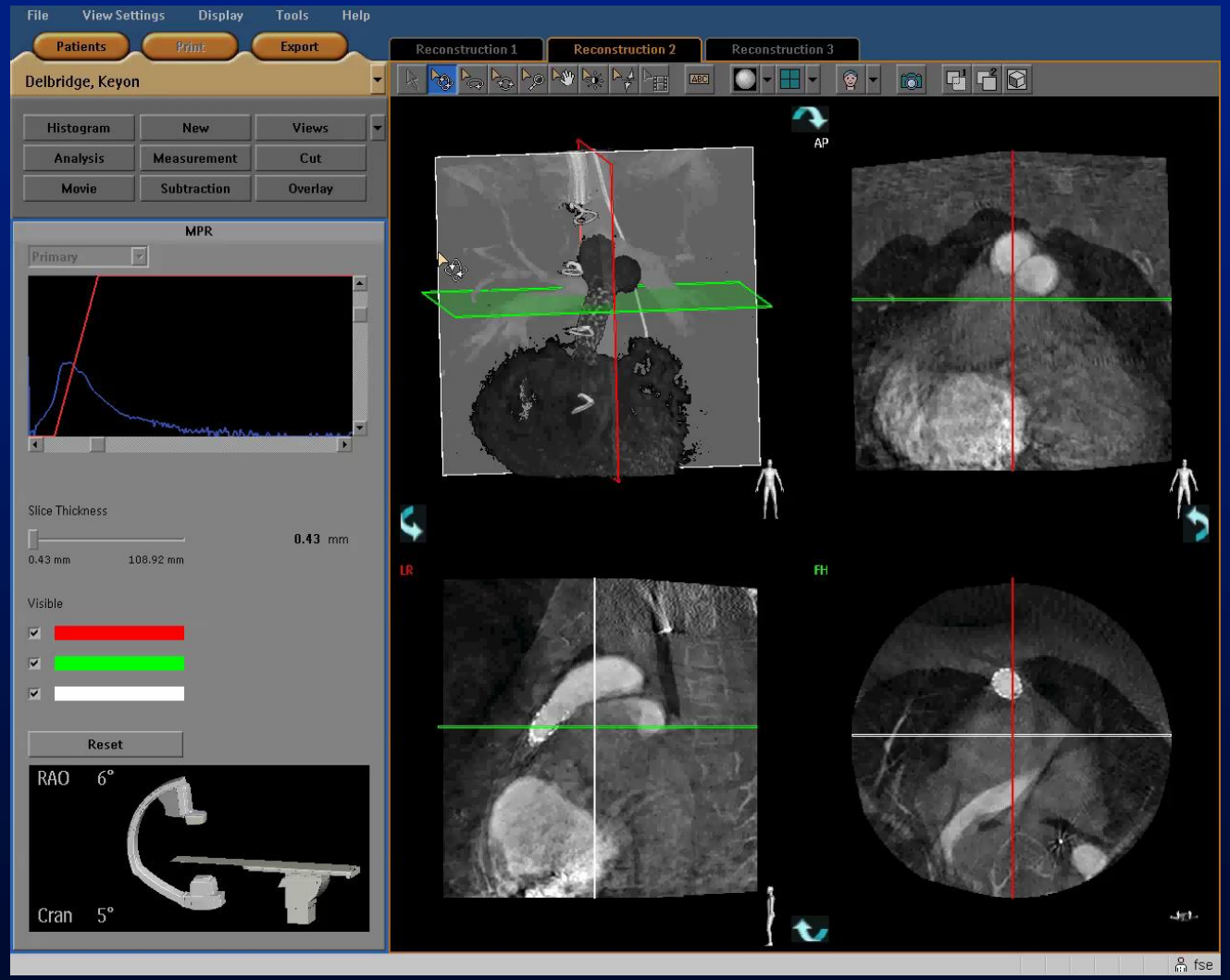


- Signal averaged imaging

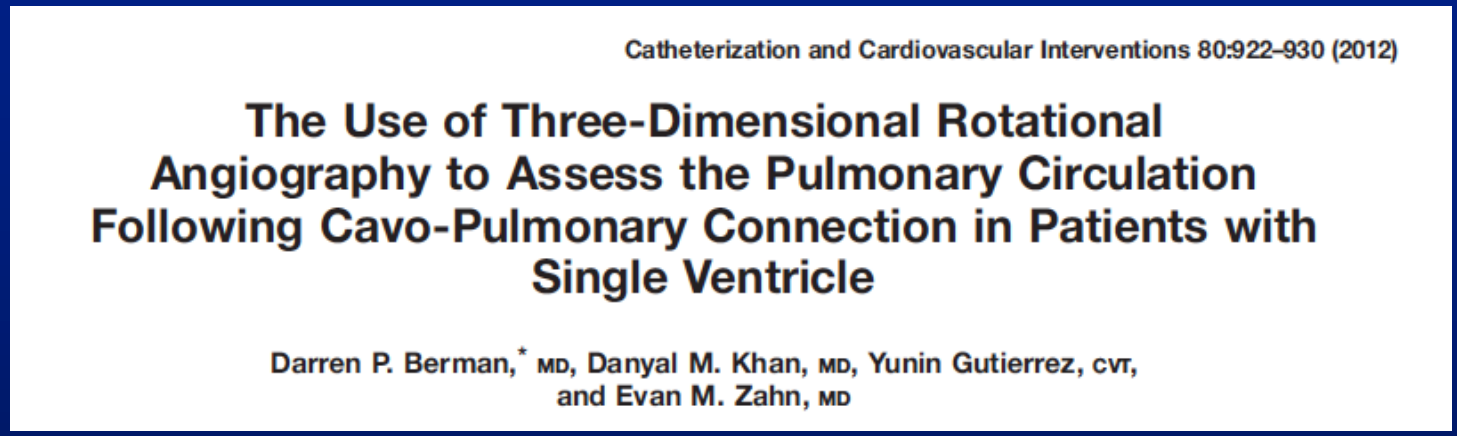
Cardiovascular Quantification

3DRA Multiplanar Reformat

- Window leveling



Cardiovascular Quantification
3DRA Multiplanar Reformat



