Optimizing Aortic Interventions with 3DRA

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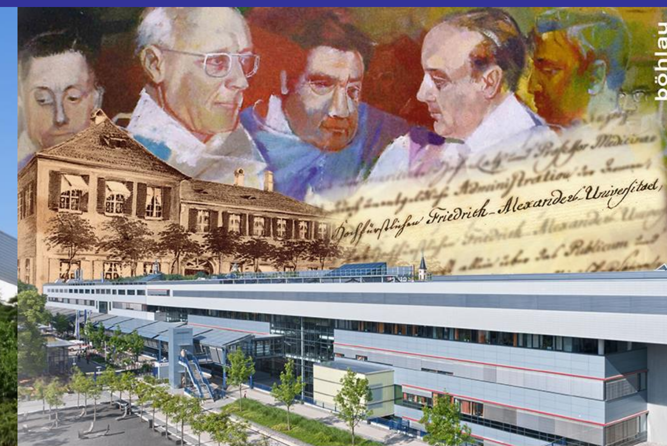

200 Jahre
Universitätsklinikum
Erlangen

1815–2015

1014 Jahre urban settlement

1002-2016

273 Jahre University

1743-2016

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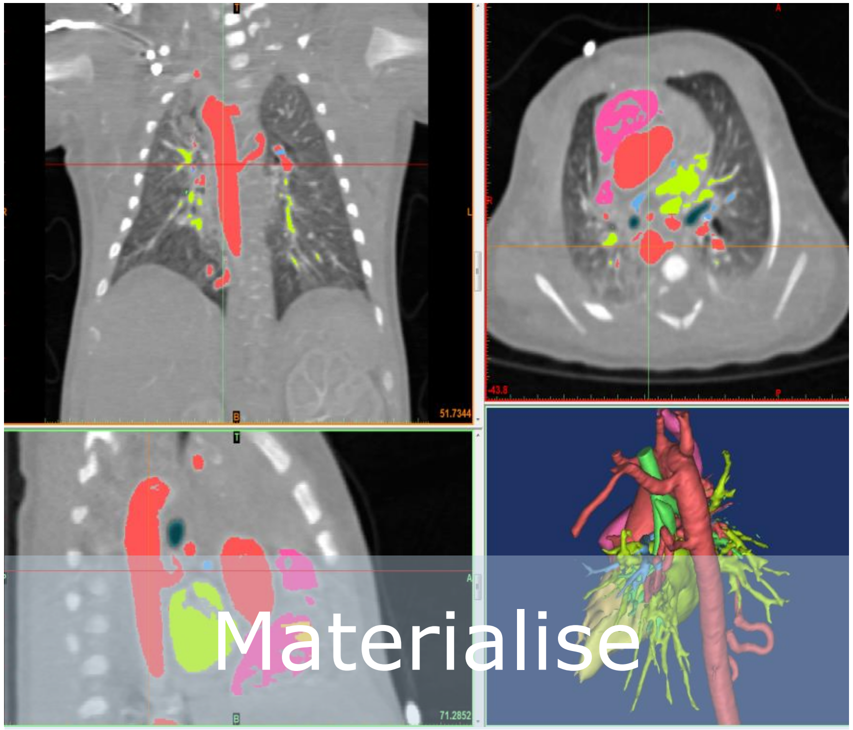
No conflict of interest

Disclosure: Cooperation with SIEMENS and MATERIALIZE



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The task: Optimizing aortic interventions with 3DRA

- coarctation +/- hypoplastic arch segments
- re-coarctation +/- presence of patches or aneurysms after surgery
- infant hypoplastic left heart / Norwood procedures

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Optimizing aortic interventions with 3DRA

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- balloon angioplasty
- implantation of stent / covered stent

The task: Optimizing aortic interventions with 3DRA

- coarctation +/- hypoplastic arch segments
- re-coarctation +/- presence of patches or aneurysms after surgery
- infant hypoplastic left heart / Norwood procedures
- balloon angioplasty
- implantation of stent / covered stent
- perfect interventional result
- no gradient, no complication
- short procedure time, no or low radiation exposure

The task:
Optimizing aortic interventions with 3DRA

- perfect interventional result
- no gradient, no complication
- short procedure time, no or low radiation exposure
- access (retrograde/antegrade)
- wire position
- stent / balloon dimensions (length, diameter)
- choice of material (balloon pressures, cell design …)
- perfect position control during the whole procedure

Theoretical benefit of 3DRA for aortic intervention

- strategy of access and positioning in 3D model
- selection of material in 3D model
- support position control during procedure
- safe radiation exposure and procedural time

Glöckler M, Halbfaβ J, Koch A.M, Achenbach S, Dittrich S. Multimodality 3D-roadmap for cardiovascular interventions in congenital heart disease—a single-center, retrospective analysis of 78 cases. Catheter Cardiovasc Interv 2013; 82(3):436-442

3DRA is only one possibility to create a 3D-dataset

- 3D-echocardiography
- MRI
- CT

3DRA is only one possibility to create a 3D-dataset

- 3D-echo
- MRI
- CT
- special advantages of a particular imaging technique?
- 3D-3D or 3D–2D -registration for the dataset?
- registration for 1 or for 2 C-arms?

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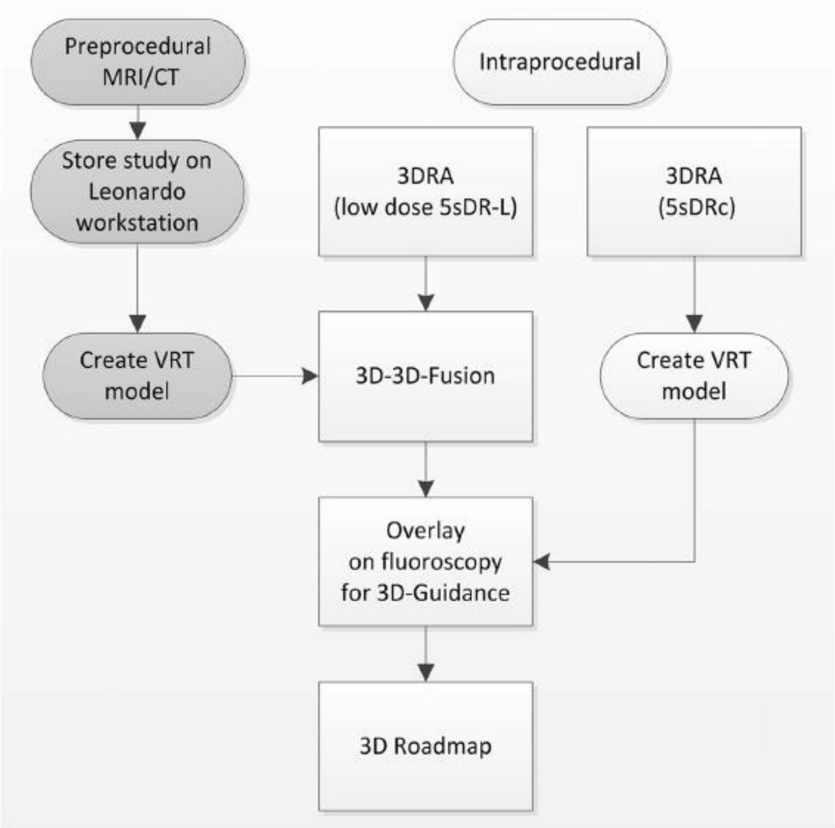
Workflow for the registration of 3D-datasets for projection on the fluoroscopy screen

3D-3D



Stenger A, Dittrich S, Glöckler M. Three-Dimensional Rotational Angiography in the Pediatric Cath Lab: Optimizing Aortic Interventions. Pediatr Cardiol 2016 Mar;37(3):528-36

