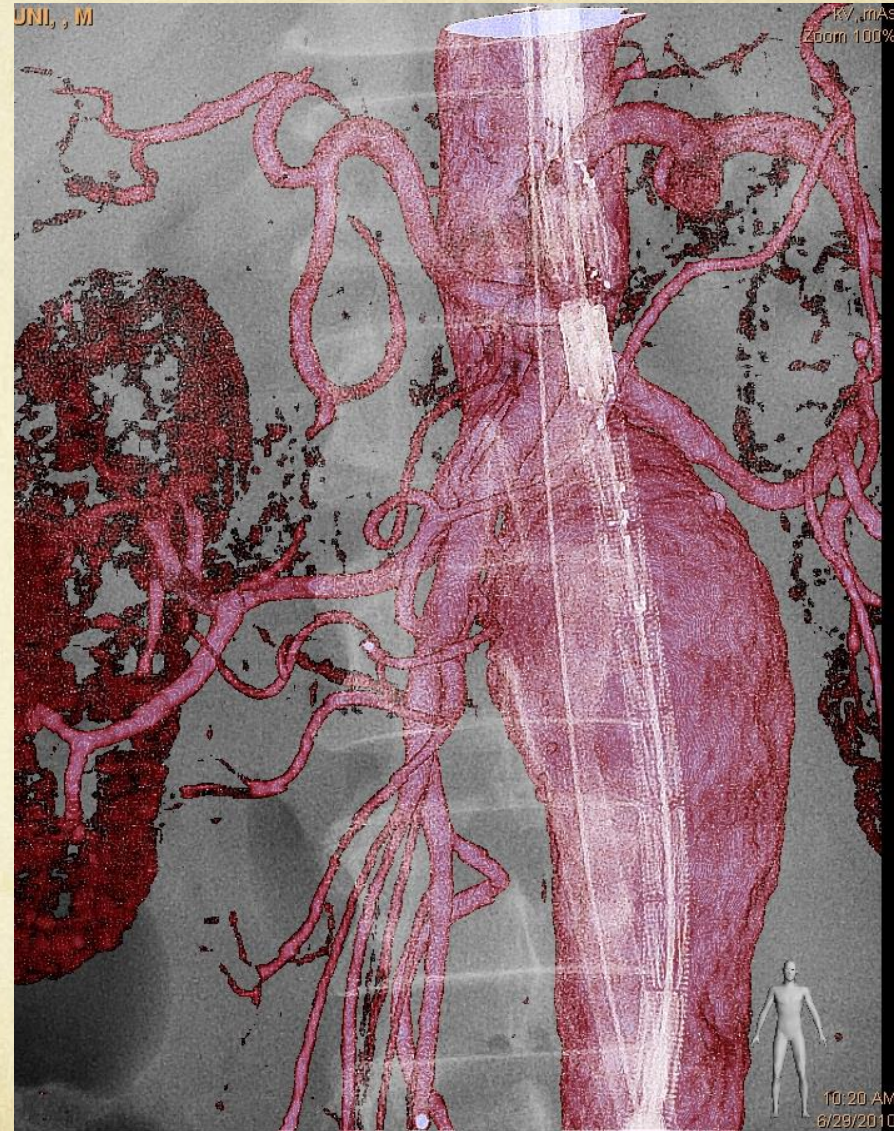


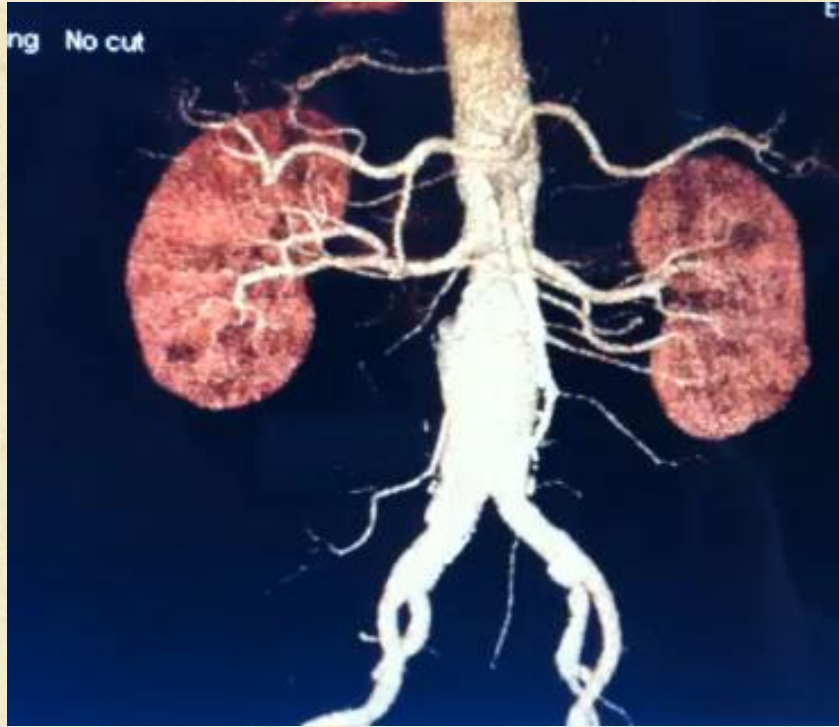
How accurate is intraoperative overlay imaging?

H. Kobeiter, JF Deux,, K You
JP Becquemin, A. Rahmouni, P
Desgranges
Service d'Imagerie Médicale
CHU Henri Mondor
Créteil-Paris XII



Accuracy

- The quality or state of being correct or precise



- Technical the degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard

Vessel deformation

- Prediction of deformations during endovascular aortic aneurysm repair using finite element simulation.

Kaladji A Comput Med Imaging Graph. 2013 Mar

- (EVAR), the introduction of medical devices deforms the arteries
- The aortoiliac structure was extracted from the preoperative CT angiography of fourteen patients underwent EVAR. The simulation consists in modeling the deformation induced by the stiff wire used during EVAR. The results of the simulation were projected onto the intraoperative images, using a 3D/2D registration. The mean distance between the real and simulated guidewire **was 2.3 ± 1.1 mm**. Our results demonstrate that finite element simulation is feasible and appear to be reproducible in modeling device/tissue interactions and quantifying anatomic deformations during EVAR.

Feasibility

- Evaluation of automated 2D-3D image overlay system utilizing subtraction of bone marrow image for EVAR: feasibility study.

Fukuda T. Eur J Vasc Endovasc Surg. 2013 Jul

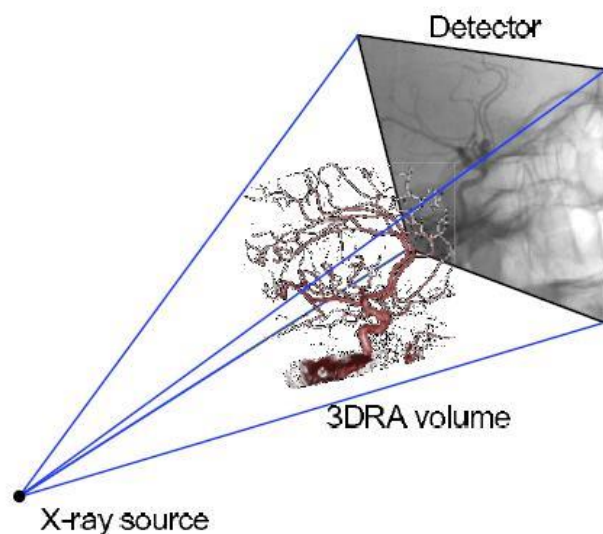
- To evaluate the automated 2D-3D image overlay system ("3D Roadmap") for use during endovascular aneurysm repair (EVAR).
- preoperative CT images were modified to subtract dense bone marrow to improve the visualization of vasculature on the overlaid image, and allow for accurate navigation of the endovascular devices. The 3D-CT overlay image was registered on the 2D fluoroscopy image to mark the iliac crest and lumbar vertebrae on both images as landmarks. Arteriography was performed only twice to confirm the precision of the position of renal artery and the final evaluation. Twenty patients underwent EVAR with Medtronic Endurant, Gore Excluder, or COOK Zenith using "3D Roadmap". **The origin of the renal artery and iliac bifurcation were registered with complete accuracy in 10 patients (50%). The lower renal artery deviated toward the cranial side less than 3 mm in six patients.** In all cases, EVAR was successful, and completed with the volume of contrast material limited to 43.8 ± 3.1 mL.