Catheterization and Cardiovascular Interventions 80:922–930 (2012)

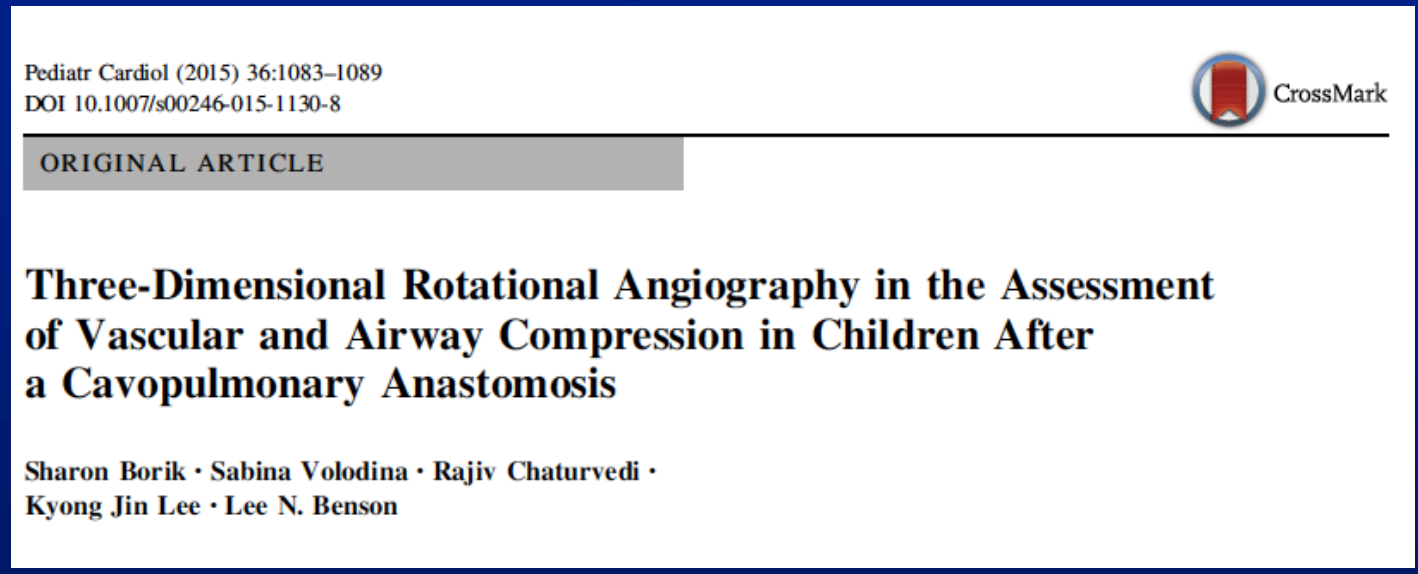
The Use of Three-Dimensional Rotational Angiography to Assess the Pulmonary Circulation Following Cavo-Pulmonary Connection in Patients with Single Ventricle