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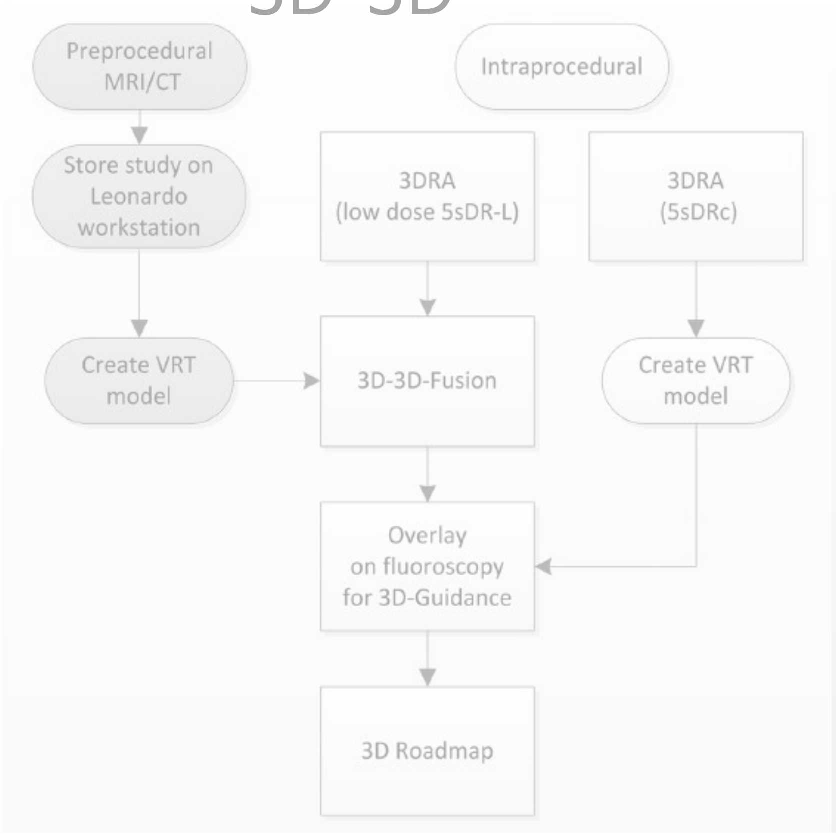
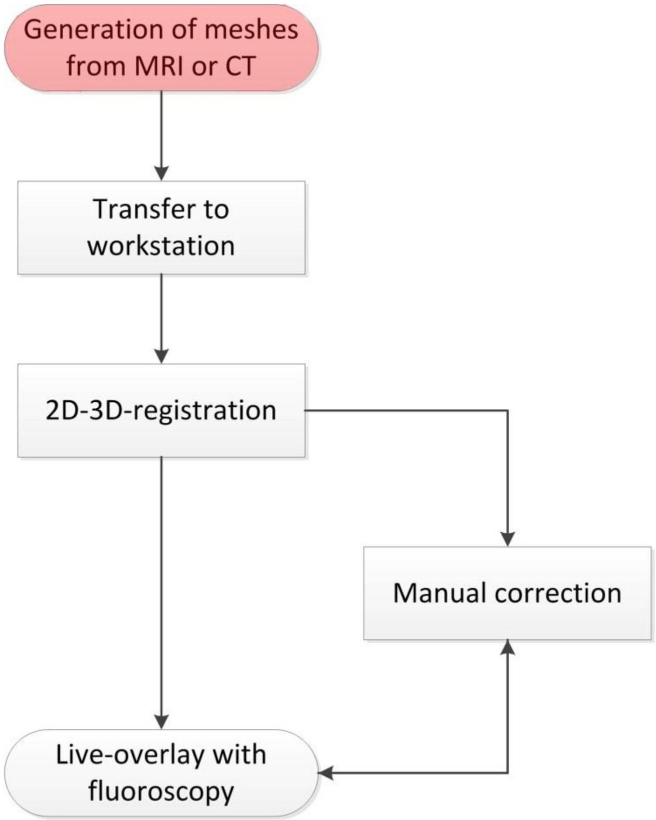
3D-3D



3D-2D



3D-2D-Overlay (Monaco Workstation, Siemens)

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Overlay: Flat-detector cone beam CT (3DRA)

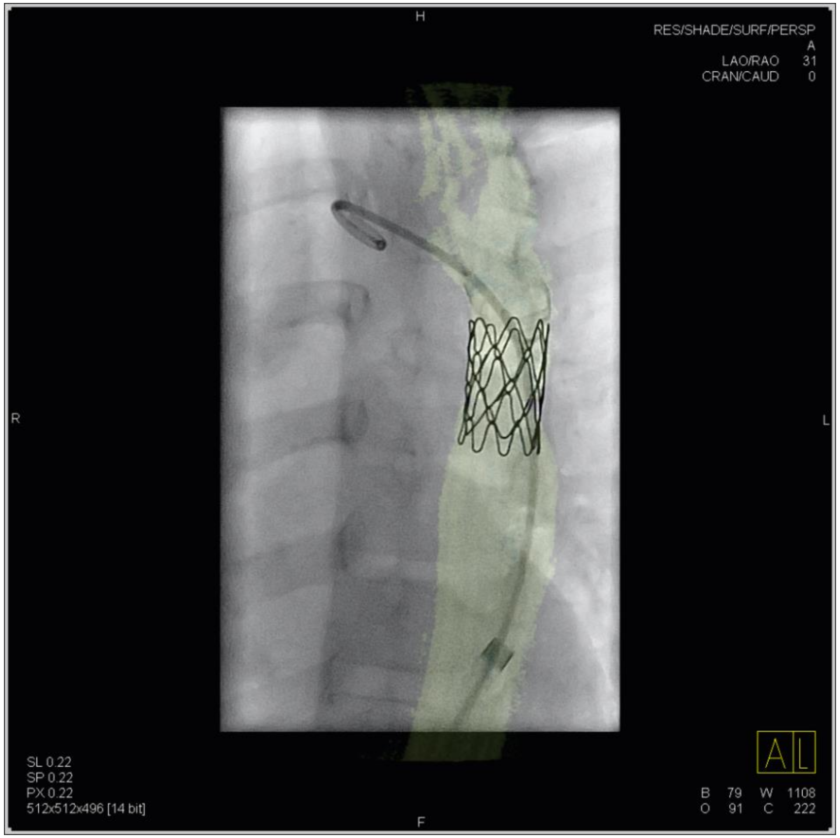
Poor temporal resolution

Invasive

Acquisition during procedure

Contrast injection in VOI

Only visible on A-camera



Glöckler M, Koch A, Greim V, Shabaiek A, Rüffer A, Cesnjevar R, Achenbach S, Dittrich S. The value of flat-detector computed tomography during catheterisation of congenital heart disease. Eur Radiol 2011; 21(12):2511-2520.

Overlay: MRI

Poor temporal resolution

Lower spatial resolution

Acquisition pre-procedure

Glöckler M, Halbfaß J, Koch A.M, Achenbach S, Dittrich S. Multimodality 3D-roadmap for cardiovascular interventions in congenital heart disease—a single-center, retrospective analysis of 78 cases. Catheter Cardiovasc Interv 2013; 82(3):436-442

Overlay: CT

high temporal resolution

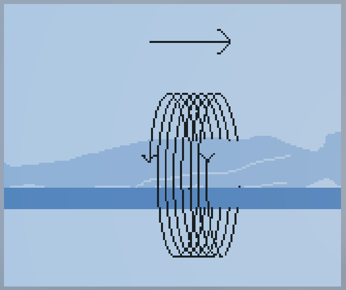
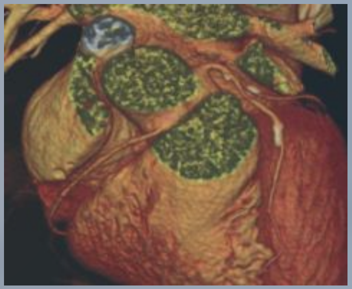
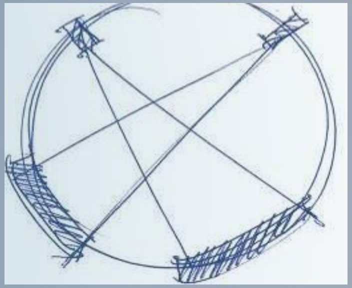
high spatial resolution