Dynamic 3D Roadmap

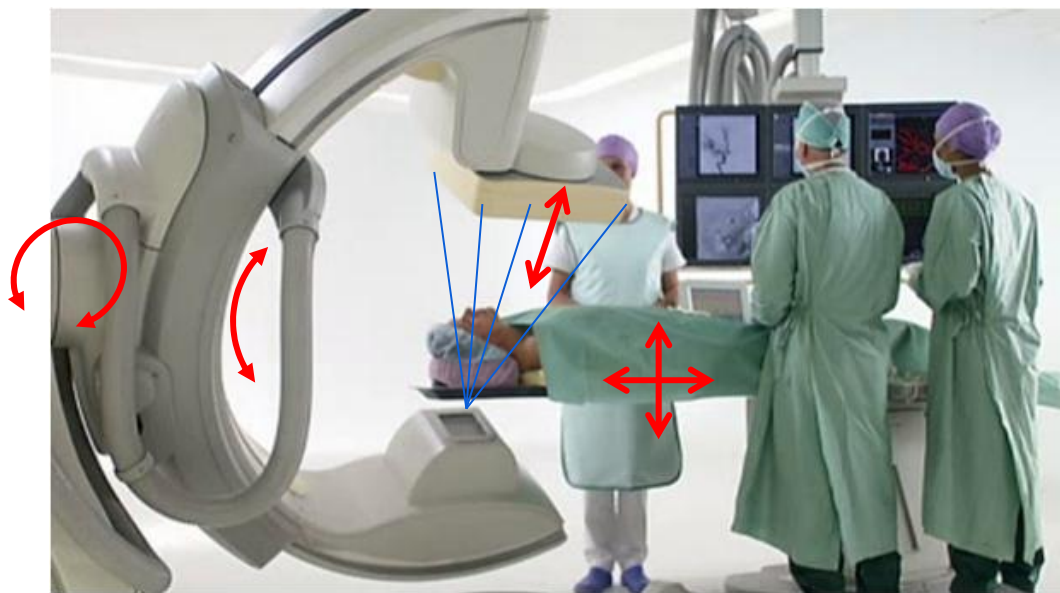
Basics

- Overlay of live fluoroscopy onto 3D-RA or CBCT volumetric projection
- Synchronized with FPD magnification, C-arc angulations and Table movements

registration precision < 0.2 mm



Inverse perspective



On-the-fly tracking

MR/CT roadmap

Basics

- Registration of 3D-RA or CBCT with previously acquired CT/MR datasets
- Same technical principles (inverse perspective) and synchronization as in dynamic 3D roadmap
- Precision of 3D-3D registration < 0.55 mm

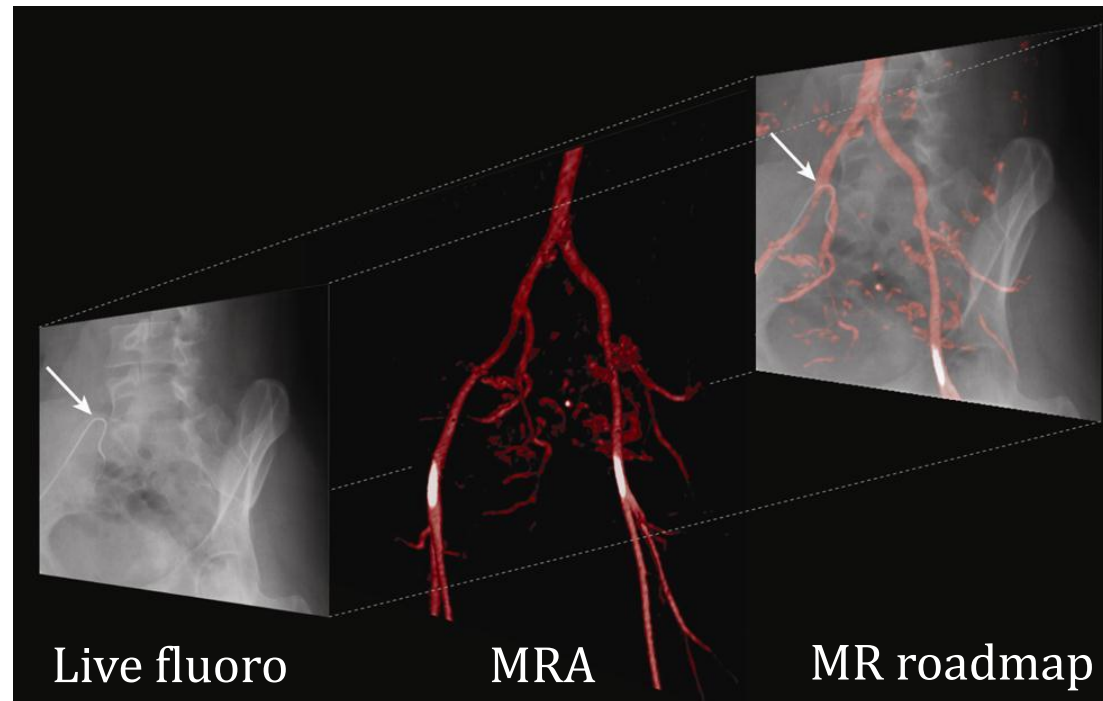
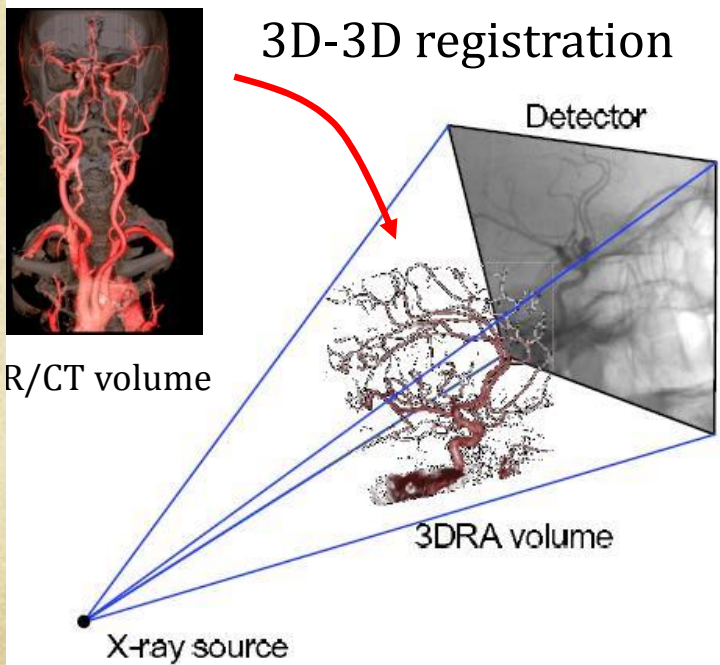
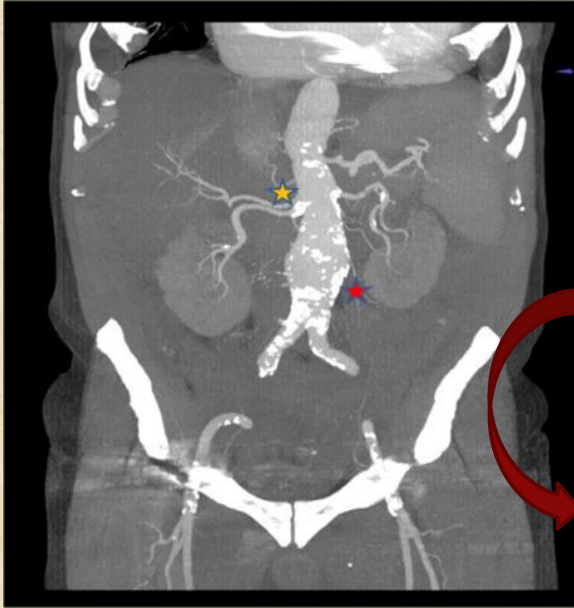


Image overlay ?



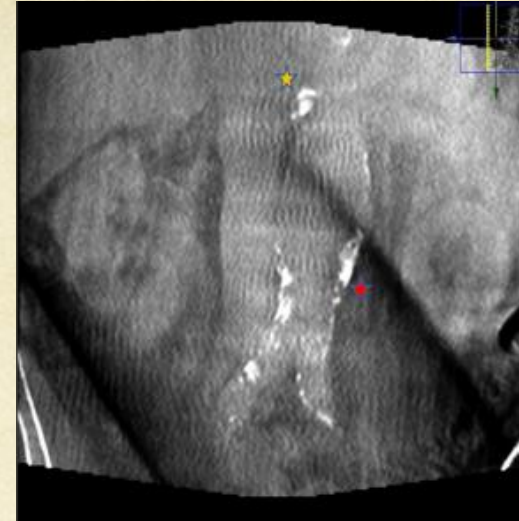
CBCT

Superimposed with CTA

Overlay to fluoroscopy

3D CTA Road mapping

Combined to table
movements and to the C-
arm



Circulation

JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart
Association® 
Learn and Live™

Zero-Contrast Thoracic Endovascular Aortic Repair Using Image Fusion

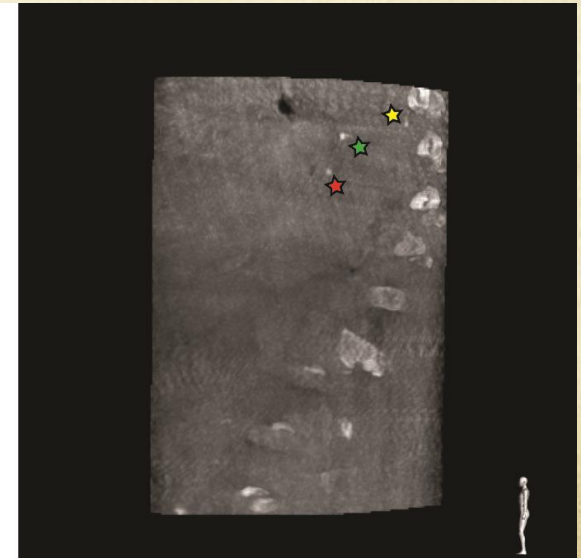
Hicham Kobeiter, Julien Nahum and Jean-Pierre Becquemin