Darren P. Berman,* MD, Danyal M. Khan, MD, Yunin Gutierrez, CVT, and Evan M. Zahn, MD

- Found correlation MPR and static angiograms (n= 33 studies)
  - RPA: correlation coefficient 0.94 (P <0.001)
  - LPA: correlation coefficient 0.97 (P < 0.001)
- Alignment of MPR vessels with angio projections not performed*
- CPCs; non-pulsatile vessels and some paced
  - Expect to correlate better than in pulsatile vessels

*3DRA …oblique angulations that best profiled the vessel of interest

Cardiovascular Quantification
3DRA Multiplanar Reformat



Pediatr Cardiol (2015) 36:1083–1089
DOI 10.1007/s00246-015-1130-8

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ORIGINAL ARTICLE

Three-Dimensional Rotational Angiography in the Assessment of Vascular and Airway Compression in Children After a Cavopulmonary Anastomosis

Sharon Borik · Sabina Volodina · Rajiv Chaturvedi · Kyong Jin Lee · Lee N. Benson

- Studied correlation MPR and static angiograms (n= 25 studies)
  - Branch PA measurements correlated well
  - SVC and prox RPA: poor to moderate correlation
- Alignment of MPR vessels with angio projections not specified*
- CPCs; non-pulsatile vessels
  - Expect to correlate better than in pulsatile vessels

* using two-dimensional tomographic slices created by the intersection of the parallel and perpendicular planes at each reference point.