Acquisition pre-procedure

DS-CT
1600g,
3ml contrast,
0.1mSv

Glöckler M, Halbfaß J, Koch A, Dittrich S, Achenbach S, Rüffer A, Ihlenburg S, Cesnjevar R, May M, Uder M, Rompel O. Preoperative assessment of the aortic arch in children younger than 1 year with congenital heart disease: utility of low-dose high-pitch dual-source computed tomography. A single-centre, retrospective analysis of 62 cases. Eur J Cardiothorac Surg. 2014 Jun;45(6):1060-5

Technical evolution of CT

Clinical CT	Spiral-CT	Cardiac CT	Dual Source CT
			
1974	1987	1999	2005

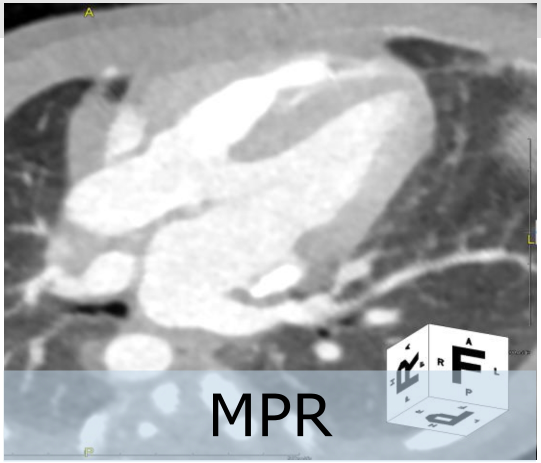
DSCT in CHD today

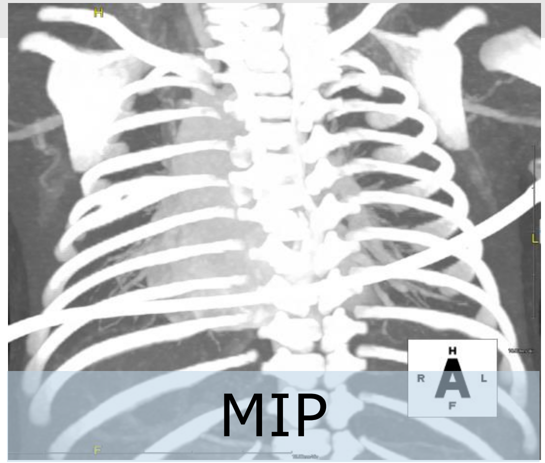
- 70 kV-setting
- New dose reduction techniques
  - ECG- and anatomic-based tube current modulation
  - Iterative reconstructions
  - New detector technologies
- Effective dose <0.5mSv [1]
- Free breathing
- Nearly no sedation

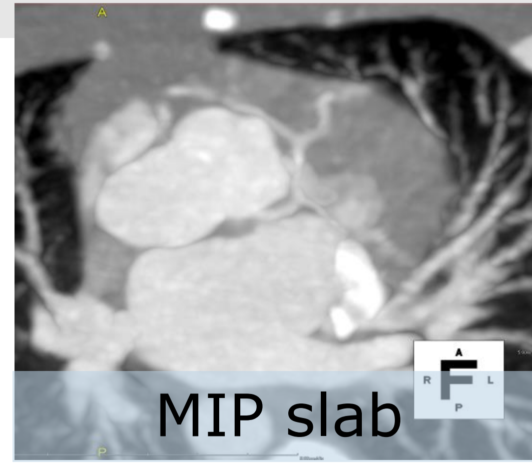
Effective Radiation Dose (mSv) [2]	
X-Ray	0,02
Diagnostic catheter	4.6
Interventional catheter	6.0
Rotational angiography	0.2-0.4

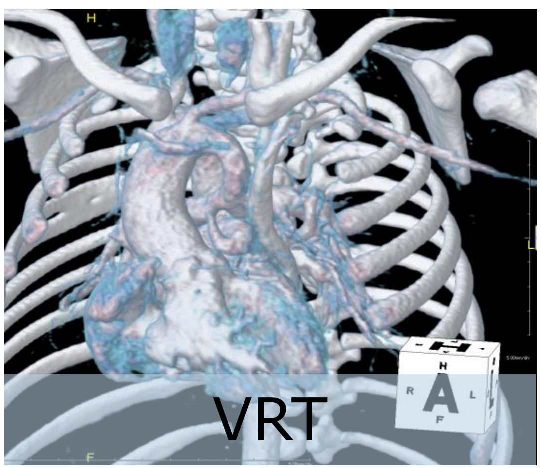
1. Rompel, O., M. Glöckler, R. Janka, S. Dittrich, R. Cesnjevar, M. M. Lell, M. Uder and M. Hammon. "Third-Generation Dual-Source 70-Kvp Chest Ct Angiography with Advanced Iterative Reconstruction in Young Children: Image Quality and Radiation Dose Reduction." Pediatr Radiol, (2016).
2. Bacher, K., E. Bogaert, R. Lapere, D. De Wolf and H. Thierens. "Patient-Specific Dose and Radiation Risk Estimation in Pediatric Cardiac Catheterization." *Circulation* 111, no. 1 (2005)

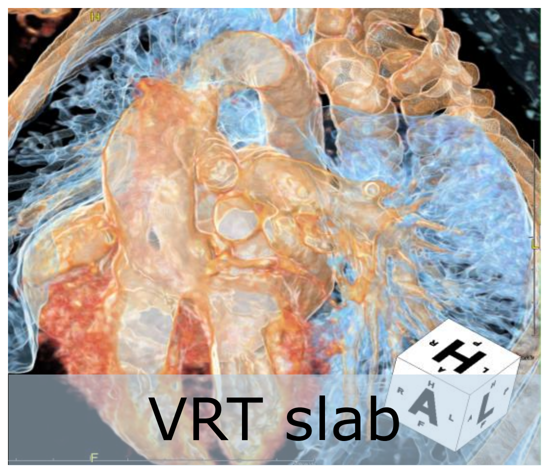
Visualization forms

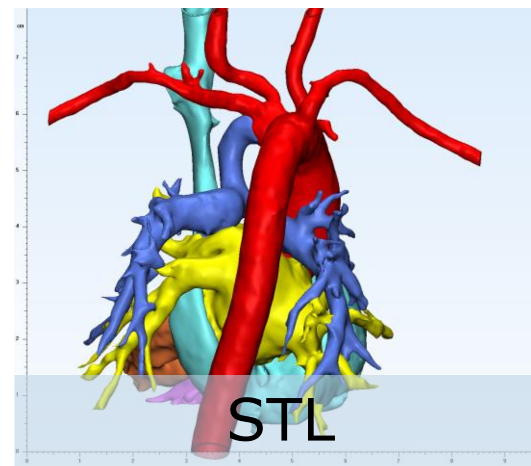












Hausmann,…M. Glöckler. "Application of Dual-Source-Computed Tomography in Pediatric Cardiology in Children within the First Year of Life." *Rofo* (2016)

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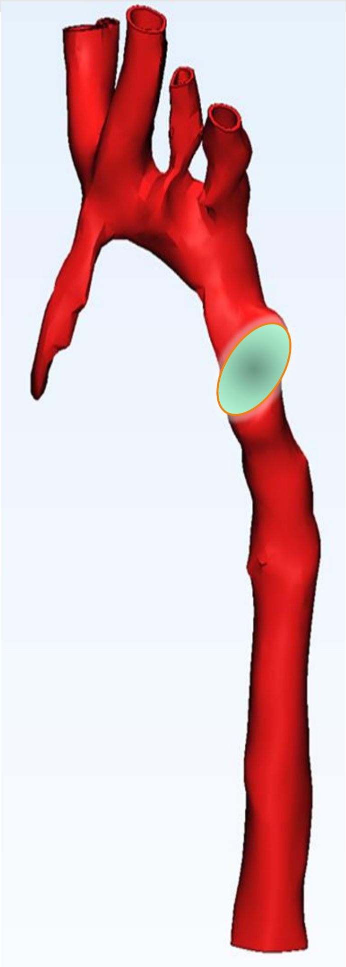
Hypoplastic left heart syndrome