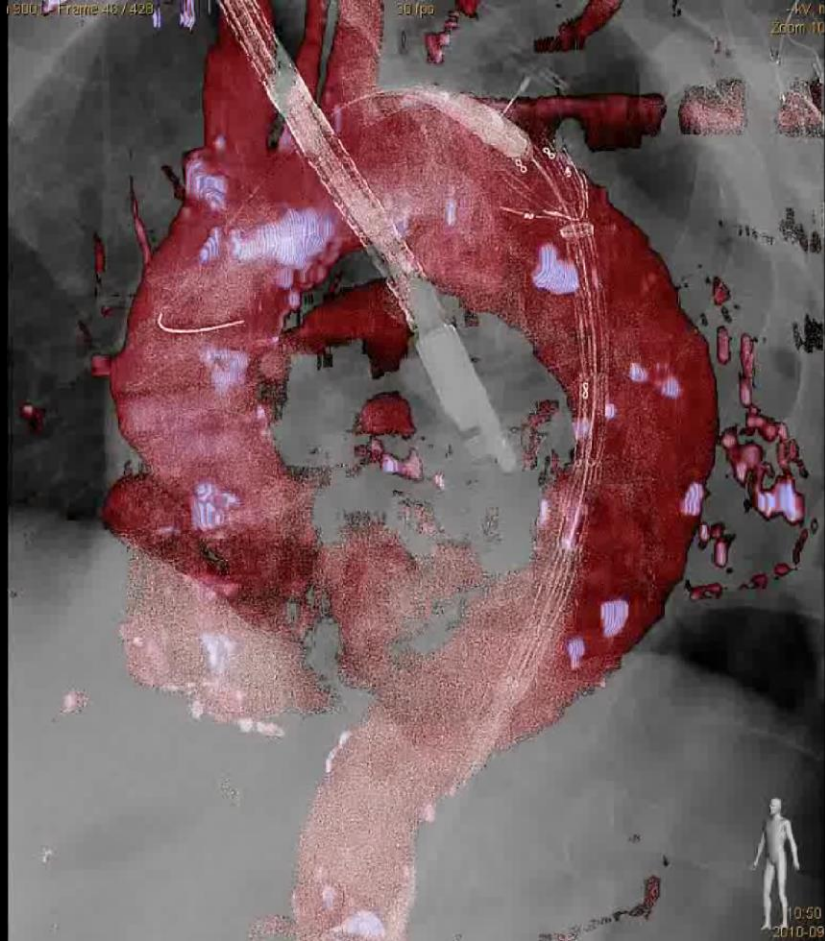
Calcifications



Thick-slab MIP rendering of diagnostic CTA



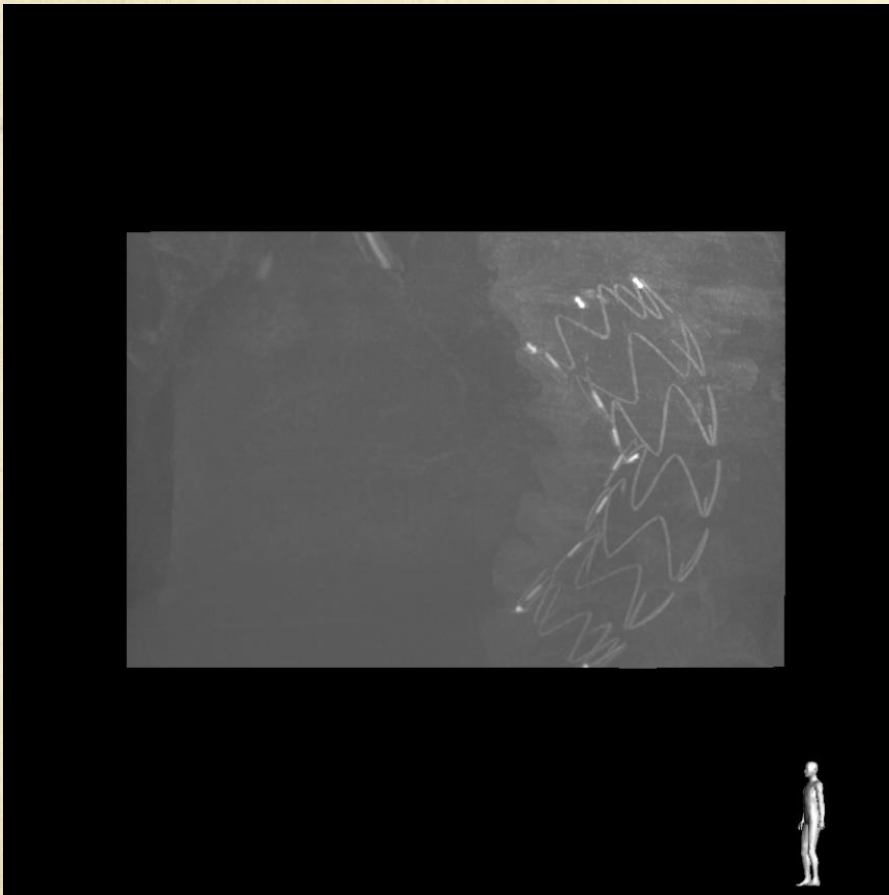
Sagittal slice of blanco XperCT



10:50
2010-09



Results



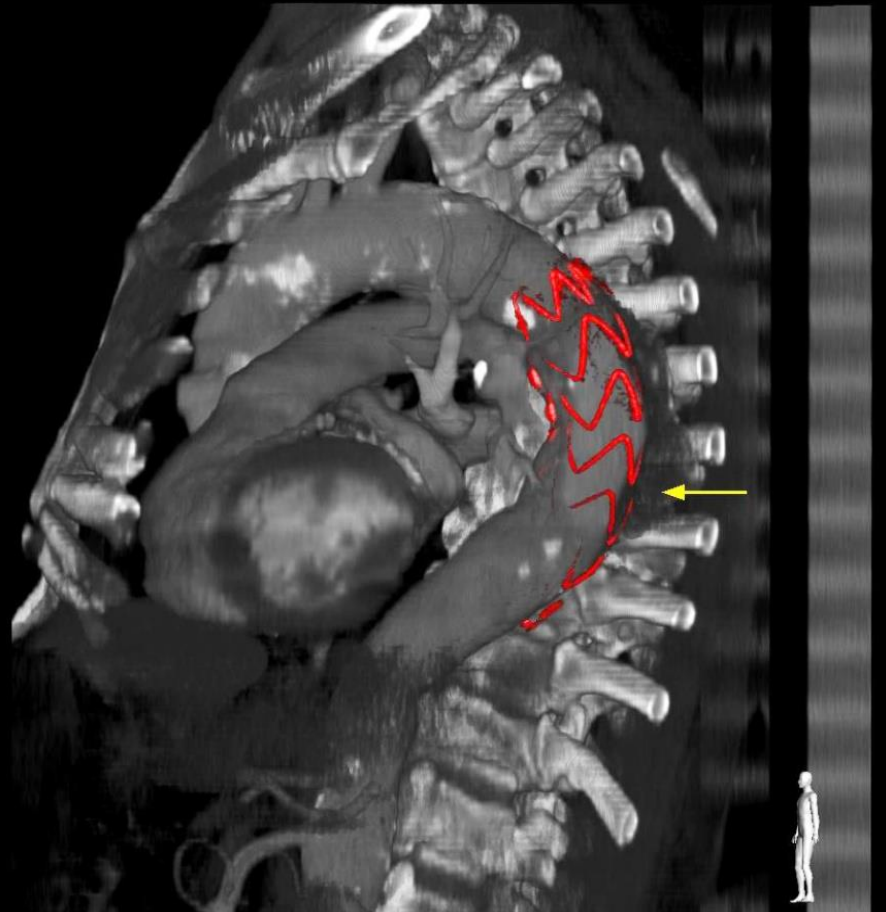
XperCT showing complete stent-graft deployment



Control CTA confirms complete aneurysm coverage and no endoleaks

Results

Virtual stent position

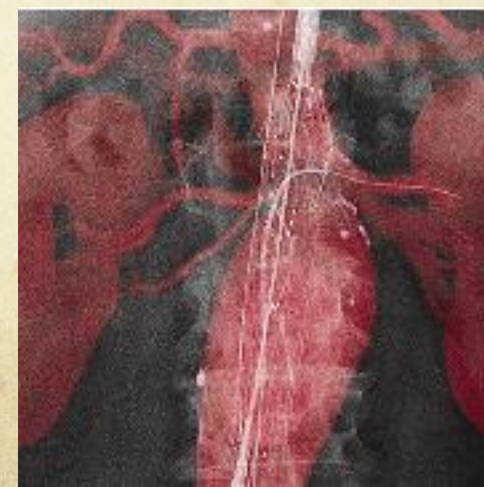
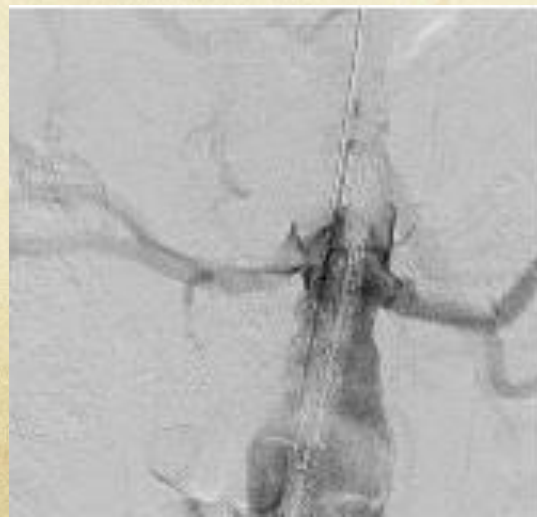
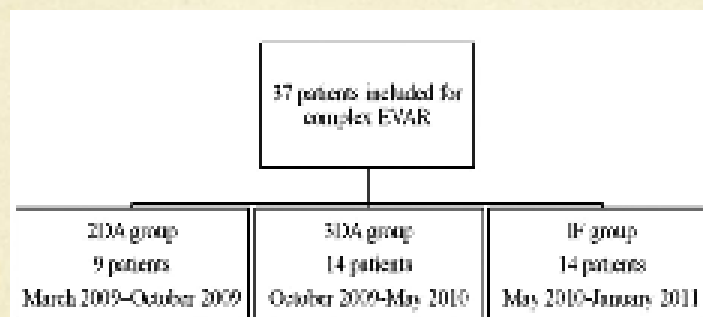