Cardiovascular Quantification
3DRA Multiplanar Reformat

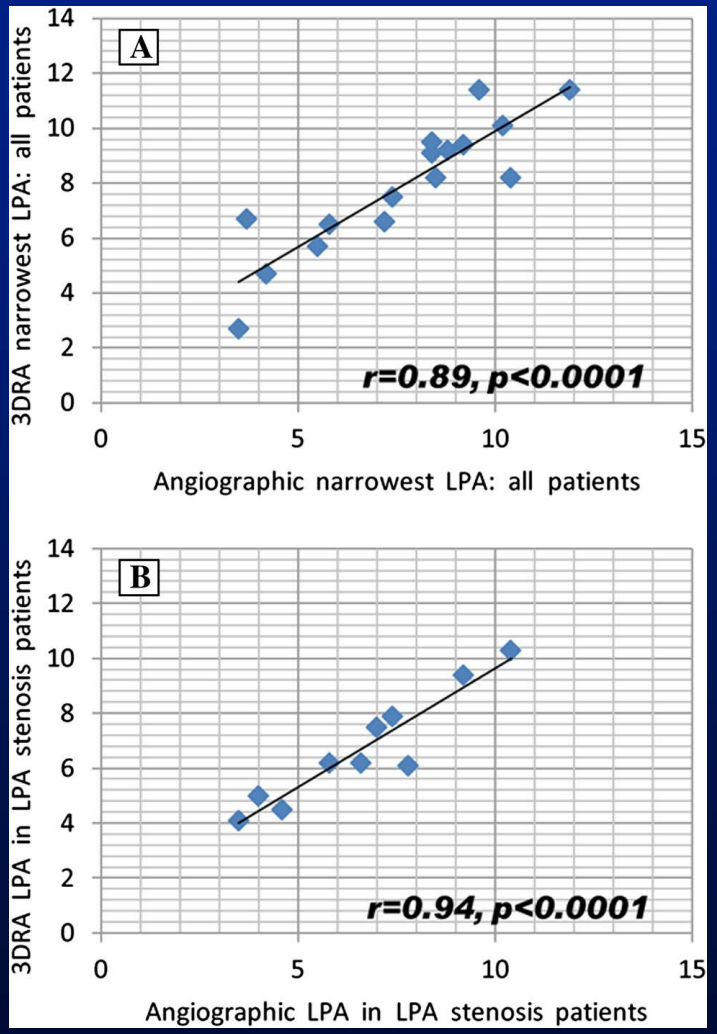


Table 2 Correlation between measurements on 3DRA-derived tomographic images and 2D angiography

Vessel	2D angiography (mm)	3DRA (mm)	Correlation coefficient (*r*)	*p* value
Proximal LPA	9.6 ± 2.3	9.6 ± 1.7	0.81	<0.0001
Narrowest LPA	7.7 ± 2.5	8.0 ± 2.1	0.89	<0.0001
Distal LPA	7.7 ± 2.5	7.8 ± 2.0	0.83	<0.0001
Proximal RPA	10.0 ± 1.8	10.2 ± 1.7	0.28	0.30
Distal RPA	8.7 ± 1.4	8.5 ± 1.6	0.75	0.001
SVC	11.4 ± 2.1	12.4 ± 1.9	0.50	0.06

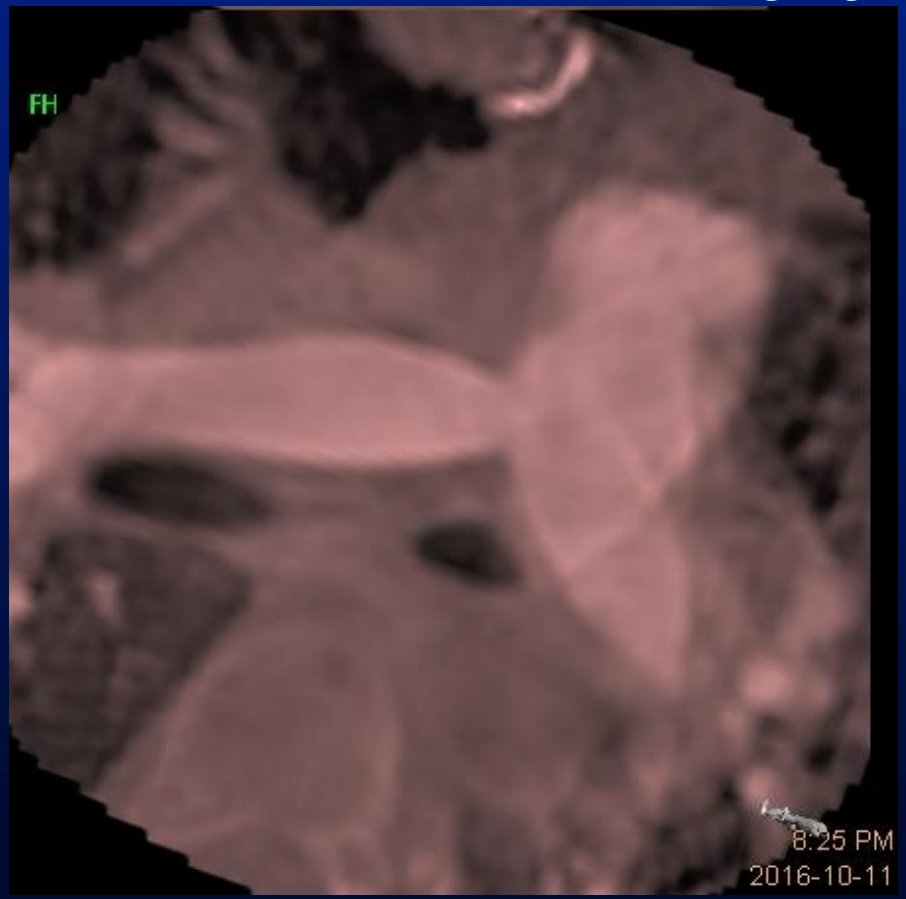
Measurements listed as mean ± standard deviation