Newborn; 3.2kg; female

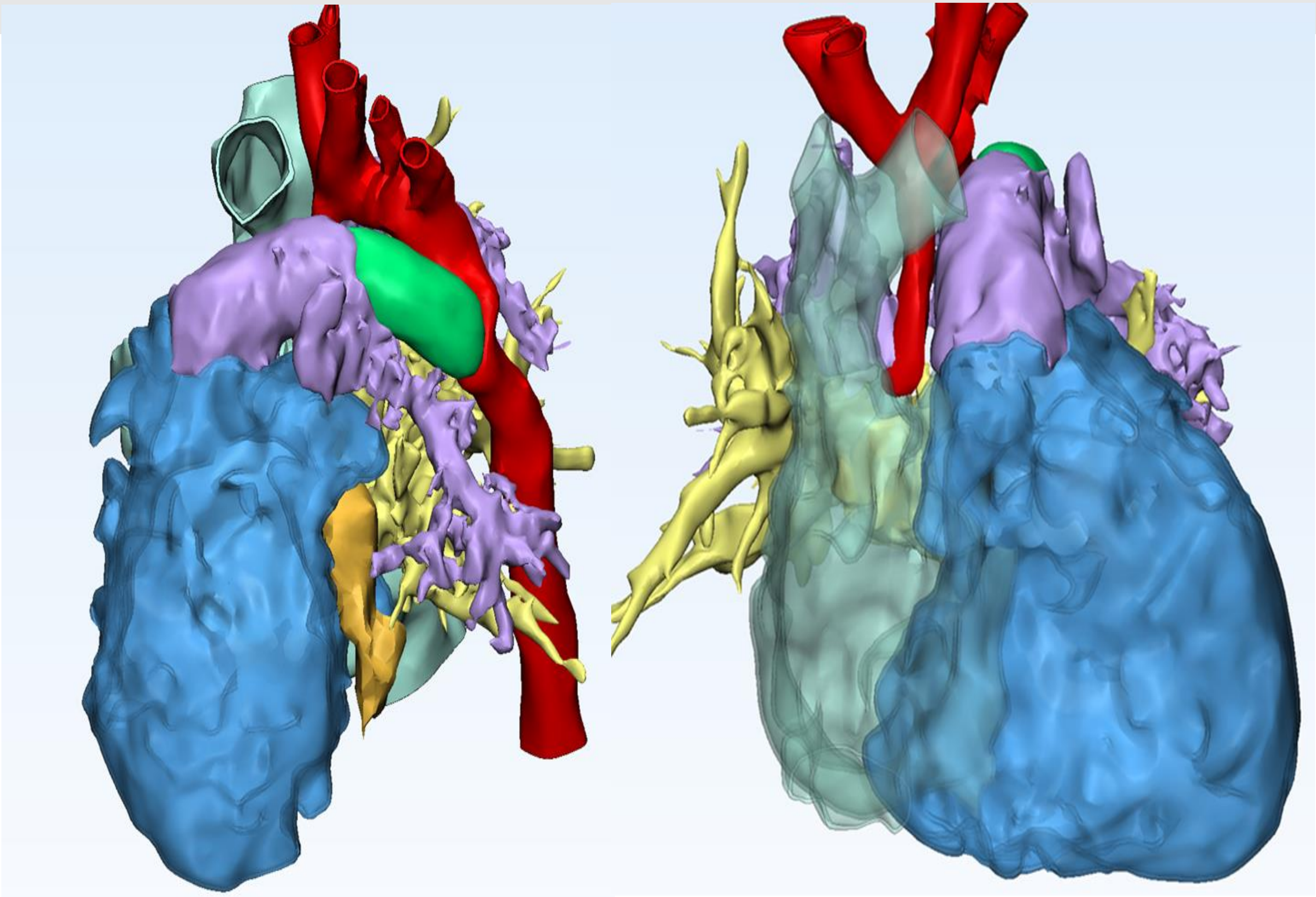
Hypoplastic left ventricle

Bilateral pulmonary banding at 5th day

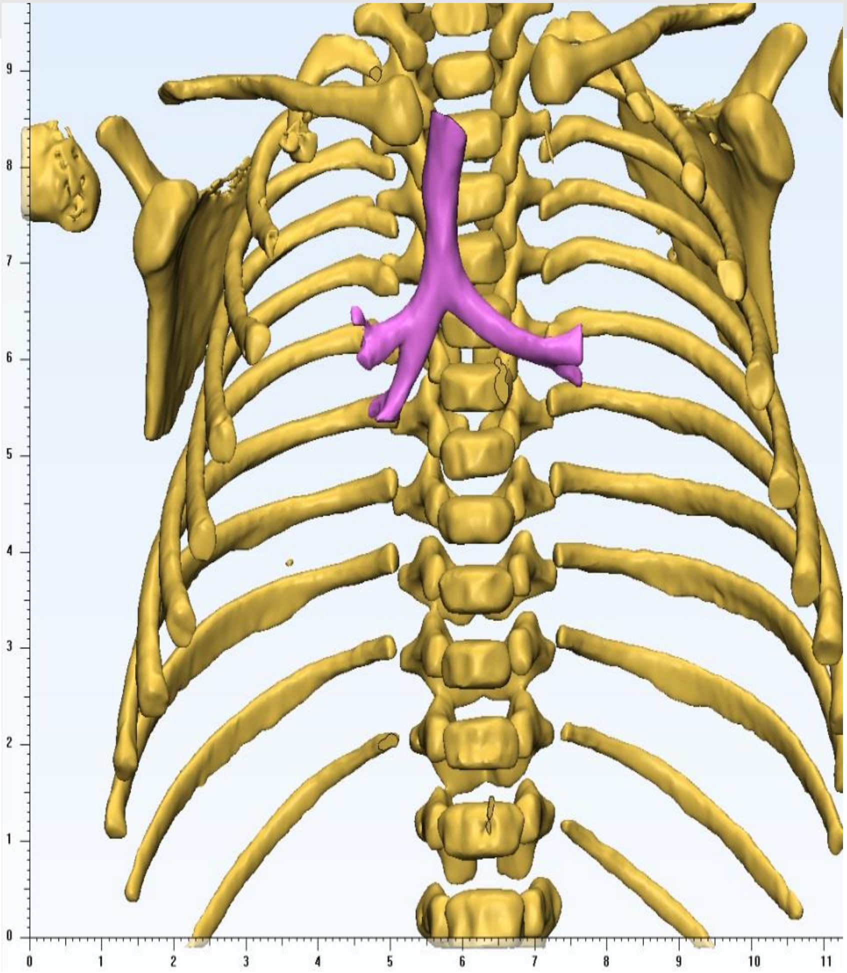
cardiac DSCT (3rd generation)