Post-interventional CTA



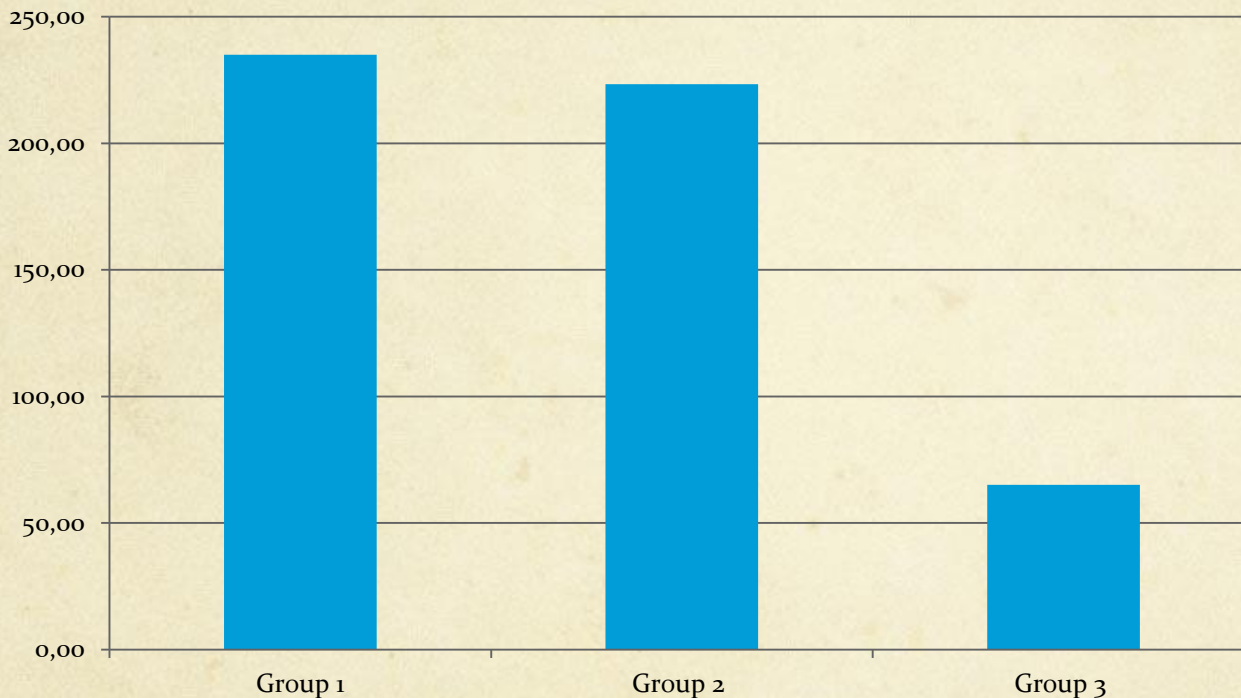
Comparison of Two-dimensional (2D) Angiography, Three-dimensional Rotational Angiography, and Preprocedural CT Image Fusion with 2D Fluoroscopy for Endovascular Repair of Thoracoabdominal Aortic Aneurysm

Vania Tacher, MD, MingDe Lin, PhD, Pascal Desgranges, MD, PhD, Jean-Francois Deux, MD, PhD, Thijs Grünhagen, PhD, Jean-Pierre Becquemin, MD, Alain Luciani, MD, PhD, Alain Rahmouni, MD, and Hicham Kobeiter, MD



Volume de PDC

Contrast (ml)



Group 1 : 235 ml

Group 2 : 223 ml

Group 3 : 65 ml

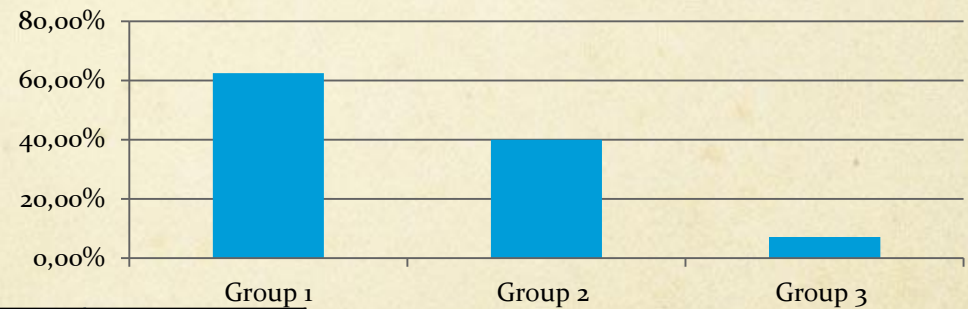
$p(g1/g3)$ and $p(g2/g3)$:

5

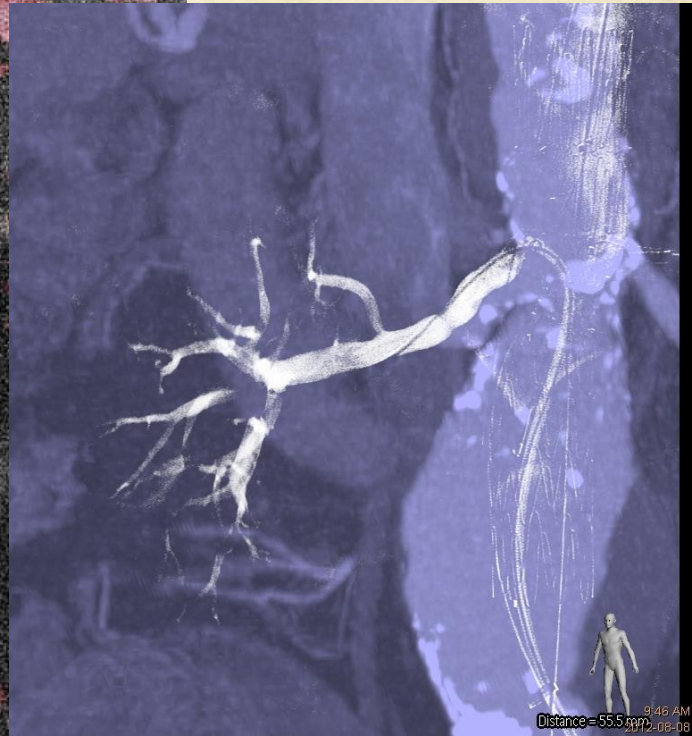
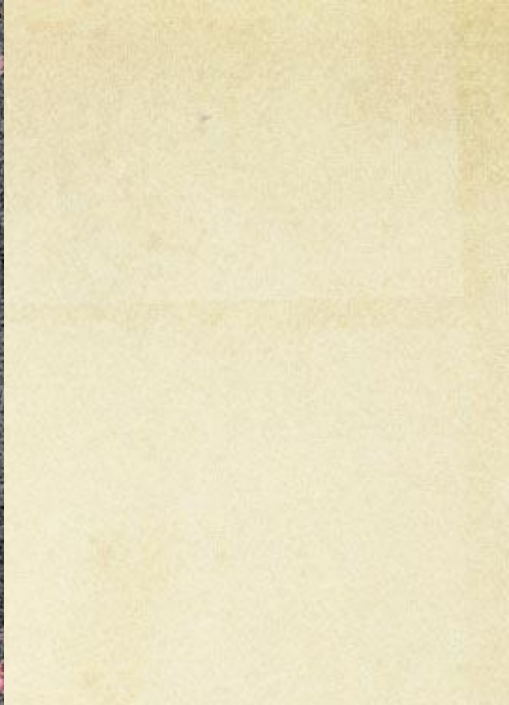
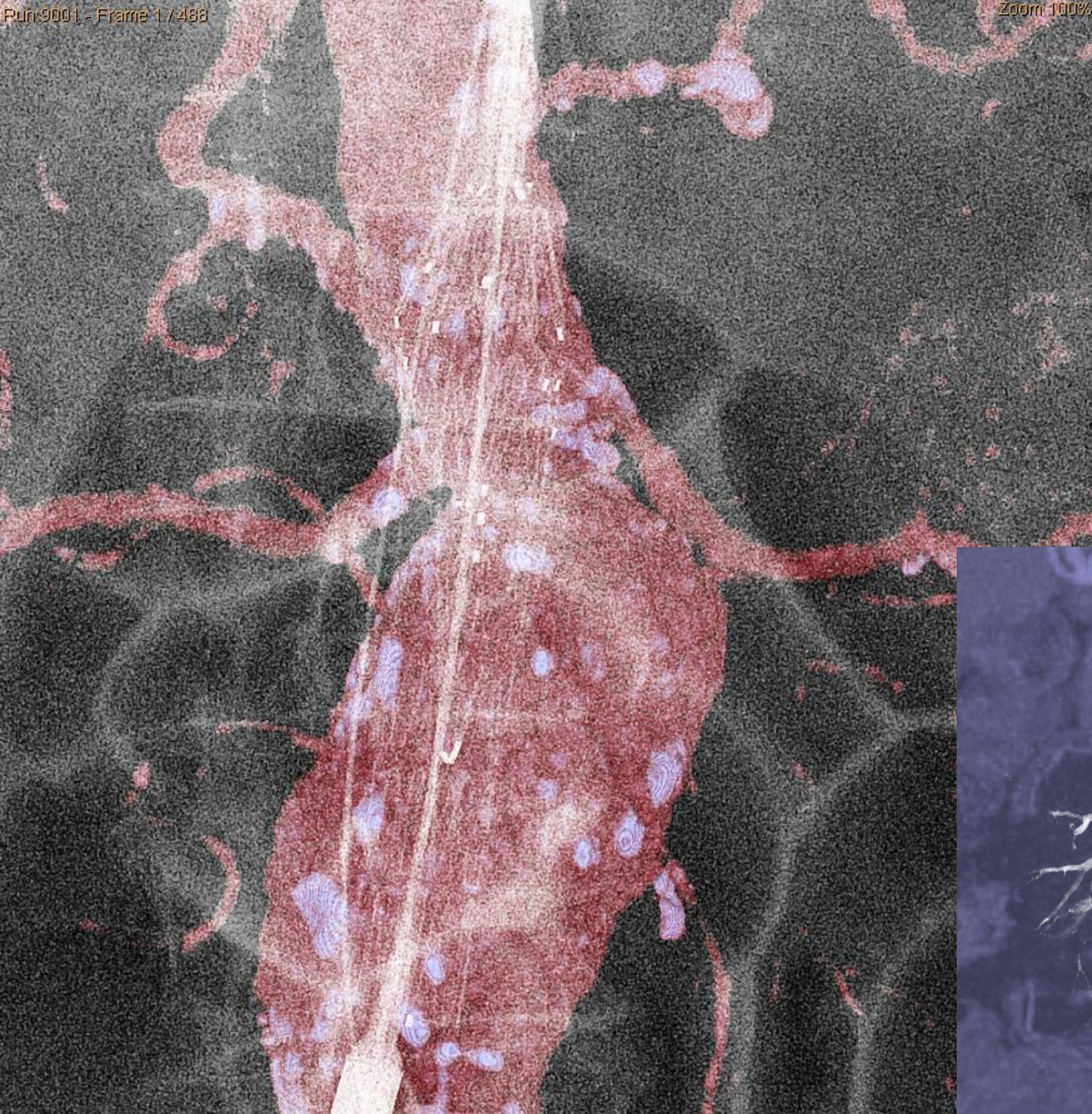
Intervention Data