Abbreviations as in Table 1; *RPA* right pulmonary artery, *SVC* superior vena cava

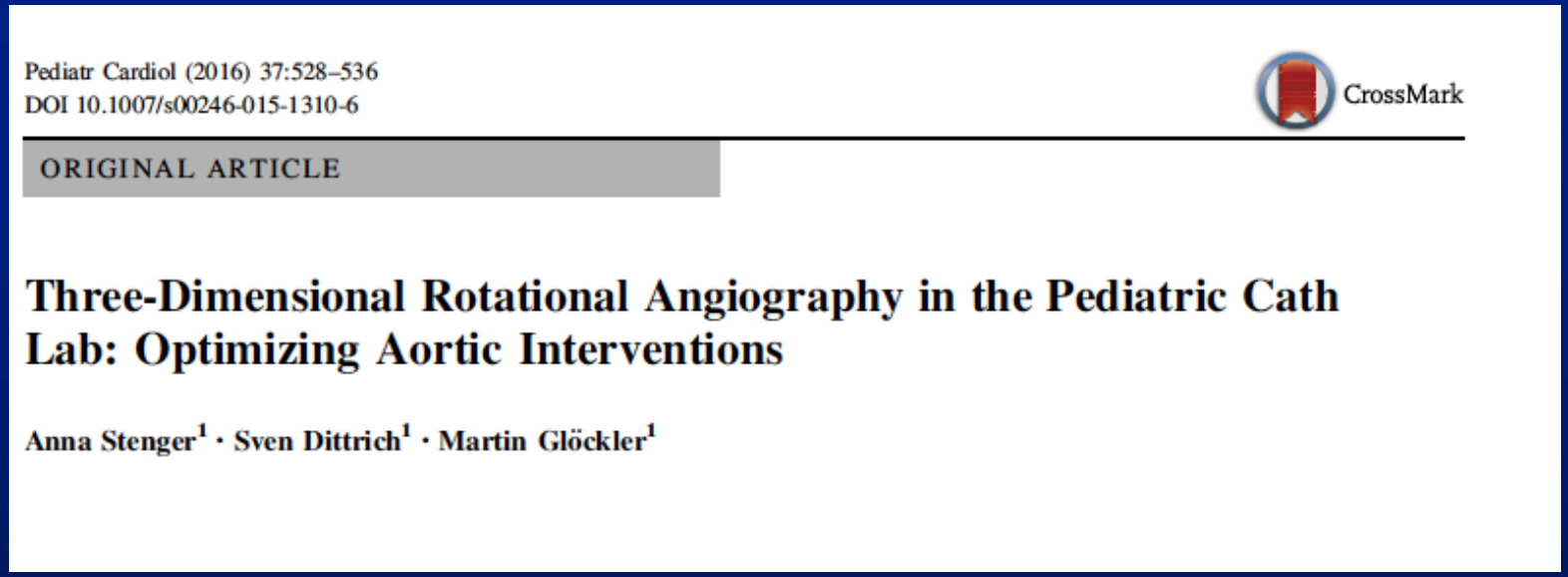
Borik, *Pediatr Cardiol.* 2015 Jun;36(5):1083-9

Cardiovascular Quantification
3DRA Multiplanar Reformat

- **Pulsatile vessels:**
  - **Image blur may represent systolic dimensions**
  - **Alignment of vessels with control imaging cumbersome**