Preparing the arterial duct stenting



Preparing the image fusion



Segmentation of specific fiducial markers

Image fusion

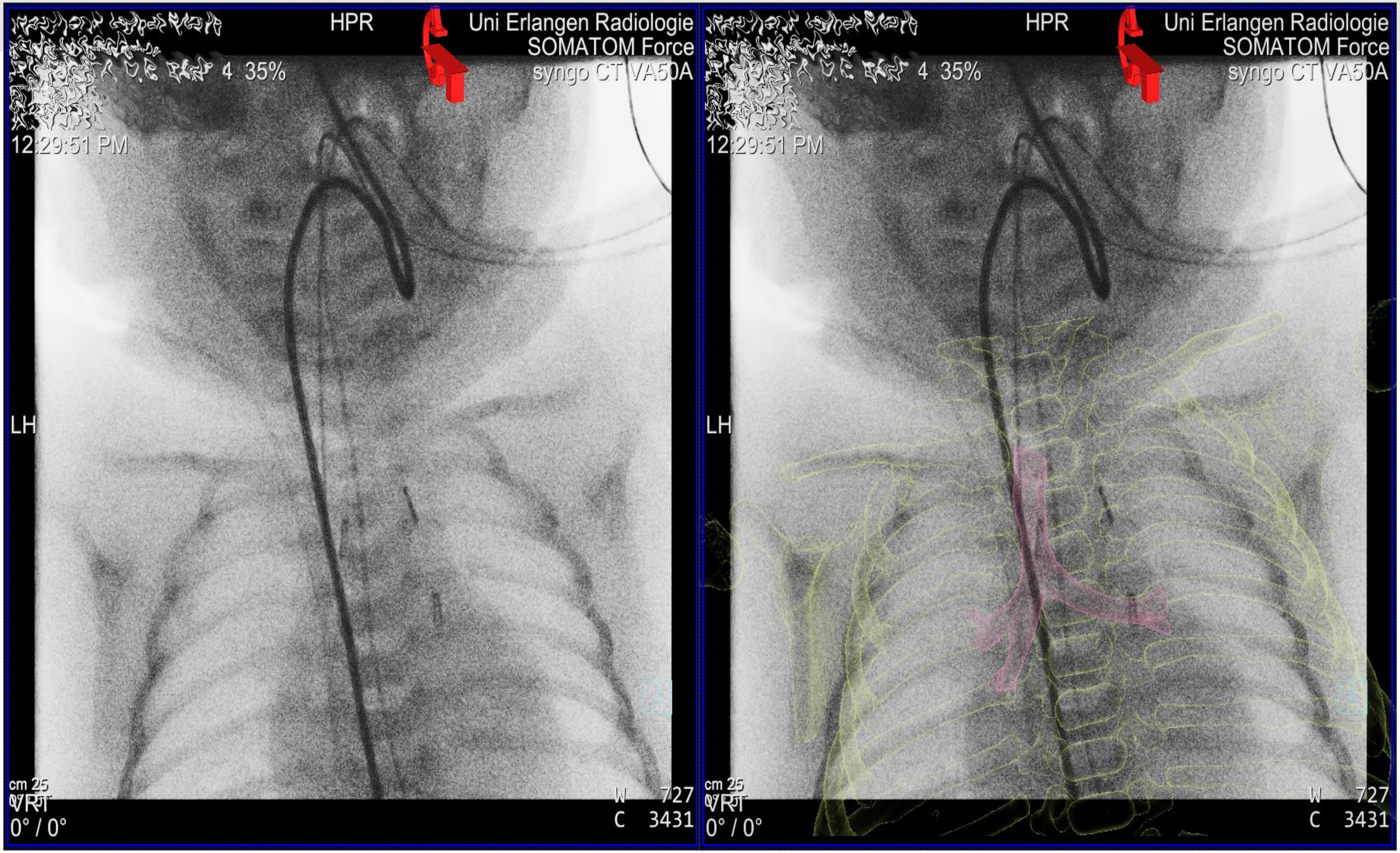
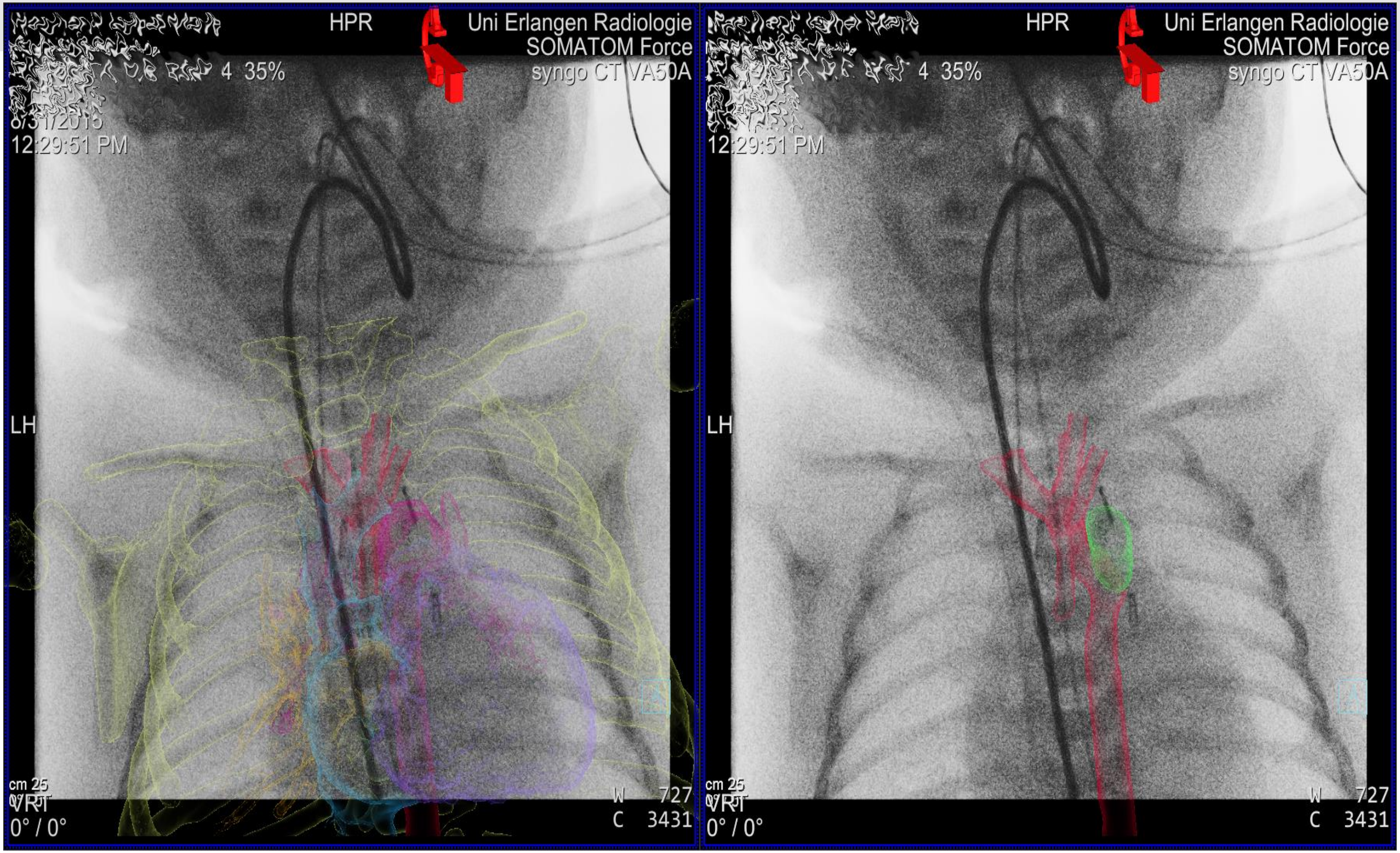