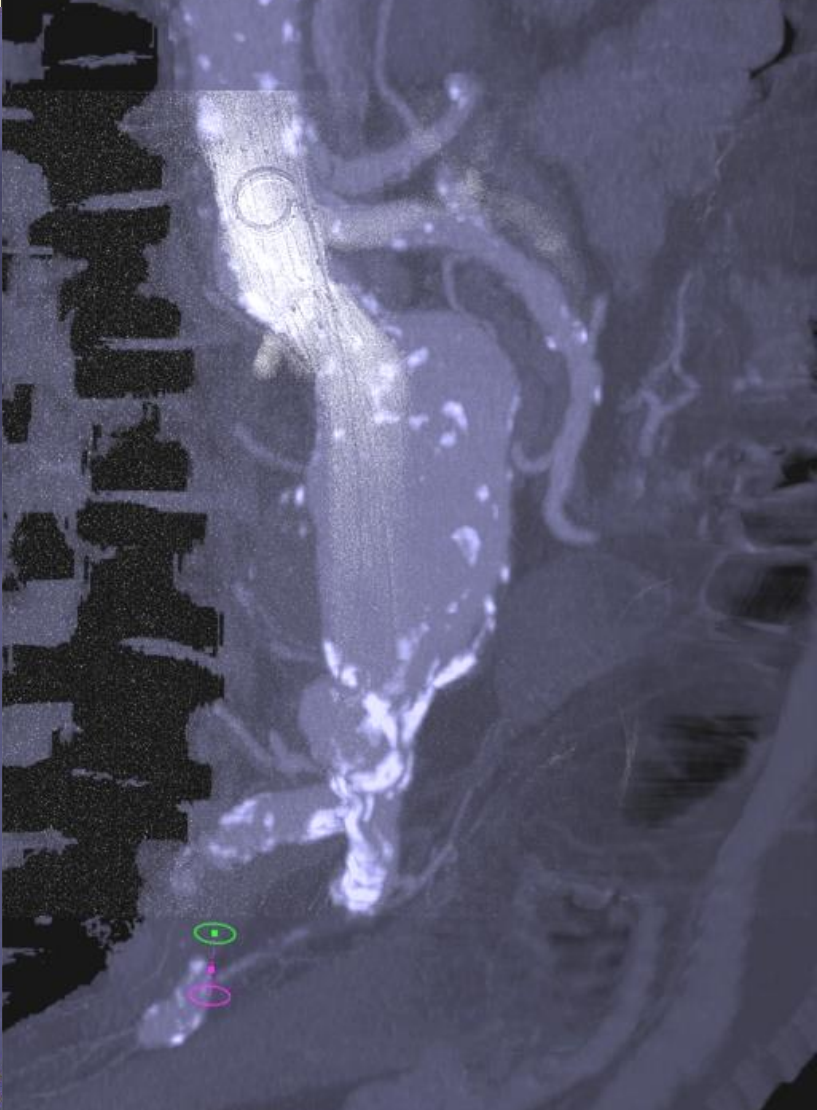
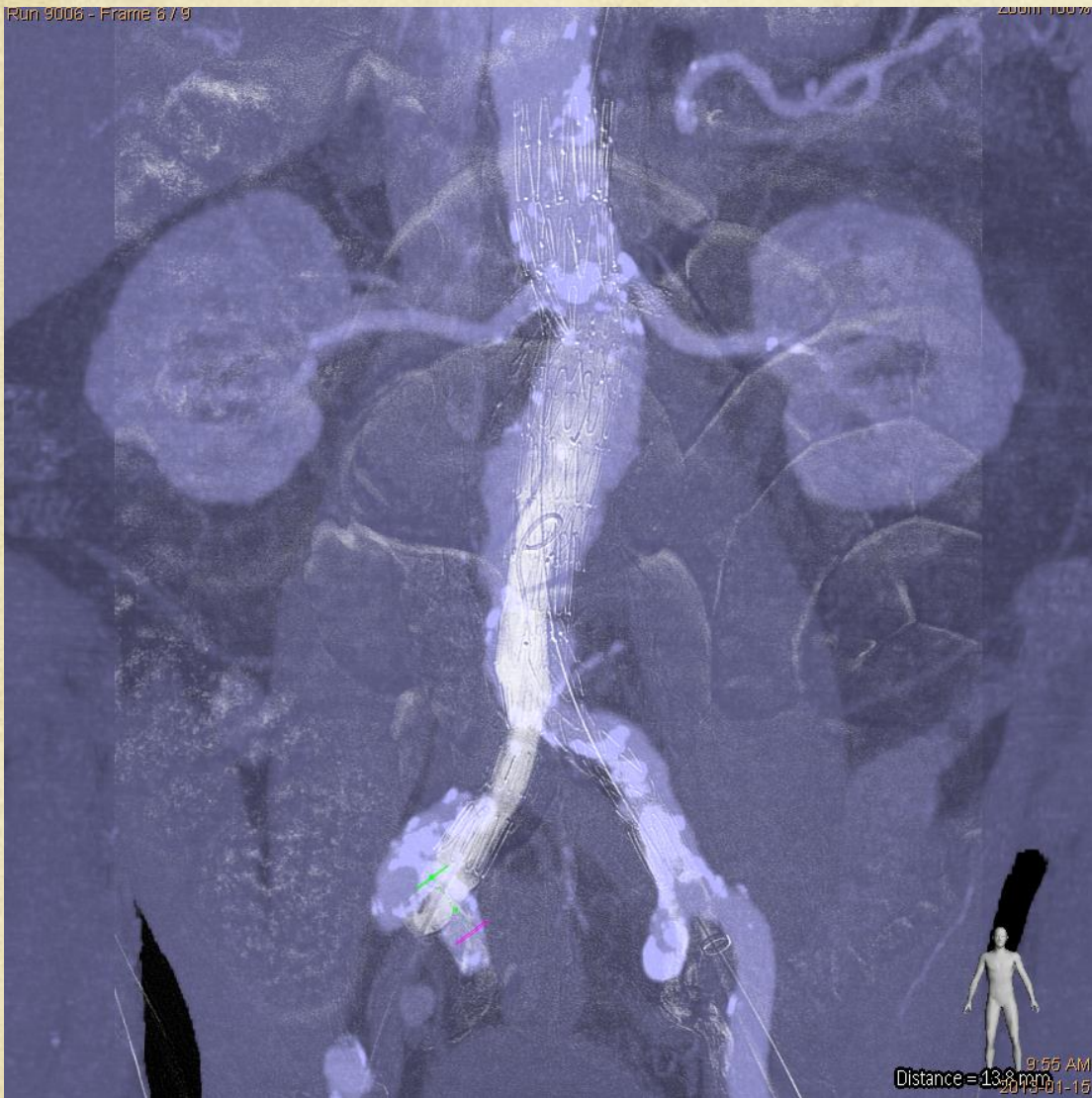
Parameters (n ± SD or %)	2DA Group	3DA Group	IF Group	p-value
	n=9	n=14	n=14	
Success of procedure	8(89%)	14(100%)	14(100%)	0.24
Duration of Intervention (minute)	233(±123)	181(±53)	189(±60)	0.59
DAP (Gy×cm ²)	1188(±1067)	984(±581)	656(±457)	0.18
Contrast (ml)	235(±145)	225(±119)	65(±28)	<0.0001