Cardiovascular Quantification
3DRA Maximal Intensity Projections



Pediatr Cardiol (2016) 37:528–536
DOI 10.1007/s00246-015-1310-6

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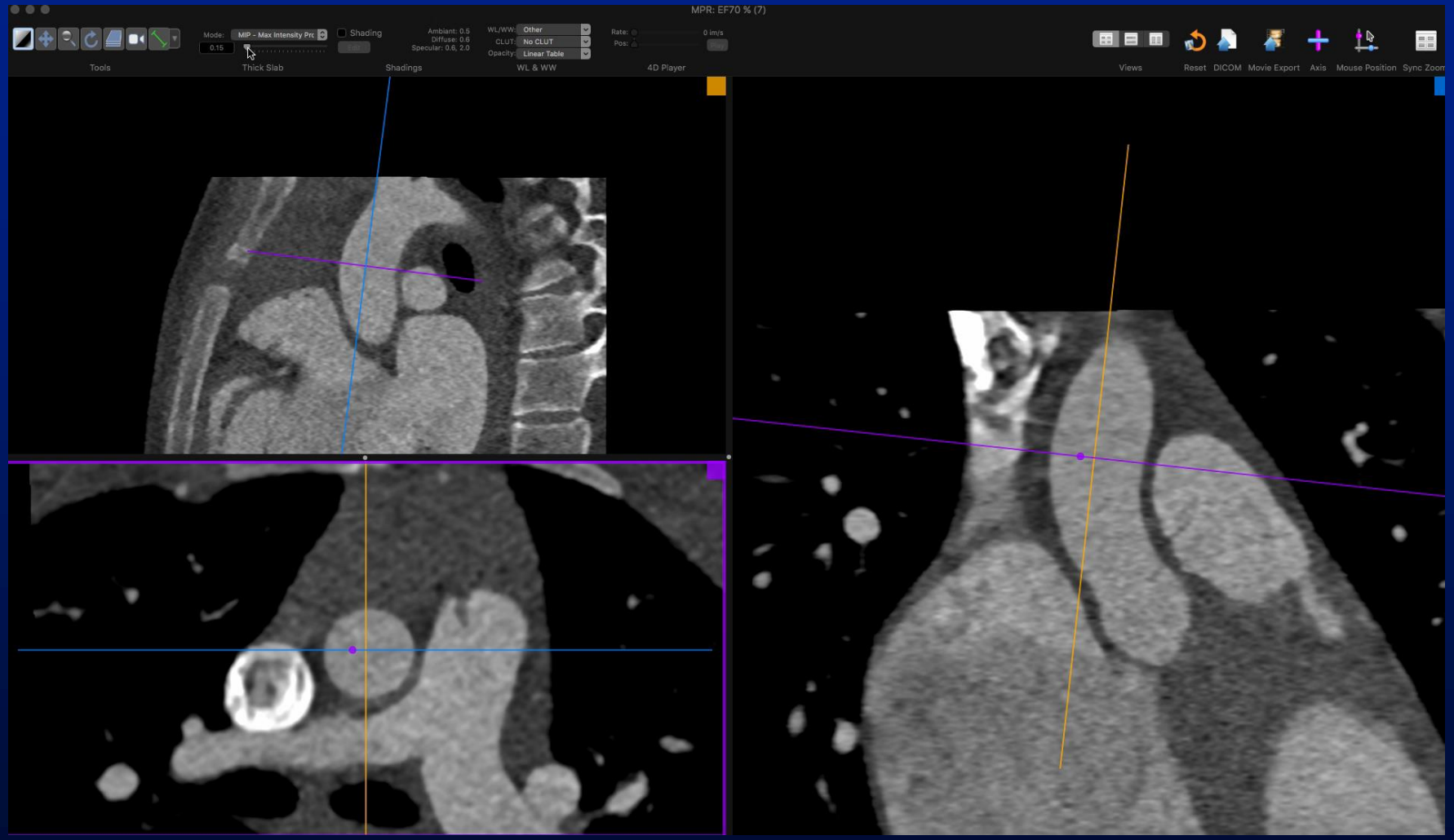
ORIGINAL ARTICLE

Three-Dimensional Rotational Angiography in the Pediatric Cath Lab: Optimizing Aortic Interventions

Anna Stenger[1] · Sven Dittrich[1] · Martin Glöckler[1]