Image fusion



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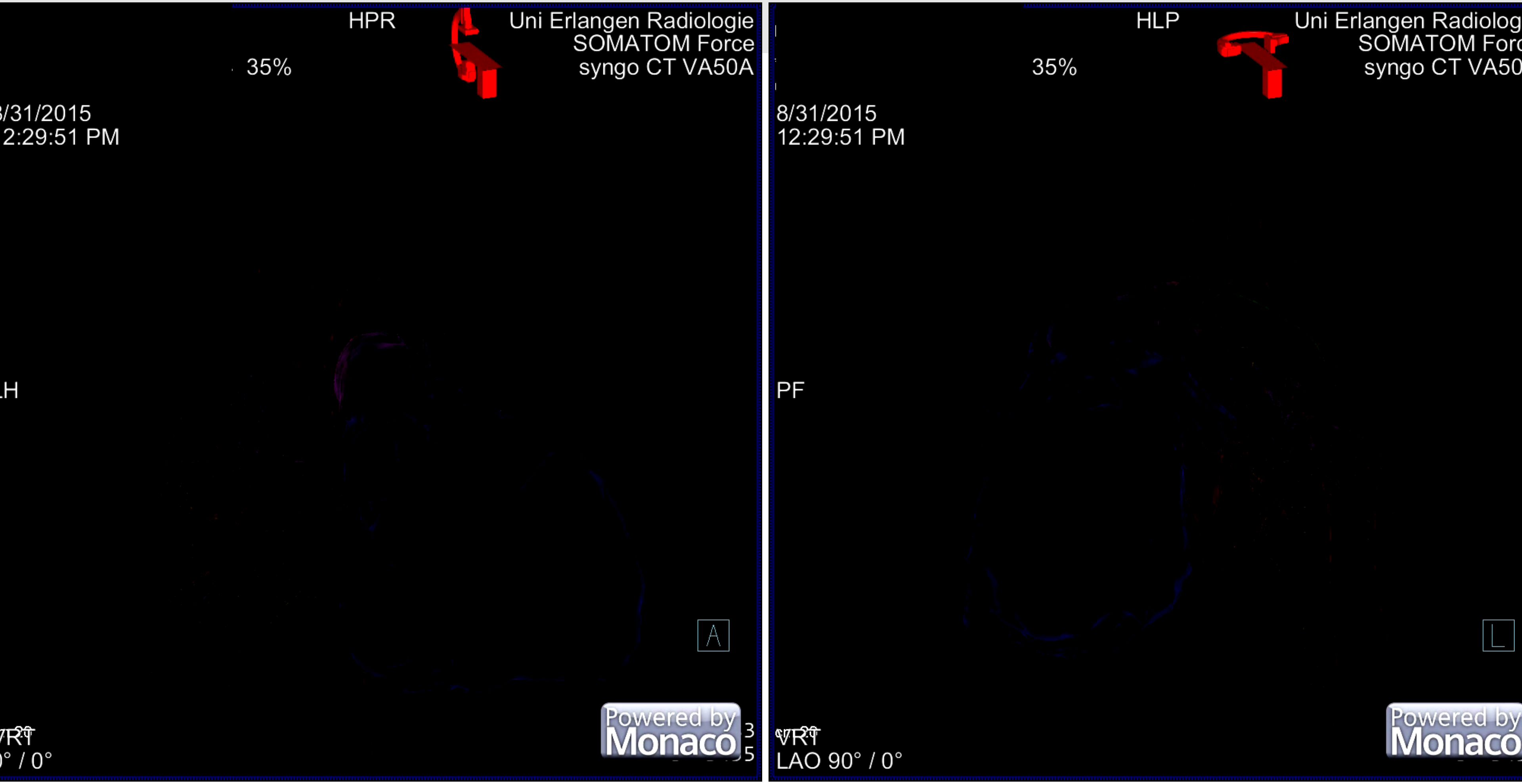
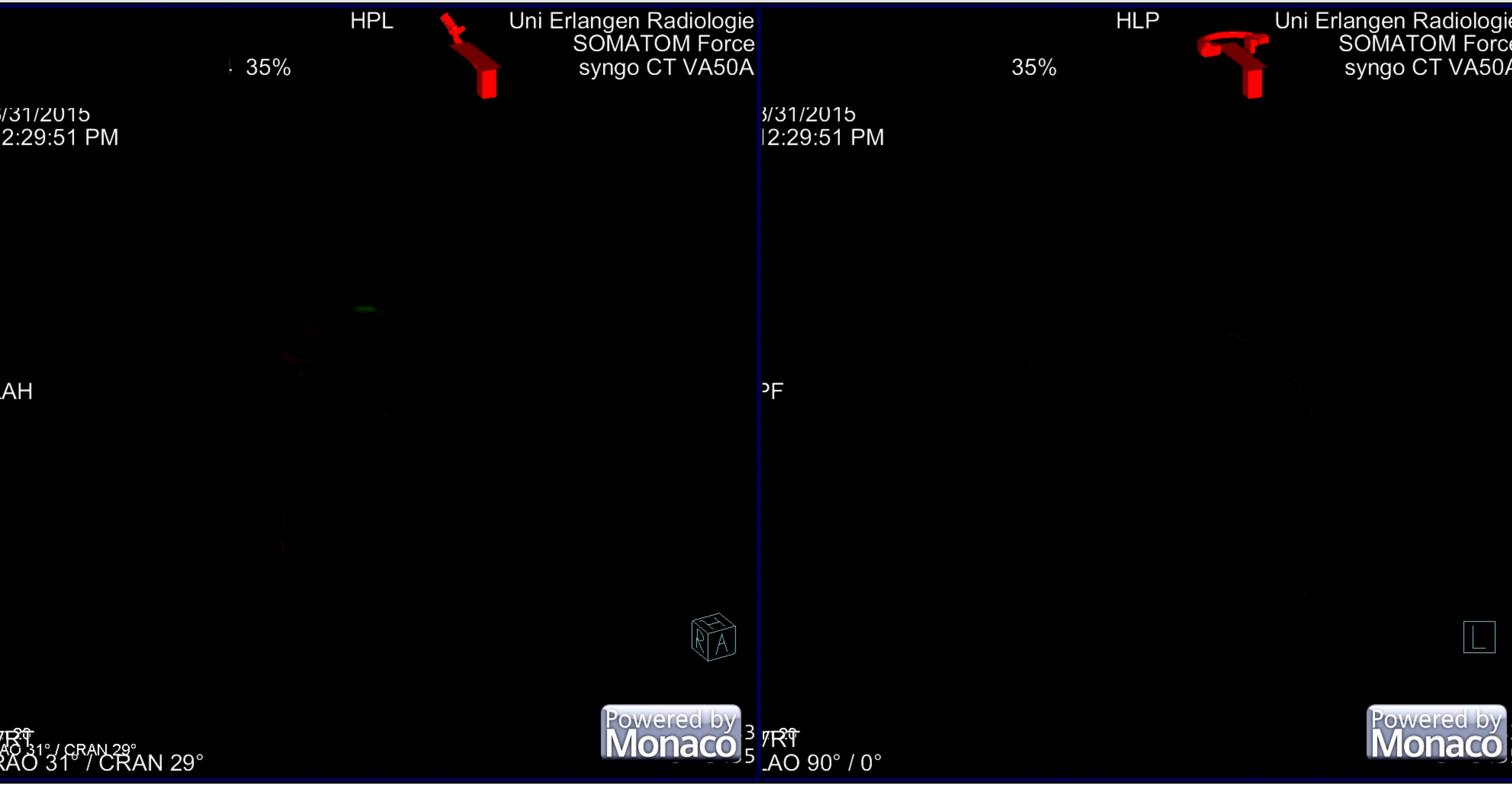
3D-Guidance during Catheterization



Duct-Stenting



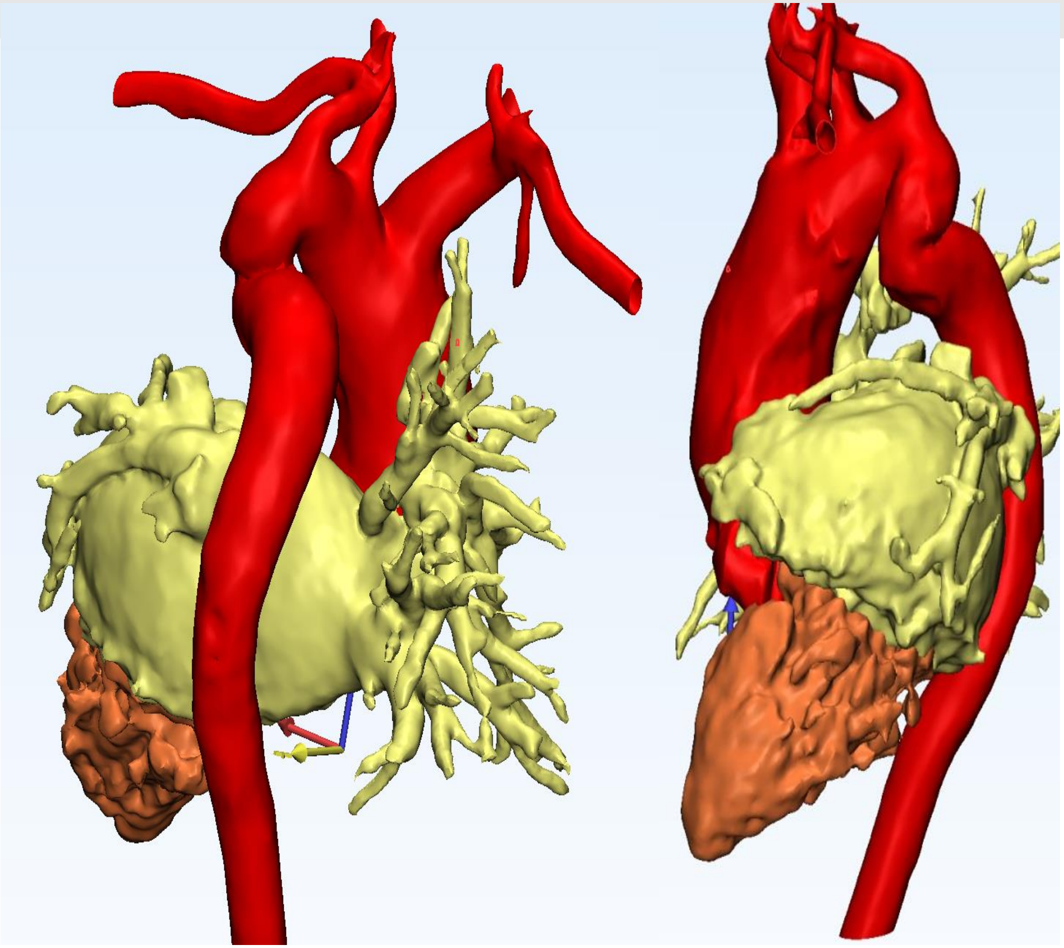
Case 2: Stenting an Aortic Coarctation (CoA)