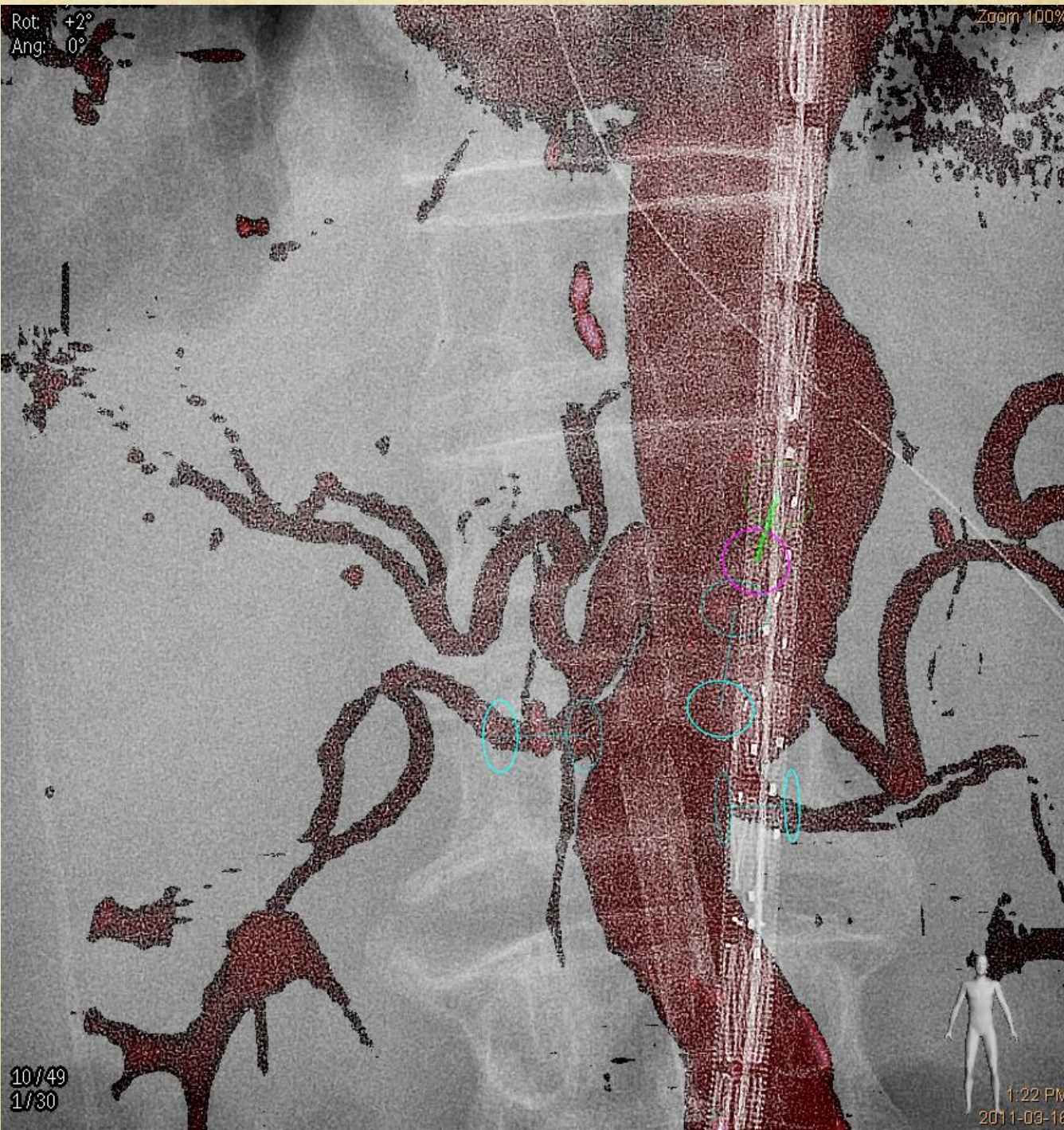
Endoleaks



Endoleak on the first CT control	Group 1		Group 2		Group 3	
Endoleak	5	62,50%	6	40,00%	1	7,14%
Type 1	3	37,50%	2	13,33%	0	0,00%
Type 2	2	25,00%	4	26,67%	1	7,14%
Type 3	0	0,00%	0	0,00%	0	0,00%