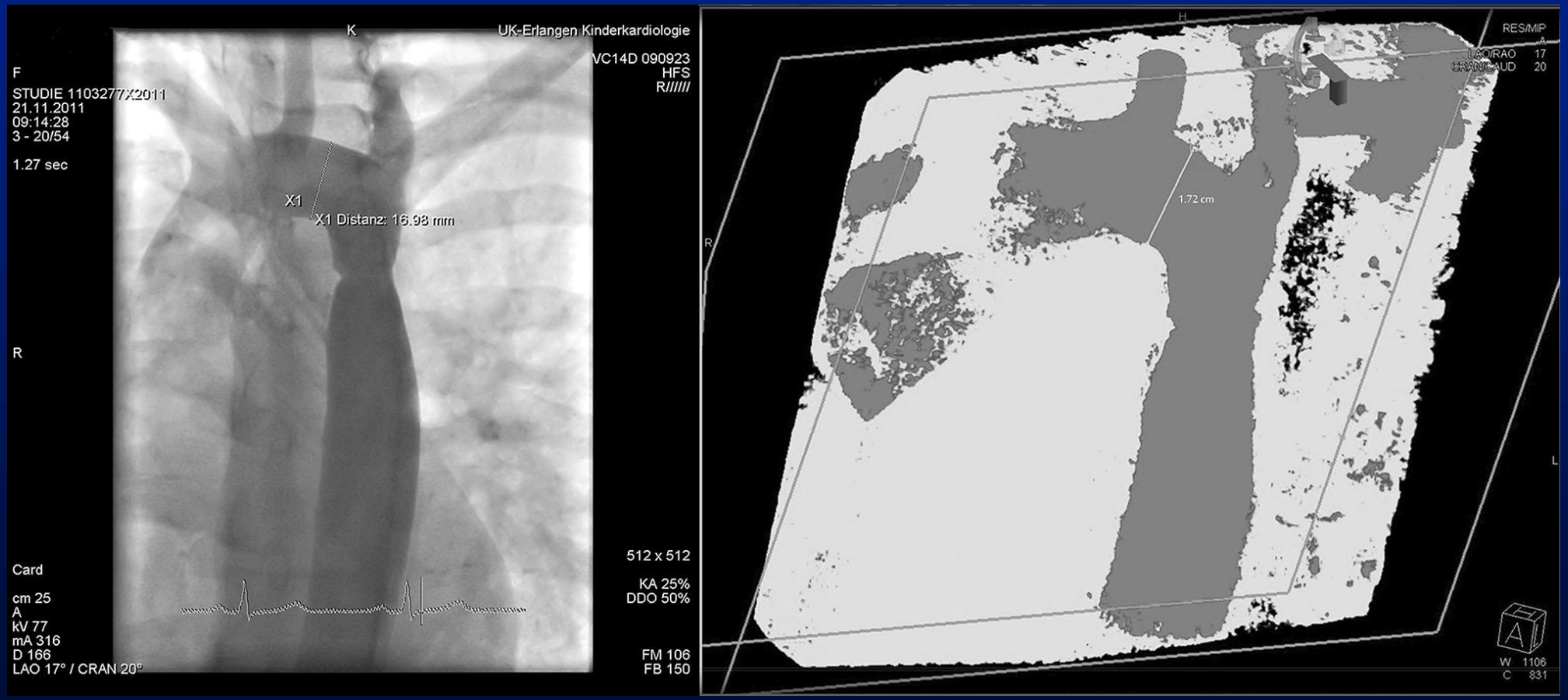
- Assessed correlation of static projection angiograms to MIP (n=60 pts)
  - Location of aortic measurement
  - Correlated angulation of MIP to the aortic arch projection
  - Both systolic and diastolic angio aortic diameters
  - Controlled window leveling of the MIP images