16 year old girl, 65kg

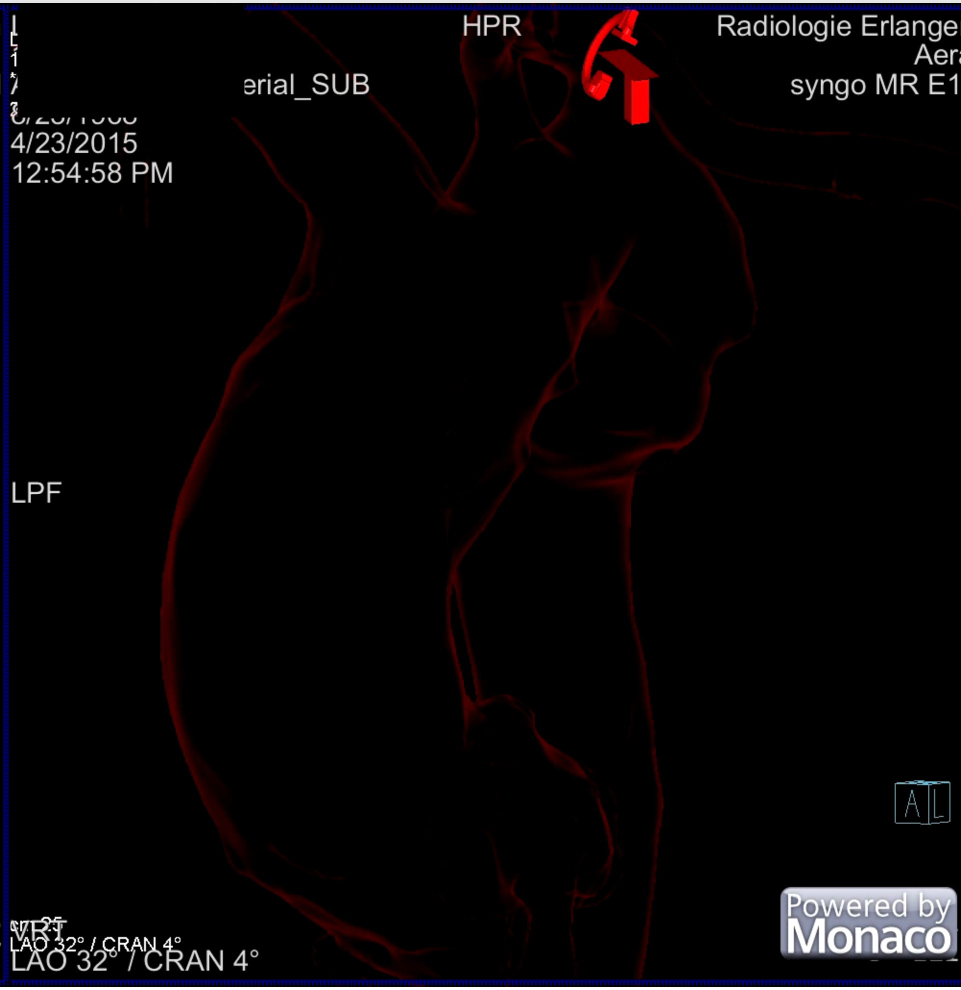
Severe mitral regurgitation

Elongated Aorta with CoA

Aortic coarctation



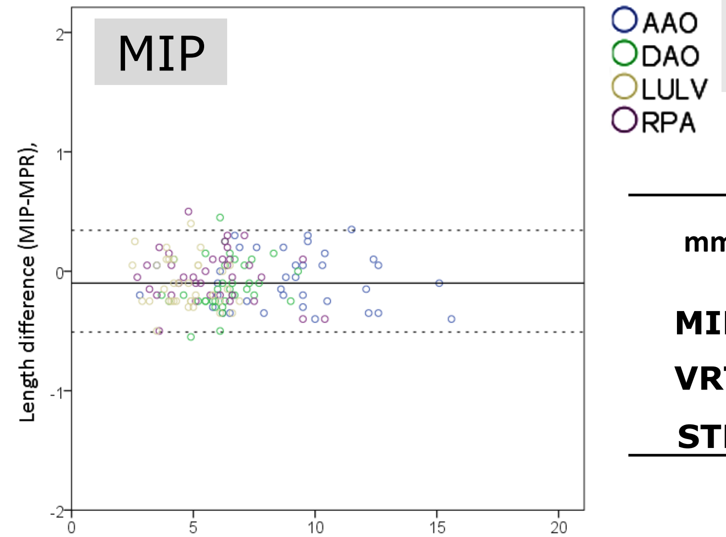
Coarctation of the aorta



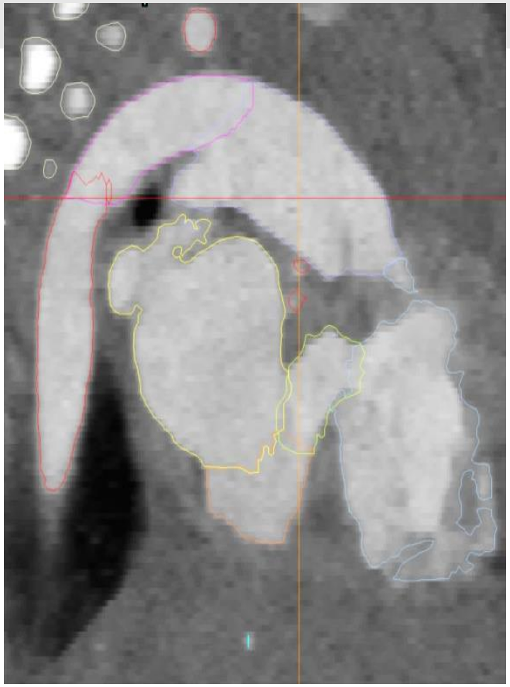
Coarctation of the aorta

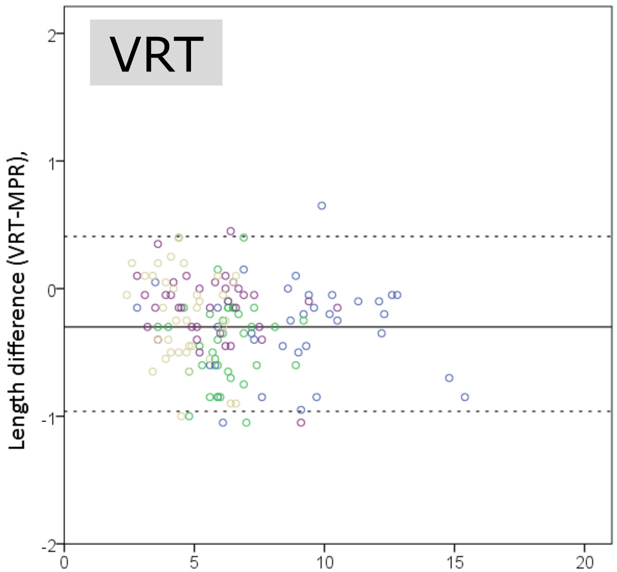
Coarctation of the aorta

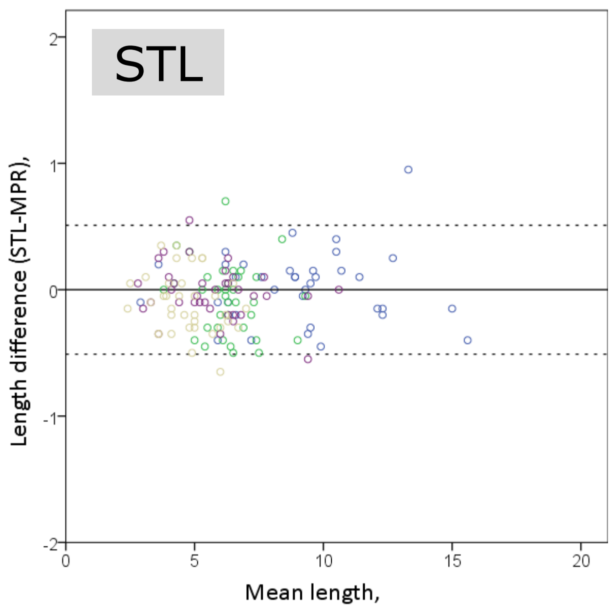
Accuracy of STL-Models (3rd generation DSCT)



mm	Mean	Min	Max
MIP	-0.1	-0.51	0.34
VRT	-0.3	-0.95	0.41
STL	0	-0.51	0.51







Glöckler, M.; Hammon M.; Rompel O., 2016; unpublished

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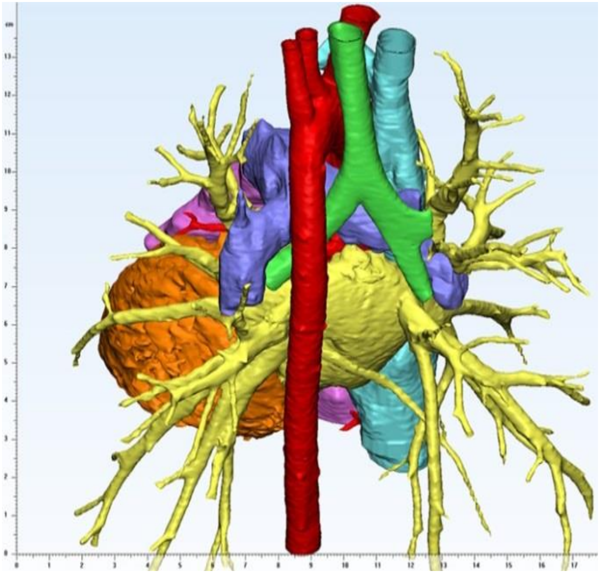
3D-2D registration, trachea as fiducial marker (n=50)

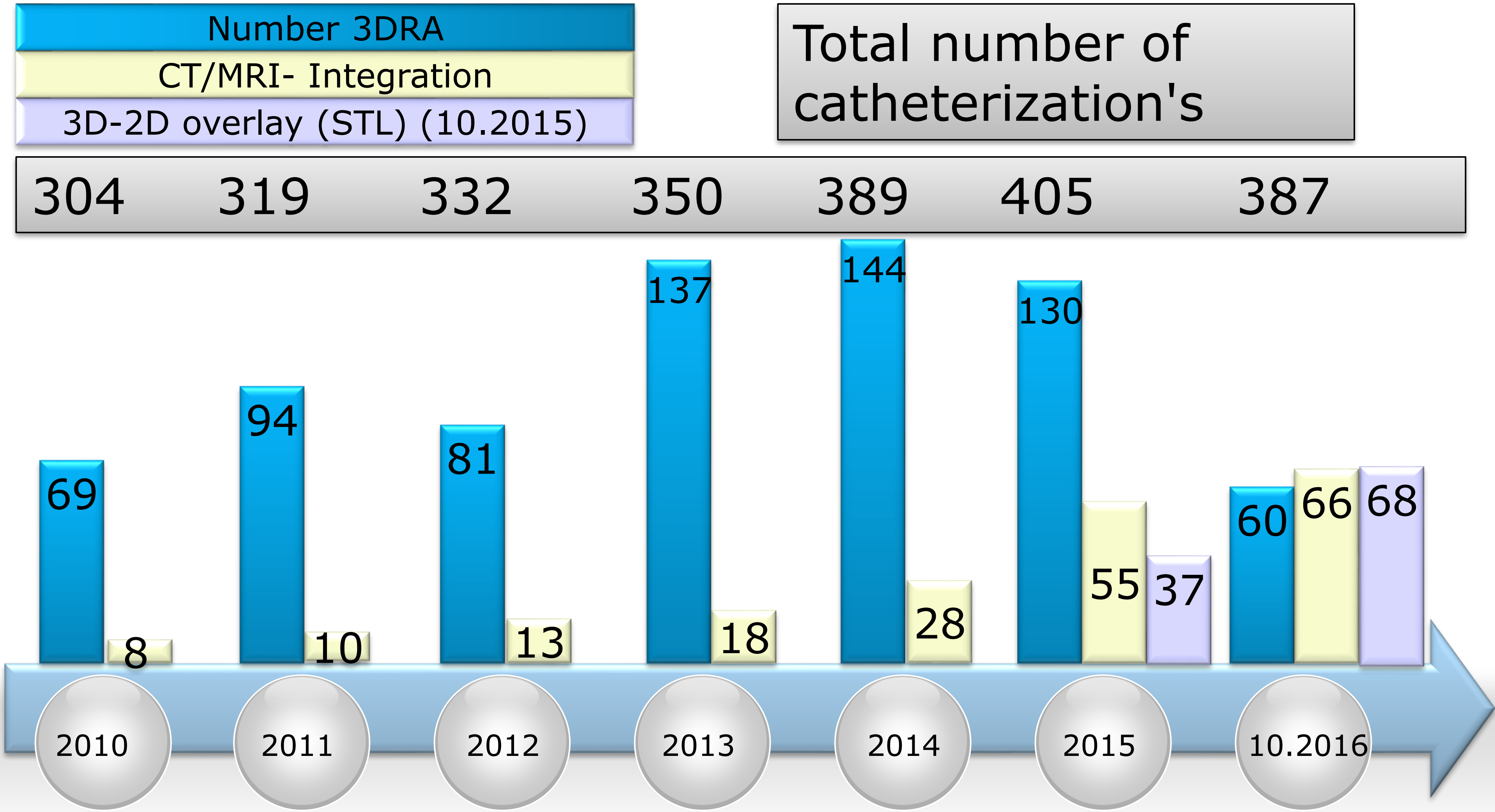
Deviation of aortic diameter; A- and B-Plane (%)		
	A-plane	**B-plane**
Median	**7.5**	**9.1**
Min-Max	**4.5-25.3**	**1.1-29.7**



Comparison of Aortic Interventions with and without 3D-Guidance

Parameter	2D-3D group	Without 3D	Significance
N **Male (n (%))**	13 9 (69.2)	20 15 (75)	
Age (yrs)	18.1 (0.2-47.1)	14.5 (7.8-29)	
Height (cm)	170.9 (50-186)	168 (130-186)	
Weight (kg)	68 (4-85)	56.2 (31.5-85.5)	
Total contrast-medium/wt (ml/kg)	0.96 (0.51-7.67)	1.85 (1-4.4)	<0.01 (U-test)
Dose-area product total (µGy/m²)	938.8 (30.6-3645.5)	1942 (599-6298)	<0.02 (U-test)
Fluoroscopy time (min)	4.5 (1.4-12.8)	10.2 (6.4-32.4)	<0.01 (t-test)

Own data for the use of the different overlay techniques (Ped Cardiol Erlangen)



3D roadmaps optimize aortic interventions with

- models to optimize the interventional strategy
- providing proper orientation during the whole procedure
- best with segmented surface-overlays (STL)
- saving radiation time