Rot: +2°
Ang: 0°

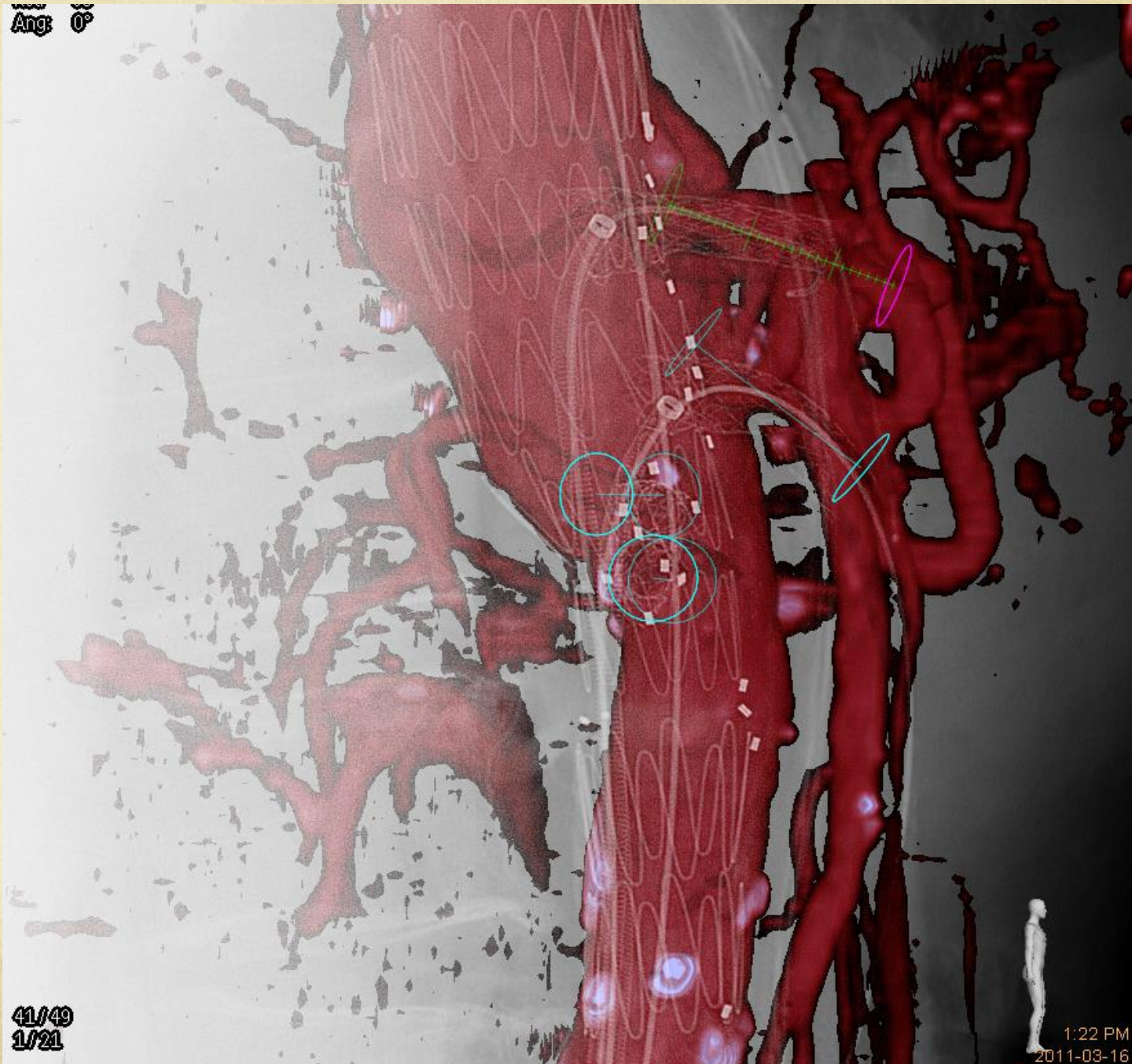
Zoom: 100%

4 Fenestrations
No Angio KT
Neck deformation

10/49
1/30

1:22 PM
2011-09-16

Ang: 0°



**KT in the 4
target vessels
After
stentgraft
deployment
No correction**

41/49
1/21

1:22 PM
2011-03-16

Rot: +1
Ang: +2°



47/49
1/71

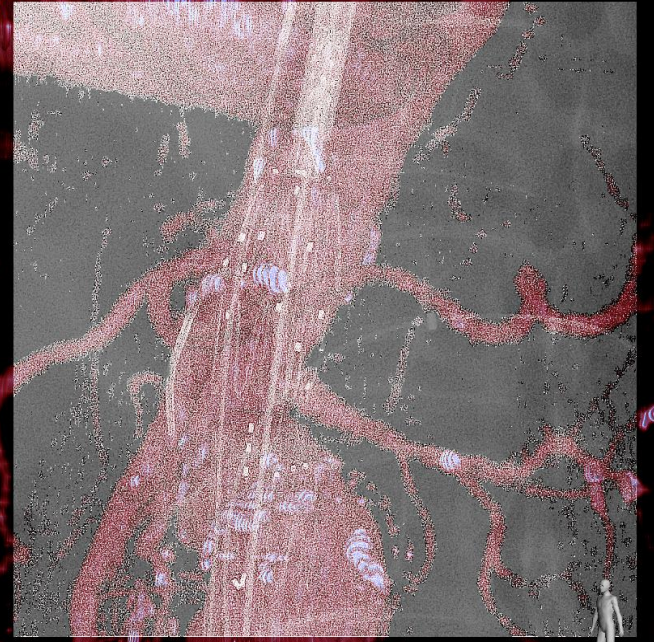
1:22 PM
2011-03-16

Table has been moved, check alignment



Vessel deformation and shift

7.21EVDVD, BERNARD492 80 fps - KV, mAs
Rot +46°
Ang -1°
Zoom 100%



11 / 22
1 / 432

4:13 PM
2010-09-08

Origine of Errors

○ Vessels shifts:

- central<<<peripheral
- Straight <<< tortuosity and angulation
- Floppy<<<stiff

○ Patients movements:

- General anesthesia<<<local anesthesia
- Pain, and patient shifts
- Respiratory and heart movements

○ Errors of overlay:

- 2D/3D<3D/3D
- Time between diagnostic and treatment

Stentgraft with MRA overlay

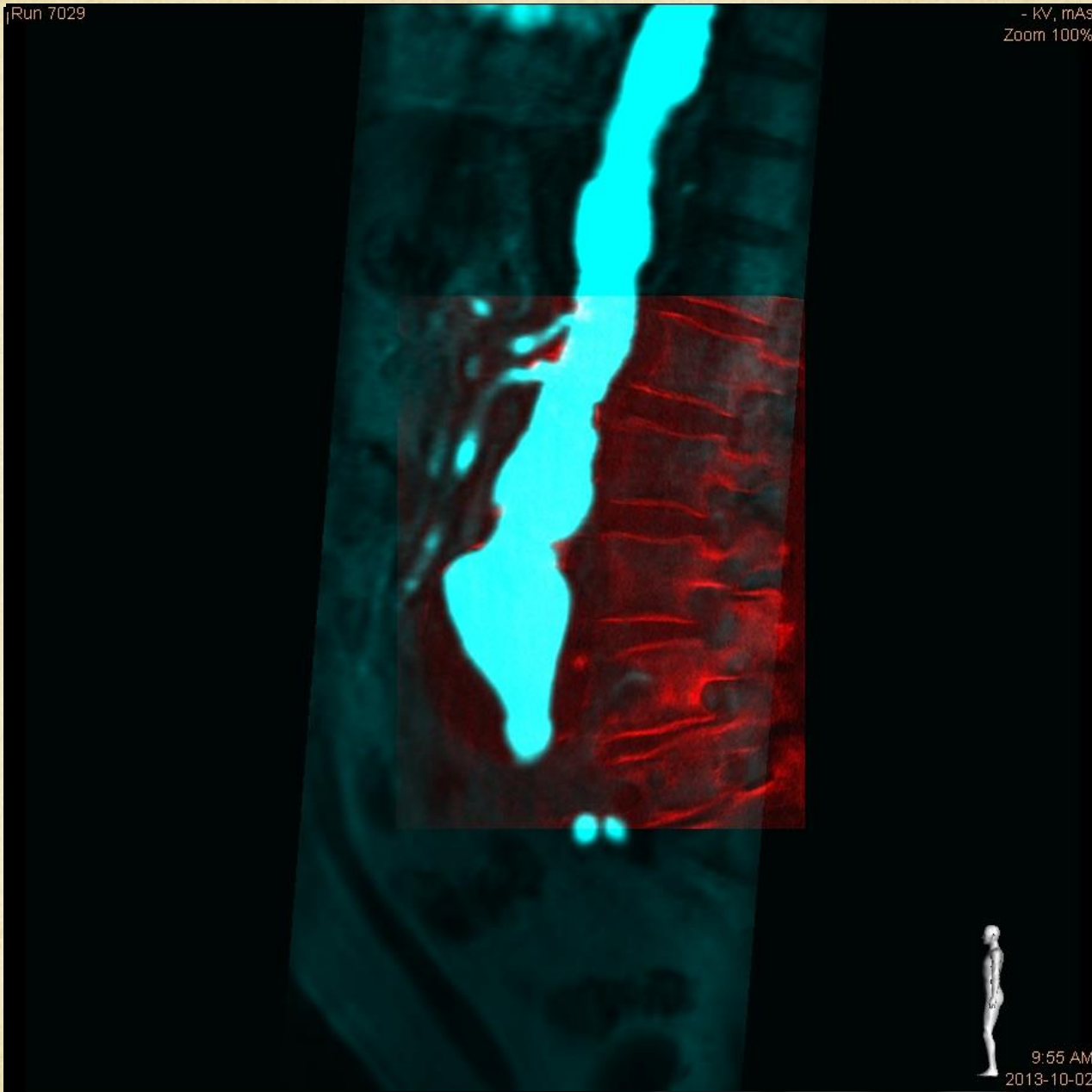
Zero contrast



Sever Allergy

Run 7029

- kV, mAs
Zoom 100%



Fusion with MRA
Technique



R CENTROLAND
Rot -9°
Ang 0°

- kV, mAs
Zoom 100%

6/20
9/13



9:45 AM
2011-09-27

- kV, mAs
Zoom 100%

20/20
1/115



9:45 AM
2011-09-27

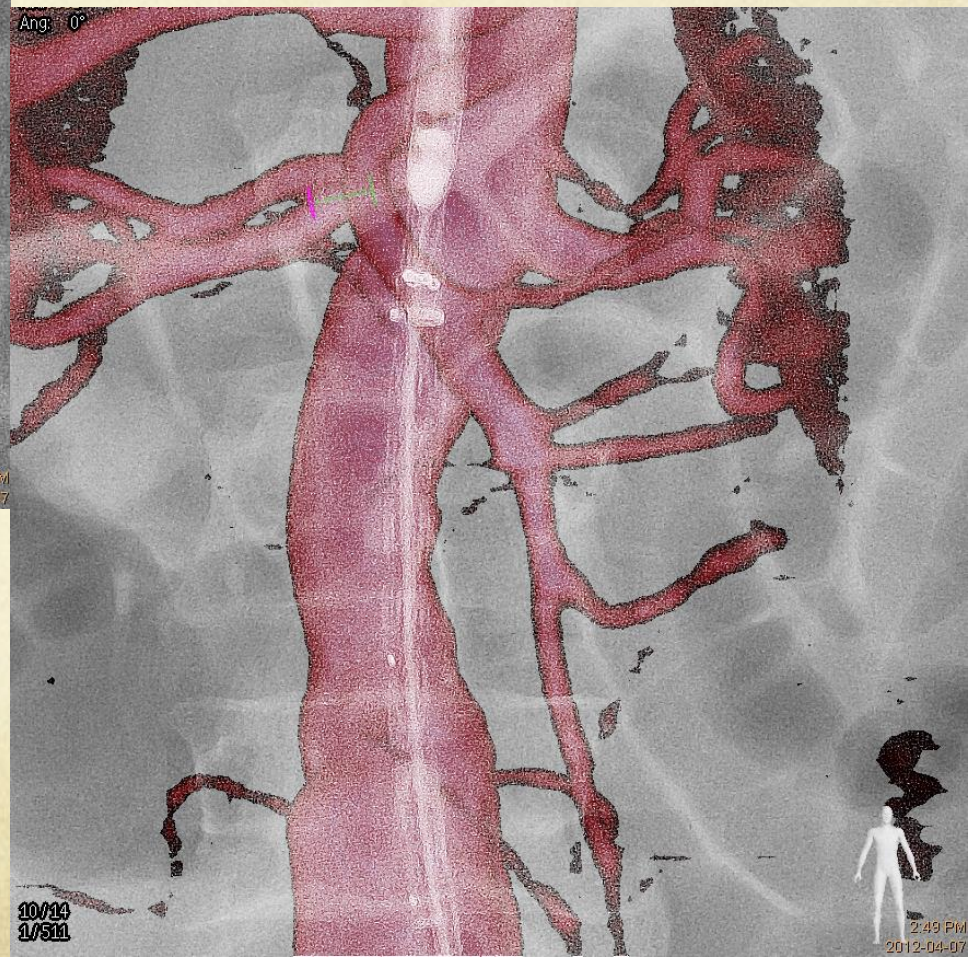
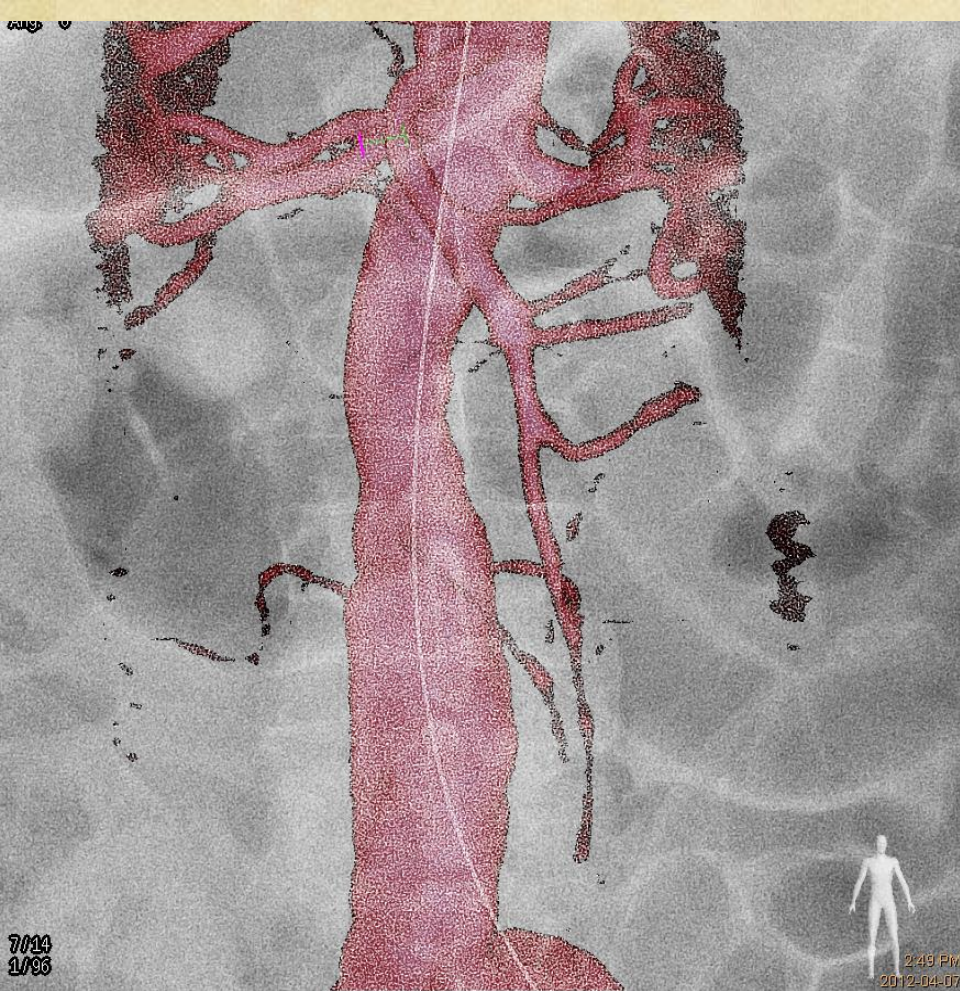
Application:

AAA symptomatic: 56 mm

MRA No rupture but wall enhancement

Anaphylactic Choc during 2 coronarography «15 stents »





MRA

Symptomatic AAA

**Anaphylactic choc to
CM: 2 episodes**

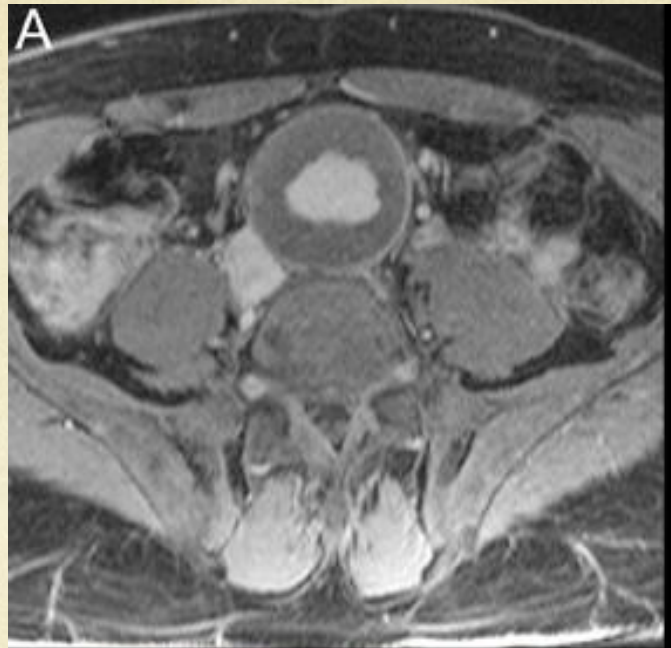
MRA overlay

Intervention: 70 Min

Fluoro: 15 Min

Graphic acquisition: 0

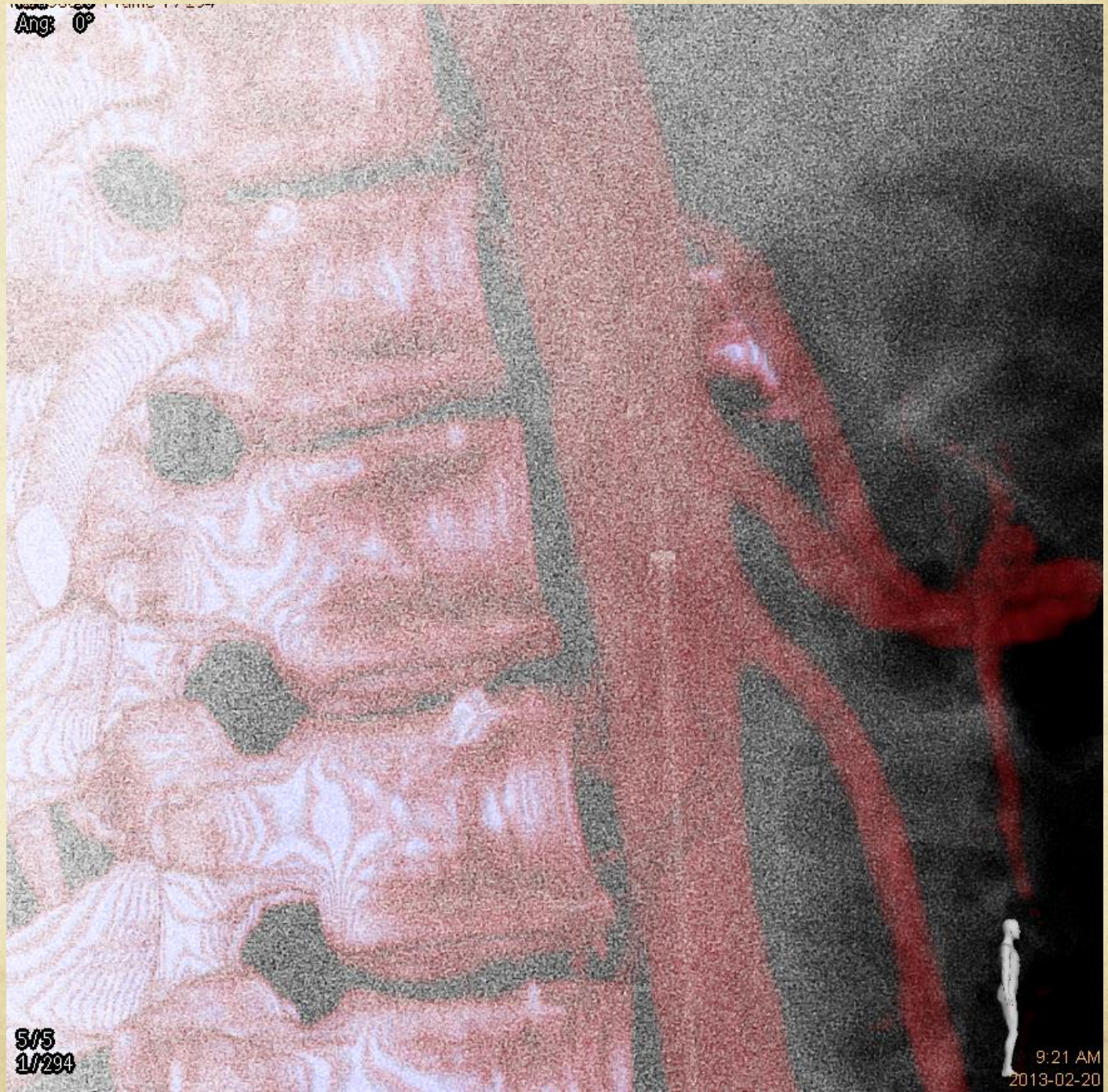
CM: 0cc



Magellan system:

KT in the CT

Splenic aneurysm
embolization



Conclusions

- All aortic parts and vessels are not equal to deformations
- Technology is accurate but we induce errors
- 3D/3D seems to be $>$ to 2D/3D (my opinion)
- Several origin of errors: +/- easy to avoid
- Clinical applications for today technology is enough
- Futur (robotics and automatic navigation) need more accuracy???