Cardiovascular Quantification
3DRA Maximal Intensity Projections



- Window leveling

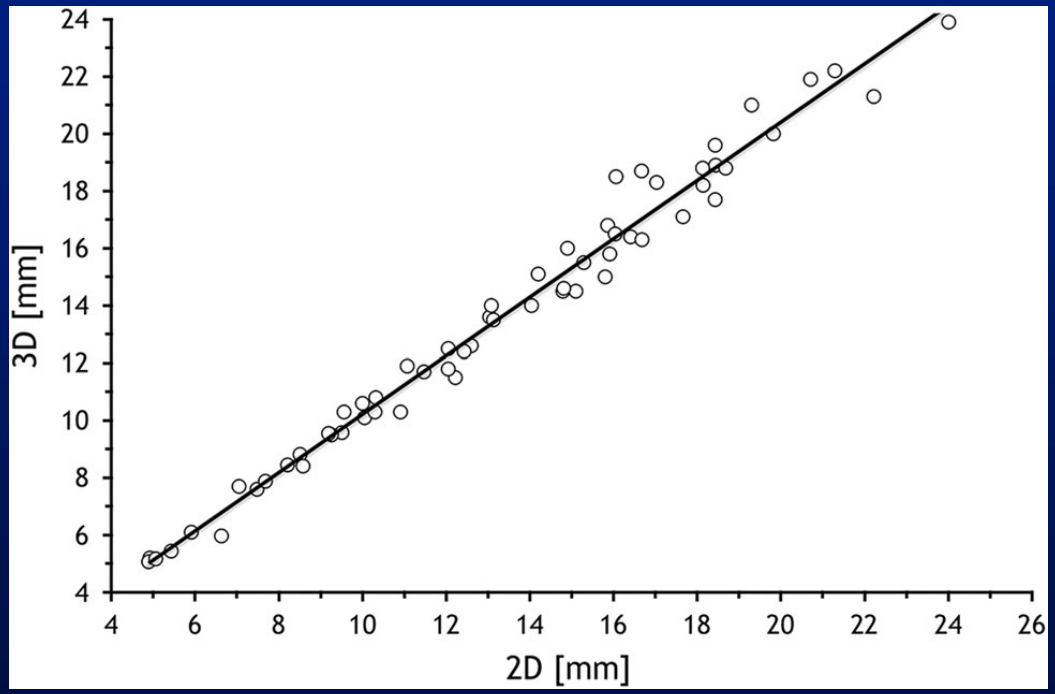
Cardiovascular Quantification
3DRA Maximal Intensity Projections



Stenger, *Pediatr Cardiol*. 2016 37; 528-36

Cardiovascular Quantification
3DRA Maximal Intensity Projections

Correlation of measurements (n = 60)



(r = 0.99 after Pearson, p\0.0001)

Stenger, *Pediatr Cardiol*. 2016 37; 528-36

Cardiovascular Quantification
3DRA Maximal Intensity Projections

“Our optimized measurement methodology is likely to be a reason for (the high correlation) result. Also the variation in vessel diameter between systole and diastole of about 6 % appears clinically not relevant.”

“Thus, we assume that quantitative 3D vessel measurements are of at least similar precision as measurements taken with conventional 2D angiographies.”

Stenger, *Pediatr Cardiol*. 2016 37; 528-36

Cardiovascular Quantification
3DRA – Original Question

- Is quantification from 3DRA *reconstructions* "accurate"?
  - Reliability questionable!
- Is quantification from 3DRA "adequate"?
  - We need further study
  - Reasonable studies can be undertaken; esp. MPR and MIP

Cardiovascular Quantification
3-DRA Reconstruction

Cardiovascular Quantification
3-Dimensional Rotational Angiography
A Current Strategy

- 3DRA performed
- Use 3DRA reconstruction and MPR
  - Anatomical diagnostics*
  - Define optimal projection for further work
- QA performed on rotational angiogram if adequate projection (calibration)
- If RA not adequate, QA performed on “optimized” angiogram

Aldoss, *Pediatr Cardiol.* 2016 Oct;37(7):1211-21

Cardiovascular Quantification
3-Dimensional Rotational Angiography
Conclusions

- Quantification can be performed on rotational angiograms if calibration adequate
- MPR and MIP may be useful but requires further investigation and different clinical settings
- There may be a potential roll for quantification of 3DRA reconstructions, but there are significant hurdles to overcome

Acknowledgements

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- Shyam Sathanandam, MD
- Martijn van der Bom

Thank you

tfagan1@uthsc.edu

Cardiovascular Quantification
3DRA Multiplanar Reformat

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